

# **Trade Barriers and Functional Foods — What are the Forgone Benefits?**

A Thesis Submitted to the College of  
Graduate Studies and Research  
in Partial Fulfillment of the Requirements  
for the Degree of Master of Science  
in the Department of Bioresource Policy,  
Business and Economics  
University of Saskatchewan  
Saskatoon

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# ABSTRACT

Functional foods provide positive externality benefits to society through the promotion of health benefits that lower the potential of illness for individual consumer and reduce the health care costs that are borne by governments. With strong market growth and considerable potential social benefits, functional foods appear to be an important area for future expansion in the global food market. However, pre-existing trade barriers to international commerce reduce, or sometimes eliminate, trade in functional foods. Given that there are benefits associated with health-giving attributes from functional foods, retaining trade restrictions on functional foods may lead to additional forgone benefits.

To examine the effects of the positive health benefits arising from functional foods when pre-existing trade restrictions are in place, a comparative-static partial equilibrium trade model is modified. Four cases pertaining to import restrictions on functional foods are examined in the trade model based on two categories: trade policies and ability to produce. The theoretical framework provides an illustration of the potential welfare benefits forgone from the existence of trade barriers when a traditional food becomes a functional food.

Empirical case studies examined canola oil as a functional food. The value of the benefits foregone from maintaining trade barriers to canola oil in two countries: China and United Kingdom were estimated. In addition, a cost of illness model was used to estimate health care savings. The final ratio suggests that existing trade policies directly result in non-trivial costs to society. . As a result, current trade regulations might be re-evaluated by policy makers to better reflect the evolving markets for functional foods.

# ACKNOWLEDGEMENTS

This thesis represents my two and half years of study and research in Canada. I would like to thank Dr. William A. Kerr who not only for his instruction, supporting and guidance during this research project as my supervisor but also for his inspiration, encouragement and patience throughout my whole study in Canada as a kind and helpful friend. Thanks for his insistence and strong faith in my capabilities in study and research.

I would also like to extend my appreciation to my committee members, Jill E. Hobbs and Peter W.B. Phillips for their participation and suggestions. I am also grateful to Brian T. Oleson for serving as external examiner and for his valuable suggestions provided during the defence. I would also like to thank Canadian Agricultural Trade Policy Research Network for their funding supports during my thesis composition. I would also address my thanks to the entire faculty, staff and graduate students in the department of bioresource policy, business and economics for their generous help and supports.

I am greatly thankful to my parents who raised me up in a warm and peaceful atmosphere that full of trusts and encouragements. I deeply thank my father, Heng Zhang who sets up an excellent model during my education and always supports my study with infinite patience and help. I eternally thank my mother, Weike Zhang who gave me a chance to see the whole world and provide any support whenever I need. I am also thankful to my boyfriend, Li Lin for his encouragement and understanding throughout my master program. Thanks for their forever love along with me.

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# Chapter 1: Introduction to functional foods

*“Let food be your medicine and medicine be your food.”*

— Hippocrates, 400 BC<sup>1</sup>

## 1.1 Introduction

The presence in the market of foods enriched to improve human health and/or that naturally promoted good health is not a new phenomenon. In recent years, however, food consumption for natural purposes is increasingly comingled with a desire to improve health and well-being (Niva and Mäkelä 2007). Consumers have expanded their interest in food beyond it being solely a source of nutrition to it being a source of additional health benefits (El Hafid, 2004). Increasing incomes have made it possible for consumers to think more about their broader well-being and they have become interested as to whether food can contribute to that well-being. Further, as the population in high income developed countries ages, there is a rising demand for food products to maintain and improve one’s health - as an alternative to pharmaceuticals. As a result, it is important to take account of these additional benefits in economic analysis. This thesis is a first step in incorporating the benefits associated with functional foods into the economic analysis of international trade.

## 1.2 Overview of functional food

New types of foods designed to promote health or to reduce the risk of diseases have been recognized as functional foods since the 1990s (Niva and Mäkelä 2007). These new products are designed to meet specific health concerns by assisting disease prevention and helping to promote health. In addition to new products which are designed to be health-enhancing, a number of traditional and familiar foods are also now considered functional foods as new health benefits been recently discovered

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<sup>1</sup> As cited in Siegfried Gursche, *Let Food Be Your Medicine and Medicine Be Your Food*.  
[http://www.alive.com/1293a4a2.php?subject\\_bread\\_cramb=725](http://www.alive.com/1293a4a2.php?subject_bread_cramb=725)

(Hasler, 2000). For example, at the annual Frontiers in Cancer Prevention Research conference in Seattle 2004 it was pointed out that, an apple a day may be an effective approach to cancer prevention (Davis, 2004). Eggs have proved to be an excellent dietary source of many essential (e.g., protein/choline) and non-essential (e.g., lutein/zeaxanthin) elements that promote optimal health (Hasler, 2000).

Consumers are increasingly interesting in combining their diet decision with the promotion of health benefits. Research conducted by the International Food Information Council (IFIC) starting in 1996 suggests that consumer demand for functional foods has steadily increased and will continue to do so (Schmidt, 2000). In 2007, the IFIC commissioned its fifth survey on Americans' awareness and attitudes toward functional foods. This survey revealed that most Americans believe in the idea of functional foods and the health benefits they can provide. Consumers retain a strong interest in foods and food's links with specific benefits that can help promote health and reduce the risk of disease (IFIC, 2007).

### **1.3 Problem statement**

Due to consumers' increasing interest in functional foods, there appears to be strong market growth and considerable potential for the functional food industry to expand into the global marketplace. However, the agri-food sector is one of the most heavily protected sectors in the global economy (Gaisford and Kerr, 2001). Trade barriers in agriculture are largely historic in origin – they predate the rise of information pertaining to the potential benefits of functional foods. The decisions to put trade barriers in place were, hence, made on the basis of an acceptable rise in the price of food considering only its nutritional attributes. In other words, those imposing trade barriers did not at the time consider the forgone benefits associated with health-giving attributes.

## **1.4 Objective**

Given that there may be additional benefits forgone from the existence of trade barriers, with better information those responsible for trade policy may wish to alter their decisions to impose trade barriers on individual food products. This thesis has two objectives: (1) to develop a theoretical framework to illustrate the potential welfare benefits foregone from the existence of trade barriers when a traditional food becomes a “functional food” and; (2) to provide illustrative case studies of the value of the benefits foregone from maintaining trade barriers.

## **1.5 Thesis outline**

This thesis is organized as follows. Chapter 2 consists of a literature review pertaining to functional foods. First, the terminology pertaining to functional foods and their definitions are introduced. Second, the current state of functional food markets around the world is described. This gives a macro-view of the industry globally. Next, the health benefits of functional foods are discussed. With information on the various health benefits associated with functional food attributes, a better understanding of the meaning of “functional” can be attained. Last, health benefit models are reviewed to assist in selecting the analytical tools used in the case studies selected for this thesis.

Following the literature review, Chapter 3 fully develops a trade model that explicitly incorporates functional foods. Starting with the standard partial equilibrium trade model, four cases pertaining to trade restrictions on functional foods are developed and analyzed.

Illustrative empirical case studies are provided in Chapters 4 and 5. Canola/rapeseed oil with functional attributes is examined as a functional food. By examining markets with different trade restrictions for canola/rapeseed oil, estimates of the value of additional foregone benefits from the retention of existing trade barriers are provided. Sensitivity analysis is conducted for key assumptions made during the benefits

calculations. Generally, the estimates of the foregone benefits and health care savings are based on published sources.

Lastly, summary, conclusions and suggestions for further research are provided in Chapter 6.

# Chapter 2: Literature Review

## 2.1 Functional food

### 2.1.1 Definitions and distinctions internationally

Functional food is a concept that is gaining ever wider acceptance around the world.

There is, however, no agreement on an exact definition (Health Canada, 1998).

The Bureau of Nutritional Sciences, of the Food Directorate of Health Canada, has proposed the following definition:

A functional food is similar in appearance to, or may be, a conventional food, is consumed as part of a usual diet, and is demonstrated to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions (Health Canada, 1998, Page 3).

In Canada, functional foods range from traditional food products with health-enhancing attributes to new agricultural technologies including GM food products (Malla et al., 2007).

Both nutraceuticals<sup>2</sup> and functional foods are sometimes classified as “natural health products” in Canada. One of the major distinctions is that functional foods remain food products during consumption, unlike nutraceuticals which are taken in a processed form such as a capsule or oil in medical sized doses. A large number of traditional medicines based on herbal and homeopathic preparations fall within the scope of “natural health products”. Normally, such products are typically available for purchase in the “vitamins, herbs and supplements” sections of most Canadian grocery stores. (House of Commons, 1998; Health Canada, 1999). Another similar term is “novel foods”. Food that has been genetically modified so that the characteristics of

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<sup>2</sup> A *nutraceutical* is a product isolated or purified from foods that is generally sold in medicinal forms not usually associated with foods. A *nutraceutical* is demonstrated to have a physiological benefit or provide protection against chronic disease (Health Canada, 1998, Page 3).

the plant, animal or microorganism have been altered or changed from those which it is derived is also called a novel food (Health Canada, 1999). The term would include some functional foods.

Currently, the Food and Drug Administration (FDA) in the United States has no specific definition or special regulatory regime for foods being marketed as “functional foods”. FDA regulates foods labeled as “functional foods” under the same regulatory framework as other conventional foods (FDA, 2006a). Although there is no formal definition for “functional food”, a report by the Institute of Food Technologists (IFT) in the US defined “functional foods” as “foods and food components that provide a health benefit beyond basic nutrition (for the intended population)” (IFT, 2005).

In the US, the term “Dietary Supplements” (usually viewed as nutraceuticals) is often used to refer to health-enhanced products. The FDA regulates dietary supplements under a special set of regulations that cover both conventional foods and drug products (prescription and over-the-counter) (FDA, 1997). Following the definition in the US Dietary Supplement Health and Education Act (DSHEA) of 1994, a dietary supplement is “a product taken by mouth that contains a ‘dietary ingredient’ intended to supplement the diet” (FDA, 1995). The "dietary ingredients" may include: vitamins, minerals, herbs or other botanicals, amino acids, and substances such as enzymes, organ tissues, glandulars, and metabolites (FDA, 1995). Dietary supplements can be found in many forms such as tablets, capsules, softgels, gelcaps, liquids, or powders (FDA, 2001). Under DSHEA, “dietary supplements” is a special category classified as foods instead of drugs.

In Japan, policy development in the area of functional foods is directed at “foods for special health uses” (FOSHU). Regulated by the Ministry of Health, Labor and Welfare (MHLW) in Japan, FOSHU refers to “foods containing ingredients with functions for health and consumed for the maintenance/promotion of health or special

health uses by people who wish to control health conditions, including blood pressure or blood cholesterol” (MHLW, n.d.). FOSHU must be assessed for the safety of the food and effectiveness of the functions for health and the claim must be approved by the MHLW.

With increasing attention being paid to the concept of “functional foods” and their markets, the European Union set up the European Commission Concerted Action on Functional Food Science in Europe (FUFOSE). In European Union countries, foods recognized as “functional foods” must be normal products that can easily be consumed in the diet. A functional food can be a natural food approved as “functional” or a food with modified components to improve health by technological or biotechnological means (EUFIC, 2006).

Although there is no universal definition for the concept of “functional foods”, the central theme is the same regardless of the exact definition - functional foods are introduced into the market as a normal food form in order to promote human health.

### **2.1.2 Health benefits**

*“If we are going to live so intimately with these chemicals — eating and drinking them, taking them into the very marrow of our bones — we had better know something about their nature and their power.”*

-----Rachel Carson, *SilentSpring*, 1962.

It seems that all foods are functional in that they provide nutrients. However, conventional foods become marketable as “functional foods” when they are endowed or supplemented with ingredients that contain health benefits beyond basic nutrition (NIEHS, 1999). Functional foods are particularly focused on health-enhancing ingredients or common components that have potential benefit to human beings.



Many foods we eat everyday contain natural components that provide benefits beyond basic nutrition. Examples<sup>3</sup> of functional foods provided by the International Food Information Council (IFIC) can be divided into four categories. Basic foods with functional properties (e.g., anti-oxidant beta-carotene in carrots; lycopene in tomatoes; omega-3 fatty acids in salmon) are the most common functional food in the daily diet of individuals. Some processed foods (e.g., oat bran cereal) are viewed as a second type of functional foods which provide functional attributes from their original components. Processed foods with added functional ingredients (e.g., calcium-enriched fruit drinks) are also recognized as functional foods. Finally, foods enhanced to express higher levels of functional components (as through livestock feeding or plant and livestock breeding) are also considered as functional foods. (IFIC, 2000).

Understanding the complex interactions between nutritional components and the human body is still in its scientific infancy. However, there is already strong scientific evidence that suggests eating foods with functional benefits<sup>4</sup> as part of the daily diet is a positive way to reduce the risk of, or relieve a number of, health problems such as cancer, heart and cardiovascular disease, gastrointestinal disease, menopausal symptoms, osteoporosis, eye problems, etc. (NYSOFA, n.d.). For example, lycopene in tomatoes and tomato products is well known as a potent antioxidant in protecting cells against harmful damage from oxidation. Soy contains hormone-like actors that help protect against hormone-dependent cancers such as endometrial and ovarian cancers (IFIC, 2001).

New health giving attributes are being identified through ongoing scientific research. For example, a new process was recently developed by researchers at the University of Maryland which transforms ordinary flour into flour with enhanced levels of antioxidants — compounds that have been found to fight against cancer and heart

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<sup>3</sup> For functional foods and their components, see Appendix 1.

<sup>4</sup> For functional foods and their potential benefits for human health, see Appendix 1.

disease. Likewise, scientists at Nihon University in Japan found an easy way to remove phytate — a chemical that is known to hinder absorption of calcium in the human body (ScienceDaily, 2006).

With health attributes beyond basic nutrition, functional foods are viewed as a convenient food type in promoting health benefits to human bodies. It improves the health condition of citizens and reduces health care costs. Functional foods also offer a great opportunity to the agriculture and food industry as the potential market for functional foods is expanding (AAFC, n.d.).

### **2.1.3 The functional food industry**

The growth of the functional foods industry provides an opportunity for enhancing consumer understanding of the link between diet and disease, analyzing health care costs and examining the process of technological improvement in food production (El Hafid, 2004). Functional foods appear to be significant in improving the health of citizens, reducing health care costs and supporting development in the agri-food sector. As a result, food products associated with benefits which enhance human health can be identified as a potential growth area for the food industry.

Functional food products represent a value-added growth opportunity for the agri-food industry around the world. According to Euromonitor International (2006), the world market for functional foods has grown by more than 50 percent in the last 5 years. The United States, Japan and Europe are major global markets, contributing over 90 percent of total sales (Kotilainen et al., 2006).

Healthy foods (natural and organic foods, functional foods and lesser evil foods<sup>5</sup>) sales in the United States reached US \$102 billion in 2004. Among them, functional foods accounted for 20 percent of total US healthy food sales (excluding food service).

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<sup>5</sup> Lesser-evil foods are manufactured by removing unwanted substances including fat, calories, preservatives, caffeine, alcohol, salt, etc. from their originally state (NBJ,2008).

In addition, with increasing concerns regarding human health, the functional foods market grew 6.8 percent in 2004 compared to a 1.6 percent growth rate in total food sales (NBJ, 2006). Functional attributes are becoming an important factor in food market success. The sales of functional and fortified foods were expected to reach US \$35.86 billion in 2006, up to 22% over 2005, and \$59.87 billion in 2009 (Sloan, 2006).

Japan is the second-largest market in the world for functional products after the US (JETRO, 2006). Starting from the early 1980s, functional foods developed rapidly in Japan. The government has had a strong involvement in this industry as a result of Japan's aging population with its increasing health problems and the expected future increases in health care costs (Kotilainen, 2006). With an ongoing increase in demand expected for functional foods, Japan represents one of the most sophisticated markets for these products. The Japanese market is valued between US \$4 billion and US \$15 billion annually (SWMI, 2002).

The functional food market in Europe is expected to grow quickly — by as much as 16 percent annually — with approximate value US \$15 billion (SWMI, 2002). Within Europe, Germany, France, the United Kingdom and the Netherlands represent the most important markets for functional foods (Menrad, 2003). In the United Kingdom, sales of functional foods and drink were valued at £835 million (US \$1.65 billion<sup>6</sup>) in 2003. The market is forecast to double in the next few years, reaching £1.72 billion (approximate US \$3.4 billion) in 2007 (IGD, 2007).

As a whole, the functional foods sector appears to provide a large potential for rapid growth in global markets. The market is expected to grow much faster than the overall food industry.

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<sup>6</sup> GBP: USD = 1:1.98, based on the current market foreign exchange rate (average, July 7, 2008).

## **2.2 Valuing health benefits**

Correct valuation of risks to human health is essential to health, safety, and the environment (Berger et al., 1987). A number of economics studies of health benefits have been developed to measure the benefits from health savings. Economic evaluation methods considered to take a comprehensive approach include cost-illness analysis, cost-effectiveness analysis, cost-utility analysis and cost-benefit analysis; while partial economic evaluations depend on cost analysis, cost-comparison studies and cost-outcome descriptions (Higgins and Green, 2008).

### **2.2.1 Cost-of -illness model**

Traditionally, measuring the benefits of improved health has been based on avoidance of the damage that occurs as a result of contracting disease (Berger et al., 1987). One of the most simple and straightforward approaches to estimate the medical costs avoided based on health improvements is the cost-of-illness (COI) model (EPA, 1991).

Cost of illness studies were first used in the late 1950s and early 1960s and have been used extensively since that time (Cooper and Rice, 1976). They are most common in the medical literature. The basic idea in COI studies is to estimate the maximum economic costs that could potentially be saved or gained if a disease were to be lessened or eradicated (Segel, 2006). The cost of illness is measured by the sum of the direct costs for prevention, detection and treatment from health care and the indirect costs or loss due to disability (morbidity) and premature death (mortality) (Cooper and Rice, 1976). A COI study, however, may be conducted in several different ways. Each approach in calculating costs may vary due to different perspectives from society, the health care system, businesses, the government, and citizens (Segel, 2006).

COI studies are valuable because they provide informative evidence for policy makers (Segel, 2006). COI analysis helps policy makers and government make their decisions on public programs by showing the financial impact of certain diseases (Bartlett et al., 1994). For example, a COI model was used by Miller et al. (1998) to estimate medical costs borne by US states related to smoking, this strengthened the fight against the tobacco industry in state lawsuits attempting to recover losses associated with cigarette smoking. Cost of injury studies based on a version of the COI approach can also provide information on disease control and prevention strategies which may be useful to safety and health professionals (Rice et al., 1989; Biddle et al., 2005). Thus, the COI model is a powerful method in addressing important relationships between medical incidents and social policy.

### **2.2.2 Cost-of-illness — an example**

Malla et al. (2007) valued the potential health benefits of trans fat-free canola oil by using the COI model. In their paper, a COI model is adapted to estimate the impact of a change in dietary fat intake on coronary heart disease (CHD) costs in Canada (Malla et al., 2007). Their model is based on an assumption that a 1% drop in the incidence of the disease in the long run will result in a 1% decrease in the COI. By including direct and indirect CHD costs (i.e., the total cost of illness, disability, and premature death) in the calculation, two alternative methods of calculating reductions in the cost of illness are embedded in the study. Both approaches followed basic assumptions of the COI model, however, Method 1 is focused on total cholesterol level changes based on reviews of the scientific literature; while Method 2 concentrated on the percentage of energy intake change from a study by the US Food and Drug Administration (Malla et al., 2007).

Using the two different calculation methods, Malla et al. (2007) have shown that the potential health-care or cost of illness savings in Canada from healthier trans fat-free

canola oils are important. The authors suggest valuing health improvements through food industry innovations is a subject worthy of further study (Malla et al., 2007).

### **2.2.3 Assessments of the Cost-of -illness model**

#### **2.2.3.1 Weaknesses of COI model**

There are, however, weaknesses associated with the use of cost-of-illness studies. The COI model is developed under the assumption that the impact of a disease is to be mitigated or eradicated. However, from the characteristics of diseases, most chronic illnesses that generate large medical expenses cannot be greatly reduced or completely eradicated. Thus, the “cost savings” estimated by COI studies will likely be overestimated under the optimal assumption (Roux and Donaldson, 2004).

In addition, as a basic and straightforward method, a COI model may overlook additional information that could be used to better value the impact. Opportunity costs, for example, should be considered in a health evaluation to obtain the optimal solution for the allocation of resources (Donaldson and Narayan, 1998). Another example is the difficulty associated with measuring the utility foregone by consumers in a COI model compared to a contingent valuation (CV) model. Based on a survey of willingness-to-pay or willingness-to accept among responders, a CV model is superior in valuating non-market attributed which give people utility. Without taking into account the loss in utility to individuals, the COI model may underestimate the true cost of illness. Furthermore, instead of establishing a relationship between costs and benefits, the static COI model simply tabulates the two concepts and adds them together to establish the net total cost (Roux and Donaldson, 2004). Without the appropriate information and a comprehensive treatment, COI studies are likely to be sub-optimal in determining how resources are to be allocated (Drummond, 1992.).

Further, the COI calculations must be done carefully to avoid double-counting problems (Roux and Donaldson, 2004). Many diseases are connected with each other

stemming from a common origin. Simply calculating the total costs resulting from certain diseases might lead to underestimation or incomplete analysis (Donaldson and Narayan, 1998).

Hence, sensitivity analysis is an appropriate cautionary approach when there is uncertainty. By setting several different levels or discount rates as well as ranges for other important variables, a range of possible costs would provide more credibility for policy analysis (Segel, 2006).

### **2.2.3.2 Conclusions regarding the COI model**

Although the COI model has several disadvantages, a COI study can be a superior method under some conditions. First, by placing emphasis on the whole society rather than the individual's perspective, the COI model is appropriately designed for a public health agency to make their decision (Rice, 1962). Secondly, the choice of models is usually limited by the availability of data. The COI model is a simple approach that requires little restriction on the type of data that can be used. Thus, a COI model is an easy and realistic solution if obtaining the data is a relatively easy task compared to other health valuation models (Rice et al., 1989). Moreover, as a simple and straightforward model, the COI approach is relatively straightforward to calculate and easy to understand (Biddle et al., 2005). If the economic analysis is formulated to general questions about health cost impacts, the COI model is likely a suitable choice.

In this thesis, the objective is to calculate foregone benefits from international trade barriers placed on functional foods in order to provide suggestions for both trade and public health policy. Following the trade model developed in the next chapter, the health benefit evaluation in the case studies is targeted at a general problem. From this perspective, a COI model is viewed as an acceptable analytic tool for fulfilling the objective of this study.

# **Chapter 3: Modelling Trade and Functional Foods**

## **3.1 Basic model**

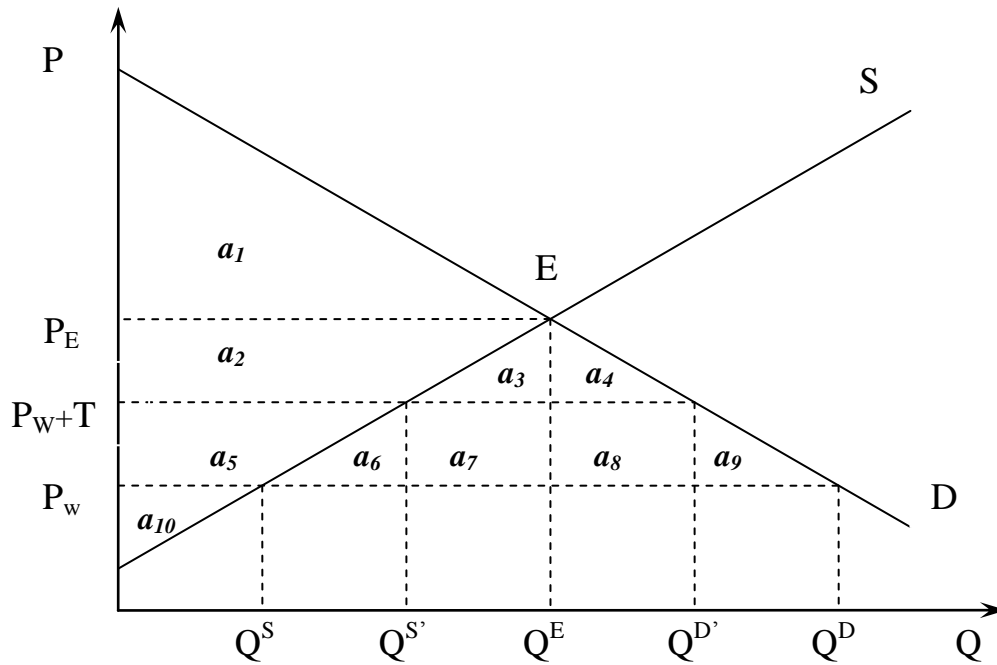
There are a number of theoretical and empirical approaches used in economic modeling of international trade. A general equilibrium approach is often preferred because it captures shifts in resource use and consumption between sectors of the economy (Gaisford and Kerr, 2001). A disaggregated, general equilibrium approach would be desirable when the trade effects for an entire economy with its multiple markets are desired - especially if the cross market effects are expected to be important. Unfortunately, general equilibrium models quickly become intractable when all but the simplest disaggregation is attempted.

Computer-based computational general equilibrium (CGE) models can be used to overcome the limitations of general equilibriums models. CGE models, however, have two major practical problems. They can only be undertaken using a high degree of aggregation, meaning a CGE model is still limited in valuing the interrelationships among sectors. Further, even the simplest CGE models have very high, and costly, data requirements (Gaisford and Kerr, 2001).

While the general equilibrium approach has a useful role in evaluating multiple markets with different commodities, an alternative but complementary approach should be considered if analysis is focused on individual disaggregated commodities and where cross-market effects are expected to be small (Gaisford and Kerr, 2001). In such cases, a comparative-static partial equilibrium approach to modeling international trade relations may be preferable.



In this thesis, the objective is to examine the forgone benefits from international trade barriers placed on functional foods. The economic analysis is focused on the impact of policy changes on specific functional food market viewed in isolation. The cross-market effects are expected to be sufficiently small to be safely ignored. Therefore, a comparative-static partial equilibrium trade modeling approach for the domestic functional food market of an importing country is selected and applied in this thesis.. The comparative-static partial equilibrium trade model can be illustrated in Figure 3.1.



**Figure 3.1 Basic trade model**

D is the domestic demand curve for a particular product. As the price of the product,  $P$ , rises, consumers will not be willing to purchase the same quantity as at the lower price. Consequently, the quantity demanded,  $Q$ , declines and the demand curve is negatively sloped. For supply, as the price,  $P$ , rises, production becomes more profitable and the output supplied by producers increases. Thus, the quantity supplied,  $Q$ , increases, leading to a positively sloped supply curve,  $S$  (Gaisford and Kerr, 2001).

Without the opportunity to engage in international trade, the equilibrium price is determined where the total domestic supply of the commodity is equal to the total domestic demand. At this point, E, the market clears at  $P_E$  because the quantity being supplied by firms,  $Q_E$  is exactly equal to the quantity of the commodity being demanded by consumers.

In Figure 3.1 in the autarky case, consumer surplus is represented by area  $a_1$  which is a triangle above the domestic price and below the demand curve. Producer surplus is area  $a_2+a_5+a_{10}$ , a triangle below the domestic price and above the supply curve. Combined, the consumer surplus and the producer surplus, make up the total surplus or the welfare arising in this market.

Now assume the opportunity to engage in international trade in this product arises. The price consumers and producers face in the international markets is  $P_w$  — the world price. In this case,  $P_w$  is the price at which imports can be obtained in the international market,  $P_w < P_E$ . Assuming transport and transaction costs associated with international shipments are sufficiently small to ignore, the domestic price will decline to equal the world price. At  $P_w$ , domestic consumers are willing to purchase  $Q^D$  while domestic producers are only willing to supply  $Q^S$ . The difference between demand and supply at  $P_w$  is filled by imports. The import quantity is shown as  $(Q^D-Q^S)$ . Consumer surplus  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9$  is a triangle above the world price and below the demand curve. Producer surplus is area  $a_{10}$ . Total welfare is  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9 + a_{10}$  and greater than under autarky (i.e.  $a_1 + a_2 + a_5 + a_{10}$ ). Thus, trade is welfare enhancing.

If  $P_w$  is too low for some producers to make normal profit, they may lobby for protection from imports. Political decision makers may wish to supply protection. Protection could be provided through the imposition of a tariff (tax) on imports. After the tariff, T, is imposed, the domestic price rises from  $P_w$  to  $(P_w + T)$ . At price  $(P_w + T)$ , domestic firms are willing to produce additional quantity because they must now

compete with imports priced at  $(P_w + T)$  instead of with imports priced at  $P_w$ . The supply expands from  $Q^S$  to  $Q^{S'}$ . However, the higher price leads to a reduction in consumption from  $Q^D$  to  $Q^{D'}$ . Thus, imports decrease to  $(Q^{D'} - Q^{S'})$ .

After imposing the tariff, total welfare also changes. The higher domestic price leads to an increase in producer surplus but a loss in consumer surplus. At price  $(P_w + T)$ , the consumer surplus shrinks from area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9$  to area  $a_1 + a_2 + a_3 + a_4$  and producer surplus increase from area  $a_{10}$  to area  $a_5 + a_{10}$ . The tariff causes a loss of consumer surplus equal to  $a_5 + a_6 + a_7 + a_8 + a_9$  for a gain in producer surplus of  $a_5$ . If the objective of the protection policy was to increase producer surplus by  $a_5$ , decision makers must weigh the benefits of producers more heavily than benefits of consumers. In this case, we assume that the revenue received by government is not a motivation in the decision to provide protection. This is a reasonable assumption for most modern market economies where tariffs receipts are a relatively trivial source of revenue<sup>7</sup>. In the case of functional foods, the trade restricting policies may not be tariffs<sup>8</sup>. Thus, the protection would have been granted on the basis of a weighting of consumer and producer benefits only. Let us denote  $\eta$  as the ratio giving decision makers' weighting of the changes in consumer surplus and producer surplus arising from the imposition of a protectionist policy<sup>9</sup>.

$$\eta = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}}$$

Compared to the situation before the tariff, consumers suffer a loss of area  $a_5 + a_6 + a_7 + a_8 + a_9$  and producer gain area  $a_5$ . Thus,

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<sup>7</sup> This may not be the case for some developing countries and the analysis would have to incorporate tax revenues for those countries. We ignore these cases.

<sup>8</sup> It is assumed that the rents available from the imposition of non-tariff barriers do not influence policy makers' decisions.

<sup>9</sup> The ratio will be underestimated without the tariff revenue. The tariff revenue could be used for social welfare improvement – an addition to the numerator of the ratio formula. However, the tariff revenue need not be spent in the market we are examining and thus would represent a loss to the market. In this thesis, however, tariff collected as government revenue will not be considered as part of the policy makers' decision to extend protection to producers. As suggested above, it might, however, be a factor in the decision process in some developing countries and the model used in our analysis would have to be modified in those cases.

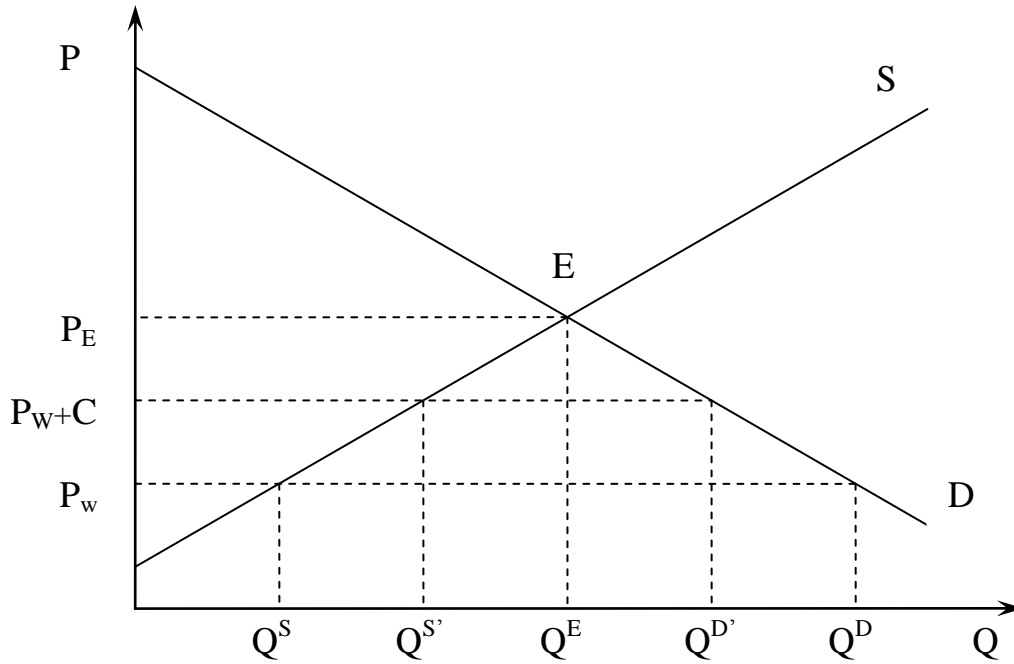
$$\eta = \frac{\Delta \text{ consumer surplus}}{\Delta \text{ producer surplus}} = \frac{\mathbf{a}_5 + \mathbf{a}_6 + \mathbf{a}_7 + \mathbf{a}_8 + \mathbf{a}_9}{\mathbf{a}_5}, \text{ Which is larger than 1.}$$

In order to clarify the effects before and after the granting of protection, let's simply assume  $\eta = 3$  for this specific situation. When  $\eta = 3$ , the loss for consumers arising from the higher price is three times larger than the gain by producers. Political decision makers must assign at least three times the weight to producer benefits than they assign to consumer benefits. Given that the tariff was imposed, a weight of three is the minimum weight they could have used in their decision, although a higher weighting may have been possible. While political decision makers may not explicitly make these weighed trade offs, they must do it implicitly with some "rule of thumb". The change in trade policy turns out to be welfare reducing for the domestic economy (Gaisford and Kerr, 2001). If the situation in the market changes such that  $\eta$  rises, a case might be made for decision makers to re-evaluate their decisions.

### **3.2 Four cases for trade barriers applied to functional foods**

This thesis focuses on the trade policy effects when new products with health improving attributes — functional foods — become available in markets with pre-existing restrictions on trade in place. Functional foods have significant potential to improve the health of citizens, reduce health care costs, and support economic development (AAFC, n.d.). Functional foods represent a value-added growth opportunity for the Canadian agri-food industry, both domestically and internationally. As suggested in the previous chapter, the market is large, global and growing (Tebbens, 2002).

While the trade barrier in place could be a tariff, non-tariff barriers are also common in agriculture (Hobbs, 2007). Food products normally face two broad types of non-tariff barriers. One set of non-tariff barriers acts like an import ban — prevents any imports. Other non-tariff barriers raise the cost of exporting so that imports still take place, but at lower levels — the effect is similar to a tariff (Kerr, 2007).



**Figure 3.2 Non-tariff barriers effects**

Figure 3.2 illustrates the differential effects of a ban compared to an increase in costs as a result of an import regulation. Before any import regulation is put into place, domestic consumers and producers face  $P_w$ , a world price in the international market. At  $P_w$ , domestic demand from consumers is  $Q^D$  while domestic supply is  $Q^S$ . The difference between demand and supply at  $P_w$  leads to imports. The import quantity is shown as  $(Q^D - Q^S)$ . However, when there are non-tariff barriers pertaining to imports, the market will be constrained. If the non-tariff barrier acts like an import ban, it prevents any imports. There is only domestic production sold in the market and imports at  $P_w$  cannot take place. The market will clear at  $P_E$ . The equilibrium quantity is  $Q^E$ . Thus, equilibrium will be reached at  $P_E$ , a higher price than  $P_w$ .

Non-tariff barriers can also raise the cost of exporting. In such a case, the domestic price will increase from  $P_w$  to  $(P_w + C)$  - where  $C$  is the additional cost increase faced by the exporter in satisfying the importing country's requirements. At  $(P_w + C)$ , import quantity shrinks to  $(Q^{D'} - Q^{S'})$ .

In order to gain market access, exporters may have to satisfy cost increasing regulations of importing countries. An example might be testing to ensure that imports are free of a drug residue. These regulations may be unduly onerous and thus provide economic protection — they are a disguised protectionist measure. Thus, there are additional costs incurred in the process of production when firms in the exporting country wish to export their products. If there are different requirements for testing and proof of scientific evidence, the importing country may refuse to accept foreign credentials or scientific procedures and the importer's regulations are equivalent to an import ban.

The welfare effects of a trade restriction also vary depending on whether or not the new functional food can be provided domestically in the importing market. Therefore, four different cases pertaining to import restrictions on functional foods can be examined. These four cases fall into two categories: trade policy and ability to produce. Within “trade policy”, the focus is on the trade barrier faced by exporters. The barrier is either equivalent to an import ban or a cost increasing regulation<sup>10</sup>. Under “ability to produce”, functional foods are divided by the ability to acquire the new products from domestic producers as well as imports (domestic production or imports) or solely from imports (imports only).

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<sup>10</sup> Tariffs are treated as part of the latter category.

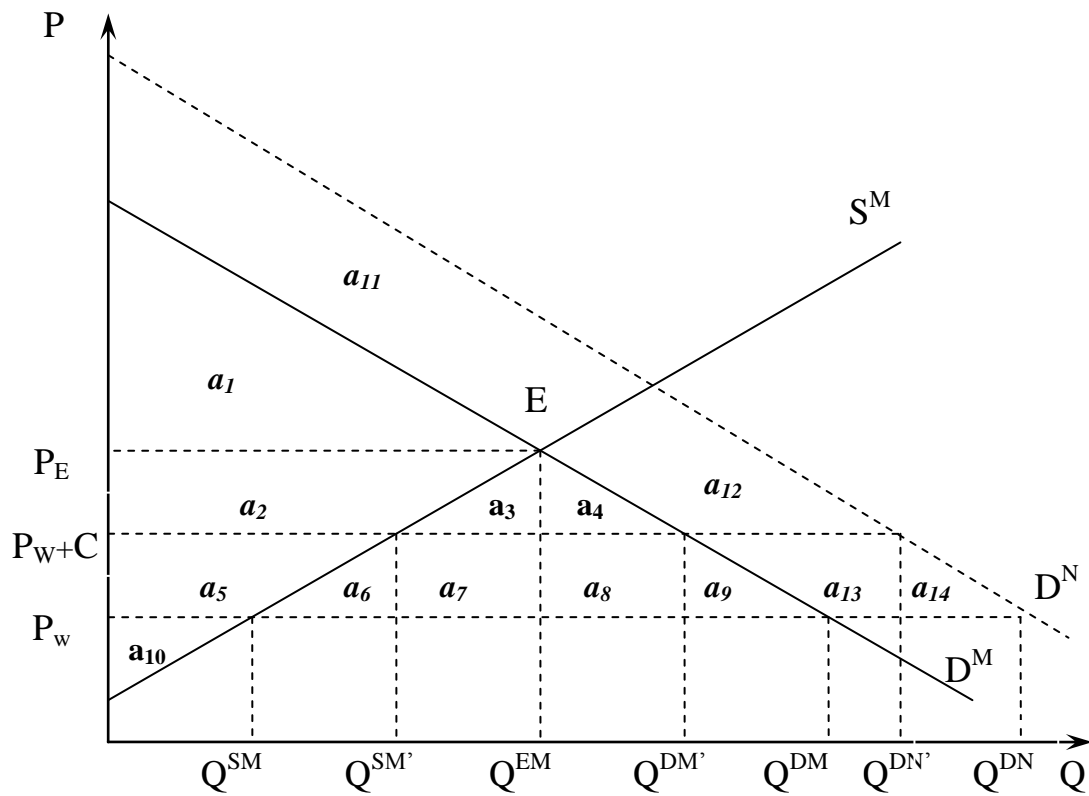
**Table3.1 Four cases for trade policy and the supply of functional foods**

Trade Policy Ability to produce	Cost increasing regulation	Import prohibition
Domestic production or imports	Case 1	Case 2
Imports only	Case 3	Case 4

Table 3.1 outlines the four cases under different trade policy and production constraints. Case 1 and Case 3 are based on the same trade policy but different assumptions regarding the ability to produce. Products in Case 1 can be supplied by domestic producers and obtained from the international market. On the other hand, for Case 3 the functional food version of the product can only be acquired from the international market. In Case 2 and Case 4 the supply choices are the same as above but the market is constrained by the more restrictive policy such that imports are effectively banned.

### **3.2.1 CASE 1**

For Case 1, there are both domestic sellers and an international source of supply for a new functional food — an innovative product.



**Figure 3.3 Case 1 — domestic and import supply, cost increasing regulation**

Figure 3.3 shows the domestic market of the conventional product as well as functional food.  $D^M$  is the demand curve for a pre-existing product M that does not have health enhancing attributes. There is a supply curve  $S^M$  for product M. At  $P_w$ , the world price for M, consumers are willing to purchase the product M at  $Q^{DM}$  and producers will only supply  $Q^{SM}$ . Imports would be  $(Q^{DM} - Q^{SM})$ . If a cost increasing import restriction has been put in place that raises costs so that the “landed price” equals  $(P_w + C)$  — cost increasing regulation (or equivalent tariff) — imports will fall to  $(Q^{DM'} - Q^{SM'})$ .

The cost increasing policy will alter welfare in the market. Without the regulation, the consumer surplus is area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9$ . Producer surplus is shown as area  $a_{10}$ . After trade policy is implemented, consumer surplus decreased to area  $a_1 + a_2 + a_3 + a_4$ . Consumers suffer a loss of area  $a_5 + a_6 + a_7 + a_8 + a_9$  in consumer



surplus because of the higher price. On the other hand, producer surplus increases to an area  $a_5 + a_{10}$  — a change equal to  $a_5$ . The relative weighing ratio is

$$\eta^M = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}} = \frac{a_5 + a_6 + a_7 + a_8 + a_9}{a_5}$$

Now assume a new health enhancing functional food version of product M, denoted product N, comes onto the market. In order to simplify the exposition, we make three assumptions. First, we assume the new product, N, can be produced at the same cost as product M by both domestic and foreign suppliers. Second, product N can be represented by the same demand curve as product M and that the new health attribute does not change the slope of the demand curve in a meaningful way.<sup>11</sup> Thirdly, from the perspective of consumers, more people are willing to buy the new health enhancing product N at the same price. Therefore, demand increases shifting out the demand curve from  $D^M$  to  $D^N$ . As the additional demand can be accommodated by acquiring additional imports at  $(P_w + C)$ , there is no change in price. Thus there is no change in domestic producer surplus.

The new product, N, faces the original world price  $P_w$  and distorted landed price  $(P_w + C)$ , the same as with product M. With the new demand curve, consumers receive more surplus than that from product M. With no trade restriction, consumer surplus changes from area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9$  to area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9 + a_{11} + a_{12} + a_{13} + a_{14}$  an increased benefit of area  $a_{11} + a_{12} + a_{13} + a_{14}$ . After the cost increasing trade policy is applied, new world price  $(P_w + C)$  leads to a decline in consumer surplus to area  $a_1 + a_2 + a_3 + a_4 + a_{11} + a_{12}$ . Therefore, the cost increasing policy generates a loss in consumer welfare of area  $a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14}$ . In addition to the direct consumer benefits from functional foods which arise in this market, there may be savings in health care costs<sup>12</sup> for the government as a result of

<sup>11</sup> It is possible that the slope of demand curve for product N will be changed due to a technology innovation in production of N or a change in consumer's perception of the product. As no information is available on how the slope may have changed, a parallel shift in demand is assumed in this thesis.

<sup>12</sup> Health care costs include direct health care cost such as inpatient care cost and out patient care cost as well as indirect health care cost such as loss in productivity and informal care.

the consumption of the functional food. We assume for the moment that these cost savings are a positive constant denoted HCS<sup>13</sup>. The relative weighting ratio is now at least

$$\eta^N = \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}} = \frac{a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14} + \text{HCS}}{a_5}$$

Therefore,  $\eta^N > \eta^M$  ;

$$\frac{a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14} + \text{HCS}}{a_5} > \frac{a_5 + a_6 + a_7 + a_8 + a_9}{a_5}$$

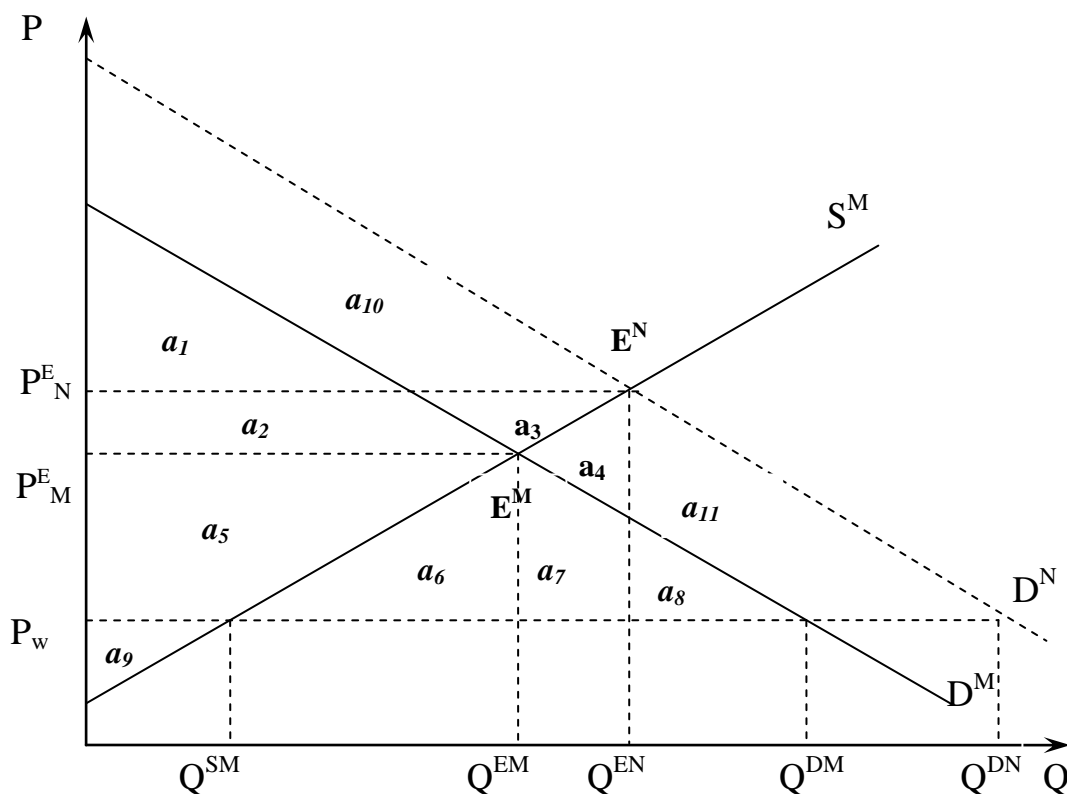
As a result, policy makers may wish to revisit their decision to impose a trade barrier.

### 3.2.2 CASE 2

For Case 2, there still exist both domestic producers and international sources of supply for a new functional food — an innovation product. However, the new functional food, N, faces a regulatory trade barrier that is equivalent to an import ban.

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<sup>13</sup> This assumption will be relaxed at a later stage.



**Figure 3.4 Case 2 — domestic and import supply, trade prohibiting regulation**

Figure 3.4 illustrates the domestic market when a new functional food enters the marketplace. As in Case 1,  $D^M$  is the demand curve for a pre-existing product that does not have health enhancing attributes, product M.  $S^M$  is the domestic supply curve for product M. At  $P_w$ , the world price for M, consumers are willing to purchase  $Q^{DM}$  and producers will only supply  $Q^{SM}$ . Imports would be  $(Q^{DM} - Q^{SM})$ . The consumer surplus is area  $a_1 + a_2 + a_5 + a_6 + a_7 + a_8$  and the producer surplus is area  $a_9$ . If there is an import ban imposed on product M, the price will rise to  $P^E_M$  and the quantity consumed will be  $Q^{EM}$ . Therefore, the consumer surplus will decrease to area  $a_1 + a_2$  a reduction of  $a_5 + a_6 + a_7 + a_8$ . Producer surplus increases to area  $a_5 + a_9$  with an increase equal to area  $a_5$ .

The relative weighting ratio is

$$\eta^M = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}} = \frac{a_5 + a_6 + a_7 + a_8}{a_5}$$

Now product N — a new health enhancing version of functional food — arrives in the market. Our two assumptions still hold: (1) The new version product, N, can be produced at the same cost as product M by both domestic and foreign suppliers and; (2) product N can be represented by the same demand curve as well as same slope as product M and; (3) more consumers are willing to buy the new health enhancing product N at the same price. Therefore, the new health enhancing functional food, N, shifts demand curve out to  $D^N$ . Product N faces the same world price as product M. At  $P_w$ , the consumer surplus increases to area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{10} + a_{11}$ . As the world price is unchanged and supply curve is not altered, domestic producer surplus remain equal to area  $a_9$ .

With the import ban in place, the domestic price rises to  $P^E_N$  and the quantity consumed equals to  $Q^{EN}$ . At  $P^E_N$ , consumer surplus decreases to area  $a_1 + a_{10}$ . Consumers suffer a loss of area  $a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}$  in consumer surplus because of the higher price. On the other hand, new producer surplus increases to a area  $a_2 + a_3 + a_5 + a_9$  — a change equal to  $a_2 + a_3 + a_5$ . Again, there may also be a health cost savings — HCS. The relative weighting ratio is

$$\eta^N = \frac{\Delta \text{consumer surplus} + \text{HCS}}{\Delta \text{producer surplus}} = \frac{a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11} + \text{HCS}}{a_2 + a_3 + a_5}$$

Thus,

$$\eta^N = \frac{a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11} + \text{HCS}}{a_2 + a_3 + a_5}$$

$$\eta^M = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}} = \frac{a_5 + a_6 + a_7 + a_8}{a_5}$$

It is an empirical question whether  $\eta^N > \eta^M$  or  $\eta^N < \eta^M$  or  $\eta^N = \eta^M$  due to the different producer surplus change in the denominator of our weighting ratio formula. It is possible that  $\eta^N > \eta^M$ . So, policy makers may wish to reconsider the imposing import ban after the introduction of the health-enhancing functional food.

### 3.2.3 CASE 3

For Case 3, there is only an international supply for a new functional food. Figure 3.5 shows the domestic market of both conventional product and the new functional food version of the products. Before the new innovative product enters into the market, the situation for the original product M is the same as in Case 1.  $D^M$  is the demand curve for a pre-existing product M and the supply curve  $S^M$  for product M. At  $P_w$ , the world price for M, imports would be the difference between what consumers are willing to purchase,  $Q^{DM}$ , and what producers will supply,  $Q^{SM}$ , that is  $(Q^{DM} - Q^{SM})$ . If a cost increasing import restriction has been put in place that raises costs so that the “landed price” equals  $(P_w + C)$ , imports will fall to  $(Q^{DM'} - Q^{SM'})$ .

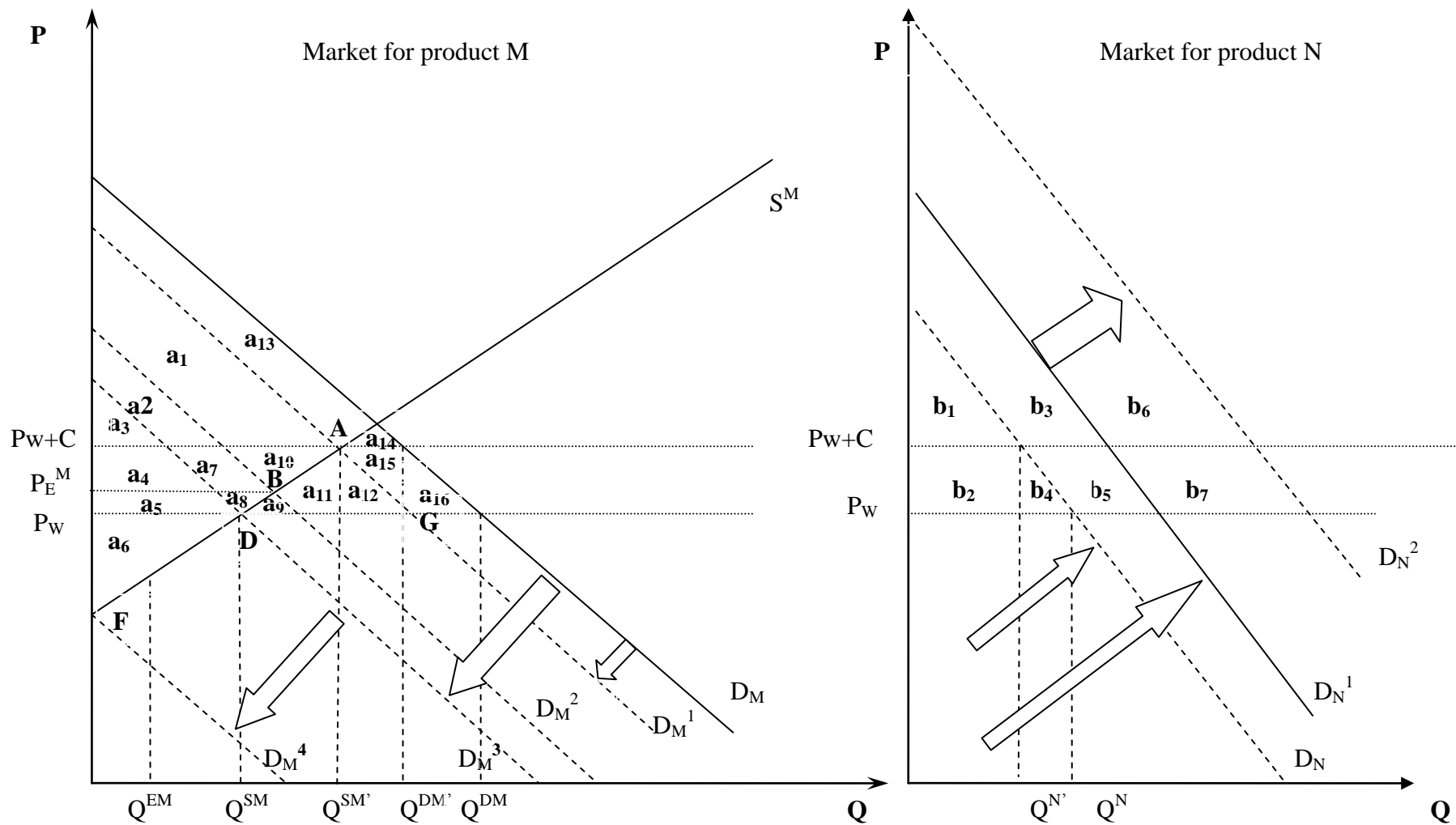


Figure 3.5 Case 3 —import supply only, cost increasing regulation

The cost increasing policy will change the welfare in the market. Without the regulation in place, the consumer surplus is area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + a_{13} + a_{14} + a_{15} + a_{16}$  and producer surplus is area  $a_6$ . However, after trade policy is implemented, consumer surplus decreased to area  $a_1 + a_2 + a_3 + a_{13} + a_{14}$  with a loss of area  $a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + a_{15} + a_{16}$ . In contrast, producer surplus increases to area  $a_4 + a_5 + a_6 + a_7 + a_8 + a_{10}$  — a gain equal to  $a_4 + a_5 + a_7 + a_8 + a_{10}$ . The relative weighting ratio is

$$\eta^M = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}} = \frac{a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + a_{15} + a_{16}}{a_4 + a_5 + a_7 + a_8 + a_{10}}$$

Now assume the new version of product M — a health enhancing functional food N — comes onto the market but can only be sourced from imports. Our three assumptions: (1) new product, N, can be produced at the same cost as M by foreign suppliers and, (2) product N can be represented by a demand curve that has the same slope as product M. (3) more people are willing to buy the new health enhancing product N at the same price, still apply here.

To begin with, product M and N are facing the same world price at  $P_w$  with no trade barrier. At any price above  $P_w$ , no consumers are willing to purchase product M. Based on assumptions, consumers switch to the market for N, which shifts the demand curve from  $D_M$  to  $D_M^1$  in the market for M. This unambiguous switch to product N will continue until curve  $D_M$  reaches  $D_M^3$ . The difference between demand curve  $D_M$  and  $D_M^3$  leads to a separate market for N. In the market for N in figure 3.5, we take  $D_N^1$  for the demand curve of product N when the demand for product M is  $D_M^3$ . Once the demand curve for M shifts further left of  $D_M^3$ , product M's price will be less than  $P_w$  and some consumers will choose to continue to consume it. This means that the rate that consumers are switching to product N slows. The further to the left the demand curve for M moves, the larger the price advantage for product M and the more attractive product M will be to consumers. An equilibrium may well be

reached somewhere between point D and F in figure 3.5. If the demand curve for M reached  $D_M^4$ , no firms are willing to supply product M. At point F, the market for M no longer exists and all consumers have moved to the market for N.

When there is a cost increasing restriction in place, the demand will again shift in as consumers switch to the more desirable product, N. When demand for M reaches  $D_M^1$ , point A in figure 3.5, product M and N both face price  $(P_w + C)$ . The difference between demand curve  $D_M$  and  $D_M^1$  leads to demand curve  $D_N$  for product N in the separate market for N.

After point A, the demand curve of M still shifts in because consumers might be more interested in the new version of the product with functional attributes. However, it is possible that domestic producers can supply product M at a lower price than  $(P_w + C)$ . Therefore, some consumers may stay in the market for M because it is lower priced than N. Let's suppose the price of M declined to  $P_E^M$ , where  $D_M^2$  equals  $S^M$ . Point B, may be an equilibrium if no more consumers are willing to switch to product N. As more consumers switch from M to N, the demand curve for N shifts out from  $D_N$  in Figure 3.5. Finally, the demand curve in market for M could reach  $D_M^4$  and the demand curve in market for N will move to  $D_N^2$  in figure 3.5. At point F, there is no supply for product M and consumers will all have switched to the market for N.

As the demand changes are dynamic, we calculate the welfare of both consumers and producers based on minimum changes at demand curve  $D_M^1$  (point A and G) for the maximum change at demand curve  $D_M^4$  (point F). In both markets together, consumers receive more surplus than that arising from only product M being in the market — N gives more utility per unit than M. At point G, without trade barrier, consumer surplus equal area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + b_1 + b_2 + b_4$ . However after the cost increasing trade policy is applied, at point A, new world price  $(P_w + C)$  makes consumer surplus changes to area  $a_1 + a_2 + a_3 + b_1$  with a



loss in consumer welfare of area  $a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + b_2$ . The change of producer surplus remains  $a_4 + a_5 + a_7 + a_8 + a_{10}$ .

The relative weighting ratio is now at least

$$\eta^{NA} = \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}} = \frac{a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + b_2 + \text{HCS}}{a_4 + a_5 + a_7 + a_8 + a_{10}}$$

Since

$$\eta^M = \frac{\Delta \text{ consumer surplus}}{\Delta \text{ producer surplus}} = \frac{a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + a_{15} + a_{16}}{a_4 + a_5 + a_7 + a_8 + a_{10}},$$

where only product M available at the domestic market.

Noticing that  $(a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12})$  is common term in both  $\eta^{NA}$  and  $\eta^M$ . Therefore,  $\eta^{NA} > \eta^M$  if  $b_2 + \text{HCS} > a_{15} + a_{16}$ ;

$$\frac{a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + b_2 + \text{HCS}}{a_4 + a_5 + a_7 + a_8 + a_{10}} > \frac{a_4 + a_5 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + a_{15} + a_{16}}{a_4 + a_5 + a_7 + a_8 + a_{10}}$$

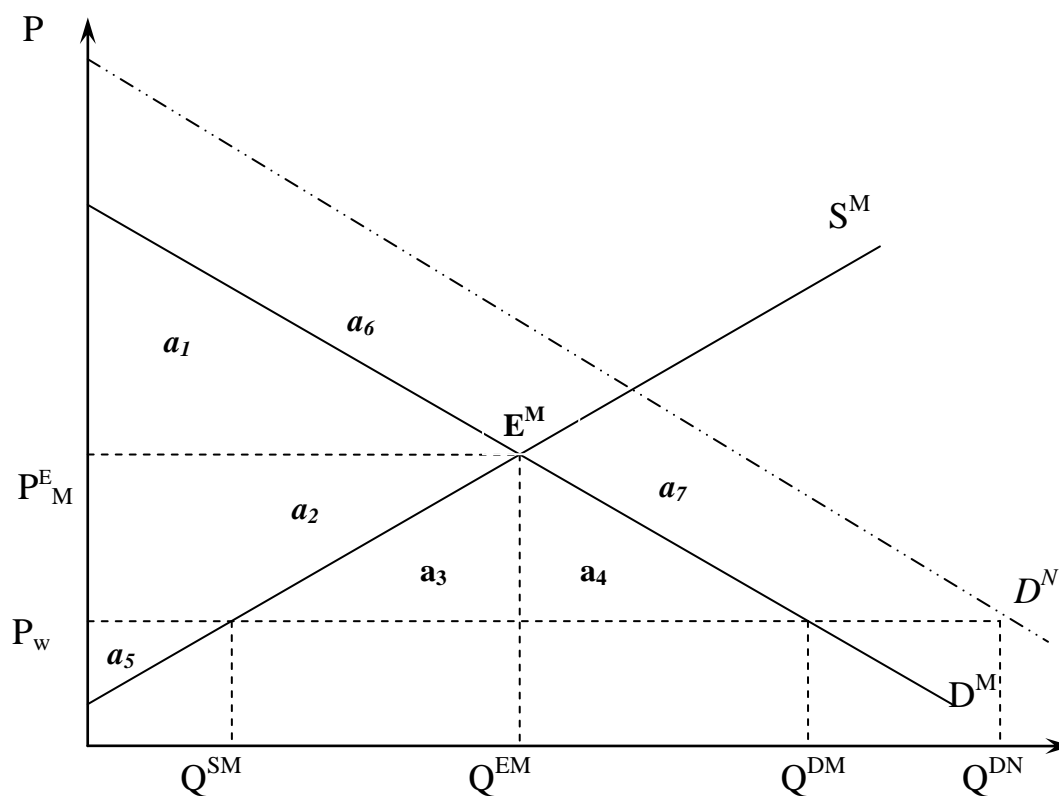
As a result, political decision makers may wish to reconsider their decision to impose a trade barrier which adds to the cost of imports.

At point F in figure 3.5, without a trade barrier, demand in market for product N has shifted to  $D_N^2$  and consumer surplus equals area  $b_1 + b_2 + b_3 + b_4 + b_5 + b_6 + b_7$ . However after the cost increasing trade policy is applied, new world price ( $P_w + C$ ) makes consumer surplus changes to area  $b_1 + b_3 + b_6$ , with a loss in consumer welfare of area  $b_2 + b_4 + b_5 + b_7$ . From the producer side, at point G, the producer surplus is  $a_6$  before any policy applied. After the cost increasing regulation is implemented, at point A, the producer surplus is equal to  $a_4 + a_5 + a_6 + a_7 + a_8 + a_{10}$  with a gain of  $a_4 + a_5 + a_7 + a_8 + a_{10}$ . Nevertheless, the producer surplus is decreasing with the movement

of demand curve for M. When the demand curve for M moves from  $D_M$  to  $D_M^2$ , that is from point A to point B, the producer surplus changes to  $a_5 + a_6 + a_8$  with a reduction of  $a_4 + a_7 + a_{10}$ . Compared to the producer surplus before product N entering into the market, calculated as  $a_6$ , however, producers still gain  $a_5 + a_8$  if there is no trade restriction existing in the market. Once the demand curve shifts to point D, the producer surplus returns to  $a_6$  which is exactly the same as when only product M was available in the market without any trade restriction. Thus, producers do not receive any benefits from the trade restriction policy at point D. From Point D to Point F, the producers lose surplus from the arrival of the new good in the market. The price increasing policy provides no benefit to producers after point D is reached, and consumers suffer a loss in consumer surplus because of the cost increasing regulation. Thus, the policy has no merit and should be abandoned.

#### **3.2.4 CASE 4**

In Case 4, while there is domestic market to supply the conventional version of product, no domestic capacity to supply the functional food exists. The new products can only be acquired from the international market. However, the new functional food can't be acquired from abroad because of an import policy that is equivalent to a ban.



**Figure 3.6 Case 4 —import supply only, trade prohibiting regulation**

Figure 3.6 give us an insight into the domestic market before and after introducing a new functional food product. As in the previous cases,  $D^M$  represents the demand curve for a pre-existing product that does not have health enhancing attributes, product M.  $S^M$  is the supply curve for product M. At  $P_w$ , the world price for M, consumers will purchase  $Q^{DM}$  and producers are only willing to supply  $Q^{SM}$ . The difference between demand and supply would be  $(Q^{DM} - Q^{SM})$  for imports. Thus, the consumer surplus is area  $a_1 + a_2 + a_3 + a_4$  and the producer surplus is area  $a_5$ . As in case 2, if there is a import ban imposed on the product M, both consumers and producers will reach the new equilibrium  $E^M$  with  $P^E_M$ , a higher price than  $P_w$ , and quantity  $Q^{EM}$ . Therefore, the consumer surplus will decrease to area  $a_1$  with reduction of  $a_2 + a_3 + a_4$ . Producer surplus changes to area  $a_2 + a_5$  with an increase of area  $a_2$ . The relative weighting ratio is

$$\eta^M = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}} = \frac{\mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4}{\mathbf{a}_2}$$

If the new health-enhancing product N can be introducing into the domestic market successful through imports, there will be a demand shift from the original demand curve  $D^M$  to  $D^N$ . From our previous assumption, product N can be produced at the same world price as product M. So, at  $P_w$ , there is larger demand,  $Q^{DN}$ , for the new product. However, in this case, there is no domestic production of product N that can be supplied to the consumers. Thus, the total imports are equal to total demand  $Q^{DN}$ . The consumer surplus expands to area  $\mathbf{a}_1 + \mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4 + \mathbf{a}_6 + \mathbf{a}_7$ .

However, in case 4, we assume there exists an import regulation that still acts like a ban, thus allowing none of product N into the market. The demand for product N cannot be supplied by the international producers. Thus, the new demand curve,  $D^N$ , does not apply under an import ban. The domestic market has to move back to the previous situation with the product in an autarky market.

We assume there is no supply of the old product M from foreign market — the exporter no longer produces product M. Thus, consumers and producers return to the domestic price  $P_M^E$ . At the autarky equilibrium point, consumer surplus decreases to area  $\mathbf{a}_1$ , a reduction of area  $\mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4 + \mathbf{a}_6 + \mathbf{a}_7$  and the producer surplus is area  $\mathbf{a}_2 + \mathbf{a}_5$ . There would also be a health care savings equal to HCS. Therefore, the relative weighting is

$$\eta^N = \frac{\Delta \text{consumer surplus} + \text{HCS}}{\Delta \text{producer surplus}} = \frac{\mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4 + \mathbf{a}_6 + \mathbf{a}_7 + \text{HCS}}{\mathbf{a}_2}$$

Since

$$\eta^M = \frac{\Delta \text{consumer surplus}}{\Delta \text{producer surplus}} = \frac{\mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4}{\mathbf{a}_2}$$

Thus,  $\eta^N > \eta^M$ .

$$\frac{\mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4 + \mathbf{a}_6 + \mathbf{a}_7 + \text{HCS}}{\mathbf{a}_2} > \frac{\mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4}{\mathbf{a}_2}$$

Therefore, political decision makers may wish to change their trade inhibiting policy.

### 3.3 Health care costs

In each case, we assumed that the HCS is constant. However, savings in health care costs for the government is not likely to be a constant. In most cases, it is likely to be some function of the consumption of the particular functional food. Following our analysis in every case, the HCS that would arise from the remove of the trade barrier is a function of the increased consumption of product N. That is,

$\text{HCS} = f(\Delta Q^N)$ , where  $\Delta Q^N$  is the difference between the consumption of N with a trade barrier and that which arises without the trade barrier.

HCS will be different depending on each case given the different trade situations illustrated above. In Case 1, there are both domestic sellers and an international source of supply for functional food N. The cost increasing regulation increases the import price from  $P_w$  to  $(P_w + C)$  which leads to a reduction in the demand of product N. Thus, the difference between the consumption of N with a trade barrier and that of without a trade barrier is measured by the quantity change along the demand curve  $D^N$  from  $(P_w + C)$  to  $P_w$ .

$$\text{HCS}^1 = f(\Delta Q^N) = f(Q^{\text{DN}} - Q^{\text{DN}'})$$

In Case 2, product N faces both domestic and international supply but with a regulatory trade barrier that is equivalent to an import ban. The import ban leaves no supply for product N from the international market. Thus, the difference between the

consumption of N with a trade barrier and that without the trade barrier is measured by the quantity change on the demand curve  $D^N$  from  $P_w$  to  $P_M^E$ .

$$HCS^2 = f(\Delta Q^N) = f(Q^{DN} - Q^{EN})$$

In Case 3, there is only an international supply for functional food N. Like Case 1, the cost increasing regulation makes the import price  $P_w$  increase to  $(P_w + C)$  which leads to a reduction in the demand of product N. Thus, the difference between the consumption of N with a trade barrier and that without the trade barrier is measured by the quantity change along the demand curve  $D^N$  from  $(P_w + C)$  to  $P_w$ . As the figure in Case 3 is dynamic, the change in consumption of the product N, which based on the shift of demand curve  $D^N$ , can't be calculated precisely.

$$HCS^3 = f(\Delta Q^N) = f(\Delta Q^N) \geq f(Q^N - Q^{N'})$$

In Case 4, there is no domestic capacity to supply the functional food N. However, product N cannot be acquired from abroad because of an import policy that is equivalent to a ban. Before the import ban, the consumption of N is based on imports only and the import quantity is equivalent to domestic demand which is  $Q^{DN}$ . With the import ban in place, the imports of product N do not take place. Therefore, there is no consumption of product N. The change in the consumption of product N is just equal to  $Q^{DN}$ .

$$HCS^4 = f(\Delta Q^N) = f(Q^{DN} - 0)$$

### **3.4 Summary**

This chapter has developed a partial equilibrium model to examine the effects of the introduction of functional foods that provided consumers with positive health benefits when pre-existing trade restrictions are in place. In order to illustrate the model's usefulness in the next two chapters, two case studies are used to provide empirical evidence of the value of forgone health benefits.

# Chapter 4: Chinese Case study

## 4.1 Introduction

Over time, consumers have responded to new scientific information related to food consumption by switching consumption to products with healthier or less harmful components (Malla et al., 2007). Recently, the relationship between consumption of *trans* fatty acids (TFA) and associated heart disease has become a *hot topic* with the public. Coronary heart disease (CHD) refers to the failure of the coronary circulation system to supply adequate blood to the heart muscle and surrounding tissue. Over 451,000 Americans die of coronary heart disease every year (AHA, 2008a). In the United Kingdom, over 100,000 deaths annually are attributed to coronary heart disease (BHF, 2007). Scientific studies suggest that consumption of *trans* fat will increase the risk of CHD. The Food and Drug Administration (FDA) in the United States ruled that the reporting of *trans* fat levels had to be added to the Nutrition Facts Panel on food labels starting from January 1, 2006. Identifying saturated fat, *trans* fat, and cholesterol on the food label provides consumers with information so that food choices that help reduce the risk of CHD can be made. The revised label was expected to be helpful to people who are concerned about high blood cholesterol and heart disease (FDA, 2003a).

This chapter provides a Chinese case study to examine the potential welfare benefits forgone from the existence of trade barriers when a selected product becomes a functional food. First, the chapter gives a detailed overview of the connection between *trans* fat and health. Further, the selected product — canola/rapeseed oil is introduced from two aspects — its functional attributes to reduce the risk of CHD and its current market in the international trade. Following this introduction, the empirical case study of Chinese canola/rapeseed oil is examined according to Case 1 in the framework developed in Chapter 3. The forgone benefits of functional



canola/rapeseed oil in China arising from the trade barriers — a high tariff are calculated.

## **4.2 *Trans* fat and health**

*Trans* fat (also known as *trans* fatty acids) is a specific type of fat formed when liquid oils are processed into solid fats like shortening and hard margarine. However, a small amount of *trans* fat is naturally occurring, primarily in selected animal-based foods. The majority of *trans* fat comes from adding hydrogen to vegetable oil through a process called hydrogenation. *Trans* fats are more solid than oil but less likely to spoil. In processed foods, *trans* fat helps food keep fresh, extends the self life and gives products a less greasy feel (MFMER, 2006).

Animal-based fats were once the only *trans* fats consumed, but by far the largest amount of *trans* fat are formed during the partial hydrogenation of vegetable oils, a process that converts vegetable oils into semisolid fats for use in the food industry (Mozaffarian et al., 2006). The FDA in the United States estimates that animal-based fats constitute only 21 percent of the TFA intake, with hydrogenated vegetable oil representing the main source of TFA in human diets (FDA, 2005). Besides animal fat, 24 percent of TFA intake is from visible fats such as margarine, shortening, and salad oils (17%, 4%, and 3%, respectively); the rest (55%) is consumed through fast food products and processed food items like bread, cookies, chips, candy, etc. (FDA, 2003b). These partially hydrogenated fats have displaced natural solid fats and liquid oils in much of the human diet, notably in fast foods, snack foods, fried foods and baked goods.

Production of hydrogenated fats increased steadily as a healthy alternative to animal fats due to their being unsaturated and being available at lower cost. As early as 1988, however, scientific studies suggested that *trans* fats could be a cause of the large

increase in coronary artery disease (Booyens et al., 1988). Additional studies over the years have confirmed this finding. The consumption of *trans* fatty acids raises the levels of low-density lipoprotein (LDL) cholesterol<sup>14</sup>, so called *bad cholesterol* and reduces levels of high-density lipoprotein (HDL) cholesterol<sup>15</sup>, so called *good cholesterol*. *Trans* fats alter the ratio between LDL and HDL by decreasing the ratio HDL in total cholesterol<sup>16</sup>. The latter is a powerful predictor of the risk of CHD (Stampfer et al, 1991). *Trans* fats also increase the levels of triglycerides<sup>17</sup> in the blood when compared with the intake of other fats (Mensink et al., 2003), increase levels of Lp(a) lipoprotein<sup>18</sup> (Ascherio et al., 1999) and reduce the particle size of LDL cholesterol<sup>19</sup> (Mauger et al., 2003), each of which may further raise the risk of CHD.

A study published in the *New England Journal of Medicine* reported that *trans* fat is linked to a 93 percent rise in the risk of cardiovascular disease. The research also revealed that replacing of 2% of *trans* fat consumed with monounsaturated fat (MUFA) that are derived from plant sources such as canola, peanuts and olives could reduce heart disease risk by 53 percent (Lam, 2002).

## 4.3 Selected product

### 4.3.1 Healthy choice-Canola oil

Canola was developed from rapeseed plants by Keith Downey and Baldur Stefansson in the 1970s (MCGA, n.d.). Using the selective breeding method, canola was created by lowering the anti-nutritional components erucic acid and glucosinolates in

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<sup>14</sup> LDL (bad) cholesterol could lead to heart attack or stroke by forming clots in the inner walls of the arteries and blocking the way to feeding the heart and brain (AHA, 2008b).

<sup>15</sup> High levels of HDL (more than 40 mg/dL) protect against heart attack by carrying cholesterol away from the arteries to the liver, where it is passed from the body (AHA, 2008b).

<sup>16</sup> The total cholesterol to HDL cholesterol ratio is obtained by dividing the total cholesterol value by the value of the HDL cholesterol. High ratios (High total cholesterol and low HDL cholesterol) indicate higher risks of heart attacks (Kinosian et al., 1994).

<sup>17</sup> Triglyceride is a form of fat made in the body. High triglyceride levels may cause heart disease (AHA, 2008b).

<sup>18</sup> Lp(a) lipoprotein is a genetic variation of LDL (bad) cholesterol. A high level of Lp(a) is a risk factor for the heart disease (AHA, 2008b).

<sup>19</sup> LDL particles carry the LDL through the bloodstream. Smaller LDL particles may more easily become trapped in blood vessel walls than larger ones, possibly increasing risk for heart disease (UWNEWS, 1999).

traditional rapeseed plants so that it would be absolutely safe for human and animal consumption (Canola Council of Canada, 2008a). In order to differentiate this product from rapeseed, the word "canola" was derived from "CANadian Oil, Low Acid" in 1978 (Klahorst, 1998).

Natural rapeseed oil, also called "industrial rapeseed oil" contains at least 44 percent erucic acid (high-erucic rapeseed oil, HERO), which is mainly used as an additive in animal feed (Piazza and Foglia, 2001). Only small quantities can be added to animal feed. By introducing an edible form of rapeseed that is low in erucic acid and glucosinolates, rapeseed production via canola has experienced significant growth in the past forty years (Walker, 1999). This may cause confusion as the term "rapeseed oil" is sometimes used without specifying its erucic acid content. Since some countries still apply the term "rapeseed oil" when identifying low-erucic rapeseed oil (Canola oil), the term "rapeseed oil" when used in this thesis specially refers to low-erucic rapeseed oil, known in some markets as Canola oil. HERO will be used if high-erucic rapeseed oil is discussed.

Conventional canola oil and soybean oil require hydrogenation to make them stable. Hydrogenation is the process that turns fats into *trans* fat. New technology, however, gives canola oil a very high degree of stability, eliminating the need for hydrogenation (Malla et al., 2007). At present, there are two types of canola oil: commodity and high-oleic. The former is sold directly to consumers; the latter is characterized by high stability which is newer and sold almost exclusively to food processing companies and food service operations. Both oils have the same low level of saturated fat and positive health attributes (Canola Council of Canada, 2008b).

The FDA (2006b) states that:

Limited and not conclusive scientific evidence suggests that eating about 1½ tablespoons (19 grams) of canola oil daily may reduce the risk of coronary heart disease due to the unsaturated fat content in canola oil. (n.p.)

Thus, Canola oil is seen as a healthier alternative to a number of important vegetable oils due to its *trans* fat-free and very low, or even zero, saturated fat but high—almost 60%—monounsaturated oil content and beneficial omega-3 fatty acids profile. Saturated fat has been linked to rising levels of bad LDL cholesterol in the blood and increased risk of CHD. Monounsaturated fat is helpful in reducing the risk of coronary heart disease and controlling blood glucose by lowering bad LDL cholesterol in the blood. Omega-3 fats are essential for a healthy daily diet and it helps protect against heart attacks and strokes. Thus canola oil might be a better choice in avoiding *trans* fat in deep fried and baked foods and is becoming a popular oil of choice in restaurants and commercial food products (Canola Council of Canada, 2008c).

As outlined in Chapter 2, functional food is defined by Health Canada (1999) as a food product that has physiological benefits and/or reduces the risk of a chronic disease beyond that provided by a basic nutritional function. As one of the healthiest oils in the marketplace with zero *trans* fat and cholesterol, canola oil may result in health benefits and medical cost savings by reducing the potential risk of coronary heart disease in addition to any nutritional value derived from its consumption. Therefore, canola oil can be recognized as a functional food.

Currently, Canola oil represents approximately 70 percent of the vegetable oil consumed by Canadians. Only 25 percent of the seed that is produced each year is required to satisfy the domestic market. Nearly 75 percent of the canola seed, oil and meal produced in Canada are exported to destinations such as the United States, Japan, Mexico, and China (CanolaInfo, n.d.). However, export markets do not provide barrier free access to Canadian canola products. Tariff and regulatory costs raise the landed price of canola, which reduces consumption in import markets. Imports are

banned by some countries. Requirements in some countries limit the canola varieties that Canada can export. Testing requirements for de-registered varieties and pesticides that can be used on canola are being increased in some countries. (Canola Council of Canada, 2008d). Removing bans and opening up markets for genetically modified (GM) canola products is still a slow process in European Union countries.

Thus, canola oil, with its functional attributes, also suffers from export barriers to market access. Hence, it is an appropriated product to use for the case studies in this thesis.

### **4.3.2 Canola/Rapeseed oil market**

Due to the recent expansion of the bio-fuels sector and the growing health concerns in North America as well as continued economic growth and the rising population in Asia (AAFC, 2007), since 2000-2001, the world vegetable oil sector has been growing at a rapid rate. For 2006-2007, the value of world vegetable oil trade is expected to exceed the value of world trade in wheat and be more than twice the value of the trade in corn. The percentage distribution of vegetable oils by type is: palm oil (31%), soy oil (29%), canola/rapeseed oil (15%) and sunflower seed oil (9%) (AAFC, 2007).

World Production of canola/rapeseed oil is expected to rise to 18.2 Mt<sup>20</sup> in 2006-2007 (AAFC, 2007). The EU is the world's largest producer of canola/rapeseed oil at 6.8 Mt, China is in second place at 4.6 Mt, India produces 2.2 Mt while Canada is the world's 4th largest producer of canola oil at 1.5 Mt. Canada is the world's largest exporter of canola/rapeseed oil, accounting for approximate 60 percent of world trade. The US is the world's largest importer of canola oil, which is primarily used in salad and cooking oils. Imports into the US were approximately 0.8 Mt for

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<sup>20</sup> Mt: Million tonnes.

2006-2007. The EU is the world's second largest importer of canola/rapeseed oil — 0.5 Mt for 2006-2007 (AAFC, 2007). However, these European imports are primarily used in the rapidly growing biodiesel sector because Canadian canola is produced using genetic modified plants, which had faced a *de facto* import ban<sup>21</sup> in the past and in meeting the current regulatory hurdles due to ongoing food safety concerns over GM technology in the EU.

## **4.4 Chinese case study**

### **4.4.1 The Chinese vegetable oil market**

The market for vegetable oils is growing across Asia as a result of expanding populations and rising incomes. China's population growth rate is approximately 8.6 million people per year. Further, gross domestic product (GDP) in China is growing by 10.5 percent annually in 2006. Per-capita GDP in China is approximately US\$7,600 on a purchasing power parity basis (AAFC, 2007). Given a tight international market for edible oils, in 2007, the Chinese oilseed market reached historically high price levels. According to the China State Administration of Grain<sup>22</sup>, total vegetable oil imports reached 8.5Mt in 2006-2007, accounting for 18 percent of global imports of vegetable oils. However, the annual consumption of vegetable oils increased to 23.4Mt, meaning only 15.14Mt are being supplied domestically. The consumption of canola/rapeseed oil is 4.34 Mt and domestic production only supplies 4.01 Mt at the existing price level (USDA, 2008). As a result, approximate 0.33 Mt total of canola/rapeseed oil are imported. This is approximately to 15% of the world canola/rapeseed oil imports.

Since the 1990s, China has had an import management control system for vegetable oils. A tariff rate quota (TRQ) restricts the amount of vegetable oils that can be imported. All imports up to the quantity limit known as the "TRQ-quota" are subject

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<sup>21</sup> *de facto* moratorium means that no commercial releases of genetically modified organisms (GMOs) have been approved from 1998 to 2004. The releases include new authorizations on adoption of rules, marketing and labelling of biotechnology products (Baumüller, 2004).

<sup>22</sup> State Administration of Grain can be accessed at: <http://www.grain.gov.cn>

to a low “within-quota tariff” of 9 percent, while any additional imports are subject to a higher “above-quota tariff” ranging between 19.9 percent and 52.4 percent (Xu and Wang, 2006). From 2006, however, China removed all of the import management restrictions on vegetable oils as part of its WTO accession commitments. However, there still a flat tariff rate of 9 percent on imports of vegetable oils.

Recall from the model developed in chapter 3, in Case 1, there are both domestic producers and international source of supply for a functional food. China’s current import regime is consistent with Case 1. In the China case study, canola/rapeseed oil is a new identified functional food with extra health benefits. Given the constraints on Chinese production and processing capacity, imports of canola/rapeseed oil are required. However, the existing tariff level still acts as a trade barrier on imports. As developed in the case 1, tariffs restrict trade and protect the domestic market by raising the domestic price in the importer’s market. The protection benefits producers at the expense of consumers. There is an overall welfare loss because the gain of the producer surplus cannot offset the decline in consumer surplus. This tariff was put in place prior to the health benefits of canola becoming apparent. Given that the social costs can be expected to rise as the health benefits become known, the Chinese government may wish to revisit having a tariff on canola oil.

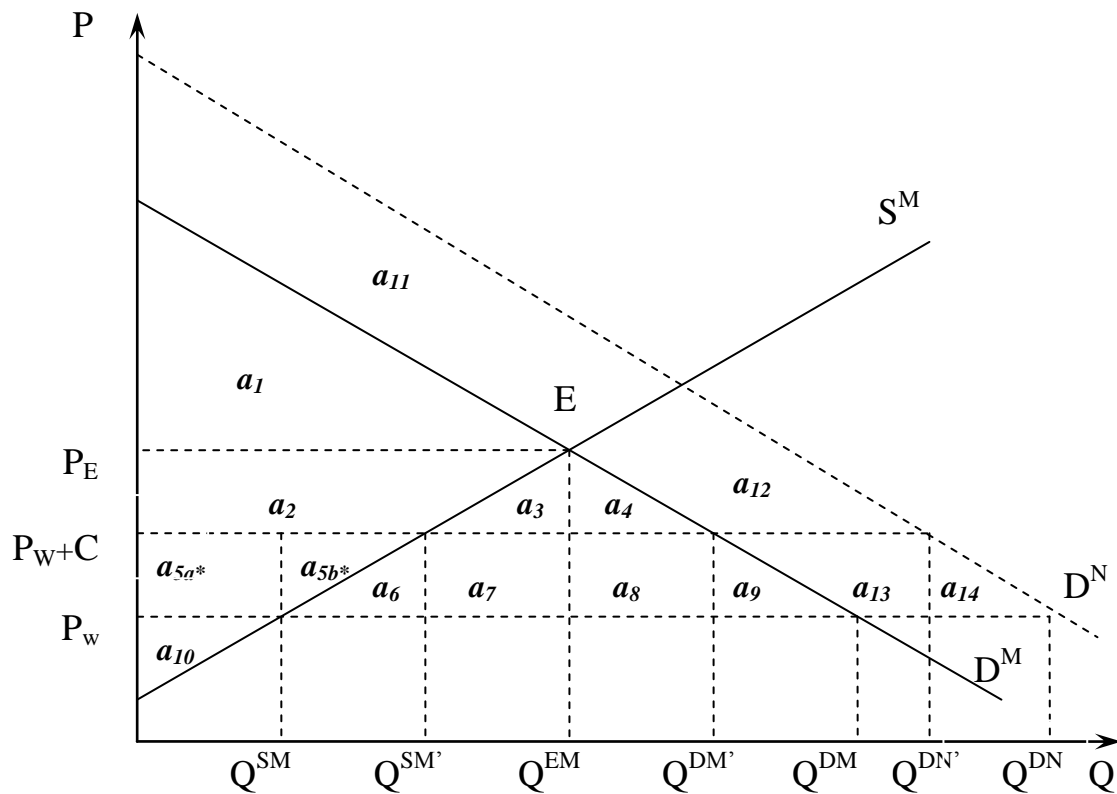
Canola oil is selected as the product to be examined for in the case study. Oil is the final consumer product from which the health benefit is derived. Of course, canola oilseed is the major traded product. Since the focus of this thesis is on the forgone benefits of *trans* fat free canola oil from existing trade barriers, the calculations will not address trade canola oilseed directly because oilseeds are semi-finished products that need further processing into oil and meal. The import data used in the Chinese case study are estimated through domestic production and consumption for oil – they

are net oil import quantities. The benefits consumer and health care cost savings are derived from oil consumer by those living in China.<sup>23</sup>

## 4.4.2 Case study calculations

### 4.4.2.1 Trade effects calculation

Recall from Case 1 in chapter 3, in Figure 4.1,  $D^M$  is the demand curve and  $S^M$  is the supply curve for canola/rapeseed oil before people realize the health benefits it provided. At world price  $P_w$ , consumers are willing to purchase  $Q^{DM}$  and domestic producers will only supply  $Q^{SM}$ . Imports would be  $(Q^{DM} - Q^{SM})$ . However, a 9% import tariff is in place in China. It raises the domestic price above the world price so that the new domestic price equals  $(P_w + C)$ . Imports will fall to  $(Q^{DM'} - Q^{SM'})$ .



\* In order to calculate the area,  $a_5$  is divided into  $a_{5a}$  and  $a_{5b}$ .

**Figure 4.1 Case 1 — domestic and import supply with tariff in China**

<sup>23</sup> If one wished to calculate the benefits for exporters, the proportion of trade arising from oil imports and seed imports that would be processed into oil would have to be considered. As there is a degree of tariff escalation in Chinese tariffs, using the tariff on oil may overestimate the trade benefit to some degree.



Without the tariff, the consumer surplus is area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9$ . Producer surplus is area  $a_{10}$ . After the tariff is implemented, consumer surplus decreased to area  $a_1 + a_2 + a_3 + a_4$ . Consumers suffer a loss of area  $a_5 + a_6 + a_7 + a_8 + a_9$  in consumer surplus because of the higher price. On the other hand, producer surplus increases to an area  $a_5 + a_{10}$  — a change equal to  $a_5$ .

As pointed out in section 4.2.1, canola/rapeseed oil can be seen as a functional food in the current food market in China. Keeping the same assumption as in Case 1, more people are willing to buy the canola/rapeseed oil with health enhancing attributes that are newly recognized by the public. Alternatively, consumers are willing to pay a premium for a higher quality (health enhancing) product. Therefore, demand increases shifting out the demand curve from  $D^M$  to  $D^N$ . As the additional demand can be accommodated by acquiring additional imports at  $(P_w + C)$ , there is no change in price. Thus, there is no change in domestic producer surplus.

With the new demand curve, consumers receive more surplus than before. With no tariff, consumer surplus changes from area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9$  to area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9 + a_{11} + a_{12} + a_{13} + a_{14}$ , an increased benefit of area  $a_{11} + a_{12} + a_{13} + a_{14}$ . After the tariff is applied, new world price  $(P_w + C)$  leads to a decline in consumer surplus to area  $a_1 + a_2 + a_3 + a_4 + a_{11} + a_{12}$ . Therefore, the tariff generates a loss in consumer welfare of area  $a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14}$ .

Thus, without new health information regarding canola/rapeseed oil, the direct welfare changes arising from the tariff are areas  $a_5 + a_6 + a_7 + a_8 + a_9$  — the decrease in consumer surplus and  $a_5$  — the increase in producers surplus. Both  $a_5 + a_6 + a_7 + a_8 + a_9$  and  $a_5$  are trapezoid areas that can be divided into rectangles and triangles for the calculation of their values. Assume that over the relevant ranges, the supply and demand functions are linear. After health enhancing attributes of canola/rapeseed oil having been accepted, the trade change for consumer is area  $a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14}$  while the increase in producer surplus remains  $a_5$ . Area  $a_5 + a_6 + a_7 + a_8 + a_9 +$

$a_{13} + a_{14}$  can be divided into rectangle  $a_5 + a_6 + a_7 + a_8 + a_9 + a_{13}$  and triangle  $a_{14}$ . Combined with the data from Table 4.1, the calculations and resultant values can be found in Table 4.3.

**Table 4.1 Market data of canola/rapeseed oil in China (2006-2007) <sup>a</sup>**

Total consumption (Mt) - $Q^{DM}$	4.343 <sup>b</sup>	
Domestic supply (Mt) - $Q^{SM}$	4.013 <sup>c</sup>	
Supply elasticity - $\epsilon^S$	0.32 <sup>d</sup>	
Demand elasticity - $\epsilon^D$	-0.20 <sup>e</sup>	
World price(\$ US dollar/tonne) – $P_w$	852 <sup>f</sup>	
Tariff rate	9% <sup>g</sup>	
tariff cost (\$ US dollar/tonne) – $C$	76.68 <sup>h</sup>	
Total consumption (Mt) without tariff - $Q^{DM}$	4.415 <sup>i</sup>	
Domestic supply (Mt) without tariff – $Q^{SM}$	3.907 <sup>j</sup>	
Demand increasing rate <sup>k</sup>	Base	20%
	High	50%
	Medium	40%
	Low	10%
Increased domestic consumption (Mt) - $(Q^{DN} - Q^{DM})^l$	Base	0.883
	High	2.207
	Medium	1.776
	Low	0.441

<sup>a</sup> 2006-2007 is from October, 2006 to September, 2007.

<sup>b</sup> Source: United States Department of Agriculture (USDA), Foreign Agricultural Service, July 2008.

<sup>c</sup> Source: USDA, Foreign Agricultural Service, July 2008.

<sup>d</sup> Note: it is a short-term supply elasticity for national rapeseed supply. (Source: Shen, 2007)

<sup>e</sup> Note: it is a direct price elasticity for oilseed oil demand. (Source: Meilke et al, 2001)

<sup>f</sup> Average price from October, 2006 to September, 2007. Rotterdam CIF, Any Origin, Oil World. Source: USDA, Foreign Agricultural Service, July 2008.

<sup>g</sup> Source: China Customs..

<sup>h</sup> Cost - C = P<sub>w</sub> \* 9%.

<sup>i</sup> Q<sup>DM</sup> is calculated from following steps using demand elasticity:

$$\begin{aligned}\mathcal{E}^D &= \frac{\Delta Q}{\Delta P} * \frac{P}{Q} = \frac{(Q^{DM} - Q^{DM'}) * P_W + C}{P_W - (P_W + C)} * \frac{P_W + C}{Q^{DM'}} = \frac{(Q^{DM} - Q^{DM'}) * P_W + C}{(-C)} * \frac{P_W + C}{Q^{DM'}} \\ Q^{DM} &= \mathcal{E}^D * (-C) * \frac{Q^{DM'}}{P_W + C} + Q^{DM'} \\ &= (-0.20) * (-76.68) * \frac{4.343}{852 + 76.68} + 4.343 \\ &= 4.415 \text{ (Mt)}\end{aligned}$$

<sup>j</sup> Q<sup>SM</sup> is calculated from following steps using supply elasticity:

$$\begin{aligned}\mathcal{E}^S &= \frac{\Delta Q}{\Delta P} * \frac{P}{Q} = \frac{(Q^{SM'} - Q^{SM}) * P_W + C}{(P_W + C) - P_W} * \frac{P_W + C}{Q^{DM'}} = \frac{(Q^{SM'} - Q^{SM}) * (P_W + C)}{C} * \frac{P_W + C}{Q^{DM'}} \\ Q^{SM} &= Q^{SM'} - (\mathcal{E}^S * C * \frac{Q^{SM'}}{P_W + C}) \\ &= 4.013 - (0.32 * 76.68 * \frac{4.013}{852 + 76.68}) \\ &= 3.907 \text{ (Mt)}\end{aligned}$$

<sup>k</sup> Demand shift rate is estimated from current reports and studies regarding to China's functional food market. For details, see section A2.1 in Appendix 2.

<sup>l</sup> (Q<sup>DN</sup> - Q<sup>DM</sup>) = demand shift rate \* (Q<sup>DM</sup>)

Much of the data used in the Chinese case study calculations are derived from previously published sources including the demand and supply elasticities used. The elasticity of demand in the Chinese case study was obtained from Meilke et al. (2001). In their model, a direct price elasticity is used for the vegetable oil demand equations. Although, canola/rapeseed oil is one of the five major oilseeds products in the world (the others are soybeans, cottonseeds, peanuts and sunflower seeds), it only accounts for 12% of world consumption (Meilke et al., 2001).

The supply elasticity used in the Chinese case study was obtained from Shen (2007). In her analysis, supply elasticity is calculated for the supply response to price changes for rapeseed production in China. However, the elasticity of supply is for rapeseed production rather than rapeseed oil so that there might be some divergence between them.

Since both the elasticity of demand and supply are derived from previously published studies, there is a need to check the robustness of the results in the case studies. Hence,

a sensitivity analysis is conducted at both higher and lower levels. Table 4.2 shows the trade effects ratio under different elasticity values in Chinese case study. In the sensitivity analysis in Chinese Case study, the final ratio  $\eta^M$  is 0.003 larger (smaller) than its original value. The results indicate that the trade effects ratio is not particularly sensitive to the different elasticity values. The impact of elasticity values on the trade effects ratio is small, a change of 0.2 percent. Therefore, the original combination of demand and supply elasticity can still be used in the Chinese case study without any particular concerns.

**Table 4.2 Sensitivity analysis for elasticities in the Chinese case study**

	$\varepsilon^D$	$Q^{DM}$ (Mt)	$\varepsilon^S$	$Q^{SM}$ (Mt)	$\eta^M$
Original level	-0.20	4.415	0.32	3.907	1.106
Higher level (+20%)	-0.24	4.429	0.38	3.887	1.109
Lower level (-20%)	-0.16	4.400	0.26	3.927	1.103

**Table 4.3 Trade effects calculation in Chinese case study**

	$a_5 + a_6 + a_7 + a_8 + a_9$		$a_5$		$a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14}$		
	Rectangle $a_5 + a_6 + a_7 + a_8$	Triangle $a_9$	Rectangle $a_{5a}$	Triangle $a_{5b}$	Trapezoid $a_5 + a_6 + a_7 + a_8 + a_9$	Parallelogram $a_{13} + a_{14}$	
Formula	$Q^{DM} * C$	$1/2 * (Q^{DM} - Q^{DM'}) * C$	$Q^{SM} * C$	$1/2 * (Q^{SM'} - Q^{SM}) * C$		$(Q^{DN} - Q^{DM}) * C$	
Calculation	4.343 * 76.68	$1/2 * (4.415 - 4.343) * 76.68$	3.907 * 76.68	$1/2 * (4.013 - 3.907) * 76.68$	High	2.207* 76.68	
					Medium	1.776* 76.68	
					Base	0.883* 76.68	
					Low	0.441* 76.68	
Result (Million\$)	333.021	2.750	299.589	4.064	335.771	High	169.26
						Medium	135.408
						Base	67.704
						Low	33.893
	335.771		303.653		High	505.031	
					Medium	471.179	
					Base	403.475	
					Low	369.664	

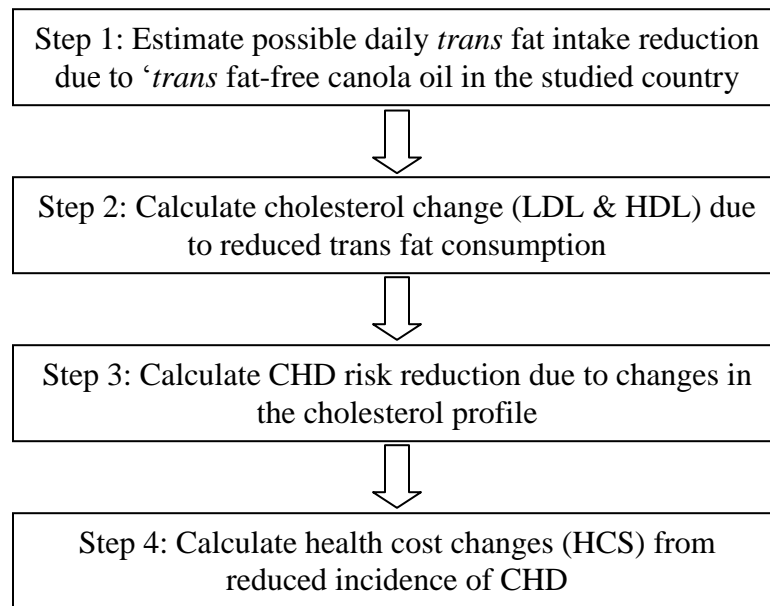
Table 4.3 shows all the calculations and results for the trade effects of canola/rapeseed oil. According to above table, with the 9 percent tariff rate on import of canola/rapeseed oil in China, consumers suffer a loss of US\$335.8 million in consumer surplus change (area  $a_5 + a_6 + a_7 + a_8 + a_9$ ) because of the higher landed price. On the other hand, producers gain US\$303.7 million in producer surplus change (area  $a_5$ ). Results indicate that the consumer loss is larger than producer gain.

After health information regarding canola/rapeseed oil becomes well-known to the Chinese consumers, consumers' loss increases, but producer gain remains constant. For the four levels of demand shift under the sensitivity analysis in appendix 2, a US\$403.5 million in base level, a US\$505 million in high level, a US\$471.2 million in medium level and a US\$369.7 million loss in low level in consumer surplus change (area  $a_5 + a_6 + a_7 + a_8 + a_9 + a_{13} + a_{14}$ ) have been calculated in Table 4.3. At the base level of demand shift, for example, consumers suffer a US\$403.5 million reduction in consumer surplus because of the increased consumption of canola/rapeseed oil. This loss is increased about 20 percent compared to the former US\$335.8 million consumer surplus change. High level represents around 50 percent increase compared to previous situation. Even at lower levels, increased consumption of healthy canola/rapeseed oil leads to a much greater loss in consumer surplus than when the health benefit was unknown. As expected, the results of trade effects indicate that the tariff generates a larger loss in consumer welfare than the gain on the producer side. The loss becomes even larger after the increased consumption of canola/rapeseed oil with health attributes are taken into consideration.

#### **4.4.2.2 Estimating the Potential Health Care Cost Savings for the Chinese Case study**

There are a variety of methods used in health economics to measure the potential benefits of improved health. They include costs of illness (COI) (consisting of medical expenditures and forgone earnings), household production of health and preventive expenditures (Berger et al., 1987), willingness to pay, cost-benefit analysis, and cost-utility analysis (Gyrd-Hansen, 2003).

In this chapter, the model developed by Malla et al. (2007) is adapted to estimate the potential health benefit and related medical cost savings arising from the consumption of more healthy *trans* fat-free canola oil. Malla et al. (2007) use a variation on the COI approach to estimate the impact of a change in dietary fat intake on CHD costs in Canada. Drawing heavily on the model developed by Malla et al. (2007), their method is developed in four steps (See Figure 4.2). The calculation will start from the *trans* fat intake reduction caused by the substitution of a *trans* fat-free canola oil for other vegetable oils to the effect of reduced cholesterol levels on the incidence of CHD in the studied country and from there to the relationship between CHD and medical costs savings. Following Malla et al. (2007), it is assumed that a 1% drop in the incidence of the disease in the long run will result in a 1% decrease in the COI.



**Figure 4.2 Steps of COI model analysis**

(Source: Malla et al., 2007)

Step 1: Estimate possible daily *trans* fat intake reduction due to '*trans* fat-free canola oil in China

In step 1, a total *trans* fat consumption (intake) per day is estimated using available studies. Due to different diets and eating habits, calculations and results vary among countries.

In China, there is no database for TFA consumption. Therefore, detailed research studies on citizens' daily TFA intake do not appear to be available. Generally in China, the total fatty acids in the daily diet come from natural fatty acids in food and from vegetable based cooking oils that contain very low TFA. In general, the Chinese diet leads to a lower intake of shortening oil when compared to diets in North America and Europe. According to FAO (2006) statistics, however, there is an increasing trend for both production and consumption of fats. The average fat consumption (g/person/day) in the world increased 1.3 times from 1979-1981 to 2001-2003. In China, the rise of fat intake has been dramatic increasing 2.7 times from 33g/person/day to 90 g/person/day over the same period (FAO, 2006). With rising incomes and the opening of the economy, Chinese dietary tastes are broadening. The dietary structure is changing from traditional oriental cooking towards diverse dining. North American and European food and fast food in particular, is becoming increasingly popular. While no studies on fat consumption in China could be found, the TFA intake of the daily diet in China is increasing due to rising shortening oil consumption, especially among young people.

While no studies on *trans* fat consumption in mainland China could be found, a study on *trans* fats in locally available foods conducted jointly by the Centre for Food Safety (CFS) and the Consumer Council (CC) in Hong Kong, China is available. The study tested a total of 80 products which, for the most part, use hydrogenated vegetable oils (shortening oil, salad oil and margarine) in their production. Samples included (i) bakery products (including breads, cakes, egg tarts, chicken pies and batter-made food such as egg rolls, waffles and egg puffs); (ii) deep fried foods (including French fries, fried chicken, pork chops, fritters and pastries); and (iii) butter and margarine/margarine-like spreads were collected for testing. The study found that *trans* fats levels varied considerable among similar food products. For example, *trans* fats levels in 23 bread samples ranged from zero to 1.8 g/100 g. *Trans* fats levels in 11 butter-made products ranged from zero to 1.0 g/100 g. For the 14 fried products, there was also a wide range of *trans* fats levels from 0.034 to 0.38 g/100 g. These results suggest that it is possible to reduce *trans* fats levels in food products (CFS, 2007).



Following the CFS (2007) study, a total *trans* fat consumption (intake) per day in daily food sources can be estimated. The estimated average consumption used in the case study on China is 1.99 g, including 0.54 g/day from baked goods and 0.03 g/day from butter-made products, 0.03 g/day from fried products and 0.39g/day from margarine/margarine like spreads <sup>24</sup>.

**Table 4.4 *Trans* fatty intake reduction in China due to *trans*-fat-free canola oil**

	Base	High	Medium	Low
Total TFA intake daily (g) in sample foods <sup>a</sup>	1.99	1.99	1.99	1.99
Assumed TFA reduction (%) in sample foods <sup>b</sup>	20	50	40	10
Total TFA reduction (g) in sample foods <sup>c</sup>	0.40	0.99	0.79	0.20

<sup>a</sup> The Total TFA intake daily (g) in sample foods is calculated in Section A3.1 in Appendix 3.

<sup>b</sup> TFA reduction (%) in sample foods is assumed to have four levels from high, medium, and base to low. These four levels indicate the percentage of vegetable oils found in daily food consumption that is assumed to be replaced by *trans* fat-free canola oil. The TFA reduction ratio guarantees the subsequent calculations focus solely on the health care cost savings for a certain group of people who consumed *trans* fat-free canola/rapeseed oil rather than other vegetable oils.

<sup>c</sup> The total TFA reduction = The Total TFA intake daily (g) \* Assume TFA reduction (%)

From Table 4.4, the effect of *trans* fat-free canola oil substitution can be seen. Using sensitivity analysis, the estimation assumes four level of substitution from base (20%), high (50%), medium (40%) and low (10%). The resulting reductions in *trans* fat consumption are 0.40 g (Base), 0.99 g (High), 0.79 g (Medium) and 0.20 g (Low) daily in China.

**Step 2: Calculate cholesterol change (LDL & HDL) due to reduced *trans* fat consumption**

According to Malla et al. (2007), a number of studies have measured the effects of TFA consumption on LDL, HDL, and total cholesterol levels using controlled diets. Following Malla’s conclusion, in step 2, the assumption is made that for every 1 g reduction in TFA, total cholesterol will reduced by 1.55 percent.

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<sup>24</sup>The main TFA intake in China is assumed from the above categories - baking, butter-made fried products and margarine/margarine like spreads. The average calculation method was used for TFA intake in each category. For details, see Section A3.1 in Appendix 3.

### Step 3: Calculate CHD risk reduction due to changes in cholesterol profile

Drawing on the conclusions of the US National Cholesterol Education's Expert Panel (Expert Panel, 1988), the assumption can be made that there is a 2% reduction in the risk of CHD for every 1 percent reduction in cholesterol levels for the medium, base and low cases, while for the high level a 3 percent reduction in CHD risk is assumed (Malla et al., 2007).

### Step 4: Calculate health cost changes from reduced incidence of CHD

The final step in the analysis (step 4) is to calculate the potential health-care cost savings from *trans* fat-free canola oil.

According to the World Health Organization (WHO), globally, cardiovascular diseases were the number one cause of death in the past and remain so currently. An estimated 17.5 million people died from cardiovascular disease in 2005, which accounts for 30 percent of all global deaths. By 2015, an estimated 20 million people will die from cardiovascular disease (mainly from heart attacks and strokes) if current trends continue (WHO, n.d.). In China, the annual deaths due to cardiovascular disease are about 3 million, accounting for 45 percent of total deaths in the population (NCCD, 2005).

Treatment of cardiovascular-related diseases is also a major cost in China. In a Chinese government cardiovascular report, it was estimated that in 2003, the direct cardiovascular disease expense<sup>25</sup> accounted for 16.13 percent (RMB 92.6 billion, approximate US \$13.2 billion<sup>26</sup>) of total health care costs. According to the prediction in the report, CHD costs have increased at an average annual growth rate of 12.83 percent over the last 10 years. Currently, CHD costs are ranked in the second place in the total medical expense in China. The overall health care costs for CHD is around RMB 26.4 billion (US \$3.85 billion) with RMB 13.3 billion (US \$1.94 billion) for outpatient care<sup>27</sup> and RMB 13.1 billion (US \$1.91 billion) for inpatient care (NCCD, 2005). Due to absence of

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<sup>25</sup> Direct costs of CHD represent the value of resources spent that could have been used for other purposes in the absence of illness (e.g., hospital expenditures, drug expenditures, medical care, and research) (Malla et al, 2007).

<sup>26</sup> USD: CNY = 1:6.86, based on the current market foreign exchange rate (2:00pm, July 7, 2008). These exchange rates apply for all exchange calculations between US dollar and Chinese Yuan in this thesis.

<sup>27</sup> Outpatient care includes outpatient care, emergency medical treatment and medications.

indirect health care costs data for China, the health care costs for CHD calculated within this case study are limited to only the direct health care costs including outpatient and inpatient care costs.

In order to simplify the calculation, the estimated cost of illness savings under *trans* fat-free vegetable oil substitution are limited to savings only from cardiovascular disease. Other possible health improvements from reduced consumption of TFA are not considered in this case study. Following Malla et al. (2007), a 1:1 ratio is assumed between reduced CHD risks and health-care cost savings for first three levels; thus, the related costs will be decreased by 1 percent if CHD is reduced by 1 percent. For the low level, it is assumed that for every percentage reduction in CHD, cost will only be reduced by half a percent (Malla et al., 2007). The calculation for health care savings concentrate solely on the expansion quantities in the market due to trade liberalization, a HCS rate (%) is introduced into the last step calculation ( For details, see section A3.2.1 in appendix 3).

**Table 4.5 Potential health care savings estimated in China**

	Base	High	Medium	Low
TC change due to 1 g TFA reduction daily(%) <sup>a</sup>	1.55	1.55	1.55	1.55
Daily TFA reduction (g)	0.40	0.99	0.79	0.20
Total change in TC (%) <sup>b</sup>	0.62	1.53	1.22	0.31
TC to CHD ratio <sup>c</sup>	2.0	3.0	2.0	2.0
Change in CHD (%) <sup>d</sup>	1.24	4.60	2.45	0.62
Change in CHD (%) to change in cost (%)	1 : 1	1 : 1	1 : 1	1 : 0.5
Total annual CHD cost(\$ million US dollars) <sup>e</sup>	3850	3850	3850	3850
Total change in annual CHD cost due to TFA reduction in daily diet (\$ million US dollars) <sup>f</sup>	48	177	94	12
Health Care Savings (HCS) rate <sup>g</sup>	1.66%	1.65%	1.66%	1.66%
Final HCS (\$ million US dollars) <sup>h</sup>	0.79	2.92	1.56	0.20

<sup>a</sup> Total Cholesterol (TC) change is rated at 1.55: 1 due to 1 g of TFA reduction.

<sup>b</sup> Total change in TC (%) = TC change due to 1 g TFA reduction daily(%) \* Daily TFA reduction (g)

<sup>c</sup> The relationship between total cholesterol and CHD is 1:2 based on Expert Panel (1988). For the 1:3 ratio is used for high level estimation which assumed to be the long-term ratio. (Source: Malla et al., 2007)

<sup>d</sup> Change in CHD (%) = total change in TC (%) \* TC to CHD ratio

<sup>e</sup> Source: NCCD (2005).

<sup>f</sup> Total change in CHD cost = total annual CHD cost \* Change in CHD(%) \* Change in CHD (%) to change in cost (%) ratio

<sup>g</sup> See Section A3.2.1 in Appendix 3 for details.

<sup>h</sup> HCS = Total change in annual CHD cost \* HCS rate (%)

In Table 4.5, the total change in annual CHD cost due to *trans* fat-free canola/rapeseed oil substitution is calculated. A range of scenarios are calculated given the incomplete nature of the data on HCS. These scenarios are based on Malla et al. (2007).

The base case estimation assumes that 20 percent of the hydrogenated vegetable oils market is replaced by *trans* fat-free vegetable oils, leading to a 0.40g daily *trans* fat intake reduction in China. With the assumed 1:2 cholesterol to CHD risk ratio it provides a saving of about US \$0.79 million in health-care and medical costs annually in China.

The high level assumption is based on an optimistic perspective that *trans* fat-free vegetable oils cover a 50 percent market share in hydrogenated vegetable oils such as the shortening and the salad oil, accounting for a 0.99g *trans* fat intake reduction daily in China. With the assumption that every percentage change in total cholesterol leads to a 3 percent change in CHD and 1:1 ratio between the incidence of CHD and the resulting costs to society, high level estimation results in a saving of about US \$2.92 million in Chinese health care costs.

For medium estimate, *trans* fat-free vegetable oil is assume to substitute 40 percent of the hydrogenated vegetable oils market, which together results in a 0.79g *trans* fat intake reduction daily in China. Given a smaller ratio with every percentage change in cholesterol level which lead to a 2 percent reduction in CHD, this results in a saving of about US \$1.56 million in health care costs annually in China based on an assumed 1:1 ratio between the incidence of CHD and the resulting costs to society.

The low scenario demonstrates potential health-care cost savings under very conservative assumptions. *Trans* fat-free oils are assumed to reach only a 10 percent market share in the hydrogenated vegetable oils market. There is a 0.20g *trans* fat intake reduction daily

in China. Besides, a reduced ratio with 1:0.5 is applied between CHD change and health-care costs instead of the former 1:1 ratio. Although every step is extremely conservative, the low scenario still suggests a potential reduction of about US \$0.2 million in health-care and medical costs annually in China.

#### 4.4.2.3 Final Ratio Calculation

Recall from Chapter 3, putting a tariff in place changes total welfare. If the objective of the protection policy was to increase producer surplus, decision makers must weigh the benefits of producers more heavily than benefits of consumers. According to the assumption made in Chapter 3, the ratio  $\eta$  will be applied here to give decision makers weighting of the changes in consumer surplus and producer surplus as well as the health cost savings arising from the imposition of a tariff on canola/rapeseed oil imports in China.

Table 4.6 shows the calculations undertaken to derive the ratios used in the comparison. From the table, the ratios for canola/rapeseed oil are calculated based on the results from the previous sections. In summary, in the absence of the information pertaining to the health benefits from canola/rapeseed oil,  $\eta^M = 1.11$ . With the health benefits, this ratio rises to 1.33 in the base case, 1.67 in the high case, 1.56 in the medium case and 1.22 in the low case. Two conclusions can be made from final results. First, notice that both  $\eta^M$  and  $\eta^N$  are larger than 1. That means, the loss for consumers arising from the higher price caused by tariff is larger than the gain by producers. The empirical study of China is consistent with the analysis in Case 1 of Chapter 3. The ratio shows a bias towards producers when policy makers in China framed their trade policy. Currently, canola and canola product imports face significant obstacles in China. Even if the tariff rate has been reduced from 19.9 percent due to WTO commitments, both canola oil and canola seed still face a tariff rate of 9 percent. The trade policy on canola/rapeseed oil imports is welfare reducing for the domestic economy. The tariff restriction on imports reduced consumer benefits from consumption of canola/rapeseed oil to a considerable degree. In

addition, canola and canola products face considerable discrimination as the Chinese tariff on canola and its products is 9 percent while there is only a 3 percent tariff on soybeans (Grain Growers of Canada, 2007). The current 6 percent difference in tariffs between soybeans and canola leads to additional losses for consumers due to the relatively higher prices caused by the limitation on imports of canola/rapeseed oil. Policy makers in China may wish to reconsider the trade policy related to canola/rapeseed oil imports given the new information on the ratio of losses versus benefits.. Reducing tariff levels on canola/rapeseed oil might be a better trade policy for China.

Secondly, the result shows that  $\eta^N$  is larger than  $\eta^M$  at all four levels which is also consistent with the analysis from Case 1 in Chapter 3. Given the demand for canola/rapeseed oil, consumers suffer a greater loss due to the higher domestic price. Considering health benefits and health care cost savings on canola/rapeseed oil, the weighting ratio is considerably larger than before the health benefits of canola/rapeseed oil became known. At the base level with 20 percent TFA reduction in daily *trans* fat intake, the loss for consumers arising from the higher price is nearly one and a half times larger than the gain by producers. The high and medium levels even show over one and a half times weight given to producer benefits relative to consumer benefits. Though at the low level, consumers still lose more than the gain for producers. Therefore, from a welfare perspective, political decision makers may wish to re-evaluate their decisions on the import policy towards canola/rapeseed oil.

**Table 4.6 Final ratio calculation**

$\eta^M$		$\eta^M = \frac{\Delta \text{ consumer surplus}}{\Delta \text{ producer surplus}} = \frac{\mathbf{a}_5 + \mathbf{a}_6 + \mathbf{a}_7 + \mathbf{a}_8 + \mathbf{a}_9}{\mathbf{a}_5} = \frac{335.77}{303.65}$	<b>1.11</b>
$\eta^N$	Base	$\begin{aligned} \eta^N &= \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}} \\ &= \frac{(\mathbf{a}_5 + \mathbf{a}_6 + \mathbf{a}_7 + \mathbf{a}_8 + \mathbf{a}_9 + \mathbf{a}_{13} + \mathbf{a}_{14})^{\text{Base}} + \text{HCS (Base)}}{\mathbf{a}_5} \\ &= \frac{403.475 + 0.79}{303.65} \end{aligned}$	<b>1.33</b>
	High	$\begin{aligned} \eta^N &= \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}} \\ &= \frac{(\mathbf{a}_5 + \mathbf{a}_6 + \mathbf{a}_7 + \mathbf{a}_8 + \mathbf{a}_9 + \mathbf{a}_{13} + \mathbf{a}_{14})^{\text{High}} + \text{HCS (High)}}{\mathbf{a}_5} \\ &= \frac{505.031 + 2.92}{303.65} \end{aligned}$	<b>1.67</b>
	Medium	$\begin{aligned} \eta^N &= \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}} \\ &= \frac{(\mathbf{a}_5 + \mathbf{a}_6 + \mathbf{a}_7 + \mathbf{a}_8 + \mathbf{a}_9 + \mathbf{a}_{13} + \mathbf{a}_{14})^{\text{Medium}} + \text{HCS (Med)}}{\mathbf{a}_5} \\ &= \frac{471.179 + 1.56}{303.65} \end{aligned}$	<b>1.56</b>
	Low	$\begin{aligned} \eta^N &= \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}} \\ &= \frac{(\mathbf{a}_5 + \mathbf{a}_6 + \mathbf{a}_7 + \mathbf{a}_8 + \mathbf{a}_9 + \mathbf{a}_{13} + \mathbf{a}_{14})^{\text{Low}} + \text{HCS (Low)}}{\mathbf{a}_5} \\ &= \frac{369.664 + 0.2}{303.65} \end{aligned}$	<b>1.22</b>

## **Chapter 5: United Kingdom (UK) Case Study**

This chapter provides a UK case study to examine the potential welfare benefits forgone from the existence of trade barriers when canola oil becomes a functional food. First, the chapter gives a brief introduction on the EU vegetable oils market. Further, the existence of trade barriers — notable as GMO ban is discussed. Following this introduction, the empirical case study of UK's canola/rapeseed oil is examined according to Case 2 in the framework developed in Chapter 3. The forgone benefits of functional canola/rapeseed oil in UK arising from the trade barriers — a GMO ban — are calculated.

### **5.1 The EU vegetable oils market**

In recent years, the vegetable oil market in the EU has changed dramatically and is now strongly driven by the demand for biodiesel. As a result, there is competition between vegetable oil used as an input to biodiesel and for human consumption (Bendz, 2007). Across the whole range of oils and fats, approximately 80 percent is used as human food, a further 6 percent is an input to animal feed and the balance (14 percent) provides the raw material for the oleochemical (bio-fuels, solvents) industry (Gunstone, 2001).

Rapeseed oil has become the primary feedstock for biodiesel in Europe. Government mandated bio-diesel production led to rapeseed oil consumption across the EU increasing by 20 percent in 2004-2005. By 2006, approximate 60 percent of the total rapeseed oil produced in the EU was used to provide biodiesel (Ho, 2006). The major producing countries are Germany, France, the UK and Poland (Profarmer, n.d.). In the UK, rapeseed oil represents about 33 percent of total oil and fat output (Gunstone, 2001). The area planted to rapeseed in the UK has been steadily increasing and is estimated to continue to increase by over 20 percent year by year in the near term (Bendz, 2007).



Prices of rapeseed and rapeseed oil have been strong due to rising demand for rapeseed from both the biodiesel and food industries. Strong demand for bio-fuels, however, has led to a considerable decline in imports of rapeseed and canola oil moving into food supply chains (Bendz, 2007). The price of rapeseed oil across the EU rose by 45 percent in 2005, and then an additional 30 percent to about US\$800 per tonne in 2006 (Ho, 2006).

## **5.2 GMO ban**

While the domestic market is expanding rapidly, the import market for rapeseed oil is heavily constrained. The EU has had community-wide legislation on genetically modified organisms (GMOs) since 1998. Before being placed on the market, GMOs must first undergo a very strict assessment process. If approved, they must be labeled and managed in accordance with strict product traceability requirements (EUROPA, n.d.). The majority of products that use genetic modification technology in their production, especially imported products, could not enter into the market because of a stringent science-based assessment and a lengthy approval process. GMOs are a contentious political issue in the EU which delayed the establishment of an expeditious approval mechanism and continues to inhibit approvals (Phillips, 2006).

Europeans preferred the name oilseed rape, rape oil, or rapeseed oil to the name canola. One unique difference, however, is that Europe does not permit the making of canola oil from genetically modified plants (VitaminsDiary, n.d.). European farmers are prevented by law from growing genetically modified rapeseed. However, over the period since 1995 about 80 percent of the canola grown in Canada has now been modified using biotechnology to make it tolerant to some herbicides (Canola Council of Canada, 2008f). Thus, Canadian canola is currently banned from the European food market as the GM varieties of canola have not been approved for import into the EU and there is no segregation of GM and non-GM canola in the post-harvest supply chain (Smyth et al., 2006).

In the past, Australia has been an important supplier of canola to the EU market. Canola is now Australia's third largest broad-acre crop just after wheat and barley (AOF, n.d.). Australia is viewed as the major non-GM canola products exporting country for Europe. The non-GM attribute provides a marketing advantage for Australian canola products in the EU market. On the one hand, however, Australia exports canola primarily in seed form, with only small quantities of oil exports and virtually no canola meal exports (Foster and French, 2007). On the other hand, Australian canola exporters have not been able to consistently capture non-GM premiums because the EU is an inconsistent market for Australian canola (AOF, 2003). The import trade of canola products from Australia has been considerably influenced by weather conditions in the EU. Large imports are required only when adverse weather conditions affected the EU rapeseed harvest (see Table 5.1).

**Table 5.1 EU rapeseed products imports from Australia**

	2000 (Kt) <sup>a</sup>	2001 (Kt)	2002 (Kt)	2003 (Kt)	2004 (Kt)	2005 (Kt)	2006 (Kt)
Australia (mainly in rapeseed)	0	362	63	1	94	0	287

<sup>a</sup> 1 Kt = 1000 tonne.

Sources: United Nations Statistics Division (2006).

Due to potentially large export markets for GM products outside the EU, in 2003, Australia's gene technology regulator approved the release of canola that had been genetic modified to resist the herbicide Glufosinate ammonium (Sydney Morning Herald, 2003). There appears to be a rapid shift to the growing of GM varieties of canola in Australia.

In the face of pressure from major GM grain exporting countries, the EU has made some concessions on the imports of GM products. In late 2004, some GM grain varieties were approved but imports of the most important varieties of GM canola are still not allowed (Foster and French, 2007). In 2006, the European Commission announced that three oilseed rapes known as Ms8, Rf3 and Ms8xRf3 that are genetically modified for tolerance to the herbicide glufosinate-ammonium are authorized to be placed on the EU market. These oilseed rapes are allowed to be imported but only for processing into animal feed or for industrial purposes not for cultivation (EUROPA, 2007). They cannot be imported if destined for the human food supply channel. Thus, the EU market including the UK is effectively closed to canola imports that can enhance human health.

### **5.3 Modelling the UK rapeseed oil market**

Recall from the model developed in Chapter 3, Case 2, where both domestic producers and international sources of supply are assumed for a new functional food. In Case 2, the new functional food faces a regulatory trade barrier that is equivalent to an import ban. Therefore, canola oil that suffers from a GMO import ban which prevents market access to the U.K is a suitable example for a case study under the assumptions contained in Case 2<sup>28</sup>.

The European Union is a major producer of rapeseed. In the past, it has been a net exporter of rapeseed products. The EU's net exports have declined in recent years and the EU is now becoming a net importer of both rapeseed and rapeseed oil due to strong demand as an input to biodiesel production (Foster and French, 2007). For example, the EU increased its imports of rapeseed oil from 38 Kt to 335 Kt in 2006 (see Table 5.2). However, the increased imports of rapeseed and rapeseed oil are still small relative compared to the large domestic production — approximately 5 percent of domestic production in 2006 (see Table 5.2). Further, the EU has diverted more

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<sup>28</sup> The assumption being made is that any small remaining quantities of non-GM imports of canola provided from Australia can be safely ignored.

than three million tonnes, or 60 percent, of its rapeseed oil production to biodiesel production (Business Times, 2008). More than half of the imports went to biodiesel production in order to satisfy mandated increased utilization of this new transport fuel. Thus, the remaining imports of rapeseed oil for food use from other countries only cover a tiny portion of the domestic market for rapeseed oil consumption. Thus, it is assumed for the purpose of this case study that the EU, and hence the UK, are closed to cheaper international sources of canola oil.

**Table 5.2 EU - supply and disposal of rapeseed oil (Kt)**

	2002-2003	2003-2004	2004-2005	2005-2006
Opening Stocks	320	315	152	200
Production	4353	4339	5365	5945
Imports	7	33	38	335
Total supply	4680	4687	5555	6480
Domestic Consumption	4115	4392	5365	5945
Exports	250	143	125	75
Closing stocks	315	152	200	190

Source: US Department of Agriculture (2006).

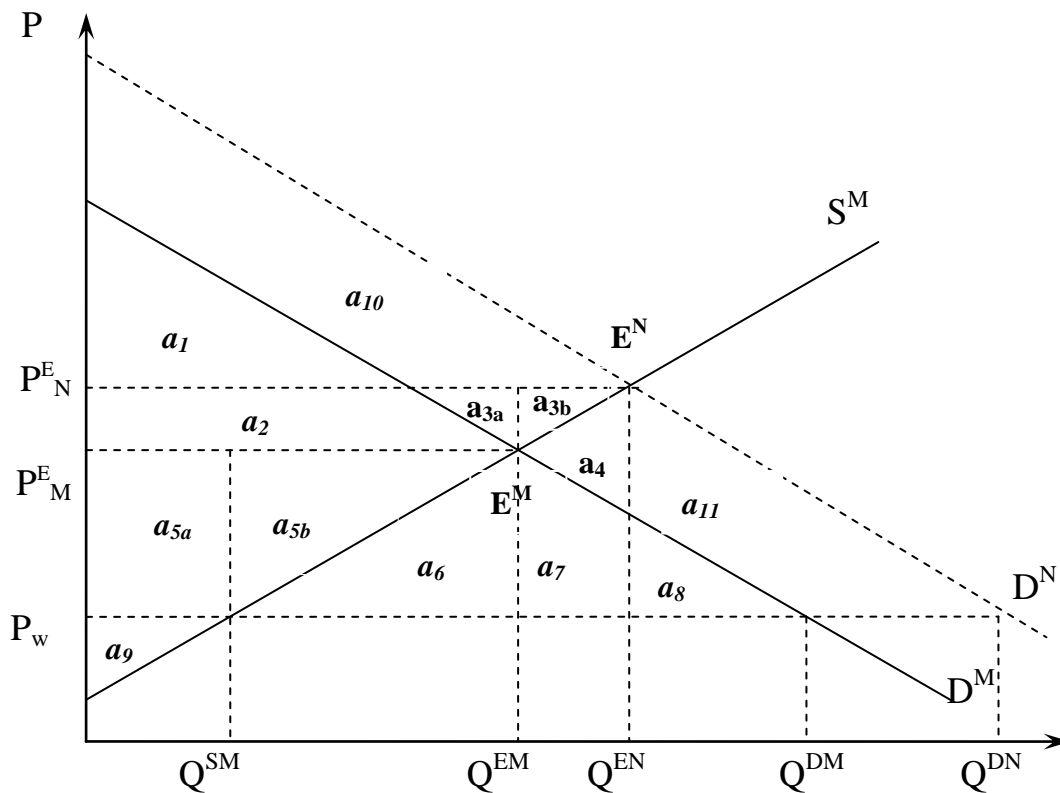
With its *trans* fat-free health enhancing attributes, it is assumed that canola/rapeseed oil as a functional food will have increased in popularity in the EU market if consumers have access to the functional product. However, since the EU has established very strict laws governing the import of GM canola, opportunities in promoting health benefits may be lost while GM canola imports are prohibited.

Hence, in the UK case study, imports of rapeseed oil from countries outside the EU are assumed to be zero in order to better capture the foregone benefits arising from the GMO ban.

## 5.4 Case calculation

### 5.4.1 Trade effects calculation

Recall from Case 2 in Chapter 3, reproduced in Figure 5.1,  $D^M$  is the demand curve of canola/rapeseed oil in the UK market prior to the health improvement benefits becoming apparent. There is also a supply curve  $S^M$  for canola/rapeseed oil. At  $P_w$ , the world price for canola/rapeseed oil, consumers are willing to purchase  $Q^{DM}$  and domestic producers will only supply  $Q^{SM}$ . Imports would be  $(Q^{DM} - Q^{SM})$ . However, there is a GMO ban in the UK imposed on the import of canola/rapeseed oil. Therefore, it raises the price to  $P^E_M$  and the quantity consumed will be  $Q^{EM}$ .<sup>29</sup>



\* For calculation purposes,  $a_5$  is divided into  $a_{5a}$  and  $a_{5b}$ .  $a_3$  is divided into  $a_{3a}$  and  $a_{3b}$ .

**Figure 5.1 Case 2 — domestic and import supply,  
trade prohibiting regulation in the UK**

<sup>29</sup> Note we are assuming that the  $S^M$  curve includes any transfers within the EU's single market.

Without the GMO import ban, the consumer surplus is area  $a_1 + a_2 + a_5 + a_6 + a_7 + a_8$ . Producer surplus is area  $a_9$ <sup>30</sup>. After the GMO import ban is implemented, consumer surplus decreases to area  $a_1 + a_2$  with a reduction of  $a_5 + a_6 + a_7 + a_8$ . Producer surplus increases to area  $a_5 + a_9$  with an increase equal to area  $a_5$ .

As in the Chinese case study presented in Chapter 4, canola/rapeseed oil can also be seen as a functional food in the current food market in the UK. As we assumed in the Case 2, more people are willing to buy canola/rapeseed oil given its newly recognized health enhancing attributes — only recognized after the GM import ban was put in place. In addition, consumers are willing to pay at least the same price or a premium for higher quality (health enhancing) canola/rapeseed oil. Therefore, the increased consumption of new health enhancing canola/rapeseed oil shifts the demand curve out to  $D^N$ . Faced with the same world price at  $P_w$ , the consumer surplus increases to area  $a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{10} + a_{11}$ . As the world price is unchanged and the supply curve is not altered, domestic producer surplus remain equal to area  $a_9$ .

With the import ban in place, however, no import of canola/rapeseed oil exists in the domestic market in the UK. Hence, the domestic price  $P_M^E$  rises to  $P_N^E$  and the quantity consumed equals  $Q^{EN}$  with the increased demand. With higher price  $P_N^E$ , consumer surplus decreases to area  $a_1 + a_{10}$ . Consumers suffer a loss of area  $a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}$  in consumer surplus because of the higher price. On the other hand, new producer surplus increases to area  $a_2 + a_3 + a_5 + a_9$  — a change equal to  $a_2 + a_3 + a_5$ .

Thus, before new health information on canola/rapeseed oil was received, the trade changes are areas  $a_5 + a_6 + a_7 + a_8$  — the decrease in consumer surplus and  $a_5$  — the increase in producers surplus. Both  $a_5 + a_6 + a_7 + a_8$  and  $a_5$  are trapezoid areas that can

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<sup>30</sup> Given that  $S^M$  includes within EU transfers, the estimates of producer surplus may exceed the value of producer surplus that accrues to British producers.

be divided into rectangles and triangles for the calculation of their values<sup>31</sup>. After the health enhancing attributes of canola/rapeseed oil having been recognized by the consumers, the trade change is area  $a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}$  in consumer surplus and  $a_2 + a_3 + a_5$  in producer surplus. Area  $a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}$  can be divided into rectangle  $a_2 + a_3 + a_4 + a_5 + a_6 + a_7$  and triangle  $a_8 + a_{11}$ . Area  $a_2 + a_3$  can be divided as rectangle  $a_2 + a_{3a}$  and triangle  $a_{3b}$ . Combined with the data from Table 5.3, the calculations and resultant values can be found in Table 5.5.

**Table 5.3 Market data of canola/rapeseed oil in the UK (2006)<sup>a</sup>**

Total domestic consumption/supply (Mt) – $Q^{EN}$ <sup>b</sup>	0.63 <sup>c</sup>	
Supply elasticity - $\epsilon^S$	0.84 <sup>d</sup>	
Demand elasticity - $\epsilon^D$	-0.50 <sup>e</sup>	
Average world price(\$ US dollars/tonne) - $P_w$	553 <sup>f</sup>	
Current domestic price(\$ US dollars/tonne) – $P_N^E$	983 <sup>g</sup>	
Domestic demand (Mt) without GMOs ban- $Q^{DN}$	0.77 <sup>h</sup>	
Domestic supply (Mt) without GMOs ban - $Q^{SM}$	0.40 <sup>i</sup>	
Demand increasing rate <sup>j</sup>	Base	30%
	High	50%
	Medium	40%
	Low	20%
Original domestic consumption (Mt) at $P_M^E$ - $Q^{EM}$ <sup>k</sup>	Base	0.48
	High	0.42
	Medium	0.45
	Low	0.525
Original price before demand shifts– $P_M^E$ (\$ US dollar/tonne) <sup>l</sup>	Base	704
	High	593

<sup>31</sup> Assuming, of course, linear supply and demand curves.

	Medium	649
	Low	788
domestic consumption (Mt) at $P_w - Q^{DM}$	Base	0.53
	High	0.43
	Medium	0.48
	Low	0.60

<sup>a</sup> All the data period is based on year 2006.

<sup>b</sup> Different from the Chinese case study in the chapter 4, rapeseed oil has been well-known for its *trans* fat-free and other health enhancing benefits in the UK market for over 10 years. Thus, it is assumed that the total domestic consumption/supply of rapeseed oil is  $Q^{EN}$ . That means the demand curve  $D^M$  has already been shifted to  $D^N$  in the current market. The initial price for the purpose of calculation is, hence,  $P_N^E$ .

<sup>c</sup> Source: FEDIOL(2006).

<sup>d</sup> Note: it is a oilseed area response elasticity for oilseed oil supply. (Source: Meilke et al, 2001)

<sup>e</sup> Note: it is a direct price elasticity for oilseed oil demand. (Source: Meilke et al, 2001) See

<sup>f</sup> Average  $P_w$  is based on period from 87/88 to 05/06. Source: USDA (1999) and USDA (2008).

<sup>g</sup> Raw vegetable oil price in Netherlands and Germany. Source: Horváth, 2006.

(Origin: 162,663 HUF. Convert to US \$ 982 based on 1:0.006042 (HUF: USD) currency rate. Source: Yahoo Finance, Sept 27th, 2008.)

<sup>h</sup>  $Q^{DN}$  is calculated from the following steps using demand elasticity:

$$\begin{aligned}\mathcal{E}^D &= \frac{\Delta Q}{\Delta P} * \frac{P}{Q} = \frac{(Q^{EN} - Q^{DN})}{P_N^E - P_w} * \frac{P_N^E}{Q^{EN}} \\ Q^{DN} &= Q^{EN} - \mathcal{E}^D * Q^{EN} * \frac{(P_N^E - P_w)}{P_N^E} \\ &= 0.63 - (-0.50) * 0.63 * \frac{(983 - 553)}{983} \\ &= 0.77 \text{ (Mt)}\end{aligned}$$

<sup>i</sup>  $Q^{SM}$  is calculated from following steps using supply elasticity:

$$\begin{aligned}\mathcal{E}^S &= \frac{\Delta Q}{\Delta P} * \frac{P}{Q} = \frac{(Q^{EN} - Q^{SM})}{P_N^E - P_w} * \frac{P_N^E}{Q^{EN}} \\ Q^{SM} &= Q^{EM} - (\mathcal{E}^S * (P_N^E - P_w) * \frac{Q^{EN}}{P_N^E}) \\ &= 0.63 - (0.84 * (983 - 553) * \frac{0.63}{983}) \\ &= 0.4 \text{ (Mt)}\end{aligned}$$

<sup>j</sup>. Demand increases are estimated from current reports and studies regarding to the UK's functional food market.

For details, see Appendix 2.2.

<sup>k</sup>  $Q^{EM} = Q^{EN} / (1 + \text{Demand increasing rate})$

<sup>l</sup>  $P_M^E$  is calculated from following steps using supply elasticity:

$$\mathcal{E}^S = \frac{\Delta Q}{\Delta P} * \frac{P}{Q} = \frac{(Q^{EN} - Q^{EM})}{P_N^E - P_w} * \frac{P_N^E}{Q^{EN}}$$



$$P^E_M = P^E_N - \frac{(Q^{EN} - Q^{EM}) * P^E_N}{\epsilon^S * Q^{EN}}$$

<sup>m</sup> Q<sup>DM</sup> is calculated from following steps using demand elasticity:

$$\epsilon^D = \frac{\Delta Q}{\Delta P} * \frac{P}{Q} = \frac{(Q^{EM} - Q^{DM}) * P^E_M}{P^E_M - P_W * Q^{EM}}$$

$$Q^{DM} = Q^{EM} - (\epsilon^D * (P^E_M - P_W) * \frac{Q^{EM}}{P^E_M})$$

Similar to China's case study, much of the data used in the UK case study calculations are derived from previously published sources including the demand and supply elasticities used. The elasticity of demand and supply in the UK case study were obtained also from Meilke et al. (2001). Since both the elasticity of demand and supply are derived from previously published studies, there is a need to check the robustness of the results in the case studies. Hence, a sensitivity analysis is conducted at both higher and lower levels. Table 5.4 shows the trade effects ratio under different elasticity values in the UK case study.

**Table 5.4 Sensitivity analysis for elasticity in the UK case study**

	$\epsilon^D$	Q <sup>DM</sup> (Mt)	$\epsilon^S$	Q <sup>SM</sup> (Mt)	$\eta^M$
Original level	-0.50	0.67	0.84	0.56	<b>1.09</b>
Higher level (+20%)	-0.60	0.68	1	0.55	<b>1.11</b>
Lower level (-20%)	-0.40	0.66	0.67	0.57	<b>1.08</b>

In the sensitivity analysis for elasticities in the UK Case study, the final ratio  $\eta^M$  is 0.02 larger and 0.01 smaller than its original value. The impact of elasticity values on the trade effect, is small approximately 2 percent. Since the elasticity values in the UK case study are larger than they are in Chinese case study, the 2 percent changes is also

an acceptable result indicating that the trade effects ratio is not particularly sensitive to the different elasticity values. Therefore, the original combination of demand and supply elasticities can still be used in the UK case study without any particular concerns.

**Table 5.5 Trade effects calculation in the UK case study**

		$a_5 + a_6 + a_7 + a_8$		$a_5$		$a_2 + a_3 + a_5$			$a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}$	
		Rectangle $a_5 + a_6$	Triangle $a_7 + a_8$	Rectangle $a_{5a}$	Triangle $a_{5b}$	Rectangle $a_2 + a_{3a}$	Triangle $a_{3b}$	$a_5$	Rectangle $a_2 + a_3 + a_4 + a_5 + a_6 + a_7$	Triangle $a_8 + a_{11}$
Formula		$Q^{EM} * (P_M^E - P_W)$	$1/2 * (Q^{DM} - Q^{EM}) * (P_M^E - P_W)$	$Q^{SM} * (P_M^E - P_W)$	$1/2 * (Q^{EM} - Q^{SM}) * (P_M^E - P_W)$	$Q^{EM} * (P_N^E - P_M^E)$	$1/2 * (Q^{EN} - Q^{EM}) * (P_N^E - P_M^E)$		$Q^{EN} * (P_N^E - P_W)$	$1/2 * (Q^{DN} - Q^{EN}) * (P_N^E - P_W)$
Result (Million\$)	High	16.8	0.2	16	0.4	163.8	40.95	16.4	270.9	30.1
	Med	43.2	1.44	38.4	2.4	150.3	30.06	40.8		
	Base	72.48	3.78	60.4	6.04	133.92	20.93	66.44		
	Low	123.38	9.4	94	14.69	102.38	10.24	108.69		
	High	17		16.4		221.15			301	
	Med	44.64		40.8		221.16				
	Base	76.26		66.44		221.29				
	Low	132.78		108.69		221.31				

Table 5.5 shows all the calculations and results for the trade effects of canola/rapeseed oil. According to the above table, with a GMO ban on imports of canola/rapeseed oil in the UK, consumers suffer a loss from US\$17 million to US\$133 million at four different levels for consumer surplus change (area  $a_5 + a_6 + a_7 + a_8$ ) because of the higher domestic price. On the other hand, producers gain US\$16.4 million to US\$108.7 million at four different levels in producer surplus change (area  $a_5$ ). Results showed that consumer loss at every level is more than producer gain. However, after health information regarding canola/rapeseed oil become well-known to the public, consumers' loss increases relative to producers' gain. A US\$301 million loss in consumer surplus (area  $a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}$ ) has been calculated in Table 5.5. Without sufficient imports, increased consumption of canola/rapeseed oil raised the domestic market price leading to the loss in consumer surplus. This loss is increased substantially compared to former loss in consumer surplus at the four different levels. Even at base levels with the US\$221 million gain in producer surplus, the increased consumption of healthy canola/rapeseed oil leads to more loss in consumer surplus than when the health benefit was unknown. Although the producer surplus also increased (area  $a_2 + a_3 + a_5$ ), the comparative increase is less than the decline in consumer surplus. As expected, the results of trade effects indicate that the import ban generates a larger loss in consumer welfare than the gain on the producer side and it is even larger after the shift in demand for canola/rapeseed oil arising from its health attributes becoming known.

## **5.4.2 Estimating the potential health care cost savings for the UK case study**

Following a similar methodology to that used in section 4.3.2.2 for the Chinese Case study, the model developed by Malla et al. (2007) is adapted to estimate the potential health benefit and related medical cost savings arising from the consumption of more healthy *trans* fat-free canola/rapeseed oil in the UK.

Step 1: Estimate possible daily *trans* fat intake reduction due to ‘*trans* fat-free canola oil in the UK

In step 1, a total *trans* fat consumption (intake) per day is estimated using available studies. Hulshof et al. (1999) studied the intake of fatty acids in Western Europe. They found that in the United Kingdom, the main sources of TFA were partially hydrogenated oils and fats which contribute 35 percent of the intake of total *trans* fatty acids in the diet. Of these, margarines, spreads, frying and cooking fats and oils contributed at least 31 percent TFA in the diet. The study further revealed that a total daily intake of individual *trans* fatty acids among 11 fatty acid isomers from selected food sources per day is 40.92g in the UK.<sup>32</sup>

From Table 5.6, the effect of *trans* fat-free canola oil substitution can be seen. Using sensitivity analysis, the estimation assumes four level of substitution from base (20%), high (50%), medium (40%) and low (10%). The resulting reductions in *trans* fat consumption are 0.89 g (Base), 2.22g (High), 1.78 g (Medium) and 0.44 g (Low) daily in the UK.

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<sup>32</sup> 11 fatty acid isomers are C<sub>14:1t9</sub> (0.11 g methylesters/day), C<sub>16:1t9</sub> (0.18 g methylesters/day), C<sub>18:1t</sub> (2.00 g methylesters/day), C<sub>18:2t</sub> (0.28g methylesters/day), C<sub>18:3t</sub>+C<sub>20:1</sub> (0.17g methylesters/day), C<sub>20:2t11,14</sub> (0.02 g methylesters/day), C<sub>22:1t</sub> (0.06 g methylesters/day), C<sub>18:1c9</sub> (19.3 g methylesters/day), C<sub>18:2c9,12</sub> (11.4 g methylesters/day), C<sub>18:3c9,12,15</sub> (1.4 g methylesters/day), C<sub>18:0</sub> (6.0 g methylesters/day). Source: Hulshof et al. (1999).

**Table 5.6 *Trans* fatty intake reduction in the UK due to *trans*-fat-free canola oil**

	base	High	medium	Low
Total daily TFA (intake) per person (g) <sup>a</sup>	40.92	40.92	40.92	40.92
Contribution rate (%) <sup>b</sup>	10.85	10.85	10.85	10.85
TFA intake due to hydrogenated oils consumption <sup>c</sup>	4.44	4.44	4.44	4.44
Assume TFA reduction (%) <sup>d</sup>	20	50	40	10
Total TFA reduction (g) <sup>e</sup>	0.89	2.22	1.78	0.44

<sup>a</sup> Source: Hulshof et al. (1999).

<sup>b</sup> According to Hulshof et al. (1999), the main sources of TFA were partially hydrogenated oils and fats which contribute 35 percent of the intake of total trans fatty acids in the diet. Of these, margarines, spreads, frying and cooking fats and oils contributed at least 31 percent TFA in the diet. Thus, a contribution rate is applied to reveal total TFA intake due to hydrogenated oils consumptions. Contribution rate (%) is calculated from the product of 35% times 31%.

<sup>c</sup> TFA intake due to hydrogenated oils consumptions = Contribution rate \* total TFA (intake) per day

<sup>d</sup> TFA reduction (%) in sample foods is assumed have four levels from base, high, medium to low. These four levels indicates the percentage of vegetable oils found in daily food consumption that is assumed to be substituted by *trans* fat-free canola oil. The TFA reduction ratio guarantees the subsequent calculations focus solely on the health care cost savings for a certain group of people who consumed trans fat-free canola/rapeseed oil rather than other vegetable oils.

<sup>e</sup> The total TFA reduction = The Total TFA intake daily (g) \* Assume TFA reduction (%)

### Step 2: Calculate cholesterol change (LDL & HDL) due to reduced *trans* fat consumption

According to Malla et al. (2007), a number of studies have measured the effects of TFA consumption on LDL, HDL, and total cholesterol levels using controlled diets. Following Malla's conclusion, in step 2, the assumption is made that for every 1 g reduction in TFA, total cholesterol will reduced by 1.55 percent.

### Step 3: Calculate CHD risk reduction due to changes in cholesterol profile

Drawing on the conclusions of the US National Cholesterol Education's Expert Panel (Expert Panel, 1988), the assumption can be made that there is a 2% reduction in the risk of CHD for every 1 percent reduction in cholesterol levels for the medium, base and low cases, while for the high level a 3 percent reduction in CHD risk is assumed (Malla et al., 2007).

#### Step 4: Calculate cost changes from reduced incidence of CHD

The final step in the analysis (step 4) is to calculate the potential health-care cost savings from *trans* fat-free canola oil in the UK.

Each year cardiovascular disease causes over 4.3 million deaths in Europe and over 2.0 million deaths in the European Union which accounts for nearly half of all deaths (Allender et al., 2008a). Cardiovascular disease (CVD) leads to larger economic and human costs for Europe. From European cardiovascular disease statistics provided by European Heart Network, CVD costs the health systems of the EU about € 110 billion (US\$172.7 billion)<sup>33</sup> in 2006 which represents around 10% of the total health care expenditure across the EU (Allender et al., 2008a). Further, production losses from CVD deaths and illness are also considered into the overall CVD costs leading to a cost of € 192 billion (US\$301.44 billion) a year. CHD accounts for one-quarter of these overall costs (Allender et al., 2008a). In the United Kingdom, the total costs of CHD are approximate £9.0 billion (US\$17.82 billion)<sup>34</sup> in 2006. Of the total cost of CHD to the UK, around 36% is due to direct health care cost, 43% to productivity losses, and 21% to the informal care of people with CHD (Allender et al., 2008b).

In order to simplify the calculation, the estimated cost of illness savings under *trans* fat-free vegetable oil substitution are limited to savings only from cardiovascular disease. Any other possible health improvements from reduced consumption of TFA

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<sup>33</sup> I use EUR: USD = 1:1.57, based on the current market foreign exchange rate (2:00pm, July 7, 2008).

<sup>34</sup> I use GBP: USD = 1:1.98, based on the current market foreign exchange rate (average, July 7, 2008).

are not considered in this study. Following Malla et al. (2007), a 1:1 ratio is assumed between reduced CHD risks and health-care cost savings for the first three levels; thus, the related costs will be decreased by 1 percent if CHD is reduced by 1 percent. For the low level, it is assumed that for every percentage reduction in CHD, cost will only be reduced by half a percent (Malla et al., 2007). The health care savings are limited to the opportunities for increased consumption arising from trade liberalization, a HCS rate (%) is introduced into the last calculation step ( For details, see section A3.2.2 in appendix 3).

**Table 5.7 potential annual health-care savings estimated in the U.K**

	Base	High	Medium	Low
TC change due to 1 g TFA reduction daily (%) <sup>a</sup>	-1.55	-1.55	-1.55	-1.55
Daily TFA reduction	0.89	2.22	1.78	0.44
Total change in TC (%) <sup>b</sup>	1.38	3.44	2.76	0.68
TC to CHD ratio <sup>c</sup>	2.0	3.0	2.0	2.0
Change in CHD (%) <sup>d</sup>	2.76	10.32	5.52	1.36
CHD to cost ratio	1.0	1.0	1.0	0.5
Total annual CHD cost (million U.S dollars) <sup>e</sup>	17820	17820	17820	17820
Total change in annual CHD cost due to TFA reduction in daily diet (million US dollars) <sup>f</sup>	492	1839	984	121
Health Care Savings (HCS) rate <sup>g</sup>	22%	22%	22%	22%
Final HCS (million US dollars) <sup>h</sup>	108.24	404.58	216.48	26.62

<sup>a</sup> Total Cholesterol (TC) change is rated at 1.55: 1 due to 1 g of TFA reduction.

<sup>b</sup> Total change in TC (%) = TC change due to 1 g TFA reduction daily(%) \* Daily TFA reduction (g)

<sup>c</sup> The relationship between total cholesterol and CHD is 1:2 based on Expert Panel (1988). For the 1:3 ratio is used for high level estimation which assumed to be the long-term ratio. (Source: Malla et al., 2007)

<sup>d</sup> Change in CHD (%) = total change in TC (%) \* TC to CHD ratio



<sup>e</sup> Source: Allender et al., (2008b).

<sup>f</sup> Total change in CHD cost = total annual CHD cost \* Change in CHD(%) \* Change in CHD (%) to change in cost (%) ratio

<sup>g</sup> See Section A3.2.2 in Appendix 3 for details.

<sup>h</sup> HCS = Total change in annual CHD cost \* HCS rate (%)

In Table 5.7, the total estimated change in annual CHD cost in the UK due to *trans* fat-free canola/rapeseed oil substitution is calculated. A range of scenarios are calculated given the incomplete nature of the data on HCS based on Malla et al.(2007).

The base estimation assumes that 20 percent of the hydrogenated vegetable oils market are replaced by *trans* fat-free vegetable oils, leading to a 0.40g *trans* fat intake reduction daily in the UK. With the assumed 1:2 cholesterol to CHD risk ratio a saving of US\$108 million in health-care costs is generated annually in the UK.

The high level assumption is based on an optimistic perspective that *trans* fat-free vegetable oils cover a 50 percent market share in hydrogenated vegetable oils such as the shortening and the salad oil, accounting for a 0.99g *trans* fat intake reduction daily in the UK. With the assumption that every percentage change in total cholesterol leads to a 3 percent change in CHD and 1:1 ratio between the incidence of CHD and the resulting costs to society, the high level estimation results in a saving of US\$405 million in the UK medical costs annually.

For the Medium estimate, *trans* fat-free vegetable oil is assume to substitute for 40 percent of the hydrogenated vegetable oils market, which together results in a 0.79g daily *trans* fat intake reduction individually in the UK. Given that a smaller ratio with every percentage change in cholesterol level which leads to a 2 percent reduction in CHD, this results in a saving of US\$216 million in health-care costs annually in the UK based on an assumed 1:1 ratio between the incidence of CHD and the resulting costs to society.

The low scenario demonstrates potential health-care cost savings under very conservative assumptions. *Trans* fat-free oils are assumed to reach only a 10 percent market share in the hydrogenated vegetable oils market. There is a 0.20g *trans* fat intake reduction daily in the UK. Further, a reduced ratio of 1:0.5 is applied between CHD change and health-care costs instead of the former 1:1 correlation. Although every step is extremely conservative, the extreme low scenario still suggests a potential reduction of US\$27 million in health-care costs annually in the UK.

### 5.4.3 Final ratio calculation

Following the method in section 4.3.2.3 for the China's case study, the ratio  $\eta$  will also be applied here to derive the decision makers' weighting of the changes in consumer surplus and producer surplus as well as the health cost savings arising from the imposition of an import ban on canola/rapeseed oil import in the UK.

Table 5.8 shows the calculations undertaken to derive the ratios used in the comparison. From the table, the ratios for canola/rapeseed oil are calculated based on the results from the previous sections. In summary, in the absence of the information pertaining to the health benefits from canola/rapeseed oil  $\eta^M$  is equal to 1.19 in the base case, 1.05 in the high case, 1.11 in the medium case to 1.26 in the low case. With the health benefits, this ratio rises to 1.78 in the base case, 2.32 in the high case, 2.0 in the medium case to 1.65 in the low case. Hence, two conclusions can be drawn from the final results.

First, as predicted in chapter 3, both  $\eta^M$  and  $\eta^N$  are larger than 1. That means the loss for consumers arising from the higher price caused by tariff is larger than the gain to producers. The ratio indicates a preference for producer benefits over consumer benefits when policy makers frame trade policy for the UK within the EU. Currently, GM canola and canola product imports are strictly restricted in the EU, and hence

also the UK. Even if the import ban on GM canola and its product has been removed for certain types of GM products, most types of GM canola oil and canola seed still face a complete import ban. The ban on GMO imports largely reduced consumer benefits arising from the consumption of canola/rapeseed oil because of a higher price in the domestic market. The trade policy on canola/rapeseed oil import turns out to be welfare reducing for the domestic economy. Thus, policy makers in the EU and UK might wish to review their trade policy towards canola/rapeseed oil imports and push for removal of the import ban in the EU given the results for the ratio of losses versus benefits.

Secondly, the result shows that  $\eta^N$  is much larger than  $\eta^M$  at all four levels, which is also consistent with the analysis from Case 2 in Chapter 3. Given the increased demand for canola/rapeseed oil in the UK market, consumers suffer a significant loss due to the higher domestic price caused by the import ban. Adding forgone health benefits and health care cost savings on canola/rapeseed oil into the ratio, the weighting ratio is considerably larger than before the health benefits of canola/rapeseed oil became known. At the high level with 20 percent TFA reduction in daily *trans* fat intake, the loss for consumers arising from the 30 percent increased demand is more than two times larger than the gain by producers. The high and medium levels even show around three times weighting being given to producer benefits relative to consumer benefits. At the low level, consumers still lose more than one and a half times the gain for producers. Therefore, from a welfare perspective, it is possible political decision makers may wish to re-consider their decisions on the import policy towards canola/rapeseed oil in the EU (and the UK) — and hence to push for reform in the EU.

**Table 5.8 Final ratio calculation in the U.K case study**

	$\eta^M$	$\eta^N$
Formula	$\eta^M = \frac{\Delta \text{ consumers surplus}}{\Delta \text{ producer surplus}}$ $= \frac{(a_5 + a_6 + a_7 + a_8)}{a_5}$	$\eta^N = \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}}$ $= \frac{(a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}) + \text{HCS}}{a_2 + a_3 + a_5}$
Base	76.26/64.17	$\frac{348.61 + 108.24}{219.02}$
	<b>1.19</b>	<b>2.09</b>
High	18/17.1	$\frac{348.61 + 404.58}{216}$
	<b>1.05</b>	<b>3.49</b>
Medium	44.44/39.87	$\frac{348.61 + 216.48}{215.22}$
	<b>1.11</b>	<b>2.63</b>
Low	132.78/105.16	$\frac{348.61 + 26.62}{217.78}$
	<b>1.26</b>	<b>1.72</b>

# Chapter 6: Summary and conclusions

## 6.1 Summary

Innovation in food technology, along with increased interest in foods which provide health enhancing attributes beyond normal nutritional benefits, has led to the rapid development of the functional food industry. Functional foods provide positive externality benefits to society through the promotion of health benefits that reduce the opportunity cost of illness and lower the health care costs that are borne by governments. With strong market growth and considerable potential social benefits, functional foods appear to be an important area for future expansion in the global food market. However, the pre-existing trade barriers (i.e. those put in place before the positive health benefits became apparent) to international commerce reduce, or sometimes eliminate, trade in functional foods. As a result, the benefits associated with health-giving attributes are forgone. The relationship between trade barriers and functional food is particularly important because the impact of trade policy may directly result in social costs and unrealized direct consumer benefits.

Given that there may be additional benefits forgone from the existence of trade barriers, this thesis explored the potential welfare benefits foregone in importing countries from the existence of trade barriers when a traditional food becomes a “functional food”. A theoretical trade model is developed with four cases illustrating the range of trade restrictions that may be applied in the case of functional foods. Case studies are then developed in the thesis to give an insight into the size of the benefits as well as to explore the limitations of conducting empirical estimations. Canola/rapeseed oil with functional attributes was selected as the functional food to use for the case studies. By examining the Chinese and the UK markets which have different trade restrictions for canola/rapeseed oil, the value of additional forgone benefits from existing trade barriers were estimated. These case studies are representative of two of the four theoretical models developed in the thesis.

The primary conclusions are drawn from the result of the case studies. Under a variety of assumptions and using calculation methods from health economics, this thesis has shown that the forgone benefits from healthier *trans* fat-free canola/rapeseed oils may be important. The change in the weighting of consumer to producer benefits,  $\eta$ , is used to summarize the results. The post change ratio also includes health cost reductions.

**Table 6.1 Final ratio results from case studies**

		$\eta^M$ <sup>a</sup>	$\eta^N$ <sup>b</sup>	Increasing % <sup>c</sup>
Chinese case	Base	1.11	1.33	<b>19.8%</b>
	High	1.11	1.67	<b>50.5%</b>
	Medium	1.11	1.56	<b>40.5%</b>
	Low	1.11	1.22	<b>9.9%</b>
UK case (direct & indirect HCS) <sup>d</sup>	Base	1.19	2.09	<b>75.6%</b>
	High	1.05	3.49	<b>232.4%</b>
	Medium	1.11	2.63	<b>136.9%</b>
	Low	1.26	1.72	<b>36.5%</b>
UK case (direct HCS) <sup>e</sup>	Base	1.19	1.77	<b>48.7%</b>
	High	1.05	2.28	<b>117.1%</b>
	Medium	1.11	1.98	<b>78.4%</b>
	Low	1.26	1.64	<b>30.2%</b>

<sup>a</sup> Final ratio before canola/rapeseed oil recognized as functional food.

<sup>b</sup> Final ratio after canola/rapeseed oil recognized as functional food.

$$^c \frac{\eta^N - \eta^M}{\eta^M}$$

<sup>d</sup> Results are from the calculations in the UK case study in chapter 5. The second step calculations for potential HCS estimate in the UK are based on both direct health care cost and indirect health care cost.

<sup>e</sup> Results are from the calculations in the adjusted UK case study in Appendix 4. The second step calculations for potential HCS estimate in the UK are based solely on direct health care cost. The purpose for adjusting the ratio is to compare the forgone benefits between two case studies on a same basis with only direct health cost calculated into models. For details, see Appendix 4.

The results in the Table 6.1 show that there appear to be important forgone benefits from existing trade barriers in the canola/rapeseed oil market. Considering health benefits and health care cost savings for canola/rapeseed oil, the positive increasing rate showed that the forgone benefits from trade barriers increased when comparing the final ratio to that which existed before canola/rapeseed oil was recognized as functional food. In the UK case study, the increasing rates are greater than those in the Chinese case study because the trade barrier in the UK market is more restricting — an import ban rather than a tariff. In other words, forgone benefits increase when more constringent trade regulations are faced. Even with adjusted ratio in the UK case study, the increasing rates are also greater at all four levels than those in the Chinese case study. Hence, the results are consistent with the predictions from economic theory.

All of the results suggest that current trade regulations towards functional foods might be re-evaluated by policy makers. Existing trade policies may leave an imbalance between the gain from protection received by producers and the losses of consumers and society. Hence, policy makers may wish to reconsider past trade policy decisions in order to better reflect the evolving markets for functional foods.

## **6.2 Limitation of the research**

There are a number of limitations to the work undertaken in this thesis that should be acknowledged. First, the data and elasticities used for calculation in the case studies are limited in the current available literature. The elasticities used in the trade effect

calculations are only rough approximations for the supply and demand of canola/rapeseed oil. The *trans* fat consumption data in China was calculated from a regional report – Hong Kong - rather than broad based research on diets in China. Indirect health care cost data for China is unavailable in the current literature, hence the final weighting ratio in the Chinese case study underestimates the true cost.

Furthermore, the assumptions used in the case studies have been made based on limited information. As the consumer response to canola oil being recognized as having health enhancing properties has not been estimated, the magnitudes of the relative shifts in the demand curves are not directly available. Thus the demand shifts presented in the case studies were assumed based on the relevant studies of functional foods generally. The case studies would be more precise if the response of consumers to particular functional foods were available.

Only one product was studied in the thesis. The importance of this approach to trade policy would be enhanced if more products could be studied. Similarly, only two countries' markets for functional food were examined — making any general extrapolation to global effects imprudent. Since time and resources were limited when writing this thesis, a wider study into many other countries may provide deeper insight into the general applicability of final results.

### **6.3 Suggestions for further research**

There are some further research opportunities that have become apparent during the work undertaken in this thesis. First, more case studies would provide further empirical evidence to corroborate the results. Only two cases of the four developed in the trade policy modelling work have been operationalized in the empirical case studies in this thesis. Hence, future research could extend to other two cases in order to have a full test of the theoretical trade model. Since the market situations assumed



in the other two cases differ considerably from those in the case studies, future research may have to focus on different products or markets in additional countries.

Secondly, different health economic models could be used in the case studies to better evaluate the health care cost savings from selected functional products. In this thesis, the COI model is selected for the case studies when calculating the potential health care cost savings associated with *trans* fat free canola/rapeseed oil. The COI model is reasonable for this thesis because it has fewer restrictions on the type of data that can be used. However, it is a relatively simple approach for evaluating the health benefits. A more precise model might be a better choice if the data is available.

Moreover, additional information on consumer attitudes and behavior could assist in clarifying the key assumption in the study — the consumer response to functional foods. A consumer survey could provide information on the magnitude of the demand shifts in the trade model. The consumer survey could also provide information that would assist in estimating the substitution away from other products to selected functional foods.

Another avenue for further research would be to evaluate policy makers' responses to the results. Does it provide information that might alter policy decisions? In particular, is the ratio,  $\eta$ , the correct form to present the results to policy makers?

Last but not least, this thesis provided an analysis of the interaction between trade barriers and functional foods. Following the results from this thesis, further research may wish to examine policy design and implementation. For example, health and trade policy are made in isolation from each other. This thesis might suggest a more inclusive policy formulation mechanism.

## **6.4 Conclusion**

The functional food market is increasing rapidly on a global scale and trade policy has an important place in the markets for these products. Trade may be inhibited which inadvertently lead to consumers and society suffering an unintended loss of benefits.

This thesis provides a link between trade barriers and functional foods — and thus between trade policy and health policy. The final result in the case studies confirmed the theoretical analysis that there are indeed important forgone benefits associated with canola/rapeseed oil arising from existing trade barriers. The thesis is, of course, limited in scope and further research is needed for a more comprehensive picture of the link between trade barriers and functional foods.

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## APPENDIX 1: EXAMPLES OF FUNCTIONAL COMPONENTS<sup>a</sup>

**Table A1. Examples of functional foods and associated health benefits**

Class/Components	Source	Potential Benefit
<b>Carotenoids</b>		
Beta-carotene	carrots, pumpkin, sweet potato, cantaloupe	neutralizes free radicals, which may damage cells; bolsters cellular antioxidant defenses; can be made into vitamin A in the body
Lutein, Zeaxanthin	kale, collards, spinach, corn, eggs	citrus may contribute to maintenance of healthy vision
Lycopene	tomatoes and processed tomato products, watermelon, red/pink grapefruit	may contribute to maintenance of prostate health
<b>Dietary (functional and total) Fiber</b>		
Insoluble fiber	wheat bran, corn bran, fruit skins	may contribute to maintenance of a healthy digestive tract; may reduce the risk of some types of cancer
Beta glucan <sup>b</sup>	oat bran, oatmeal, oat flour, barley, rye	may reduce risk of coronary heart disease



Soluble fiber <sup>b</sup>	psyllium seed husk, peas, beans, apples, citrus fruit	may reduce risk of CHD and some types of cancer
Whole grains <sup>b</sup>	cereal grains, whole wheat bread, oatmeal, brown rice	may reduce risk of CHD and some types of cancer; may contribute to maintenance of healthy blood glucose levels
<b>Fatty Acids</b>		
Monounsaturated fatty acids (MUFAs) <sup>b</sup>	tree nuts, olive oil, canola oil	may reduce risk of CHD
Polyunsaturated fatty acids (PUFAs)—Omega-3 fatty acids—ALA	Walnuts, flax	may contribute to maintenance of heart health; may contribute to maintenance of mental and visual function
PUFAs—Omega-3 fatty acids—DHA/EPA <sup>b</sup>	salmon, tuna, marine, and other fish oils	may reduce risk of CHD; may contribute to maintenance of mental and visual function
Conjugated linoleic acid (CLA)	beef and lamb; some cheese	may contribute to maintenance of desirable body composition and healthy immune function
<b>Flavonoids</b>		
Anthocyanins—Cyanidin, Delphinidin, Malvidin	berries, cherries, red grapes bolsters cellular antioxidant defenses;	may contribute to maintenance of brain function
Flavanols—Catechins, Epicatechins,	tea, cocoa, chocolate, apples, grapes	may contribute to maintenance of heart

Epigallocatechin, Procyanidins		health
Flavanones—Hesperetin, Naringenin	citrus foods	neutralize free radicals, which may damage cells; bolster cellular antioxidant defenses
Flavonols—Quercetin, Kaempferol, Isorhamnetin, Myricetin	onions, apples, tea, broccoli	neutralize free radicals, which may damage cells; bolster cellular antioxidant defenses
Proanthocyanidins	cranberries, cocoa, apples, strawberries, grapes, wine, peanuts, cinnamon	may contribute to maintenance of urinary tract health and heart health
<b>Isothiocyanates</b>		
Sulforaphane	cauliflower, broccoli, broccoli sprouts, cabbage, kale, horseradish	may enhance detoxification of undesirable compounds; bolsters cellular antioxidant defenses
<b>Minerals</b>		
Calcium <sup>b</sup>	sardines, spinach, yogurt, low-fat dairy products, fortified foods and beverages	may reduce the risk of osteoporosis
Magnesium	spinach, pumpkin seeds, whole grain breads and cereals, halibut, brazil nuts	may contribute to maintenance of normal muscle and nerve function, healthy immune function,

		and bone health
Potassium <sup>b</sup>	potatoes, low-fat dairy products, whole grain breads and cereals, citrus juices, beans, bananas	may reduce the risk of high blood pressure and stroke, in combination with a low-sodium diet
Selenium	fish, red meat, grains, garlic, liver, eggs	neutralizes free radicals, which may damage cells; may contribute to healthy immune function
<b>Phenolic Acids</b>		
Caffeic acid, Ferulic acid	apples, pears, citrus fruits, some vegetables, coffee	may bolster cellular antioxidant defenses; may contribute to maintenance of healthy vision and heart health
<b>Plant Stanols/Sterols</b>		
Free Stanols/Sterols <sup>b</sup>	corn, soy, wheat, wood oils, fortified foods and beverages	may reduce risk of CHD
Stanol/Sterol esters <sup>b</sup>	fortified table spreads, stanol ester dietary supplements	may reduce risk of CHD
<b>Polyols</b>		
Sugar alcohols <sup>b</sup> —Xylitol, Sorbitol, Mannitol, Lactitol	some chewing gums and other food applications	may reduce risk of dental caries
<b>Prebiotics</b>		
Inulin, Fructo-oligosaccharides	whole grains, onions, some fruits, garlic, honey, leeks,	may improve gastrointestinal health;

(FOS), Polydextrose	fortified foods and beverages	may improve calcium absorption
<b>Probiotics</b>		
Yeast, Lactobacilli, Bifidobacteria, and other specific strains of beneficial bacteria	certain yogurts and other cultured dairy and non-dairy applications	may improve gastrointestinal health and systemic immunity; benefits are strain-specific
<b>Phytoestrogens</b>		
Isoflavones—Daidzein, Genistein	soybeans and soy-based foods	may contribute to maintenance of bone health, healthy brain and immune function; for women, may contribute to maintenance of menopausal health
Lignans	flax, rye, some vegetables	may contribute to maintenance of heart health and healthy immune function
<b>Soy Protein</b>		
Soy Protein <sup>b</sup>	soybeans and soy-based foods	may reduce risk of CHD
Sulfides/Thiols, Diallyl sulfide, Allyl methyl trisulfide	garlic, onions, leeks, scallions	may enhance detoxification of undesirable compounds; may contribute to maintenance of heart health and healthy immune function

Dithiolthiones	cruciferous vegetables	may enhance detoxification of undesirable compounds; may contribute to maintenance of healthy immune function
<b>Vitamins</b>		
A <sup>c</sup>	organ meats, milk, eggs, carrots, sweet potato, spinach	may contribute to maintenance of healthy vision, immune function, and bone health; may contribute to cell integrity
B1 (Thiamin)	lentils, peas, long-grain brown rice, brazil nuts	may contribute to maintenance of mental function; helps regulate metabolism
B2 (Riboflavin)	lean meats, eggs, green leafy vegetables	helps support cell growth; helps regulate metabolism
B3 (Niacin)	dairy products, poultry, fish, nuts, eggs	helps support cell growth; helps regulate metabolism
B5 (Pantothenic acid)	organ meats, lobster, soybeans, lentils	helps regulate metabolism and hormone synthesis
B6 (Pyridoxine)	beans, nuts, legumes, fish, meat, whole grains	may contribute to maintenance of healthy immune function; helps regulate metabolism
B9 (Folate) <sup>b</sup>	beans, legumes, citrus foods, green leafy vegetables, fortified breads	may reduce a woman's risk of having a child with a brain or spinal cord

	and cereals	defect
B12 (Cobalamin)	eggs, meat, poultry, milk	may contribute to maintenance of mental function; helps regulate metabolism and supports blood cell formation
Biotin	liver, salmon, dairy, eggs, oysters	helps regulate metabolism and hormone synthesis
C	guava, sweet red/green pepper, kiwi, citrus fruit, strawberries	neutralizes free radicals, which may damage cells; may contribute to maintenance of bone health and immune function
D	sunlight, fish, fortified milk and cereals	helps regulate calcium and phosphorus; helps contribute to bone health; may contribute to healthy immune function; helps support cell growth
E	sunflower seeds, almonds, hazelnuts, turnip greens	neutralizes free radicals, which may damage cells; may contribute to healthy immune function and maintenance of heart health

<sup>a</sup> Examples are not an all-inclusive list.

<sup>b</sup> FDA approved health claim established for component.

<sup>c</sup> Preformed vitamin A is found in foods that come from animals. Provitamin A carotenoids are found in many darkly colored fruits and vegetables and are a major source of vitamin A for vegetarians.

Source: IFIC, 2006. <http://www.ific.org/nutrition/functional/index.cfm>

## **APPENDIX 2: CANOLA/RAPSEED OIL**

### **SHIFTS IN DEMAND**

#### **A2.1 the Chinese Canola/rapeseed Oil Shift in Demand**

Recall from Chapter 3, a trade model was developed for functional food market based on two assumptions. First, the new product N, is assumed to be produced at the same cost as product M by both domestic and foreign suppliers. Second, product N can be represented by the same demand curve as product M and that the new health attribute does not change its price elasticity and hence no change in the slope of demand curve. Thirdly, from the perspective of consumers, more people are willing to buy the new health enhancing product N at the same price. Therefore, demand increases shifting out the demand curve.

In the Chinese case study, following the same logic, canola/rapeseed oil is assumed to benefit from an increase in demand and consumption due to the recent discovery of health giving attributes being associated with canola. Currently in China, however, there are no accurate surveys or reports on consumers' attitudes to canola/rapeseed oil consumption since it became well-known for its *trans* fat-free attribute. Therefore, indirect evidence must be used to reveal the consumers' behaviors towards *trans* fat-free canola/rapeseed oil. In other words, some way of determining the demand shift is needed to undertake calculations for the China case study.

Healthcare Packaging (2007) suggests that functional food product markets are booming in the Asia Pacific because of the trend towards health and wellness. Consumer demands for convenience products and for healthier and functional products show an increasing trend (Taylor and Van Osdol, 2006; Bean, 2006). China's "health food" industry experienced rapid growth from the late 1980s to the late 1990s, with the fastest increase among the urban higher income population (Kotilainen et al., 2006). China is leading the way in functional food market expansion in the Asia

Pacific region. It is reported that the value of sales of functional foods grew by nearly 20 percent in 2005 (Healthcare Packaging, 2007). Continued expansion of the functional foods market in China is predicted with a two-fold or larger growth in per capita spending on functional foods expected between 2004 and 2010 (Benkouider, 2005).

Therefore, drawing on the reports and information outlined above, four levels of demand shift are assumed for the Chinese case study calculation. A base level is estimated with a 20 percent increase in demand for canola/rapeseed oil in the Chinese market. A two-fold expansion over the base case is set at 40 percent for the medium level and an even larger increase of 50 percent is assumed for the most optimistic case. Below the base level, a 10 percent shift in demand is assumed.

## **A2.2 the U.K Rapeseed/Canola Oil Shift in Demand Estimation**

In the UK case study, the two major assumptions made in Case 2 are expected to apply. That is, more people are willing to buy canola/rapeseed oil with newly recognized health enhancing attributes and consumers are willing to pay at least the same price or a premium for higher quality (health enhancing) canola/rapeseed oil. Therefore, the increased demand for new health enhancing canola/rapeseed oil shifts the demand curve out to  $D^N$ . However, with a GMO import ban, no imports of canola/rapeseed oil exist in the domestic market in the UK. Hence, the domestic consumption rises to  $Q^{EN}$  with higher price at  $P_N^E$ .

Rapeseed oil has been the most important vegetable oil produced in the European Union since 1988. In 10 years, EU consumption of vegetable oil has risen 50%, mainly due to increased consumption of rapeseed oil for its health attributes. Currently, rapeseed oil accounts for more than one-third of total European vegetable oil production and remains the largest oil consumed in Europe (MATIF, n.d.).



At present, the competition between food consumption and biofuels usage is becoming a significant driver of the vegetable oils market and for rapeseed oil in particular. Currently, the production capacity for rapeseed is limited in the EU — demand in rapeseed oil already exceeds supply. However, the GMO import ban on rapeseed/canola oil considerably restricts import sources from other countries and further raises the domestic price.

A report from FEDIOL (2006) shows that the consumption of rapeseed oil in the UK market went up 48 percent from 0.43 million tones (Mt) to 0.63 Mt in the last 15 years (see Table A2). This increasing rate has slackened a bit in the last 5 years because of increases in the rapeseed oil price caused by the high competition for oil due to mandated bio-fuel usage. However, rapeseed oil remains the most widely consumed vegetable oil in the UK market, particularly since its health enhancing attributes became well known in the 1990s.

**Table A2. United Kingdom consumption of vegetable oils and fats  
(1000 t)**

	Groundnut	Soya	Rape	Sunflower	Cotton	Other liquid oils
2006	6	331	630	194	3	3
2005	5	248	623	121	3	5
2004	6	222	629	67	12	4
2003	8	255	599	96	0	43
2002	6	194	632	112	0	33
2001	8	199	740	130	1	16
2000	7	168	744	163	0	7
1990	9	133	427	165	1	24
1980	16	197	136	27	6	5

Source: FEDIOL (2006).

Therefore, the UK case study is consistent with the two major assumptions of the model. First, the consumption of rapeseed oil is increasing greatly due to the health giving attributes of rapeseed oil. Based on the information in FEDIOL (2006), four levels of increased demand are used in the UK's case study calculations. A base level is estimated using a 30 percent increase in the domestic price for canola/rapeseed oil as a functional food in the UK market. A 40 percent change is used for the medium level. An even greater increase of 50 percent is assumed for the most optimistic case. Below the base level, a 15 percent demand increase is assumed for the most conservative case.

## APPENDIX 3: ESTIMATION AND CALCULATIONS

### FOR THE SAVINGS IN HEALTH COSTS

#### A3.1 Estimation of daily *trans* fat intake data in China.

While no studies on *trans* fat consumption in mainland China could be found, a study on *trans* fats in locally available foods conducted by the Centre for Food Safety (CFS) and the Consumer Council (CC) in Hong Kong, China is available. However, since results vary among different tested samples, no single estimate is available for the case study. Hence, an average estimate is required. Based on CFS (2007), the average *trans* fat daily intake for four major types of food were calculated.

Combining the total *trans* fat consumption data from the CFS (2007)'s study, which used samples of 80 varied products, the final calculation of individual daily average *trans* fat intake is shown in table A3.1. Since the tested sample foods are not a major proportion of the Chinese diet, consumers may or may not choose all of the above four types of foods to include in their diet. Therefore, a 25 percent ratio is assigned to provide a conservative estimate. This ratio results in a total of 1.99g TFA daily intake for Chinese consumers.

**Table A 3.1 Estimated *trans* fat consumption in China**

	bread samples <sup>a</sup>	butter-made products <sup>b</sup>	fried products <sup>c</sup>	margarine/ margarine like spreads <sup>d</sup>	Total
Total TFA(g) <sup>e</sup>	202.7	3.37	1.59	12.4	220.06
Sample size(piece)	33	25	14	8	80

Average TFA(g) <sup>f</sup>	6.14	0.13	0.11	1.55	7.94
25% intake <sup>g</sup>	1.54	0.03	0.03	0.39	1.99

<sup>a</sup> Bread samples include sliced breads, buns, loaves, croissants and egg tarts.

<sup>b</sup> Butter-made products includes cakes, waffles, egg puffs and egg rolls.

<sup>c</sup> Fried products includes fries, fried chicken and oriental fried food.

<sup>d</sup> margarine/margarine like spreads includes butter and margarine/margarine like spreads.

<sup>e</sup> TFA is calculated from 100g/sample.

<sup>f</sup> Average TFA(g) = Total TFA(g)/ Sample size(piece)

<sup>g</sup> As the above sample foods are not frequently found in the common diet in China, it is assumed that there is only 25 percent chance that people will choose one of above four types foods in their daily diet. This means that 25 percent of total average TFA is the actual dietary intake assumed.

## A3.2 Assumed HCS rate (%)

### A3.2.1 Assumed HCS rate (%) in Chinese case study

Recall from Section 3.3 in Chapter 3, the discussion on health care costs savings (HCS) suggested that it is likely to be some function of the consumption of the particular functional food. Therefore, the HCS that would arise from the removal of the trade barrier is a function of the increased consumption of product N. That is,

$HCS = f(\Delta Q^N)$ , where  $\Delta Q^N$  is the difference between the consumption of N with a trade barrier and that which arises without the trade barrier.

Following the analysis in Section 3.2, the difference between the consumption of N with a trade barrier and that which arises without the trade barrier is measured by the quantity change along the demand curve  $D^N$  from  $P_w$  to  $(P_w + C)$ . Thus, in the Chinese case study, the HCS would arise from the quantity change, which is a function of the increased consumption of *trans* fat-free canola/rapeseed oil along the new demand curve.

Known as a functional food, *trans* fat-free canola/rapeseed oil is found to provide health enhancing benefits for consumers. However, prior to the scientific evidence

discovered on its health enhancing attributes, canola/rapeseed oil has made health contributions to consumers since it was marketed. Therefore, all the people who consumed canola/rapeseed oil benefited from its health enhancing attributes and society received health savings due to reduced risk of CHD. Among the first three steps in section 4.3.2.2, HCS calculations are based on consumption of canola/rapeseed oil in the entire domestic market, which is quantity  $Q^{DN}$ . However, in this thesis, the health care costs savings (HCS) is designed to determine the health improvement effect caused by trade liberalization. That means the HCS calculation should be focused on the quantity change of *trans* fat-free canola/rapeseed oil along the new demand curve. In order to limit the calculation to this group of people, a HCS rate is introduced into the last step calculation. The HCS rate is calculated as

$$\text{HCS rate} = \frac{Q^{DN} - Q^{DN'}}{Q^{DN}}$$

and is provided as a percent change — details can

be found in the Table A3.2.

By introducing the HCS rate in the Chinese case study, calculation for health care savings are concentrated on the expansion quantities in the market due to trade liberalization. Therefore, only those health care cost savings attributed to trade liberalization are included when determining the health care savings.

**Table A 3.2 HCS rate calculation in Chinese case study**

	High (50% demand shift)	Medium (40% demand shift)	Base (20% demand shift)	Low (10% demand shift)
$Q^{DN}(\text{Mt})^a$	6.515	6.080	5.212	4.777
$Q^{DN'}(\text{Mt})^b$	6.409	5.981	5.127	4.699
$Q^{DN} - Q^{DN'}(\text{Mt})$	0.106	0.099	0.085	0.078
HCS rate (%) = $\frac{Q^{DN} - Q^{DN'}}{Q^{DN'}}$	1.65%	1.66%	1.66%	1.66%

<sup>a</sup>  $Q^{DN} = Q^{DM} * (1 + \text{demand shift rate})$

<sup>b</sup>  $Q^{DN'}$  is calculated from the following steps using demand elasticity: (Demand elasticity is the same with both demand curves)

$$\mathcal{E}^D = \frac{\Delta Q}{Q} * \frac{P}{Q} = \frac{(Q^{DN} - Q^{DN'})}{Q^{DN'}} * \frac{P_w + C}{Q^{DN'}} = \frac{(Q^{DN} - Q^{DN'})}{(-C)} * \frac{P_w + C}{Q^{DN'}}$$

$$Q^{DN'} = \frac{Q^{DN} * (P_w + C)}{(P_w + C) + \mathcal{E}^D * (-C)} \quad \text{where } \mathcal{E}^D \text{ is } -0.20, (P_w + C) \text{ is } 928.68 \text{ (US dollar/tonne) and } (-C) \text{ is } -76.68 \text{ (US dollar/tonne) from table 4.1 in section 4.3.2.1.}$$

### A3.2.2 Assumed HCS rate (%) in the UK case study

Applying the same logic from Chinese case study, a HCS rate is also introduced into the last calculation step in the UK case study. The HCS rate is calculated as

$$\text{HCS rate} = \frac{Q^{\text{DN}} - Q^{\text{EN}}}{Q^{\text{EN}}} = \frac{0.77 - 0.63}{0.63} = 22 \text{ percent}$$

Where  $Q^{\text{DN}}$  is 0.77 Mt and  $Q^{\text{EN}}$  is 0.63 Mt from Table 5.3 in Section 5.4.1.

By introducing the HCS rate in the UK case study, calculations for health care savings are concentrated on the expansion quantities in the market due to trade liberalization. Therefore, only those health care cost savings attributed to trade liberalization are included when determining the health care savings.

## APPENDIX 4: ADJUSTMENT ON

### UK CASE STUDY

In the Chinese case study, the result of evaluation for potential health care cost savings in China is underestimated due to limitation on data. The indirect health cost data in China is unavailable from current literatures. Therefore, the final weighting ratio could partially reveal the real forgone benefits of *trans* fat free canola oil suffering from trade barriers — 9 percent tariff rate in China. In the UK case study, The indirect health cost data in UK is included in the evaluation for potential health care cost savings. Thus, the final weighting ratio could completely indicate the real forgone benefits of *trans* fat free canola oil suffering from trade barriers — an import ban on GMO in UK.

If simply comparing the both weighting ratio from Chinese case study and UK case study, the result might be less convinced because UK case study includes completed data than the Chinese case study. In order to make the conclusion supportive, unbalanced factor will be eradicated from the UK case study just for the purpose of result comparison.

As mentioned in chapter 5, in the United Kingdom, the total costs of CHD are approximate £9.0 billion (US\$17.82 billion)<sup>35</sup> in 2006. Of the total cost of CHD to the UK, around 36% is due to direct health care cost, 43% to productivity losses, and 21% to the informal care of people with CHD (Allender et al., 2008b). From previous information, the direct CHD cost that will be accounted in the calculation is around £3.2 billion (US\$6.34 billion) from the health care system in the UK in 2006. The indirect health cost will be removed from calculations in this section. Based on the

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<sup>35</sup> I use GBP: USD = 1:1.98, based on the current market foreign exchange rate (average, July 7, 2008).



calculations in section 5.4.2 of chapter 5, Table 5.6 will be redone by eliminating indirect health care cost in the total annual CHD cost.

**Table A4.1 potential health-care savings estimated in the UK  
(direct health care cost only)**

	Base	High	Medium	Low
TC change due to 1 g TFA reduction daily (%) <sup>a</sup>	-1.55	-1.55	-1.55	-1.55
Daily TFA reduction	0.89	2.22	1.78	0.44
Total change in TC (%) <sup>b</sup>	1.38	3.44	2.76	0.68
TC to CHD ratio <sup>c</sup>	2.0	3.0	2.0	2.0
Change in CHD (%) <sup>d</sup>	2.76	10.32	5.52	1.36
CHD to cost ratio	1.0	1.0	1.0	0.5
Total annual direct CHD cost ( million U.S dollars) <sup>e</sup>	6340	6340	6340	6340
Total change in annual CHD cost due to TFA reduction in daily diet ( million US dollars) <sup>f</sup>	175	654	350	43
Health Care Savings (HCS) rate <sup>g</sup>	22%	22%	22%	22%
Final direct HCS (million US dollars) <sup>h</sup>	38.5	143.88	77	9.46

<sup>a</sup> Total Cholesterol (TC) change is rated at 1.55: 1 due to 1 g of TFA reduction.

<sup>b</sup> Total change in TC (%) = TC change due to 1 g TFA reduction daily(%) \* Daily TFA reduction (g)

<sup>c</sup> The relationship between total cholesterol and CHD is 1:2 based on Expert Panel (1988). For the 1:3 ratio is used for high level estimation which assumed to be the long-term ratio. (Source: Malla et al., 2007)

<sup>d</sup> Change in CHD (%) = total change in TC (%) \* TC to CHD ratio

<sup>e</sup> Source: Allender et al., (2008b).

<sup>f</sup> Total change in CHD cost = total annual CHD cost \* Change in CHD(%) \* Change in CHD (%) to change in cost (%) ratio

<sup>g</sup> See Section A3.2.2 in Appendix 3 for details.

<sup>h</sup> HCS = Total change in annual CHD cost \* HCS rate (%)

Followed the same step in UK case study, Table 5.7 will be redone by changing HCS result from Table A4.1 and keeping all other result unchanged. Table A4.2 shows the

calculations undertaken to derive the ratios used in the comparison. From the table, the ratios for canola/rapeseed oil are calculated based on the results from the previous UK case study and the new HCS calculated above. In summary, in the absence of the indirect health cost including to the health benefits calculation of canola/rapeseed oil,  $\eta^M$  is equal to 1.19 in the base case, 1.05 in the high case, 1.11 in the medium case to 1.26 in the low case before canola/rapeseed oil has been recognized as functional food in the UK market. With the health attributes attaching on canola/rapeseed oil, the ratio  $\eta^N$  is 1.77 in the base case, 2.28 in the high case, 1.98 in the medium case to 1.64 in the low case.

**Table A4.2 Final ratio calculation in the U.K case study  
(direct health care cost only)**

	$\eta^M$	$\eta^N$
Formula	$\eta^M = \frac{\Delta \text{ consumer surplus}}{\Delta \text{ producer surplus}}$ $= \frac{(a_5 + a_6 + a_7 + a_8)}{a_5}$	$\eta^N = \frac{\Delta \text{ consumer surplus} + \text{HCS}}{\Delta \text{ producer surplus}}$ $= \frac{(a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_{11}) + \text{HCS}}{a_2 + a_3 + a_5}$
Base	76.26/64.17	$\frac{348.61 + 38.5}{219.02}$
	<b>1.19</b>	<b>1.77</b>
High	18/17.1	$\frac{348.61 + 143.88}{216}$
	<b>1.05</b>	<b>2.28</b>
Medium	44.44/39.87	$\frac{348.61 + 77}{215.22}$
	<b>1.11</b>	<b>1.98</b>
Low	132.78/105.16	$\frac{348.61 + 9.46}{217.78}$
	<b>1.26</b>	<b>1.64</b>