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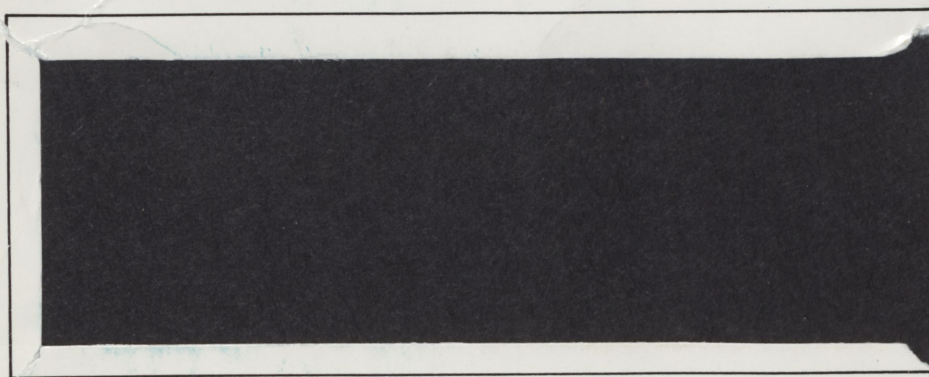


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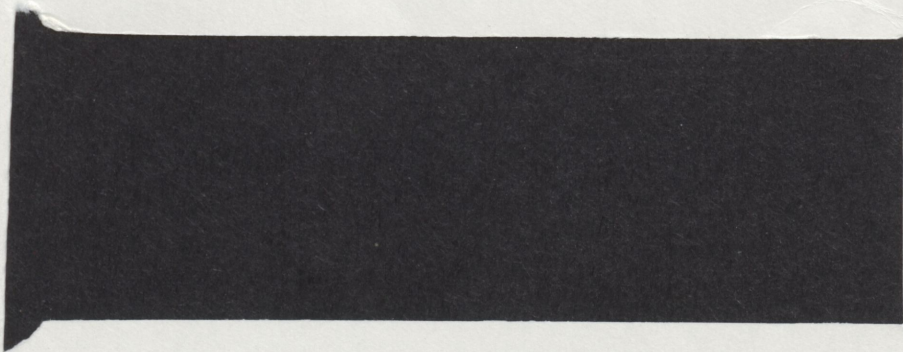
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**THE ECONOMIC IMPACTS ON CONSUMERS OF
GOVERNMENT INTERVENTION IN THE POULTRY AND
EGG SECTORS: A COMPARISON OF ALTERNATIVE
WELFARE MEASURES***

(Working Paper 5/87)

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*The study was completed under contract. The views expressed in this paper are those of the author and do not necessarily represent the position of Agriculture Canada.

AUTHOR'S FORWARD

In preparing this research document, I have had an opportunity to present preliminary results of the study at the 1986 annual meeting of the Canadian Economics Association in Winnipeg and at seminars at Agriculture Canada in Ottawa, at the University of Manitoba and at the University of Saskatchewan. In addition, I have benefited from discussions with a number of people. However, during the course of these presentations and discussions, I have received some negative feedback from individuals involved in the marketing of poultry products and eggs, individuals in both industry and government. This is partly due to the release of some preliminary figures. These indicate that, as a result of real price increases of 22.2 percent in poultry products and 33.9 percent in eggs, the costs of marketing boards in poultry products and eggs may result in an annual loss to consumers of about \$30/person. I wrote this forward in an attempt to address the concerns raised and to qualify the results. It is important that both the price increases and estimates of consumer welfare loss be considered in the context of the research.

The emphasis of the research is methodological and any set of before and after regulation prices would have sufficed. The economic (and empirical) arguments which I used to derive the two sets of prices are discussed in the study, but I briefly explain it here as follows. Provincial marketing boards were established prior to 1972 and these competed aggressively with each other,

culminating in what is now known as the "chicken and egg wars". Under the assumptions of neoclassical economics, these "wars" would not have been possible without some restriction on imports from the U.S., whether the restriction was in the form of tariffs, quotas or nontariff barriers. Without restrictions, each of the provincial boards would have been a mere price taker in the North American market and a "war" could never have taken place. Therefore, the Canadian and not the U.S. price was relevant in the period preceding the 1972 Farm Products Marketing Agencies Act. This Act allowed for national monopolies in chicken, turkey and eggs. Although the actual marketing agencies were not in place until later, the empirical evidence strongly suggests that effective competition ended with the 1972 Act. Without additional information, which institutional economists and industry insiders have apparently failed to make available in published sources, I am only able to justify using a real price difference between 1972 and 1973; the alternative is to use a price spread based on the difference between Canadian and U.S. prices. While other researchers have used the latter, I preferred not to use this spread because, as Professor Veeman shows, respective Canadian poultry and egg prices are 28.9 percent and 47.1 percent higher than U.S. prices. I felt that this spread was too large, and that the U.S. price was likely not relevant.

As pointed out by Professor Rosaasen, I should note that the real price of barley, which is used for feed, showed a

statistically significant increase between 1972 and 1973. However, I am at a loss to explain how my analysis should be modified to take this into account. The increase in barley prices did not affect prices of dairy and, furthermore, poultry and barley prices are inversely related over time. I can only conclude that one should recognize that the analysis presented in this report is static and one should not get hung up on the dates I employ.

With regard to the annual estimate of consumer welfare loss (\$30/person), this figure appears in Tables 5.1 and 5.3. In Table 5.1, it includes the costs to consumers of marketing boards in poultry, eggs and dairy products. In Table 5.3, it is the cost of regulation in poultry and eggs only. However, in Table 5.3, it is only one of five figures given; indeed, it is the largest estimate of consumer welfare loss. The values provided in Table 5.3 suggest that estimates of consumer welfare losses are just as sensitive to estimates of the cross-price elasticities of demand as they are to assumed price increases. Unfortunately, we neither have good estimates of the cross-price elasticities nor, for the same reason, adequate information concerning the direct impact of regulation via supply restrictions on prices. Without appropriate panel data on consumer expenditures, all estimates of the consumer losses due to supply management will likely remain a matter of some speculation.

Finally, I want to thank a number of individuals for their

contributions via helpful comments and suggestions, although they are not to be held responsible for any errors which undoubtedly remain. I owe a great debt to Don Gilchrist and David Winch for pointing out some major errors in the earlier results. I have also benefited from comments by and discussions with Richard Just, Andrew Schmitz, Dan Usher, Thomas Johnson and Agriculture Canada personnel. I also want to thank Judy Peachy and Ward Weisensel for computational assistance, and Michele Veeman for getting agricultural economists in Canada thinking in the right direction. The views expressed in this study are my own and are not to be mistaken as the position of Agriculture Canada.

G. C. Van Kooten,
Saskatoon, December 1986.

ABSTRACT

The consumer welfare costs of marketing boards are the focus of this research report. The emphasis of the study is methodological and, in particular, the focus is on the measurement of consumer welfare in a multiple market or general equilibrium framework. This is done in two ways. Firstly, it is assumed that marketing boards in poultry products, eggs and dairy products came into existence at the same time. While this may be an unrealistic assumption, it is an acceptable assumption in this study because the model employed here, as well as in previous studies, is a static one. The welfare impacts are calculated in all three markets simultaneously using a number of different measures of consumer welfare. Secondly, the consumer welfare impact of regulation in poultry products and eggs is investigated under the assumption that a marketing board already exists in dairy--that is, that a market distortion ($\text{price} > \text{marginal cost}$) exists in another, related market. This simulates the impact of the Farm Products Marketing Agencies Act of 1972.

In the analysis, the real (deflated) 1972 prices for poultry products, eggs and dairy are assumed to be the pre-regulation or competitive prices. As argued in Chapter 2, the regulated prices of poultry products and eggs are assumed to be 22.2 percent and 33.9 percent higher, respectively, than the competitive price. The price of other food (excluding poultry and eggs) was assumed to be 1.8 percent greater than the competitive price as a result of distortions due to regulation in the dairy industry. The price trends are examined in Chapter 2.

The economic theory underlying the welfare measures employed in the study is found in Chapter 3. Since a theoretically sound system of demand functions is required for the analysis, demand estimation is briefly discussed at the beginning of this chapter. Then, in Chapter 4, several demand systems are estimated. The system which is employed in calculating the consumer welfare losses is an indirect translog functional form for the commodities poultry, eggs and other food. The poor quality of the Canadian expenditure and price data resulted in a static demand system and prevented a greater degree of commodity disaggregation.

The consumer welfare losses are calculated in Chapter 5. One purpose of the research was to examine the validity of consumer surplus as a welfare measure, particularly when it is calculated in a single market as an area under a linear demand curve, since this method has previously been employed in analyzing the welfare impacts of government regulation. Hence, the consumer surplus measure of welfare was calculated in several ways, and these were compared to each other and to the true measures of welfare change, namely, compensating and equivalent variation. The empirical results indicate that consumer surplus is a relatively robust estimate of the true change in consumer welfares, even when it is calculated as an area under a linear demand curve. However, it appeared that McKenzie's method for calculating equivalent variation resulted in the most accurate estimate of true changes in welfare, but it is expensive to calculate.

Given these results, estimates of the consumer costs of marketing boards in poultry and eggs were made, assuming that a distortion already existed in the other food market. It is the welfare impacts of regulation in one market on other, already distorted markets which has been neglected in previous studies. Given that the distortion in the market for other food amounts to 1.8 percent, and that prices of poultry and eggs rose by 22.2 and 33.9 percent, respectively, as a result of regulation, the total annual loss to consumers from regulation in poultry and eggs is estimated to be \$30.70 per person. The impact in the market for other food accounted for 45 percent of the consumer losses. However, this result is based on cross-price elasticities estimated in Chapter 4, and these cannot be considered very good estimates due to the poor quality of Canadian expenditure and price data. Therefore, additional calculations were made using assumed values of the cross-price elasticities. Using alternative assumptions for the cross-price elasticities, the total annual loss to consumers is estimated to be between \$17 and \$22 per person. If it can be assumed that there is complementarity between poultry products and other food, and between eggs and other food, then there is a beneficial impact in the market for other food. In this case, the estimate of consumer loss due to regulation in poultry and eggs is between \$12 and \$16 per person per year. Then there is also a net welfare gain to society from government regulation in the poultry and egg sectors.

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CHAPTER 1

INTRODUCTION

The agricultural sector is considered to be important to the economies of most countries. While the economic importance of agriculture may be overstated in some cases, it is evident that, for whatever reason, governments design programs to protect or exploit agriculture. In some less developed countries, economists now recognize that exploitation of the farm sector has retarded economic growth of the entire country. In the developed countries of the West, particularly in the United States and the European Economic Community, the agricultural sector has received rather lucrative protection. Such protection is frequently the result of genuine efforts to stabilize markets for reasons of economic security or as a consequence of overt political pressure from the farm lobby.

A myriad of programs have been developed in the western countries to achieve national goals in the agricultural sector. Each country has developed programs which are unique, but their common purpose is to help farmers. In the U.S., for example, nonrecourse loans are provided to farmers growing wheat, corn and soybeans; when the loan comes due after one year, the farmer has the option of selling his product to the government at the so-called loan rate or on the open market. In Canada, on the other hand, farmers must sell their wheat to the Canadian Wheat Board or on the open market as feed grain. Thus, while the U.S. relies on a market mechanism to provide signals to its grain

producers, Canada relies on institutional structures such as the Wheat Board--that is, Canada relies on more direct forms of intervention rather than incentives which operate via markets.

In this report, the purpose is not to investigate all possible farm programs; nor is the purpose to suggest alternative programs in particular sectors of agriculture. Rather, the purpose is to investigate a particular institutional structure which has been adopted in Canada as a means for stabilizing prices and producer incomes, namely, supply-restricting marketing boards. More specifically, the purpose is to investigate the consumer welfare impacts of marketing boards to determine what the costs and benefits of such boards are to the economy as a whole, and whether the net benefits would be greater or less under alternative stabilization mechanisms. In comparing alternative programs, the free market is taken as the standard of comparison, although this might be unrealistic since any attempt to return to a free market will likely be opposed in the political arena. Nonetheless, actual measures of the welfare impacts based on the free market standard are useful to decision makers in designing farm programs.

Brief Background to the Welfare Measurement Approach to be Used

Recent articles by Veeman (1982), by Schmitz (1983), by Van Kooten and Spriggs (1984), and by Lerner and Stanbury (1985) have investigated the social welfare impacts of supply-restricting marketing boards in the Canadian agricultural sector. In these

studies, the concept of consumer surplus has been fruitfully employed, although questions regarding its applicability have recently been raised, particularly in the context of multiple markets (Morey 1984; Boadway and Bruce 1984). The previous studies evaluated the social benefits and costs of marketing boards by considering one market at a time. In addition, the demand parameters used in the studies were the same as those employed by Veeman, who constructed a linear demand curve on the basis of point elasticities of demand estimated by Hassan and Johnson (1976).

Since the welfare measures employed by previous researchers are rather naive, that is, based on linear approximations of the true demand function, the purposes of the current study are: (1) to compare the simple measures of consumer surplus with true welfare measures, namely, compensating variation (CV) and equivalent variation (EV); and (2) to make these comparisons in a multiple, as opposed to a single, market framework. In particular, one purpose is to determine how well the simple measures perform. An approximate method for measuring both the CV and EV of a policy change is found in Boadway and Bruce (1984). Starting from the utility function, McKenzie (1983) outlines an algorithm for determining the exact EV measure of consumer welfare from a system of derived demand equations. In this study, these measures are used to determine the welfare loss to consumers from price changes (1) in the egg, poultry and dairy sectors and (2) in the egg and poultry sectors with a pre-

existing distortion (i.e., price > marginal cost) in other markets (e.g., dairy). The latter simulates the impact caused by the federal Farm Products Marketing Agencies Act of 1972.

The focus in the current research is the Canadian feather industries, although supply management in dairy also plays a prominent role. In particular, the social welfare impacts of the existing quota schemes in poultry and eggs will be calculated. In addition, the welfare impacts of three alternatives--namely, (1) a commodity price stabilization scheme, as suggested by Van Kooten and Schmitz (1985), (2) an income maintenance program, and (3) a buy-only quota scheme--will be discussed. The approach is primarily that of measurement in a general equilibrium framework; hence, it is necessary to estimate a system of demand functions.

Plan of the Current Report

A number of tasks need to be completed in the chapters which follow. In the next chapter, a historical background to supply-restricting marketing boards in Canada is provided. In addition, an analysis of price movements before and after the implementation of marketing boards in various sectors is provided and, finally, the literature on welfare measurement in the context of marketing boards is reviewed. Chapter 3 constitutes the theory chapter, and the underlying theory of applied welfare economics is presented. In the fourth chapter, the results of demand systems estimation are given. The discussion of the methodology is purposely kept to a minimum since this topic has been

adequately surveyed by Hassan and Johnson (1976 and 1984) and by Johnson et al. (1984); these studies are also concerned with the demand for agricultural commodities. In addition, the theory of consumer behaviour is adequately addressed in Chapter 3. The empirical results of welfare measurement are provided in Chapter 5. In particular, the welfare impacts of supply-restricting marketing boards in the poultry and egg sectors are estimated, as are the welfare impacts of several alternative institutional arrangements. The final chapter contains the summary and conclusions.

CHAPTER 2

HISTORICAL BACKGROUND, PRICE ANALYSIS AND LITERATURE REVIEW

Unstable prices have characterized Canadian agriculture throughout its history. This instability has, in turn, created uncertainty in the minds of producers, thereby leading to an increase in producer risk. Because the agricultural producer lacks power in determining prices and must frequently sell his products to large agribusinesses, he feels frustrated in his ability to reduce income and price instability. As a result, farmers have turned to the government for help. The government has responded by developing a number of institutions to aid farmers, including the establishment of marketing boards in some sectors of agriculture. In Canada, there are currently more than 100 national and provincial agricultural marketing institutions. These numbers emphasize the important role of marketing boards in Canadian agriculture.

In this report, the focus is primarily on supply-restricting marketing boards. The effectiveness of the supply restricting mechanism is greatest when the industry is operating in the inelastic range of the demand curve. Restricting the supply will increase producer prices and the total revenue to the industry as a whole. The supply-restricting industries which are considered in this chapter are dairy, eggs and poultry. A brief history of marketing boards in Canada, and of these industries in particular, is provided in the next section. This is followed by an analysis of historic prices in the industries identified

above--that is, those with supply-restricting marketing boards. This analysis indicates that marketing boards have led to an increase in the price of agricultural products, but have not, in general, caused an increase in the underlying rate of change in prices. In the final section of this chapter, research into the measurement of the welfare impacts of marketing boards on Canadian society is reviewed.

Historical Background

In the early 1900's, farmers became increasingly dissatisfied with their lack of market power. Farmers desired sufficient market power so that they could receive higher and more stable returns for their product. The first step in this direction was the formation of farmer cooperatives such as the Farmer's Co-op Elevators of the 1920's. These and other cooperatives were effective to a certain degree, but, as is well known, after a cooperative's initial goals and objectives have been achieved support for the cooperative declines. An example of this was the cooperative elevator situation of the 1920's. Initially, the elevator cooperatives were effective in improving marketing services, reducing market discrimination, and increasing returns to growers. However, as the private traders began to lose market share to the cooperatives, they began to offer bonuses and other incentives to farmers. With these incentives, producer loyalty to the cooperatives weakened and they began to

bring their grain to the delivery point which yielded them the greatest immediate economic advantage.

The basic problem with cooperatives is their voluntary nature which is not conducive to the development of countervailing market power. Farmers realized that they needed monopoly power if they were to control a high percentage of the product and, thereby, wield market power. In order to control a high percentage of the market share, a compulsory marketing agency would be necessary. Therefore, farmers lobbied the government to pass legislation which would permit monopoly marketing agencies.

Producers had seen good times when their grain was marketed through the first Canadian Wheat Board of 1919 and 1920. The Board provided farmers a price of \$2.63/bushel using a price pooling system, but the Wheat Board was strictly a war time measure and, consequently, it was discontinued shortly after the war. Post war prices dropped back to their earlier, lower levels due to increased world production, but producers falsely blamed this reduction in prices on the discontinuance of the Wheat Board. As a result, farmers became convinced that marketing boards with price pooling were the answer to their marketing problems. Producers petitioned government to reinstate a wheat board system and, in response, the federal government established the Turgeon Commission to study the situation. The Turgeon Commission recommended that the grain trade remain privately controlled as before and that the Winnipeg Commodity Exchange remain the center of the trade.

Since farmers could get no help from the federal government, they started a price pooling system of their own. In 1924, three cooperative elevator companies formed a Central Selling Agency (CSA). The agency was a voluntary cooperative organization which offered farmers an initial payment for grain sold to the agency. Grain was then pooled and sold directly by the agency without a middleman. Farmers received a final payment which was the difference between the pooled final selling price and the initial payment received from the agency. The CSA did not have the success in gaining market power that the compulsory wheat board had achieved because it only controlled about 50 percent of the grain produced on the prairies. In 1930, the CSA like many other cooperative ventures collapsed. On August 1, 1930, the CSA set an initial price of \$0.70/bushel for the new crop year. In December, 1930, the world price was down to \$0.55/bushel. The banks who had loaned money to the CSA for the initial payment to producers now foreclosed on the agency. Once again producers petitioned the federal government for a wheat board. The response was a voluntary wheat board in 1935. This wheat board became compulsory in 1943 as a war time measure, but it continued after the war as the Canadian Wheat Board.

During the long debate in the grain sector which culminated in the establishment of the Canadian Wheat Board, other sectors in agriculture were also lobbying for increased market power. The first province to move towards a compulsory marketing organization was British Columbia with the B.C. Produce Marketing

Act of 1927. The Act was passed in an attempt to implement local area marketing boards which would assist in the orderly marketing and storage of fruit. Unfortunately, these small boards began to export their product outside the province, thereby requiring the Supreme Court of Canada to overturn the Act on the basis that it interfered with inter-provincial trade (Hiscocks 1972). This was the first of many court battles which addressed the constitutionality of provincial (and federal) legislation governing the marketing of agricultural products. Under the constitution, the provinces are given exclusive control over intra-provincial trade in agricultural commodities, while the federal government is given exclusive control over inter-provincial and export trade. In 1934, the first national legislation concerning agricultural marketing was passed. It resulted in the Dominion Agricultural Marketing Board. Twenty-two marketing schemes were set up as a result of the legislation, but the schemes were generally local in nature and were meant to benefit producer groups with commodity problems. The Dominion Agricultural Marketing Board's history was brief because, in June, 1936, the Supreme Court of Canada ruled against this legislation on the grounds that it gave the federal government control of intra-provincial trade. The Supreme Court decision was reaffirmed by the Privy Council in 1937.

After World War II, provincial marketing schemes were set up by Ontario, Saskatchewan and Prince Edward Island. Under these schemes, the provinces could only give producers the power to

control intra-provincial trade, and this limited the size of the markets available to the boards and, consequently, their effectiveness. The federal government rectified this situation in 1949 by passing the Agricultural Products Marketing Act. This Act gave provincial marketing boards new powers in the areas of inter-provincial and export trade. As a result of the federal Act, provinces with marketing board legislation had an advantage over provinces without similar legislation, but those provinces soon implemented their own marketing board legislation.

Technological advances through the 1960's and early 1970's meant that no producer group or marketing institution was isolated from the rest of the Canadian market. Advances in communications (e.g., telephone, television and newspapers) meant that information on local markets was freely available to all producers. Advances in transportation expanded the market to those that could produce, process and market their commodity most efficiently. These advances led to severe marketing and pricing problems as the opposing provincial marketing boards began to compete for each other's markets. It became obvious that the provincial approach to marketing boards was not the answer. Producer groups began to pressure the federal government for national legislation which would coordinate the provincial boards. The Canadian Federation of Agriculture led this lobby with its own proposal for legislation in 1963. In response to this pressure, the Canadian Dairy Commission (CDC) was established in 1966 by an Act of Parliament. The purpose of the

Commission was to coordinate the production and marketing of milk across Canada. The CDC introduced a subsidy eligibility quota on industrial milk which eventually resulted in price controls on all milk. However, this only dampened the inter-provincial wars for one industry. As a result of the experience with supply restrictions on milk and inter-provincial warfare between provincial marketing boards (particularly in eggs), the Farm Products Marketing Agencies Act was passed in 1972.

As a result of the Farm Products Marketing Agencies Act, two separate but related institutions were formed: (1) a National Farm Products Marketing Council (NFPMC) and (2) Farm Products Marketing Agencies (FPMA). The NFPMC operates as an advisor to the federal government. It considers proposed marketing plans put forward by producers and comments on them. If there is a proposal to establish a marketing plan for a particular commodity, the NFPMC can submit such plans to the government. If the government also approves of the proposal, the NFPMC organizes a producer plebiscite, the results of which are important in the final decision to implement the marketing plan. The plebiscite must involve all producers who will be affected by the plan, and the plan must receive at least sixty percent approval by producers. Approval of a plan will generally result in the establishment of an FPMA.

The FPMA are basically marketing boards or commissions which are set up to help farmers market their products. They are compulsory, horizontal marketing organizations for agricultural

products which are operated under government delegated authority (Hiscocks 1972). They have a wide array of powers available to them and any board, with approval from the NFPMC, may use all or some of these powers. These powers include the ability to:

- (1) license producers, collect levies, and enforce compliance to marketing through the board;
- (2) regulate the total quantity and quality of product coming to market;
- (3) negotiate a minimum selling price on behalf of producers;
- (4) establish producer prices by assuming selling responsibility or through supply control;
- (5) pool producer receipts, as is the case for the Canadian Wheat Board;
- (6) undertake market promotion and development activities;
- (7) conduct production and marketing research;
- (8) obtain product for sale, storage or processing; and
- (9) change the time, place or form of product for sale.

The marketing board may use any or all of these powers to achieve its basic objectives. These objectives can be summarized as follows:

- (1) to maintain and increase producers' incomes through higher prices, lower costs or expanding sales;
- (2) to stabilize prices and incomes of producers; and
- (3) to give each producer equal access to the market.

To fulfill these objectives each particular agricultural industry has a marketing agency of one of three types, as described by Loyns (1976). The first is a negotiating agency which has the power to negotiate producer prices and terms of sale. It also can be involved in pooling, research, market development and market promotion.

The second type of board is a central selling agency like the Canadian Wheat Board. Boards of this type negotiate and sell the product on behalf of producers, often through a price pooling system. This type of board may also be involved in research and development.

Finally, there are the supply management agencies. These institutions are the focus of this report. Supply-restricting marketing boards have all the powers of the previously described boards, but they also have the ability to control supply and, thereby, the price of the product which is marketed on behalf of producers. These marketing boards have the most impact on an industry because they directly affect price; therefore, they are also the most beneficial to producers.¹ Many supply-restricting marketing boards use a cost of production pricing formula to determine the supply-restricting price. This policy raises some controversy because, while it is fine for the primary

¹Note that, if producers are allowed to sell quota (or if rents get capitalized in land and/or building values), only those producers in the industry at the time supply management is introduced will benefit (*ceteris paribus*). New producers must purchase quota (or land, buildings, etcetera) at a price which represents the capitalized value of the supply-management scheme.

producers to be guaranteed a price which will pay for all their costs of production, it is questionable whether this support is proper in maintaining optimal resource allocation.

National marketing boards in eggs, turkeys and broilers were established in 1972, 1973 and 1978, respectively. The Canadian Turkey Marketing Agency (CTMA), the Canadian Egg Marketing Agency (CEMA), the Canadian Dairy Commission (CDC), and the Canadian Chicken Marketing Agency (CCMA) all employ a method for allocating quota to the provincial marketing boards. The national agencies target Canadian production to meet expected demand at a price that covers producers' costs of production.² Sometimes this involves restricting imports of products from the United States and other countries. CEMA differs from the other agencies because it prices eggs centrally, while CCMA and CTMA let the provincial boards do their own pricing.

An Empirical Analysis of the Impact of Marketing Boards on Price

While it is generally agreed that supply-restricting marketing boards have raised prices, it is not obvious what their impact has been on inflation. Have marketing boards contributed to a general inflationary tendency in the economy, or has their impact been simply a once-for-all increase in consumer price? In this section, ordinary least squares (OLS) regression analysis is used to investigate the impact that the introduction of supply-

²Cost of production may include the value of monopoly rents if these have been capitalized in fixed assets.

restricting marketing boards has had on both price and the rate of inflation. Since provincial marketing boards already existed prior to the 1972 Act, the U.S. price was not really relevant during that period. It only seems logical that some form of import restriction must have existed prior to 1972; perhaps this took the form of provincial trade barriers. Otherwise inter-provincial price wars would not have been possible since, in a free market, there would have been only one price--the U.S. price. Hence, the current analysis focuses on the Canadian price only.

A simple Chow test is employed in this analysis. The statistical model which is employed in the regression analysis is of the following form:

$$Y_t = b_0 + b_1*T + b_2*DUM + b_3(T*DUM) + e_t, \quad (2.1)$$

where Y_t is the retail price index of the agricultural commodity deflated by the consumer price index for food items, T is a time trend, and DUM is a dummy variable which takes on the value 1 when a supply-restricting marketing board exists in the industry and 0 otherwise. The dummy variable measures the impact of the marketing board on price, and it can have one of three effects:

- (1) an intercept changing effect,
- (2) a slope changing effect, or
- (3) a mixture of both.

If only an intercept effect is present, implementation of the marketing board results in a once-for-all impact upon price. However, if there is statistical evidence to indicate that the

slope of the regression changes when a marketing board is introduced in a particular agricultural sector, then the marketing board will affect the underlying rate of change in the consumer price index. If the slope increases, the effect of a marketing board is to increase the rate of inflation; if the slope decreases, the impact of regulation is to lower the rate of inflation.

If establishment of a marketing board only affects the intercept term, then the original regression Equation (2.1) becomes:

$$Y_t = (b_0 + b_2) + b_1 * T, \quad (2.2)$$

where b_0 is the measure of the intercept before regulation and $(b_0 + b_2)$ is the value of the intercept after regulation. Therefore, the measure of the effect of supply management on the price of the commodity would be b_2 .

If the data indicate that only the slope changes, then Equation (2.1) becomes:

$$Y_t = b_0 + (b_1 + b_3) * T, \quad (2.3)$$

In this equation $(b_1 + b_3)$ is the new slope coefficient when a marketing board is present. The measure of the change in the slope of the price trend is indicated by the value of the coefficient b_3 . If b_3 is statistically significant and positive, regulation has a direct impact on the rate of increase in retail food prices.

Finally, the model represented by Equation (2.1) consists of two regression lines--one for the pre-supply management era, the

other for the post-regulation period. The two regression lines result when the dummy variable (DUM) takes on the values 0 and 1, respectively. The respective regression lines are given by Equations (2.4) and (2.5):

$$Y_t = b_0 + b_1 * T \quad (2.4)$$

$$Y_t = (b_0 + b_2) + (b_1 + b_3) * T \quad (2.5)$$

The data used to measure the effects of marketing boards on the prices of commodities is a price series for the years 1960 to 1984. These prices are indexed prices computed by Statistics Canada and are available in Appendix A. To eliminate the effect of inflation, the price indexes are divided by the overall consumer price index, which is also provided in Appendix A. The regression model (2.1) is employed to examine the effect of marketing boards in the poultry, eggs and dairy industries.

Empirical Results

Poultry. The poultry industry is characterized by two major products, namely, broilers and turkeys. The data used here do not include data for both turkey and broiler products but only for poultry products as a whole. A turkey marketing agency, CTMA, came into existence in December, 1973, while a marketing board for chickens, CCMA, came into effect in December, 1978. However, as a result of the 1972 Farm Products Marketing Agencies Act, supply management in these industries was effective as early as the beginning of 1973. As Loyns and Begleiter, state:

"The establishment of these marketing boards served to formalize the informal supply management agreements which had existed as agreements on production between provincial boards" (1983, p. 18). Hence, the regression model was estimated using a dummy variable for supply management set equal to one over the period 1973 to 1984.³ The regression model (2.1) was estimated by ordinary least squares (OLS), using a stepwise method for increasing R^2 to eliminate the right-hand-side variables.⁴ The regression results are found in Table 2.1.

As indicated by the significant coefficient on the intercept dummy variable (INCPT DUMMY), supply management in the entire poultry sector was taken to contribute to an initial increase in retail prices. However, the low t-statistic on the slope dummy variable (SLOPE DUMMY) indicates that regulation in the poultry sector did not contribute to inflation beyond the initial implementation of the supply management scheme.

Eggs. In the eggs sector, CEMA was created in 1973 but did not begin operating until 1975. Although some provinces had egg marketing boards prior to that time (e.g., the Saskatchewan Egg Marketing Board was implemented in 1969 with Boards established

³As part of the analysis, an attempt was made to discover if there was a statistically significant break in the inflation-corrected price series in 1974 and 1979. However, this was found not to be the case.

⁴Variables whose estimated coefficient had a t-statistic less than 1.0 were eliminated one at a time, beginning with the variable associated with the smallest t-statistic.

Table 2.1: Price Analysis of Regulation in the Poultry Industry: Regression Results, 1960-1984

DEPENDENT VARIABLE Price Index for Poultry Products			
OBSERVATIONS	25	DEGREES OF FREEDOM	21
R**2	.83484830	RBAR**2	.81125520
SSR	.30398627E-01	SEE	.38046730E-01
DURBIN-WATSON	1.56621022		

LABEL	COEFFICIENT	STAND. ERROR	T-STATISTIC
*****	*****	*****	*****
CONSTANT	1.237770	.2238473E-01	55.295
TREND	-.2294443E-01	.2820211E-02	-8.135
INCPT DUMMY	.1542889	.6686466E-01	2.307
SLOPE DUMMY	.4711040E-02	.4251628E-02	1.108

in Ontario in 1972 and Newfoundland in 1973), inter-provincial competition prevented the provincial marketing boards from having an impact on egg prices until all the provinces were coordinated under a national program. As a result of the Farm Products Marketing Agencies Act of 1972, which placed effective quotas on provincial production beginning in 1973, the dummy variable is set to 0 prior to 1973 and equal to 1 thereafter, even though CEMA was not yet fully operational. The regression results are found in Table 2.2.

The results indicate that regulation did have an impact on consumer egg prices across Canada. The empirical evidence indicates that consumer egg prices have declined in real terms since 1960 and, even after supply management, the negative trend continued. There was no evidence that CEMA affected the rate of

Table 2.2: Price Analysis of Regulation in the Eggs Industry:
Regression Results, 1960-1984

DEPENDENT VARIABLE	Price Index for Eggs		
OBSERVATIONS	25	DEGREES OF FREEDOM	22
R**2	.90548881	RBAR**2	.89689688
SSR	.13686699	SEE	.78874754E-01
DURBIN-WATSON	2.11792014		

LABEL	COEFFICIENT	STAND. ERROR	T-STATISTIC
*****	*****	*****	*****
CONSTANT	1.721214	.3763676E-01	45.732
TREND	-.4300504E-01	.4375184E-02	-9.829
INCPT DUMMY	.2001940	.6315034E-01	3.170

change in prices since the coefficient on the interaction term between the dummy variable and slope (b_3) was statistically insignificant--indeed, the SLOPE DUMMY variable was not even chosen in the stepwise regression. The only observed effect occurred in 1973 when regulation began and there was an upward shift in real consumer egg prices. As expected, therefore, the implementation of supply management did cause a significant increase in egg prices. The reason the national program could influence consumer prices across Canada was that it helped organize and coordinate inter-provincial egg marketings, and price wars among provinces were no longer a problem.

The negative coefficient on the trend variable is worth noting. It appears that real, retail egg prices exhibited a downward trend over the period 1960-1984, and supply management had no impact upon this trend. The downward trend is likely the

result of the adoption of technological change in the industry. Therefore, the results presented here suggest that regulation in the eggs sector did not have an adverse impact on the adoption of technological change in that industry. One reason for this is that regulation in this industry restricts the number of layers rather than output. Hence, producers adopt those technological advances which increase output per layer. These issues are explored further in Smulders (1986).

Dairy. A national program of supply management in the dairy industry began in 1966 when the Canadian Dairy Commission (CDC) was established. Since the 1960-1984 price data found in Appendix A do not contain sufficient observations over the period when there was no national program in the dairy sector, it was necessary to extend the price series back to 1950. Hence, the empirical analysis which follows is based on prices over the period 1950 to 1984. Regression model (2.1) was again employed in the analysis; the dependent variable is the index of dairy prices divided by consumer price index for all food. Since serial correlation appeared to be a problem, filtered least squares was used to estimate the model. The regression results are provided in Table 2.3.

If the pre- and post-regulation regression lines are plotted on a graph, they intersect in 1966. This indicates that the CDC had little impact on increasing consumer prices in 1966. However, the slope of the regression line changes. Before the establishment of the CDC, real milk prices exhibited no statis-

Table 2.3: Price Analysis of Regulation in the Dairy Industry:
Regression Results, 1950-1984

DEPENDENT VARIABLE	Price of Dairy Products		
OBSERVATIONS	33	DEGREES OF FREEDOM	29
R**2	.13340410	RBAR**2	.04375625
SSR	.16738085E-01	SEE	.24024474E-01
DURBIN-WATSON	1.96540509		

LABEL	COEFFICIENT	STAND. ERROR	T-STATISTIC
*****	*****	*****	*****
CONSTANT	.7825039	.1527652E-01	51.222
TREND	-.2939208E-02	.1965568E-02	-1.495
SLOPE DUMMY	.4884737E-02	.2475872E-02	1.972
INCPT DUMMY	-.8520966E-01	.4203813E-01	-2.026

tically significant trend; after establishment of the CDC, milk prices exhibited a slight upward trend. Hence, it would appear that supply management in the dairy industry has contributed to general inflation in food prices.

Implications for Subsequent Analysis

The foregoing results indicate that supply-restricting marketing boards have had a substantial impact on prices. Indeed, in the remainder of the study, we assume that they caused real price increases of 22.2 percent in poultry, 33.9 percent in eggs and 12.0 percent in dairy. Since dairy products are included in all other food (except eggs and poultry products), it is further assumed that the increase in dairy prices translates into an increase in the price of other food of 1.8 percent.

For calculating the welfare impacts, the price changes are taken to occur between 1972 and 1973. While the empirical

evidence presented in this section supports this break, at least for poultry products and eggs, the remaining analysis is not crucially dependent on this assumption. The reason is that the analysis upon which the welfare measures are based is static and specific dates are not crucial to a static analysis. Further, it is necessary to recognize that the price changes considered are simply assumptions required (1) to illustrate the correct methodology for welfare measurement and (2) to show that consumer surplus may still be a good tool for analyzing government agricultural policy, if it is correctly used.

Review of the Literature

Concern with the income distribution and economic efficiency impacts of marketing boards prompted the Economic Council of Canada and the Institute for Research on Public Policy to jointly sponsor a series of studies on regulation and government intervention in Canadian agriculture (e.g., Cairns 1980; Arcus 1981; Barichello 1981; Josling 1981; Martin 1981). In general, each study focused on a particular sector of the agricultural industry, and included both sectors with and without supply-restricting marketing boards. The majority of the Economic Council of Canada studies were descriptive although some researchers (e.g., Arcus, 1979) attempted to measure welfare losses by the value of the quota. Only Forbes, et al. (1982) provided a theoretical framework for measuring welfare impacts. Since that time, however, agricultural economists have recognized the need to

employ an appropriate theoretical model (e.g., Veeman 1982a; Schmitz 1983; Van Kooten and Spriggs 1984). Only Johnson et al. (1982) and Schmitz (1983) consider the possibility that a quota system could lead to gains in social welfare. However, in order to determine if gains occur, a dynamic framework is needed.

The landmark study for measuring the economic benefits and costs of supply-restricting marketing boards in Canada is by Veeman (1982a). She was criticized by Johnson et al. (1982) for implicitly including costs associated with rent-seeking activity as a cost to society. As a result, she estimated that the loss in allocative efficiency to society in the long run accounted for 35.1 percent, 32.1 percent and 45.8 percent of total annual sales in eggs, broilers and turkeys, respectively.⁵ However, it is not certain that an argument for rent-seeking can be made, and, if it can, whether the area identified by Veeman (1982b) is an appropriate measure of the loss due to rent-seeking activity. Using Veeman's data, Van Kooten and Spriggs (1984) found that the maximum loss to society constituted only 0.7 percent, 2.6 percent and 8.9 percent of total annual industry sales in eggs, broilers and turkeys, respectively.

In making her calculations, Veeman and others employ own-price elasticity estimates by Hassan and Johnson (1976). These estimates are based on a double logarithmic functional

⁵The loss in allocative efficiency was substantially less in the short run, varying between 0.1 percent (turkeys) and 7.2 percent (eggs) depending upon which assumptions are employed regarding the demand and supply elasticities and the availability of exports from the U.S.

form. Not only is this functional form ad hoc, but it implies that the price elasticities are constant for all levels of consumption. Nonetheless, previous researchers who measured the welfare impacts of supply-restricting marketing boards, posit a linear demand function. However, demand elasticity does not remain constant along a linear demand curve. If the elasticity estimates of Hassan and Johnson are used, it seems appropriate that a nonlinear functional form (namely, double logarithmic) be used as well.

In a study of the British Columbia egg marketing scheme, Borcharding and Dorosh (1981) estimate an annual deadweight loss--the loss due to the "devil of inefficiency"--of \$300,000 and an additional loss due to rent-seeking and administrative activities of \$700,000.⁶ Lerner and Stanbury (1985) argue that one needs to add an annual cost of \$1.63 million as a risk premium to quota holders because, at the producer level, there is growing unease about the future of supply-restricting marketing boards--that is, about whether they will be continued, discontinued or replaced by another form of stabilization. (While these boards provide original producers, but perhaps not later entrants, with benefits due to higher incomes, they are also the

⁶In addition, they estimate that \$100,000 per year is lost due to forgone scale economies. However, as indicated by Van Kooten and Spriggs (1984), such a loss will not arise if quota is freely traded on an open market. Unless quota is traded in an open market, it would appear difficult to establish quota values since monopoly returns will likely be capitalized in assets other than quota. This is likely the case since quota often cannot be used as an asset in securing a mortgage loan.

subject of criticism from certain economists and consumer groups.⁷⁾ Hence, Borcharding and Dorosh estimate the total loss of supply management in the B.C. egg sector to be \$1 million, while Lermer and Stanbury estimate that it is \$2.63 million: these figures amount to about 3.8 percent and 10.1 percent of gross 1983 industry sales, respectively.

Using data from Veeman (1982a), Lermer and Stanbury (1985) also provide estimates of the long-run social costs to Canada of supply management schemes in eggs, broilers and turkeys. Their estimates of the annual loss to society range from \$72.7 to \$80.5 million in eggs, from \$60.4 to \$103.1 million in broilers, and from \$35.1 to \$62.3 million in turkeys. As a percentage of gross, quota-constrained industry sales, these figures represent 23.7-26.3 percent of egg sales, 13.1-22.4 percent of chicken sales, and 23.9-42.4 percent of turkey sales. In calculating these figures, Lermer and Stanbury added to the standard losses due to allocative inefficiency and the operation of the supply management boards an additional cost of transferring income from

⁷Even producer groups are examining alternatives to the current system of supply management. For example, the Christian Farmers Federation of Ontario (CFFO) has established a Quota Transfer Committee to look into ways of reducing the adverse effects of quotas on both consumers and potential producers. At a November, 1983 meeting, this Committee considered a proposal for a buy-only quota transfer policy. The purpose of the buy-only transfer scheme is to reduce the cost of quota, a cost which constitutes a barrier to entry for potential producers and which is included as a cost of production in calculating the retail price. The CFFO does, however, recognize the need to retain some form of stabilization in agriculture in order to protect producers from the vagaries of the market place.

consumers to producers. To obtain this cost, the authors subtracted from the annual amount of the income transfer (the consumer burden) the annual rent accruing to the quota. The difference is a transfer cost which no one gains. However, since quota is not freely traded, some of the rent attributable to the supply management scheme gets capitalized in assets other than quota.⁸ Hence, the authors underestimate the value of the quota and overestimate the costs of regulation to Canadian society.

Harling and Thompson (1985) compare the economic efficiency impacts of marketing boards in the eggs and poultry sectors in Canada, the United Kingdom and Germany. The authors consider price distortions in both the final product and intermediate input markets, although they found no significant distortions in the price of Canadian inputs. Using the world price as a benchmark, they estimate that poultry meat and egg prices were 25-30 percent higher in Germany and 36-42 percent higher in Canada as a result of marketing boards, but prices were only 5-10 percent higher in the United Kingdom. These price distortions resulted in a deadweight loss to Canada of \$12.1-\$36.8 million in poultry and \$1.9-\$13.9 million in eggs over the three-year period 1975-1977. Over the same period, losses in welfare to Canadian consumers amounted to \$210-\$213 million in poultry and \$96.7-\$98.2 million in eggs. For each dollar transferred to poultry producers, consumers lost \$1.25-\$1.43; for eggs, the loss in

⁸As indicated in footnote 4, there are incentives to capitalize rents in assets other than quota. Only if quota is traded in a perfectly competitive market can this be avoided.

consumer welfare was \$1.03-\$1.18 for each dollar transferred. In their conclusions, Harling and Thompson discuss the need to take into account price distortions in one market on other markets in making welfare calculations (1985, p. 249), although they do not do so.

Other issues concerning the use of supply management schemes for agricultural commodities have also evolved. Some of these are discussed in a review article by Schmitz (1983). He points out the need to develop appropriate measures of the welfare impacts on producers and consumers, and the need to adopt a dynamic approach to the problem of regulation. He also notes that it is not clear that regulation has had an adverse effect on the adoption of new technologies.

Harvey and Hubbard (1984) have recently proposed a method for reducing the onerous burden of agricultural subsidies in the European Economic Community by using a quota system. Consumers could then purchase quota from producers.⁹ However, they do not consider a replacement for the quota scheme other than the free market.

The purpose of this review is not to suggest that there are no social costs associated with supply management of agricultural commodities. Rather, the purpose is to point out that, while the

⁹ This recommendation is based on the typical welfare result that the gainers from removal of the quota system (i.e., consumers) can compensate the losers (i.e., producers) and still be better off. Unfortunately, such a recommendation follows only in a very partial and static framework, and it does not address the original need for stabilization.

authors cited above have made substantial contributions to our understanding of the regulation of agricultural commodities, much work still needs to be done. From a policy point of view, the task facing economists is twofold. First, it is necessary to develop better measures of the social welfare impacts of government regulation, particularly quota schemes. Economists need to determine the welfare effects in both a general equilibrium and a dynamic framework, as suggested by Schmitz (1983). Second, it is necessary to develop an income stabilization program for agricultural producers which also provides a stable supply of agricultural commodities to consumers. At the same time, such a program must help farmers but should not get capitalized into long-run costs. The program must be acceptable to both producers and consumers. Perhaps all that is required is a modification of the current system of supply-restricting marketing boards; or it may be necessary to consider alternatives which are institutionally quite different from the current quota mechanism.

The remainder of this report will focus primarily on the development of measures of the social costs of supply-restricting marketing boards. The approach will be to employ a general equilibrium framework. The methodology is discussed in the next chapter.

CHAPTER 3

WELFARE MEASUREMENT IN A MULTIPLE MARKET FRAMEWORK

It is important that a theoretical framework for measuring welfare impacts across markets is developed. Since the focus of welfare measurement is primarily on the consumer side (Van Kooten and Spriggs 1984),⁸ it is necessary to develop a meaningful measure of consumer welfare. In particular, the concept of consumer surplus can be shown to be an inappropriate measure of welfare change in a multiple market (general equilibrium) framework (Boadway and Bruce 1984, p. 198-201; Morey 1984; McKenzie and Pearce 1976 and 1982; McKenzie 1983), although, as indicated in the previous chapter, it has been employed for measuring the allocative efficiency losses of regulation in agriculture. Theoretically appropriate measures of welfare change are compensating variation (CV) and equivalent variation (EV); both are used to obtain a cardinal measure of utility. The derivation and appropriateness of these concepts are discussed below.

Given that CV and EV are the correct measures of changes in consumer welfare, numerical techniques for determining their values from ordinary demand curves must be employed. McKenzie (1983) and Boadway and Bruce (1984) outline methods for obtaining

⁸In the long run, the concept of producer surplus lacks meaning (Mishan 1981, p. 228).

approximations to the true values of equivalent variation and compensating variation.⁹ Neither of these approaches has, as yet, been employed in applied agricultural research. Therefore, it is necessary to describe methods for finding the CV and EV measures of welfare change. The methodology can then be used to measure the social costs of regulation in agriculture.

In the next section, a brief overview of demand theory is provided. This overview is required as background to demand estimation and the discussion of welfare measures. This is followed by a description of three possible measures of consumer welfare, namely, consumer surplus (CS), equivalent variation and compensating variation. Finally, it is argued that EV is the appropriate measure of welfare change and numerical methods for approximating it are described.

Consumer Demand Theory

The Primal Problem

It is postulated that the consumer maximizes utility subject to a budget constraint. Formally, the consumer problem is to

$$\begin{aligned} &\text{maximize } U = \phi(x_1, \dots, x_n) \\ &\quad x_1 \dots x_n \\ &\text{subject to } m = p_1 x_1 + \dots + p_n x_n, \end{aligned} \tag{3.1}$$

⁹Vartia (1983) employs a different algorithm to measure changes in consumer welfare. However, his approach is not used in the current study.

here ϕ is the utility function,¹⁰ x_i is the i th good or service consumed by the individual, p_i is its price, m is the total amount of income (or budget) available to the individual, and n is the total number of goods and services in the economy. Solving problem (3.1) gives the Marshallian or ordinary demand functions:¹¹

$$x_i = x_i(p_1, \dots, p_n, m), \quad i = 1, \dots, n. \quad (3.2)$$

A monotonic transformation of the utility function $\phi()$, say $U = U[\phi()]$, such that $dU/d\phi > 0$, does not affect the demand functions. However, a monotonic transformation of the utility function may change the sign of the derivative of the marginal utility of income $d\lambda/dm$, where λ is the marginal utility of income or the Lagrange multiplier associated with problem (3.1) (McKenzie 1983, pp. 22-23).

The ordinary demand functions (3.2) can be substituted into the objective function--the utility function in (3.1)--to obtain the indirect utility function:

$$\begin{aligned} U &= \phi[x_1(p_1, \dots, m), \dots, x_n(p_n, \dots, m)] \\ &= v(p_1, \dots, p_n, m). \end{aligned} \quad (3.3)$$

It should be noted that the indirect utility function is constructed under the assumption that consumer satisfaction is maximized; that is, the optimizing problem has been solved. The

¹⁰The utility function must satisfy certain properties (see Deaton and Muellbauer 1980).

¹¹These are also known as the uncompensated demand functions.

indirect utility function has the important property that the ordinary demand functions can be recovered from it using Roy's identity; namely,

$$x_i = - (\delta v / \delta p_i) / (\delta v / \delta m). \quad (3.4)$$

Thus, it is possible to derive the Marshallian demand functions by starting from the direct utility function or from the indirect utility function.¹²

The Dual Problem

Problem (3.1) is known as the primal problem; the associated dual problem is:

$$\begin{array}{ll} \text{minimize} & \sum_{i=1}^n p_i x_i \\ \text{subject to} & U^0 = \phi(x_1, \dots, x_n), \end{array} \quad (3.5)$$

where U^0 is a given level of utility. Solving problem (3.5) provides the Hicksian or compensated demand functions:

$$x_i^c = x_i^c(p_1, \dots, p_n, U), \quad i = 1, \dots, n. \quad (3.6)$$

Substituting the compensated demand functions into the objective function gives the cost-of-utility function:¹³

$$\begin{aligned} C &= p_1 h_1(p_1, \dots, U) + \dots + p_n h_n(p_1, \dots, U) \\ &= c(p_1, \dots, p_n, U). \end{aligned} \quad (3.7)$$

¹²As shown in the next section, it is also possible to derive the uncompensated demand functions from the cost-of-utility function.

¹³The cost-of-utility function is the amount of income or budget required to attain the given level of utility.

The cost-of-utility function, also referred to as the consumer expenditure function, satisfies certain properties discussed by Deaton and Muellbauer (1980, pp. 38-41). The compensated demands can be recovered from the consumer expenditure function using Hotelling's lemma:

$$x_i^c(p_1, \dots, U) = \delta c / \delta p_i. \quad (3.8)$$

In addition, solving (3.7) for U gives the indirect utility function; the ordinary demands can then be obtained from the indirect utility function using Roy's identity (3.4).¹⁴

Restrictions on Demand Systems

Three restrictions on the set of derived demand functions, that is, the system of demand equations, can be identified.

(1) Adding up. Differentiating the budget constraint with respect to total expenditure m , while keeping prices constant, gives:

$$p_1(\delta x_1 / \delta m) + \dots + p_n(\delta x_n / \delta m) = 1. \quad (3.9)$$

This implies that the sum of the marginal propensities to consume the n commodities must equal 1.0. Upon multiplying each term by $(x_i/m) / (x_i/m)$, (3.9) can be written in elasticity form as follows:

$$w_1 e_1 + \dots + w_n e_n = 1, \quad (3.9')$$

where w_i is the i th budget share and e_i is the income elasticity

¹⁴ Likewise, it is possible to recover the cost-of-utility function from the indirect utility function simply by solving (3.3) for $m (=c)$. Hotelling's lemma (3.8) can then be used to obtain the compensated demands.

of good i . Equation (3.9) is referred to as the Engel aggregation condition.

Differentiating the budget constraint with respect to any price, say p_j , while keeping income and all other prices constant, gives:

$$p_1(\delta x_1/\delta p_j) + p_2(\delta x_2/\delta p_j) + \dots + p_n(\delta x_n/\delta p_j) = -x_j. \quad (3.10)$$

This can be written in elasticity form as follows:

$$w_1 e_{1j} + w_2 e_{2j} + \dots + w_n e_{nj} = -w_j, \quad (3.10')$$

where e_{ij} is the cross price elasticity of demand for good i with respect to the price of good j and e_{ii} (i.e., $i=j$) is the own price elasticity of demand. Equation (3.10) is referred to as the Cournot aggregation condition. Engel aggregation and Cournot aggregation are variants of the adding-up condition.

(2) Homogeneity. The ordinary demand functions are homogeneous of degree zero in prices and income. Therefore, doubling all prices and income will not affect the demand for a commodity. Applying Euler's theorem to the demand function (3.2) gives:

$$t x_i = (\delta x_i/\delta p_1)p_1 + \dots + (\delta x_i/\delta p_n)p_n + (\delta x_i/\delta m)m,$$

where t is the degree of homogeneity. Dividing both sides by x_i and since $t=0$, the homogeneity condition can be written in elasticity form as:

$$e_{i1} + \dots + e_{in} + e_i = 0. \quad (3.11)$$

(3) Symmetry. The Slutsky equation can be derived from the relationships obtained above (Boadway and Bruce 1984, p.38). At the consumer's equilibrium, the ordinary and compensated demands

are equal; that is,

$$x_i^C(P, U) = x_i(P, m),$$

where P is the price vector (p_1, \dots, p_n) . Substituting the consumer expenditure function for m gives:

$$x_i^C(P, U) = x_i[P, c(P, U)].$$

Differentiating with respect to p_j gives:

$$(\delta x_i / \delta p_j)_U = \delta x_i / \delta p_j + (\delta x_i / \delta m)(\delta m / \delta p_j)$$

which, upon rearranging and using Hotelling's lemma (3.8), results in the Slutsky equation:

$$\delta x_i / \delta p_j = s_{ij} - x_j(\delta x_i / \delta m), \quad (3.12)$$

where $s_{ij} = \delta x_i^C / \delta p_j$ is the compensated Slutsky substitution term. Symmetry requires that $s_{ij} = s_{ji}$ (Deaton and Muellbauer 1980, pp. 43-44). The matrix of substitution effects, $S = [s_{ij}]$, is symmetric and negative semi-definite.¹⁵

These restrictions on the system of demand functions are generally satisfied in one of two ways. First, one can begin by postulating a functional form for the direct or indirect utility function which satisfies the assumptions of consumer behavior, that is, the utility function must be quasi-concave (Deaton and Muellbauer 1980, pp. 26-30). In this case, the derived Marshallian demand functions automatically satisfy the properties identified above. However, there are serious restrictions on the number of functional forms for the direct and indirect utility functions which result in sufficiently elementary functional

¹⁵This implies that $s_{ii} \leq 0$ for all $i = 1, \dots, n$.

forms for the demand functions to permit statistical estimation.¹⁶

Alternatively, one can postulate a functional form for the demand system without being concerned about the underlying functional form of either the direct or indirect utility function. The required restrictions are imposed during the statistical estimation of the demand system. This approach allows for a greater variety of functional forms for demand systems although one cannot find the elementary functional form for the direct or indirect utility function; it is only known that they exist. An example of this approach is the Rotterdam model of Barten (1966; 1967).

A third approach, suggested by McKenzie and Thomas (1984), is employed in the next chapter. It allows the specification of any functional form which satisfies (1) the requirement that $p_j(\delta v / \delta p_i)$ is homogeneous of degree zero in prices and income, and (2) the symmetry condition. It is explained further in the next chapter.

¹⁶Of course, one can also begin with the expenditure function and derive the demand functions. However, since the indirect utility function must be derived in the process, this does not solve the dilemma.

Measures of the Economic Welfare of Consumers¹⁷

Suppose a consumer faces an infinitely small change in prices and income which may have been brought about by a particular government policy. The impact on the consumer's utility of such a small change can be determined by total differentiating the indirect utility function (3.3):

$$dv = (\delta v / \delta p_1) dp_1 + \dots + (\delta v / \delta p_n) dp_n + (\delta v / \delta m) dm.$$

Applying Roy's theorem and recalling, from the first order conditions to problem (3.1), that $\lambda = \delta v / \delta m$ is the marginal utility of income, the change in utility can be written as:

$$dv = -\lambda \sum_i x_i(P, m) dp_i + \lambda dm.$$

Since $\lambda > 0$ and approximately constant for an infinitesimally small change in prices and income, it is possible to divide both sides by λ and still obtain a perfectly adequate measure of welfare change; namely,

$$dW = dv / \lambda = dm - \sum_i x_i(P, m) dp_i. \quad (3.13)$$

However, as McKenzie argues, "a considerable jump in reasoning is required if we are to say that this differential equation is also acceptable when expressed in terms of discrete changes" (1983, p. 24); that is, when expressed as:

$$\Delta W = \Delta m - \sum_i x_i(P, m) \Delta p_i.$$

¹⁷ Much of the discussion in this section relies on Boadway and Bruce (1984) and, to a lesser extent, McKenzie (1983). Additional discussion can be found in Just, Hueth and Schmitz (1982).

In particular, the assumption that λ is constant is valid only under restrictive conditions.

Consumer Surplus

Consider a move from an initial situation 0 to some final situation 1 caused by a change in prices and income resulting from some public policy. The discrete welfare change is given by:

$$\Delta U = \int_L \lambda [dm - \sum_i x_i(P, m) dp_i], \quad (3.14)$$

where \int_L is the line integral which gives the measure of welfare change along the path L. Dividing both sides of (3.14) by λ gives:

$$CS = \Delta U/\lambda = - \sum_i \int_0^1 x_i(P, m) dp_i + \Delta m. \quad (3.15)$$

This change in welfare is referred to as Marshallian consumer surplus. The first term on the right-hand-side of Equation (3.15) is a line integral which depends upon the path of integration; that is, the value of the integral depends upon the order in which the prices are varied.¹⁸ If only one price varies then (3.15) may be a good approximation of the change in consumer welfare. However, if more than one price changes, as occurred with the introduction of the Farm Products Marketing Agencies Act

¹⁸ The integral is independent of the path chosen only if the integrand is an exact integral. This implies that $\delta x_i / \delta p_j = \delta x_j / \delta p_i$ (Thomas 1968, p. 591), which need not be the case for uncompensated demand functions.

(1972), CS may be neither a unique nor a consistent measure of welfare change.

The argument is sometimes made that, in practice, errors of measurement will occur; therefore, the difference in the measured values of welfare change obtained from (3.15) by following different paths are likely to be insignificant. However, Chipman and Moore argue that this attitude is inappropriate because it takes the position that "the existence of error [is] a reason for compounding it with more error" (1976, p. 81).

The problem with the consumer surplus measure concerns λ . One can only divide both sides of (3.14) by λ to obtain (3.15) if λ is constant, which can only occur under one of two rather restrictive assumptions (Chipman and Moore 1976; Just et al. 1982, pp. 361-363). First, CS provides a consistent measure of welfare change if preferences are homothetic. Preferences are homothetic if the ratio of the consumption of any two commodities is independent of the income level; that is, $[\delta(x_i/x_j)]/\delta m = 0$. This implies that the uncompensated demand curves have unitary income elasticity (the Engel curves are straight lines emanating from the origin) and exhibit the property that $\delta x_i/\delta p_j = \delta x_j/\delta p_i$ (Silberberg 1978, p.25). In addition, it implies that λ is a function of income only, and not prices.

Secondly, the marginal utility of income will be a constant if preferences are "parallel". Then the marginal utility of income is independent of income and of the prices of all the commodities except the numeraire commodity, say x_1 . The income

expansion paths are straight lines parallel to the x_1 axis. Thus, any increase in income is spent entirely on good 1.¹⁹ When preferences are parallel, the utility function can then be represented by the following function:

$$U(x_1, x_2, \dots, x_n) = x_1 + g(x_2, \dots, x_n).$$

Constancy of the marginal utility of income implies that there is no income effect when the price of a commodity changes; that is, the commodity is assumed to be such a small component in one's budget that changes in its price do not affect income. This is hardly a realistic assumption when demand functions for broad categories of consumption are generally estimated. Further, "the assumption that marginal utility of income is independent of numeraire prices and income is an assumption about preferences, and nothing can be inferred concerning preferences from the fact that a particular commodity under consideration absorbs a negligible proportion of the consumer's income, other than that fact itself" (Chipman and Moore 1976, p. 91).²⁰

Compensating Variation

Neither the compensating variation or the equivalent variation measure of consumer welfare suffers from the path

¹⁹Good 1 is likely interpreted as a composite commodity whose price does not change.

²⁰Also see Knight (1944) for further elaboration of these points. As for CS, Knight argues that "the area under a demand curve has no economic meaning whatever" (p. 315, emphasis in original).

dependency problem. The CV of a move from situation 0 to situation 1 is the amount of compensation which needs to be provided, or the amount of income which can be taken away, to leave the individual as well off in the new situation as he or she was in the old situation. In Figure 3.1, x_n represents Hicks-Allen money--that is, all other goods--and is the unit of measurement. The consumer is initially at point 0 on the indifference curve U_0 . A reduction in the price of x_1 and an increase in income due to some public policy enables the consumer to move to point 1 on the higher indifference curve U_1 . The CV of the public policy is given by $m_1 - c_K$, where c_K represents the minimum expenditure required to attain the utility level U_0 at the new set of prices (point K in Figure 1).

Consequently, the CV of a change in prices and incomes is given by:

$$CV = m_1 - c(P^1, U_0) \quad (3.16)$$

$$\begin{aligned} &= m_0 - c(P^1, U_0) + \Delta m \\ &= c(P^0, U_0) - c(P^1, U_0) + \Delta m, \end{aligned} \quad (3.17)$$

where $\Delta m = m_1 - m_0$, P^0 is the vector of initial prices (p_1^0, \dots, p_n^0) and P^1 is the vector of final prices (p_1^1, \dots, p_n^1).²¹

Since the expenditure function is continuous in prices,

$$CV = \int_{P^1}^{P^0} \sum_i [\delta c(P, U_0) / \delta p_i] dp_i + \Delta m$$

²¹Initial income m_0 is the income needed to attain utility level U_0 given initial prices. Final income m_1 is the income needed to achieve U_1 given final prices.

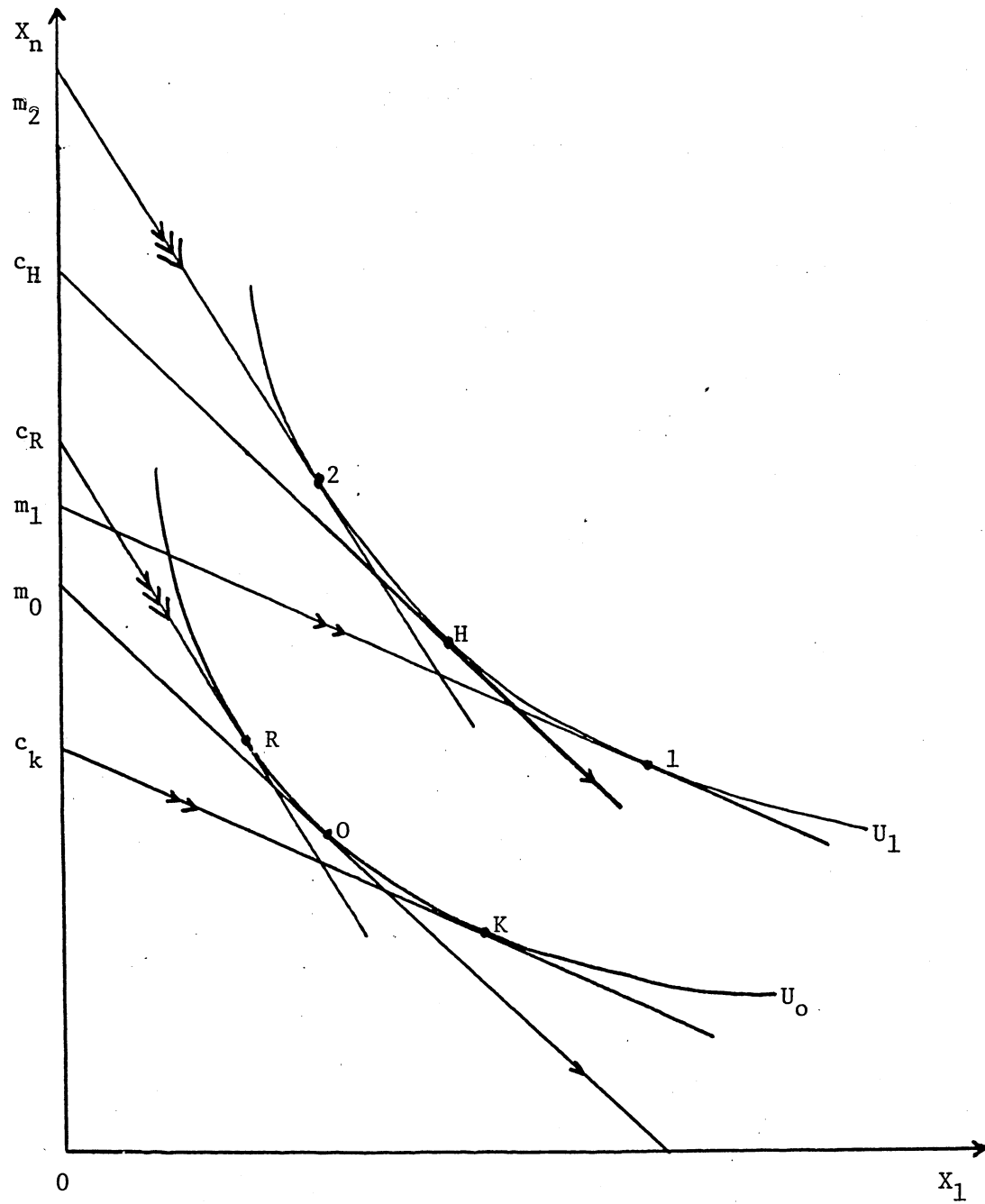


Figure 3.1: A Comparison of Alternative Welfare Measures

or, using Hotelling's lemma (3.8) and reversing the order of integration,

$$CV = -\int_{P_0}^{P^1} \sum_i x_i^C(P, U_0) dp_i + \Delta m. \quad (3.18)$$

Path dependency is not a problem since, for the compensated demand functions, $s_{ij} = s_{ji}$; that is, the symmetry condition holds automatically.

However, CV cannot be given a "clean bill of health" as a unambiguous measure of changes in consumer welfare since CV is also an inconsistent measure, just as CS. This can be seen from Figure 3.1. The CV of a move from 0 to 1 is $m_1 - c_K$, but the CV of a move from 0 to 2 is $m_2 - c_R$. While the two CV measures should be identical, this is not the case. Boadway and Bruce (1984, pp. 201-202) argue that the correct relative ranking between situations 1 and 2 can be obtained by comparing them with each other, rather than comparing both with situation 0; in that case, situations 1 and 2 will turn out to be identical. That is, the CV measure of welfare is consistent for the case of binary welfare comparisons. However, binary comparisons are not likely to occur in practice. Situations 1 and 2 are usually to be compared via situation 0 since it is the status quo situation. The CV welfare measure will also be a consistent money metric if preferences are homothetic (McKenzie 1983, pp. 34-35). Chipman and Moore (1980) have shown that CV is a valid measure of welfare change only under the same conditions as CS, namely, when λ is

constant--that is, when preferences are either homothetic or parallel.

Equivalent Variation

The EV of a move from situation 0 to situation 1 is the minimum amount of compensation an individual is willing to receive, or the maximum amount he or she is willing to pay as a "bribe", to forgo a move from the initial to the final situation. In this case, the reference level of utility is that which would occur in situation 1, the final situation. In Figure 3.1, $c_H - m_0$ is a measure of EV in terms of x_n , and c_H represents the minimum expenditure required to achieve U_1 at the old set of prices (point H in Figure 3.1). Thus,

$$EV = c(P^0, U_1) - m_0 \quad (3.19)$$

$$\begin{aligned} &= c(P^0, U_1) - m_1 + \Delta m \\ &= c(P^0, U_1) - c(P^1, U_1) + \Delta m. \end{aligned} \quad (3.20)$$

Since the expenditure function is continuous in prices, and using Hotelling's lemma (3.8) while reversing the order of integration, (3.20) can be written as:

$$EV = - \int_{P^0}^{P^1} \sum_i x_i^c(P, U_1) dp_i + \Delta m. \quad (3.21)$$

Once again, since the EV measure is in terms of the compensated demand functions, the welfare measure (3.21) is path independent--that is, the order in which the price changes are taken does not affect the value of EV.

Summary

It would appear that both CV and EV are unambiguously defined. They differ only with respect to the reference set of prices as can be seen by comparing expressions (3.16) and (3.19). EV relies on base prices while CV relies on the prices which exist in the new situation, although any set of prices could, in principle, be used to construct a measure of welfare change.

McKenzie (1983) argues that only EV constitutes a true measure of welfare change since CV is an inconsistent measure. The EV of a change from situation 0 to situation 1 is given by $c_H - m_0$; similarly, the EV of a change from situation 0 to situation 2 (with a different set of prices and income than situation 1) is also given by $c_H - m_0$ (Figure 3.1).

The CV measure of a change in the price of x_i from p_i^0 to p_i^1 is given by area $p^0 a d p^1$ under the compensated demand curve $x_i^C(P, U_0)$ in Figure 3.2; the CS measure of welfare change is given by area $p^0 a c p^1$ under the uncompensated demand curve; and the EV measure of welfare change is given by area $p^0 b c p^1$ under the compensated demand curve $x_i^C(P, U_1)$. Therefore, $CV < CS < EV$ for a reduction in price and $CV > CS > EV$ for an increase in price. While this relationship holds for a change in a single price, it may not hold when more than one price changes at a time. This is the major problem of measurement--Marshallian consumer surplus is not a consistent, and perhaps not even a good measure, of welfare

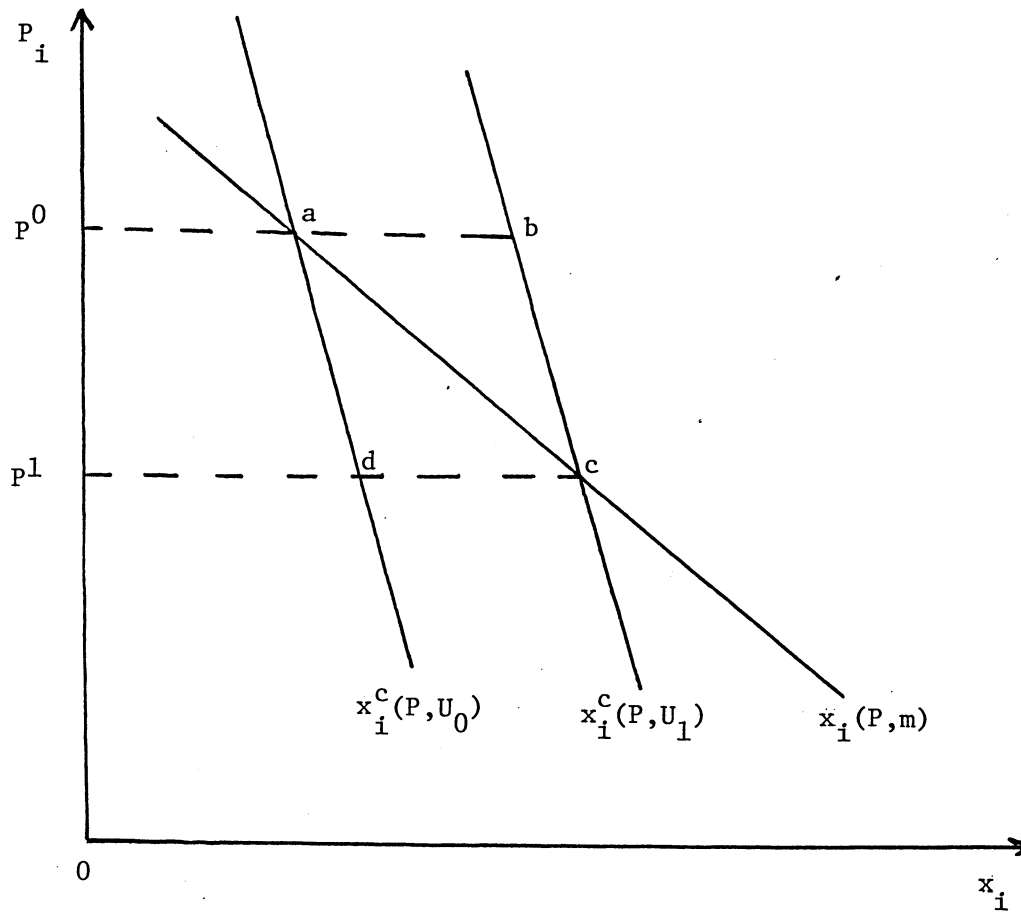


Figure 3.2: The Relationship Between the CS, CV and EV Measures of Consumer Welfare (Single Price Change)

change. In addition, CV is unlikely to be a good measure of consumer welfare.

In the next section, numerical methods for obtaining measures of consumer welfare are examined. The EV measure will be emphasized for the reasons discussed above. However, CV will also be given consideration because it is valid in some circumstances.

Calculation of Welfare Change

In this section, two approximate measures of the change in consumer welfare are considered: (1) the method described by Boadway and Bruce (1984) and (2) the money metric recommended by McKenzie (1983). A third procedure suggested by Vartia (1983) employs an average of the Paasche and Laspeyres quantity indexes as a measure of welfare change, but it is not employed here.

Expenditure Function Approach

Approximations of both compensating and equivalent variation can be found by taking a Taylor series expansion of the expenditure function about either the initial set of prices or the final set of prices. For CV, expression (3.17) is employed. Taking a Taylor series expansion of the expenditure function $c(P^1, U_0)$ about the initial set of prices, while keeping utility at the original level, gives:

$$c(P^1, U_0) = c(P^0, U_0) + \sum_i [\delta c(P^0, U_0) / \delta p_i] \Delta p_i$$

$$\begin{aligned}
& + 1/2 \sum_i \sum_j [\delta^2 c(P^0, U_0) / \delta p_i \delta p_j] \Delta p_i \Delta p_j \\
& + 1/6 \sum_i \sum_j \sum_k [\delta^3 c(P^0, U_0) / \delta p_i \delta p_j \delta p_k] \Delta p_i \Delta p_j \Delta p_k + R,
\end{aligned} \tag{3.22}$$

where R represents the higher-order terms which are assumed to be negligible.²² Using result (3.8) and the earlier equality $s_{ij} = \delta x_i^c / \delta p_j$ ($i, j = 1, \dots, n$), and upon rearranging and adding Δm , the Taylor series (3.22) can be written as an approximation of CV; namely,

$$\begin{aligned}
CV = c(P^0, U_0) - c(P^1, U_0) + \Delta m \approx & - \sum_i x_i^c(P^0, U_0) \Delta p_i \\
& - 1/2 \sum_i \sum_j s_{ij}(P^0, U_0) \Delta p_i \Delta p_j \\
& - 1/6 \sum_i \sum_j \sum_k [\delta^3 c(P^0, U_0) / \delta p_i \delta p_j \delta p_k] \Delta p_i \Delta p_j \Delta p_k + \Delta m.
\end{aligned} \tag{3.23}$$

The right-hand-side (RHS) terms in expression (3.23) are evaluated at the original prices and level of utility. The estimated (observed) Marshallian demand functions can be used to determine the approximation to CV, but only under restrictive conditions. At the original equilibrium, that is, situation 0, the compensated and ordinary demand functions intersect. Hence, it is possible to use the estimated demand function, evaluated at the original equilibrium, in place of the (unknown) compensated demand function to evaluate the first term on the RHS of expression (3.23). Similarly, since the Slutsky equation (3.12) can be written as

$$s_{ij} = \delta x_i / \delta p_j + x_j (\delta x_i / \delta m),$$

²²Boadway and Bruce (1984) do not employ the third-order term in the expansion for reasons discussed below.

the empirically estimated demand functions can be used to evaluate the second term on the RHS (Boadway and Bruce 1984, pp. 219-20). The s_{ij} are evaluated at the initial point using the empirical estimates of the consumer demand functions. However, the third term in the expression (3.23) remains unobservable. Therefore, the Taylor series approximation of CV is truncated after the second-order term in the Taylor expansion.

An approximation of equivalent variation can also be found from Equation (3.20). A Taylor series expansion of the expenditure function $c(P^0, U_1)$ about the final prices, with the final level of utility held constant, gives the following:

$$\begin{aligned} c(P^0, U_1) &= c(P^1, U_1) + \sum_i [\delta c(P^1, U_1) / \delta p_i] \Delta p_i \\ &+ 1/2 \sum_i \sum_j [\delta^2 c(P^1, U_1) / \delta p_i \delta p_j] \Delta p_i \Delta p_j \quad (3.24) \\ &+ 1/6 \sum_i \sum_j \sum_k [\delta^3 c(P^1, U_1) / \delta p_i \delta p_j \delta p_k] \Delta p_i \Delta p_j \Delta p_k + R, \end{aligned}$$

where R is the remainder which is approximately zero. Rearranging (3.24), adding Δm to both sides, and making the same substitutions as above gives an approximation of EV; namely,

$$\begin{aligned} EV &= c(P^0, U_1) - c(P^1, U_1) + \Delta m \\ &= \sum_i X_i^c(P^1, U_1) \Delta p_i + 1/2 \sum_i \sum_j s_{ij}(P^1, U_1) \Delta p_i \Delta p_j \quad (3.25) \\ &+ 1/6 \sum_i \sum_j \sum_k [\delta^3 c(P^1, U_1) / \delta p_i \delta p_j \delta p_k] \Delta p_i \Delta p_j \Delta p_k + \Delta m. \end{aligned}$$

It is possible to evaluate the first two terms on the RHS of (3.25) in the same way as in the case of CV, but at final prices rather than original prices; however, it is not possible to evaluate the third-order term. Hence, the Taylor series (3.24)

is truncated after the second-order term.

When the expenditure function is used to determine either CV or EV, and the expenditure function cannot be explicitly written, then a second-order Taylor series approximation can be used to approximate CV or EV. However, as McKenzie notes (1983, pp. 114-16), the subsequent measures rely on the ability of a second-order Taylor series expansion to measure EV and CV with sufficient accuracy. Calculations by McKenzie (1983, pp. 171-73) indicate that such an approximation may not be sufficiently accurate.

McKenzie's Money Metric

McKenzie (1983, p. 31) specifies an equivalence function or money-metric as a transformation of the indirect utility function; namely,

$$Y = c[v(m, P), P^0].$$

Since Y is a monotonic transformation of the indirect utility function v , it is also a welfare indicator. McKenzie shows that, from the first-order conditions associated with utility maximization (the primal problem), the following holds:

$$\delta Y / \delta m = \lambda \quad \text{and} \quad \delta Y / \delta P_i = -\lambda x_i(P, m). \quad (3.26)$$

Further, since any change in income is equivalent to itself in money-metric terms when evaluated at the base set of prices, this implies that the marginal utility of expenditure (or income) is equal to 1; it also implies that the first- and higher-order derivatives of the marginal utility of income with respect to

income are equal to zero (1983, pp. 32-33).²³

$$\lambda(P^0, m) \equiv 1 \text{ and } \delta^r \lambda / \delta m^r \equiv 0 \text{ (r = 1, \dots, \infty).} \quad (3.27)$$

Using the money metric, equivalent variation can be written as:

$$EV = Y - m_0 = \sum_i \Delta Y_i + \Delta m, \quad (3.28)$$

$$\text{where } \Delta Y_i = \int_{P_i^0}^{P_i^1} [\delta Y / \delta p_i (p_1^1, p_2^1, \dots, p_{i-1}^1, p_i, p_{i+1}^0, \dots, p_n^0, m^0)] dp_i.$$

The problem that remains is: How does one obtain an adequate approximation of (3.28) which employs empirically estimated demand functions? McKenzie employs a third-order Taylor series expansion of EV, using the relationships (3.26) and (3.27). The final expression (3.30), which is to be evaluated using numerical techniques, is derived as follows (see McKenzie 1983, p. 44ff).

A Taylor series expansion of (3.28) is:

$$\begin{aligned} EV = & \sum_i \frac{\delta Y}{\delta p_i} \Delta p_i + \frac{\delta Y}{\delta m} \Delta m + 1/2 \sum_i \sum_j \frac{\delta^2 Y}{\delta p_i \delta p_j} \Delta p_i \Delta p_j + 1/2 \frac{\delta^2 Y}{\delta m^2} (\Delta m)^2 \\ & + \sum_i \frac{\delta^2 Y}{\delta p_i \delta m} \Delta p_i \Delta m + 1/6 \sum_i \sum_j \sum_k \frac{\delta^3 Y}{\delta p_i \delta p_j \delta p_k} \Delta p_i \Delta p_j \Delta p_k \\ & + 1/6 \frac{\delta^3 Y}{\delta m^3} (\Delta m)^3 + 1/2 \sum_i \sum_j \frac{\delta^3 Y}{\delta p_i \delta p_j \delta m} \Delta p_i \Delta p_j \Delta m \\ & + 1/2 \sum_i \frac{\delta^3 Y}{\delta p_i \delta m^2} \Delta p_i (\Delta m)^2 + R, \end{aligned} \quad (3.29)$$

where R is assumed to be negligible. The values of the deriva-

²³ McKenzie and Pearce (1976) make a transformation which requires that the derivatives of λ with respect to income are all equal to 1 rather than 0. As McKenzie points out, the resulting indicator is not a true money-metric (1983, p. 50).

tives in (3.29) are:

- (i) $\frac{\delta Y}{\delta p_i} = -\lambda x_i$, $\frac{\delta Y}{\delta m} = \lambda$, $\frac{\delta^2 Y}{\delta m^2} = \frac{\delta \lambda}{\delta m}$ and $\frac{\delta^3 Y}{\delta m^3} = \frac{\delta^2 \lambda}{\delta m^2}$;
- (ii) $\frac{\delta^2 Y}{\delta p_i \delta p_j} = -\lambda \frac{\delta x_i}{\delta p_j} - x_i \frac{\delta \lambda}{\delta p_j}$;
- (iii) $\frac{\delta^2 Y}{\delta p_i \delta m} = -\lambda \frac{\delta x_i}{\delta m} - x_i \frac{\delta \lambda}{\delta m} = \frac{\delta \lambda}{\delta p_i}$;
- (iv) $\frac{\delta^3 Y}{\delta p_i \delta p_j \delta p_k} = -\lambda \frac{\delta^2 x_i}{\delta p_j \delta p_k} - \frac{\delta x_i}{\delta p_j} \frac{\delta \lambda}{\delta p_k} - x_i \frac{\delta^2 \lambda}{\delta p_j \delta p_k} - \frac{\delta \lambda}{\delta p_j} \frac{\delta x_i}{\delta p_k}$;
- (v) $\frac{\delta^3 Y}{\delta p_i \delta p_j \delta m} = -\lambda \frac{\delta^2 x_i}{\delta p_j \delta m} - \frac{\delta x_i}{\delta p_j} \frac{\delta \lambda}{\delta m} - x_i \frac{\delta^2 \lambda}{\delta p_j \delta m} - \frac{\delta \lambda}{\delta p_j} \frac{\delta x_i}{\delta m}$; and
- (vi) $\frac{\delta^3 Y}{\delta p_i \delta m^2} = -\lambda \frac{\delta^2 x_i}{\delta m^2} - \frac{\delta x_i}{\delta m} \frac{\delta \lambda}{\delta m} - x_i \frac{\delta^2 \lambda}{\delta m^2} - \frac{\delta \lambda}{\delta m} \frac{\delta x_i}{\delta m}$.

Employing the results from (3.26) and (3.27) enables one to reduce these derivatives to expressions which can be obtained from the ordinary demand functions.

- (i') $\frac{\delta Y}{\delta p_i} = -x_i$, $\frac{\delta Y}{\delta m} = 1$, $\frac{\delta^2 Y}{\delta m^2} = 0$ and $\frac{\delta^3 Y}{\delta m^3} = 0$.
- (ii') $\frac{\delta^2 Y}{\delta p_i \delta p_j} = -\frac{\delta x_i}{\delta p_j} - x_i \left[-\lambda \frac{\delta x_j}{\delta m} - x_j \frac{\delta \lambda}{\delta m} \right] = -\frac{\delta x_i}{\delta p_j} + x_i \frac{\delta x_j}{\delta m}$.
- (iii') $\frac{\delta^2 Y}{\delta p_i \delta m} = -\frac{\delta x_i}{\delta m}$.
- (iv') $\frac{\delta^3 Y}{\delta p_i \delta p_j \delta p_k} = -\frac{\delta^2 x_i}{\delta p_j \delta p_k} - \frac{\delta x_i}{\delta p_j} \left[-\lambda \frac{\delta x_k}{\delta m} - x_k \frac{\delta \lambda}{\delta m} \right] - x_i \frac{\delta^2 \lambda}{\delta p_j \delta p_k}$

$$\begin{aligned}
& - \frac{\delta x_i}{\delta p_k} \left[-\lambda \frac{\delta x_j}{\delta m} - x_j \frac{\delta \lambda}{\delta m} \right] \\
& = - \frac{\delta^2 x_i}{\delta p_j \delta p_k} + \frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} - x_i \frac{\delta}{\delta p_k} \left[-\lambda \frac{\delta x_j}{\delta m} - x_j \frac{\delta \lambda}{\delta m} \right] + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} \\
& = \frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta p_k} + x_i \left[\frac{\delta \lambda}{\delta p_k} \frac{\delta x_j}{\delta m} + \lambda \frac{\delta^2 x_j}{\delta p_k \delta m} \right. \\
& \quad \left. + x_j \frac{\delta^2 \lambda}{\delta m \delta p_k} + \frac{\delta x_j}{\delta p_k} \frac{\delta \lambda}{\delta m} \right] \\
& = \frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta p_k} + x_i \left[\frac{\delta^2 x_j}{\delta p_k \delta m} \right. \\
& \quad \left. + \frac{\delta x_j}{\delta m} \left(-\lambda \frac{\delta x_k}{\delta m} - x_k \frac{\delta \lambda}{\delta m} \right) + x_j \frac{\delta}{\delta m} \left(-\lambda \frac{\delta x_k}{\delta m} - x_k \frac{\delta \lambda}{\delta m} \right) \right] \\
& = \frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta p_k} \\
& \quad + x_i \left[\frac{\delta^2 x_j}{\delta p_k \delta m} - \frac{\delta x_j}{\delta m} \frac{\delta x_k}{\delta m} - x_j \frac{\delta^2 x_k}{\delta m^2} \right] . \\
(v') \quad \frac{\delta^3 Y}{\delta p_i \delta p_j \delta m} & = - \frac{\delta^2 x_i}{\delta p_j \delta m} - x_i \frac{\delta}{\delta m} \left[-\lambda \frac{\delta x_j}{\delta m} - x_j \frac{\delta \lambda}{\delta m} \right] - \\
& \quad \frac{\delta x_i}{\delta p_k} \left[-\lambda \frac{\delta x_j}{\delta m} - x_j \frac{\delta \lambda}{\delta m} \right] \\
& = - \frac{\delta^2 x_i}{\delta p_j \delta m} + x_i \frac{\delta^2 x_j}{\delta m^2} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} \\
(vi') \quad \frac{\delta^3 Y}{\delta p_i \delta m^2} & = - \frac{\delta^2 x_i}{\delta m^2}
\end{aligned}$$

Results (i') - (vi') provide an expression for EV which can be evaluated using empirical demand functions and numerical methods; namely,

$$\begin{aligned}
 EV \approx & \sum_i -x_i \Delta p_i + \Delta m + 1/2 \sum_i \sum_j \left[x_i \frac{\delta x_j}{\delta m} - \frac{\delta x_i}{\delta p_j} \right] \Delta p_i \Delta p_j \\
 & - \sum_i \frac{\delta x_i}{\delta m} \Delta p_i \Delta m + 1/6 \sum_i \sum_j \sum_k \left[\frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta p_k} \right. \\
 & \left. + x_i \left(\frac{\delta^2 x_j}{\delta p_k \delta m} - \frac{\delta x_j}{\delta m} \frac{\delta x_k}{\delta m} - x_j \frac{\delta^2 x_k}{\delta m^2} \right) \right] \Delta p_i \Delta p_j \Delta p_k \\
 & + 1/2 \sum_i \sum_j \left[x_i \frac{\delta^2 x_j}{\delta m^2} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta m} \right] \Delta p_i \Delta p_j \Delta m \\
 & - 1/2 \sum_i \frac{\delta^2 x_i}{\delta m^2} \Delta p_i (\Delta m)^2. \tag{3.30}
 \end{aligned}$$

Expression (3.30) can be reduced further if it is assumed that income does not change from the base situation to the final one (i.e., $\Delta m = m_0 - m_1 = 0$). This situation arises when government policies only affect prices, as was the case with the 1972 Farm Products Marketing Agencies Act. In that case, each term in expression (3.30) which involves Δm is eliminated, and expression (3.30) would become

$$\begin{aligned}
 EV \approx & \sum_i -x_i \Delta p_i + 1/2 \sum_i \sum_j \left[x_i \left(\frac{\delta x_j}{\delta m} \right) - \frac{\delta x_i}{\delta p_j} \right] \Delta p_i \Delta p_j \\
 & + 1/6 \sum_i \sum_j \sum_k \left[\frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta p_k} \right]
 \end{aligned}$$

$$+ x_i \left(\frac{\delta^2 x_j}{\delta p_k \delta m} - \frac{\delta x_j}{\delta m} \frac{\delta x_k}{\delta m} - x_j \frac{\delta^2 x_k}{\delta m^2} \right)] \Delta p_i \Delta p_j \Delta p_k \quad (3.31)$$

Notice that the expression in square brackets in the second term on the RHS of (3.31) is not the Slutsky term (see Equation (3.12)). Therefore, even if the final (third-order) term is eliminated, (3.31) is not the same as the second-order approximation of CV given by (3.23).

In the next chapter, the results of demand systems estimation are provided. As indicated there, the number of equations included in the system are kept to a minimum. In Chapter 5, reductions in consumer welfare are calculated using the estimates of the demand parameters obtained in Chapter 4.

CHAPTER 4

DEMAND ESTIMATION

Empirical demand estimation is necessary for public policy analysis in two important and related ways. Firstly, estimates of price and income elasticities are useful for determining the direction and magnitude of changes in the quantity and price of a commodity that might occur when a particular government policy affects any of the determinants of the demand for that commodity. Secondly, estimates of the demand parameters can be employed to obtain measures of the gain or loss in consumer welfare as a result of some public policy, as is the purpose in this report. Applied economists frequently fail to distinguish between demand functions which result from the maximization of preferences subject to a budget constraint and those which are properly considered to be statistical relationships only. The latter are referred to as empirical demand functions (Gorman 1971, p.82; Stigler 1965, p.150) since they are not, explicitly at least, the result of utility maximization and, hence, need not satisfy the integrability conditions.²⁶ Where demand relations are not derived from utility maximization, their use in evaluating the direction and magnitude of price and quantity changes may remain valid, but they do not permit welfare judgments. Since economists are often preoccupied with the need to make welfare

²⁶The integrability conditions are satisfied when the demand relation is single-valued, Lipschitzian in all its arguments, and has a symmetric, negative semi-definite substitution matrix (Hurwicz 1971).

judgments, that is, quantitative assessments of the gains and losses of public policies, demand functions derived from utility maximization are a necessary prerequisite.

In this chapter, demand functions are estimated and these are subsequently employed in the welfare analysis of supply-restricting marketing boards in the next chapter. However, there are a number of problems with demand estimation. The first of these is general and is briefly discussed in the next section under the heading of philosophical considerations. The second is more immediate to the problem at hand; namely, the available data do not permit the estimation of a complete demand system for (disaggregated) food commodities. Indeed, the data does not permit even estimation of quite simple demand systems without some judgements concerning the appropriate values of the parameters on the part of the analyst. Following Hassan and Johnson (1976), in the third section of this chapter, the results of an ad hoc method of estimating demand functions are presented. This is followed by a discussion of a method for specifying demand systems due to McKenzie and Thomas (1984) and the estimation results for a three commodity demand system.

Philosophical Considerations

In practice, it is difficult to specify a utility function which enables one to find reasonable functional forms²⁷ for the

²⁷ By reasonable functional forms is meant forms which can be derived analytically and/or ones that lead to an estimable demand model.

demand equation(s) to be estimated. As a result, several approaches have been developed to avoid directly specifying the utility function a priori. One is to employ duality theory and specify a functional form for either the indirect utility function or the cost-of-utility function. This approach has the same drawback already identified with respect to the direct utility function; there are few specifications which lead to reasonable functional forms for the associated demand model. In contrast, McKenzie and Thomas (1984) also employ duality theory in a way which permits the investigator to directly specify a large number of different functional forms for the demand system without a priori knowledge of either the direct or indirect utility function, although the functions must satisfy certain homogeneity requirements. This approach is discussed in a later section of this chapter.

A second approach is to directly specify a functional form for the system of demand equations to be estimated (without the homogeneity requirements of McKenzie and Thomas) and impose the classical restrictions of demand theory.²⁸ The Rotterdam model of Theil (1965) and Barten (1966; 1967) is an example. This approach allows explicit testing of the demand theory restrictions, but the general conclusion of such tests is that the empirical evidence contradicts demand theory (Deaton and Muellbauer 1980, p.70). Finally, a third approach has been to

²⁸ Recall from Chapter 3 that these restrictions are adding up, homogeneity, symmetry and negative semidefiniteness of the matrix of substitution effects.

use flexible forms (translog, Fourier, etcetera) to approximate the true, but unknown, direct or indirect utility function or expenditure function.²⁹ Examples are found in Christensen, et al. (1975), in Simmons and Weiserbs (1979), and in Gallant (1981). Once again, the results of these studies provide evidence for rejecting consumer demand theory.

Empirical tests of the restrictions implied by consumer demand theory--a theory based on the existence of a utility function³⁰--have led to its rejection. Yet, economists are reluctant to jettison the theory. Rather, they argue that tests based on a direct specification of the demand model may be inappropriate, while the flexible functional forms are not good enough approximations to the true functions. As a result, research is currently underway to find better functional approximations (e.g., Coleman 1982; Gallant 1981). However,

²⁹ A fourth approach has been to ignore these problems and assume that each individual has a different utility function. Therefore, although the individual demand functions must satisfy the theoretically-derived restrictions, there is no reason why the aggregate demand function should. However, this approach is not followed by most researchers since it leaves demand analysis without predictive power. One way out of the aggregation dilemma is to assume a single utility function for the entire group of consumers. Since utility is a metaphysical construct, there is no reason why this cannot be done. However, the preferred approach is to deal with a representative consumer and posit demand functions in per caput terms.

³⁰ Implicit to the modern concept of a utility function is the concept of indifference--that is, an individual may be unable to determine that one of two (or more) bundles of all possible goods and services is preferred. Indifference implies that utility is no longer a purely ordinal variable, but without it there is no longer any basis for ordering commodity bundles by an ordinal index (Georgescu-Roegen 1968, p.262).

flexible forms, poor quality data, etcetera, are only part of the explanation for failure of the empirical evidence to support consumer demand theory, and it is unlikely that effort in this direction is going to eliminate the problem. The reason is that the economist's conception of utility itself may be at fault. For example, Winrich (1984) argues that the preference relation can never be both complete and consistent (transitive) because it denies the inclusion of preferences themselves in the choice set. Ignoring preferences as an object of choice results in self-reference and, consequently, the usual preference functions of neoclassical economics cannot exist.

Just as the economist's concept of competition is unrealistic,³¹ so too is his concept of a monistic utility function. Georgescu-Roegen (1966) rejected the idea that all human wants could be reduced to a common basis, known as utility or ophelimity, opting instead for retention of the "Principle of the Irreducibility of Wants", a classical vestige repudiated by the neoclassical economists.³² While neoclassical economics retained the postulate of indifference, Georgescu-Roegen argues

³¹In economics, competition is narrowly defined. Only price competition is allowed. Darwinian competition is strictly forbidden because it might be amoral (e.g., threats against the life of your rival).

³²He also accepted the "Principle of the Subordination of Wants" (1966, p.194), which implies Gossen's law of satiable wants, that is, a bliss point (1968, p.262). Knight (1944) also accepts the notion of satiety.

that this postulate cannot be part of a realistic theory of choice.³³ Rather, a theory based on the hierarchy of wants is required.

"It has long been observed that human needs and wants are hierarchized. In fact, as the reader may convince himself by looking at random in the literature, this hierarchy is the essence of any argument explaining the principle of decreasing marginal utility" (Georgescu-Roegen 1966, p.194).

If it can be assumed that there is a one-to-one correspondence between wants and commodities, a lexicographical ordering of commodity bundles results. While Georgescu-Roegen has moved in this direction, it appears that knowledge of the direct utility function is needed before proceeding to empirical investigation. Such knowledge vitiates the need for an analysis along the lines pursued in this report.

Although important, these considerations only serve to illustrate the difficulties of demand analysis. In this report, the currently accepted approach to demand specification and estimation is followed and the reservations raised above are not taken into account. However, they do serve to remind one of the limitations of empirical demand analysis.

³³Even when it is possible to find the integral lines associated with observational data--the integrability problem--they cannot be considered indifference curves. "Revealed preference, like any theory based on preference alone, can never arrive at a criterion of indifference" (Georgescu-Roegen 1968, p.257).

Data and Aggregation Level

The data used in this study were obtained directly from Statistics Canada and are found in Appendix A. The quantity data are found in Statistics Canada Catalogue #32-226, while the price data are available in Catalogue #62-010. Since quantity is in kilograms and it was necessary to obtain budget shares, the price indexes for the various commodities were multiplied by the 1981 actual average price for commodities in the major Canadian cities (Cat. #62-010). In general, the actual prices for various items were aggregated into group prices using a weighted average. For pork and beef, however, data from Agriculture Canada regarding the various cuts of beef and pork available from a carcass were used to construct these prices. The actual 1981 prices which were calculated are found in the bottom rows of Tables A2 and A4. The 1981 prices were multiplied by their respective price indexes and, subsequently, divided by the consumer price index to obtain real product prices.

Two-stage budgeting is implicitly assumed. In the first stage, a decision is made to allocate income among major commodity classifications such as food, clothing and footwear, services, etcetera. In the second stage, the income allocated to any commodity group is treated as the budget constraint in maximizing utility over the commodities in the group (Deaton and Muellbauer 1980, pp. 120-42). In choosing how to group commodities, expediency, and not theory (e.g., Hicks' composite commodity theorem), was the main criteria.

Ad Hoc Specification

As a result of difficulties associated with demand systems analysis when data limitations are present, researchers have employed rather ad hoc specifications to empirically measure income and (own and cross) price elasticities for a variety of disaggregated commodities. Although demand systems can be estimated using Canadian expenditure data when these are highly aggregated (e.g., Spriggs and Van Kooten 1986), this is not the case for expenditures on specific commodities.³⁴ For example, Hassan and Johnson (1976) specify the following double logarithmic functional form:

$$\ln x_i = a + b \ln m + \sum_j c_{ij} \ln p_j + e_i, \quad (4.1)$$

where a , b and c_{ij} are parameters to be estimated, and there are n disaggregated commodities ($i, j = 1, \dots, n$). They only obtain realistic estimates of the income, and own- and cross-price elasticities of demand for individual food commodities grouped into relatively narrow categories.

In the current study, several ad hoc specifications were considered. Although the estimated price and income elasticities were fairly robust with respect to model specification, the

³⁴ An exception is the dynamic generalized linear expenditure system (DGLES) for protein commodities estimated by Andrikopoulos et al. (1984). While they employed data for the period 1958 to 1981, attempts to estimate a consistent DGLES system using 1960-1984 data proved unsuccessful. However, the Andrikopoulos et al. results cannot be given serious consideration since all protein commodities are considered to be complements. That is, they, find beef and pork, poultry and pork, ectetera, to be complements.

double logarithmic functional form seemed to provide the most realistic estimates of the elasticities. However, even with this specification, it was necessary to reduce the number of commodities to beef, pork, poultry products, fish and all other food items. (It was not possible to get consistent estimates using all of the food commodities listed in Appendix A.) The ordinary least squares (OLS) estimates are provided in Table 4.1. Since no attempt was made to eliminate statistically insignificant explanatory variables, the seemingly unrelated (SUR) and full information maximum likelihood (FIML) estimates--that is, the parameter estimates for the full demand system--are identical to the OLS estimates. Most of the estimated coefficients are statistically significant.³⁵

The elasticity of the dependent variable with respect to any explanatory variable is equal to the value of the estimated coefficient for that variable in the double logarithmic specification. Only the elasticities of other food with respect to income and prices are missing from Table 4.1. However, these can be determined from the Cournot and Engel aggregation conditions. Symmetry does not hold, although this should not be surprising. (In the next section, the symmetry conditions are imposed during the estimation procedure.)

All the income elasticities are positive. The income elasticities for beef and pork are greater than 1.0, indicating that these food items are not necessities; only pork and poultry

³⁵Version 4.0 of TSP was employed in the regression analyses.

Table 4.1: Parameter Estimates for the Ad Hoc Double Logarithmic Demand System

Explanatory Variable	Dependent Variable*			
	Beef	Pork	Poultry	Fish
Constant	-9.666 (-5.59)	-2.201 (-1.88)	1.163 (0.56)	-9.393 (-3.49)
Income Spent on Food	1.968 (6.85)	0.748 (3.85)	0.093 (0.27)	1.630 (3.65)
Price of Beef	-0.175 (-2.03)	0.425 (7.28)	0.323 (3.09)	0.105 (0.78)
Price of Pork	0.576 (5.66)	-0.526 (-7.65)	0.422 (3.43)	-0.032 (-0.20)
Price of Poultry Products	-0.362 (-3.33)	-0.055 (-0.74)	-1.101 (-8.37)	0.466 (2.75)
Price of Fish	-0.236 (-1.48)	0.150 (1.38)	0.669 (3.46)	-0.325 (-1.31)
Price of Other Foods	-1.402 (-4.02)	-1.216 (-5.15)	-0.269 (-0.64)	-2.264 (-4.17)
R-squared	0.942	0.965	0.956	0.623

* The t-statistics for the OLS estimates are provided in parentheses.

can be considered necessities. The own-price elasticities are all negative, as required, and their values indicate that only the demand for poultry products is elastic; the demands for beef, pork and fish are all inelastic. Finally, most of the cross-price elasticities are positive, indicating that these food items are substitutes for each other. This is not true for other foods. When the price of other foods increases, less beef, pork, poultry and fish are purchased. This indicates some degree of complementarity between the consumption of meat and other food, which seems reasonable.

Formulation and Estimation of a Demand System

Model Specification

In this section, a slightly modified version of the Composite Model employed by McKenzie and Thomas (1984) is estimated. The model needed for the current study requires a functional form for the demand system which enables one to distinguish between CS, EV and CV; that is, income effects must be permitted by the functional form. Following Weymark (1980), McKenzie and Thomas begin with Roy's identity (3.4):

$$x_i = - (\delta v / \delta p_i) / (\delta v / \delta m).$$

Multiplying both sides of Roy's identity by p_i and summing over the n commodities gives:

$$\sum_i x_i p_i = - (\sum_i \delta v / \delta p_i p_i) / (\delta v / \delta m).$$

Rearranging this expression, and noting that the left-hand-side is equal to m , gives:

$$\delta v / \delta m = - (\sum_i \delta v / \delta p_i p_i) / m.$$

From Roy's identity, we also have:

$$\delta v / \delta m = - (\delta v / \delta p_i) / x_i.$$

Equating the last two expressions and rearranging gives:

$$x_i = [m(\delta v / \delta p_i)] / \sum_j (\delta v / \delta p_j) p_j. \quad (4.2)$$

Multiplying both sides by p_i and dividing by m provides an expression for the demand system in terms of the budget shares, w_i ; namely,

$$w_i = p_i (\delta v / \delta p_i) / \sum_j p_j (\delta v / \delta p_j). \quad (4.3)$$

Since the indirect utility function is homogeneous of degree zero in income and prices, so is $p_i (\delta v / \delta p_i)$.

Based on expression (4.3), it is possible to posit a variety of functional forms for the budget shares equations, as long as homogeneity is satisfied. In addition, it is necessary to impose symmetry conditions, although, by omitting the n^{th} equation in the system, the remaining requirements of consumer demand theory are satisfied. McKenzie and Thomas (1984) employ expression (4.3) to develop the following Composite Model:

$$w_i = \frac{(\gamma_i p_i^g / \sum_j \gamma_j p_j^g) + [c_i p_i / (m - \sum_j c_j p_j)] + \sum_j \beta_{ij} \ln(p_j / m)}{[m / (m - \sum_j c_j p_j)] + \sum_k \sum_j \beta_{kj} \ln(p_j / m)}, \quad (4.4)$$

where w_i refers to the i^{th} budget share and γ_j , c_j , β_{kj} ($k, j=1, \dots, n$) and g are parameters to be estimated.³⁶

³⁶ McKenzie (1983, pp. 42-44) suggests several other functional forms for expression (4.3). Attempts to estimate these functional forms and obtain realistic values for the parameters failed.

A modified form of system (4.4) is used in the current analysis. In particular, by setting $g = 0$ and $c_i = 0$ (for all $i=1, \dots, n$), one obtains the exact indirect translog function of Christensen et al. (1975); namely,

$$w_i = [\gamma_i + \sum_j \beta_{ij} \ln(p_j/m)] / [1 + \sum_k \sum_j \beta_{kj} \ln(p_j/m)] . \quad (4.5)$$

Equality restrictions imply that $\sum_{i=1}^n \beta_{ij} = \beta_{mj}$, while the symmetry restrictions imply that $\beta_{ij} = \beta_{ji}$, for all i, j . If the n^{th} equation is omitted, then $\beta_{nk} = \beta_{mk} - \sum_{i=1}^{n-1} \beta_{ik}$.

Estimation Results

As a result of data limitations, particularly because the data are aggregated for all of Canada, a three commodity demand system is estimated. The data are found in Appendix A. The three commodities include two regulated commodities, poultry and eggs, and all other food as the third commodity. (Attempts to separate dairy from the other food category failed because, as in the ad hoc specification, the empirical evidence would suggest an upward sloping demand for dairy. It appears that data problems are insurmountable.) The all food price index is used as a proxy for the price of other food. The function for other food is not estimated directly since the parameters for this equation can be calculated directly from the parameters for poultry and eggs. When equality and symmetry conditions are imposed, the budget

shares for poultry and eggs, respectively, can be written as follows:

$$w_1 = \frac{\gamma_1 + \beta_{11} \ln(p_1/m) + \beta_{21} \ln(p_2/m) + (\beta_{m1} - \beta_{11} - \beta_{21}) \ln(p_3/m)}{1 + \sum_j \beta_{mj} \ln(p_j/m)} \quad (4.6)$$

$$w_2 = \frac{\gamma_2 + \beta_{21} \ln(p_1/m) + \beta_{22} \ln(p_2/m) + (\beta_{m2} - \beta_{21} - \beta_{22}) \ln(p_3/m)}{1 + \sum_j \beta_{mj} \ln(p_j/m)}$$

Version 4.0 of TSP, with the Davidson-Fletcher-Powell method, was used to determine the FIML estimates. In order to obtain consistent results, it was necessary to restrict the parameters β_{11} and β_{22} to negative values as positive values would imply that utility declines as more of a commodity is consumed. A maximum likelihood grid search was conducted over the permissible negative values. Unfortunately, it was not possible to determine if the negativity restrictions were statistically significant.³⁷ When the composite model (4.4) with equality and symmetry restrictions was estimated, a local optimum was achieved, but the log likelihood was smaller than for the final, more restricted model (4.6). Attempts to re-estimate the full composite model using different initial starting values for the parameters failed as data singularity problems were encountered. This implied that at least one parameter in the

³⁷ Although it was not possible to estimate model (4.5) or (4.6) without encountering singularity problems (so that one parameter could not be estimated), it appears that the restrictions were significant.

model could not be estimated. The estimation results for the restricted version of system (4.5) (i.e., Equations (4.6)) are found in Table 4.3, while the elasticity matrix for this system of demand functions is found in Table 4.4.

In general, the estimated coefficients are not statistically significant. However, the elasticities obtained from this demand system are reasonable. The own-price elasticities of demand are negative; the demand for both poultry and eggs is inelastic while the demand for other foods is only slightly elastic. Poultry is not considered to be a necessity, according to the income elasticity of demand, while eggs are an inferior good.

Although the estimation results are not very good compared to those obtained from an ad hoc specification, and the grouping of commodities is less desirable than one might wish, there is one advantage which this empirically estimated demand system has over other systems which have been estimated, including the system in Table 4.1. The current system satisfies the criteria of utility maximization. Therefore, these results can be employed in welfare analysis, while the ad hoc specifications cannot rightly be used for this type of analysis. The welfare analysis is found in the next chapter.

Table 4.2: Estimation Results for the Three-Commodity Demand Model, 1960-1984 (t-values in parentheses)

γ_1	15.68 (0.59)	γ_2	-56.45 (-1.40)
β_{11}	-0.25*	β_{m1}	3.12 (0.74)
β_{21}	-1.97 (-1.23)	β_{m2}	-8.02 (-1.39)
β_{22}	-0.90*	β_{m3}	24.10 (1.88)

Log of likelihood function = 229.208

Eq. (1): Poultry

Sum of squared residuals = 0.000607

Standard error of regression = 0.004929

Eq. (2): Eggs

Sum of squared residuals = 0.000091

Standard error of regression = 0.001912

* Estimated by manual grid search procedure and then restricted to that value.

Table 4.3: Elasticity Matrix for Three-Commodity Demand System, 1981

	Poultry	Eggs	Other Food
Poultry	-.946	.185	-.484
Eggs	.996	-.614	2.727
Other Food	-.004	-.018	-1.013
Income Elasticity	1.245	-3.109	1.051

CHAPTER 5
CONSUMER WELFARE IMPACTS OF GOVERNMENT REGULATION
IN THE POULTRY AND EGG SECTORS

In this chapter, the welfare impacts of government regulation in agricultural commodities, namely, poultry products, eggs and dairy products, are calculated using several methods of measurement. These methods are briefly outlined in the next section. This is followed by the consumer welfare loss calculations. Then, the direct impact of regulation in poultry products and eggs is calculated in a general equilibrium framework, where it is assumed that demand price does not equal supply price in the third market--that the third market is distorted. Finally, alternative methods of stabilizing incomes are considered.

Welfare Measurement

The methods of measurement employed in the subsequent section are briefly discussed in this section.

(1) The naive approach relies on a linear demand function constructed from an estimate of the own-price elasticity of demand, and knowledge concerning the initial and final prices and the initial quantity. The loss in consumer surplus, which is used as a measure of welfare loss, is taken as the area under the demand line between the initial and final price of the commodity in question--that is, measurement occurs in a single market only. This is illustrated in Figure 5.1. The deadweight loss and

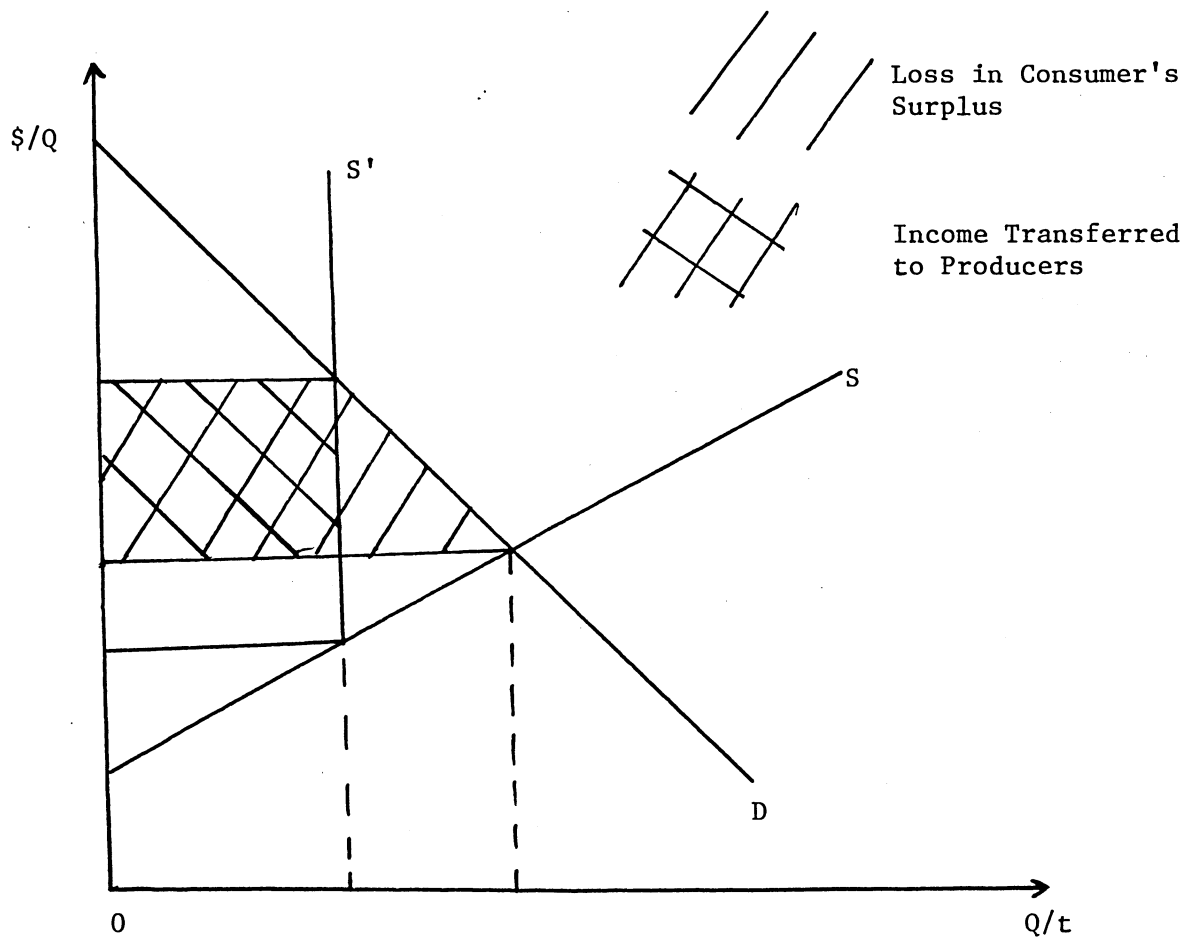


Figure 5.1: The Consumer Welfare Impacts of Supply-Restricting Marketing Boards (Single Market Framework)

income transfer are also indicated in Figure 5.1. This is the approach employed by many previous researchers.

(2) The demand functions estimated via a systems approach--that is, system (4.6) estimated in the previous chapter--are employed to calculate consumer surplus in a fashion similar to (1). CS is calculated as the area below the demand function, above the initial price and below the final price of the commodity, keeping all other prices at their initial values. Again, welfare measurement occurs within a single market only.

(3) Consumer surplus can be estimated in a multiple market framework using Equation (3.15) which is re-written here as Equation (5.1). Income is assumed to be constant in (5.1).

$$CS = - \sum_i \int_0^1 x_i(P, m) dp_i. \quad (5.1)$$

The problem is that the value of CS is dependent on the path of integration. Therefore, all possible values of this welfare measure are to be calculated.

(4) The expenditure function approach can be used to determine the values of CV and EV. Once again, measurement occurs in a multiple market framework. In this case, the expressions (3.23) and (3.25) are used to evaluate CV and EV, respectively. If income is assumed to be held constant, these can be re-written without the third-order terms as Equations (5.2) and (5.3):³⁸

³⁸Recall that the third-order terms cannot be calculated from observed data.

$$\begin{aligned}
 CV = c(P^0, U_0) - c(P^1, U_0) &\approx - \sum_i x_i c_i(P^0, U_0) \Delta p_i \\
 &- 1/2 \sum_i \sum_j s_{ij}(P^0, U_0) \Delta p_i \Delta p_j.
 \end{aligned} \tag{5.2}$$

$$\begin{aligned}
 EV = c(P^0, U_1) - c(P^1, U_1) \\
 \approx \sum_i x_i c_i(P^1, U_1) \Delta p_i + 1/2 \sum_i \sum_j s_{ij}(P^1, U_1) \Delta p_i \Delta p_j.
 \end{aligned} \tag{5.3}$$

(5) McKenzie's exact welfare measure is based on his money metric Y . A measure of EV based on the money metric Y can be used to measure consumer welfare change in a multiple market framework. The measure which is used in this report is expression (3.31) which assumes that income is held constant. This welfare measure is re-produced as Equation (5.4).

$$\begin{aligned}
 EV \approx \sum_i -x_i \Delta p_i + 1/2 \sum_i \sum_j [x_i (\delta x_j / \delta m) - \delta x_i / \delta p_j] \Delta p_i \Delta p_j \\
 + 1/6 \sum_i \sum_j \sum_k \left[\frac{\delta x_i}{\delta p_j} \frac{\delta x_k}{\delta m} + \frac{\delta x_i}{\delta p_k} \frac{\delta x_j}{\delta m} - \frac{\delta^2 x_i}{\delta p_j \delta p_k} \right. \\
 \left. + x_i \left(\frac{\delta^2 x_j}{\delta p_k \delta m} - \frac{\delta x_j}{\delta m} \frac{\delta x_k}{\delta m} - x_j \frac{\delta^2 x_k}{\delta m^2} \right) \right] \Delta p_i \Delta p_j \Delta p_k \tag{5.4}
 \end{aligned}$$

(6) It is possible to employ expression (5.4), but allow prices to change by small increments. In the analysis below, prices are incremented (i) by one percent intervals and (ii) by one-tenth of one percent intervals in adjusting price from the initial situation 0 to the final situation 1.

(7) Finally, rather than considering supply restrictions to occur simultaneously in all three sectors, the welfare impacts of restrictions in poultry products and eggs are considered. It is

assumed that a distortion due to supply restriction exists in the third market. Therefore, as shown below, the measurement of the consumer welfare impacts of government intervention in poultry products and eggs must also occur in the third (distorted) market. This is a general equilibrium approach to welfare measurement.

Consumer Welfare Loss Calculations

The estimated demand functions are used to determine the loss in consumer welfare due to the establishment of marketing boards in poultry, eggs and dairy. Since the demand system and the welfare methodology are static in nature, actual dates are essentially unimportant to the analysis. As indicated in Chapter 2, the 1972 Farm Products Marketing Agencies Act put an effective end to inter-provincial price wars in poultry and eggs, although some of the actual national institutions were not in place until later. Hence, it is assumed that the 1972 prices are the competitive prices, whereas the 1973 prices are assumed to be the quantity restricting prices. The impact of the national marketing boards is taken to increase the prices of poultry products by 22.2 percent, and the prices of eggs by 33.9 percent. For comparison, Veeman (1982a) found regulated prices of poultry products and eggs to be 14.5 percent and 14.3 percent, respectively, above the unregulated domestic price, but 28.9 percent and 47.1 percent, respectively, above the U.S. price. Harling and Thompson (1983) found the distorted wholesale market

prices to be 42.0 percent and 36.4 percent higher than the undistorted wholesale prices in poultry products and eggs, respectively, for the period 1975-1977.

In addition to the increases in the prices of poultry products and eggs, marketing boards in dairy also caused prices to rise above the competitive price. However, as indicated in Chapter 2, it is difficult to determine the difference between the competitive price and supply-restricted price of dairy products; the marketing board influenced the rate of change in dairy prices in addition to causing an immediate price impact between 1965 and 1966 (the year the CDC was established). For the purpose of this study, and given that the demand for dairy products could not be estimated separately,³⁹ the following assumptions are made:

- (i) supply-restrictions in the dairy industry resulted in prices which are 12 percent above competitive prices; and
- (ii) the impact of this distortion caused the prices of all other food (that is, excluding poultry and eggs) to be 1.8 percent above their competitive level.⁴⁰

In conclusion, it is assumed that the initial or competitive

³⁹One reason why the demand for dairy could not be determined separately was that supply was regulated in this sector for 18 of the 24 years for which data was available.

⁴⁰The all food price index is used as a proxy for the price of other food in the estimation of the demand system. Based on food expenditures derived from the data in Appendix A, dairy expenditures constitute approximately 15 percent of total expenditures on food. Therefore, it is assumed that a 12 percent increase in dairy prices causes a 1.8 percent increase in the price of other food.

prices are \$2.702/kg eviscerated weight for poultry, \$1.304/kg fresh equivalent for eggs, and \$0.837/kg retail weight for other foods. These are the 1972 prices. Although the CDC was already formed in 1966, for convenience it is assumed that the distortions in dairy are summarized in a 12 percent price impact occurring between 1972 and 1973. However, as already mentioned, since the model is essentially static, the actual date chosen is unimportant. The only data which are important are the prices chosen to represent the competitive levels and those chosen to represent the supply-restricted price. The associated quantities are obtained from the respective demand functions which have been estimated. The value of income (m) used in the welfare analysis is the real expenditure on food; it is held constant at \$1,019.09.

Firstly, the own-price elasticities of demand for poultry, eggs and other food are $-.9443$, $-.6461$ and -1.1013 , respectively, when calculated for the year 1972, using quantity data from the estimated demand functions. These elasticities, rather than those in Table 4.3, are used to construct a linear demand curve for each of poultry products, eggs and other foods. The loss in consumer welfare is then calculated as the area under the demand line, below the regulated price and above the competitive price. In 1981 dollars, the annual loss in consumer surplus is equal to \$11.44 per person for poultry products, \$4.95 per person for eggs, and \$16.18 per person for other food (Table 5.1). These figures translate into a total annual loss in the consumer

welfare of Canadians of \$251.7 million, \$109.0 million and \$356.0 million in poultry, eggs and other food (or dairy), respectively. For comparison purposes, Veeman (1982a) calculates the annual loss to consumers of regulation in poultry and eggs to be \$215.3 million and 107.7 million, respectively, in 1979.⁴¹ Harling and Thompson (1983) indicate that the consumer costs from policy distortions in the poultry, eggs and other food sectors are about \$215.8 million, \$99.6 million and \$83.0 million, respectively.⁴² Schmitz (1983) indicates that the consumer surplus loss due to regulation in dairy is \$980 million annually. Secondly, we calculate the change in CS as an area under the estimated demand curve in each market using Simpson's rule (Burden et al. 1978, pp. 192-97). As indicated in Table 5.1, these results are not too different from those obtained using the naive approach.

In this study, it was assumed that regulation in dairy led to a 1.8 percent increase in the price of other foods. The resulting loss in consumer welfares in the other food market accounts for about 50 percent of the total loss to consumers. If an alternative assumption is made regarding the impact of regulation in dairy on the price of other food (e.g., greater impact), the results reported for the poultry and egg markets will remain unaffected.

Thirdly, estimates of consumer surplus are derived from

⁴¹Veeman uses the U.S. price as the perfectly competitive price and her figures are for 1979.

⁴²Included in other food are beef, pork and potatoes, but not dairy products, while the data are for 1974-75.

Table 5.1: Estimated Losses in Consumer Surplus Due to Government Intervention via Supply-Restricting Marketing Boards in Canada.

Item	Consumer Welfare Loss
<u>Consumer Surplus</u>	(\$ per person per year)
Single Market Framework	
Naive (linear, extrapolated demand)	
Poultry	11.44
Eggs	4.95
Other Food	16.77
Sum	<u>33.16</u>
Actual (estimated demand)	
Poultry	11.76
Eggs	5.10
Other Food	16.78
Sum	<u>33.64</u>
Multiple Market Framework (Eq. (5.1))	
Order of price changes*	
P-E-0	34.18
P-0-E	34.40
E-P-0	33.85
E-0-P	33.91
0-P-E	34.44
0-E-P	34.22
<u>Expenditure Function Approach</u>	
Compensating Variation (Eq.(5.2))	34.47
Equivalent Variation (Eq. (5.3))	32.39
<u>McKenzie's Exact Welfare Measure EV (Eq.(5.4))</u>	
Single increment (100% change)	33.82
100 increments (1% change in each)	34.16
1,000 increments (1/10% change in each)	34.17

* P refers to poultry, E to eggs and 0 to other food.

expression (5.1). Since path dependency is a problem and three prices change, there are six different values for CS. These are presented in Table 5.1. Fourthly, using the expenditure function approach, CV and EV are calculated from expressions (5.2) and (5.3), respectively. Fifthly, we employ expression (5.4) to calculate McKenzie's exact welfare measure EV. Each of the latter three values is also presented in Table 5.1. Finally, we employ an iterative version of expression (5.4). We increment prices (1) by one percent and (2) by 1/10 of one percent at each increment, calculate EV, and input the new prices into the expression; the sums of the incremented EVs are found in the last two lines of Table 5.1 and they provide accurate measures of consumer welfare. In this way, shifts in demand caused by changes in the prices of other goods are taken into account.

The mathematical manipulation language MAPLE (Geddes et al. 1983), which was developed at the University of Waterloo, was used to make the actual calculations. The advantage of this computer package is that it enables the user to program the required Equations (5.2), (5.3) and (5.4) directly. The complex calculations, including symbolic and numerical differentiation, are done automatically. MAPLE was also used in calculating the consumer surplus as an area under the estimated (nonlinear) demand functions--that is, expression (5.1). However, the complexity of the calculations prevented direct numerical integration and Simpson's rule was employed. An example of the MAPLE program used to make the calculations from expression (5.4)

is found in Appendix C, while other information needed for making the welfare evaluations is found in Appendix D.

The results indicate that the use of a linear demand curve provides estimates of consumer surplus which are roughly equal to those obtained from the estimated, nonlinear function, at least in a single market framework. The sum of the CS estimates obtained in (naive or actual) single markets is approximately equal to the consumer surplus estimates obtained in a multiple market framework. The order in which the price changes are taken does not seem to matter much in the calculation of consumer surplus. All of the consumer surplus measures fall between the measures of EV and CV obtained via the expenditure function approach. Therefore, one must conclude that consumer surplus is a valid approximation of the true change in welfare, at least in this study. CS provides a good approximation even if the estimates are obtained in a single market using a linear rather than the true demand curve.

The estimate of welfare loss obtained from McKenzie's exact welfare measure lies between EV and CV calculated by the expenditure function approach. Perhaps, McKenzie's money metric approach provides a more accurate measure of welfare changes. Further, the accuracy of this measure can be enhanced by incrementing the price changes in going from the initial to the final set of prices.⁴³ This permits cross market price effects.

⁴³To increment price changes by one-tenth of one percent at a time in Equation (5.4) required 4 hours, 59 minutes and 31.1 seconds of cpu time, using the version of MAPLE available at the

The loss in consumer welfare when \$1 is transferred to producers in the poultry, egg and dairy sectors can be determined by dividing the total loss in consumer welfare by the amount transferred to producers. The income transfer is determined by multiplying the amount of the price increase in each market by the restricted quantity. The restricted quantity is determined directly from the relevant demand function. In the single market frameworks, the restricted quantity is determined by keeping the prices of the other commodities at their original levels. For the multiple markets, it is determined (i) by keeping other prices at their initial levels and (ii) by setting all prices at their final levels. The amount of the transfers is found in Table D.2 of the Appendix, while the welfare losses from transferring \$1 to producers under the various schemes are presented in Table 5.2.

While Van Kooten and Spriggs (1984), using data from Veeman (1982a), estimate that the cost of transferring \$1 to producers is \$.08 for poultry and \$.02 for eggs when a single market framework is employed, similar transfer costs obtained using the data in this study indicate that the transfer costs are about \$.11 for both poultry and eggs. Harling and Thompson (1985) obtained transfer costs of \$.25-\$.43 for poultry and \$.03-\$.18 for eggs using a single market framework, although their approach to measurement was different.

time this study was conducted.

Table 5.2: The Cost of Transferring \$1 to Agricultural Producers in Canada as a Result of Regulation in Eggs, Poultry, and Dairy with No Distortions Elsewhere

Item	Consumer Welfare Loss	
	Transfer to Producers Calculated from Restricted Quantity with Other Prices at	
	Initial Level	Final Level
<u>Single Market Framework</u>		(\$1981)
Consumer Surplus		
Naive Demand		
Poultry	1.133	N.A.
Eggs	1.141	N.A.
Other Food	1.010	N.A.
Actual (Estimated Demand)		
Poultry	1.112	1.062
Eggs	1.115	0.922
Other food	1.009	1.018
<u>General Equilibrium Framework</u>		
Consumer Surplus [*]	1.075	1.033
Expenditure Function Approach		
Compensating Variation	1.084	1.042
Equivalent Variation	1.019	0.979
McKenzie's Exact Welfare Measure EV		
Single increment	1.064	1.022
100 increments	1.032	1.032
1,000 increments	1.075	1.033

* The average of the six CS measures in Table 5.2 is used; this average is equal to \$34.17 per person.

N.A. not applicable

It is apparent from Table 5.2 that measurements of the costs of government regulation in Canadian agriculture can be evaluated using a single market framework. The transfer costs are between \$1.02 and \$1.08 when a multiple market framework is employed; that is, for every dollar transferred to producers, consumers lose about \$1.05. Indeed, as has been suggested elsewhere (Johnson et al. 1982; Schmitz 1983), complementarity may lead to a consumer loss of less than \$1 for every dollar transferred to producers--that is, there is a net gain in social welfare due to marketing boards. This appears to be a possibility, given the data in this study, since poultry is complementary in consumption with other food in the demand system (see Table 4.3).

The current study provides empirical evidence for the use of consumer surplus as an approximation to the true measures of consumer welfare, EV and CV. Indeed, CS estimates obtained from a linear demand curve constructed on the basis of elasticity of demand estimates may be reasonable approximations of consumer welfare for public policy purposes. McKenzie's exact measure of welfare falls between the approximations to EV and CV obtained from the expenditure function approach. Hence, it may be the appropriate and true measure of welfare change, as McKenzie (1983) argues.

Estimating the Direct Cost of the 1972 Farm Products Marketing Agencies Act

In the preceding sections, the feasibility of employing consumer surplus measures, obtained from an estimated demand

function and calculated in a single market, as an approximation of the true welfare loss to consumers from supply-restricting marketing boards was demonstrated. However, in the earlier analysis, it was assumed that the marketing boards in poultry products, eggs and dairy products all came into existence at the same time, namely, beginning in 1973. While the evidence in Chapter 2 suggests that this was true for eggs and poultry products, it was not the case for dairy. Therefore, in this section, a general equilibrium approach is used to find the direct consumer welfare impacts of government regulation in eggs and poultry products. In particular, this simulates the welfare losses resulting from the 1972 FPMA Act. The emphasis here is on appropriate methodology.

Methodology

The approach is to examine welfare changes in poultry products and eggs in the same fashion as previously. Indeed, since the real prices of poultry products and eggs are still assumed to increase by 22.2 and 33.9 percent, respectively, the values of welfare losses found in Table 5.1 still apply. However, since distortions exist in the market for other foods (due to supply restrictions in dairy and, undoubtedly, other government programs in agriculture), it is necessary to measure the welfare impact in this third market.

The theoretical framework is illustrated via Figure 5.2. In Figure 5.2, we assume that there are three markets. The market

which is impacted by government supported supply restrictions is indicated in panel (a). The second market (panel (b)) is distorted in the sense that, for whatever reason (e.g., existence of a marketing board), price is above marginal cost. The third market is required simply to absorb changes in income, but serves no purpose other than an accounting one. Hence, in our situation, market (a) represents the egg and poultry sectors which were affected by the 1972 Farm Products Marketing Agencies Act, market (b) represents the market for other food, and market (c) represents all other (non-food) commodities.

In Figure 5.2, it is assumed that the supply curves for the three commodities are all perfectly elastic. In market (a), government policy causes a shift of the supply curve from S_1 to S_1' , with the supply restricted quantity set at x_1^R . The price of x_1 increases from p_C to p_R as a result of government intervention. Assuming that x_1 and x_2 are substitutes, the demand curve for x_2 shifts from D_2^0 to D_2' and consumers increase purchases of x_2 from x_2^0 to x_2' . If it is assumed that the price distortion in market (b) remains equal to the distance ab , then area $(abcd)$ in market (b) is a cost of restricting supply in market (a) (see Harberger 1971).⁴⁴ Hence, the total cost of restricting supply in market (a) is equal to area $(p_C f g p_R + fgk)$ in panel (a) plus area $(abcd)$ in panel (b). Area $(p_C f g p_R)$ is a transfer to producers, but areas (fgk) and $(abcd)$ are an

⁴⁴If goods x_1 and x_2 were complements, then there would be a measurable gain in welfare in market (b) given by the height of the distortion times the reduction in quantity purchased.

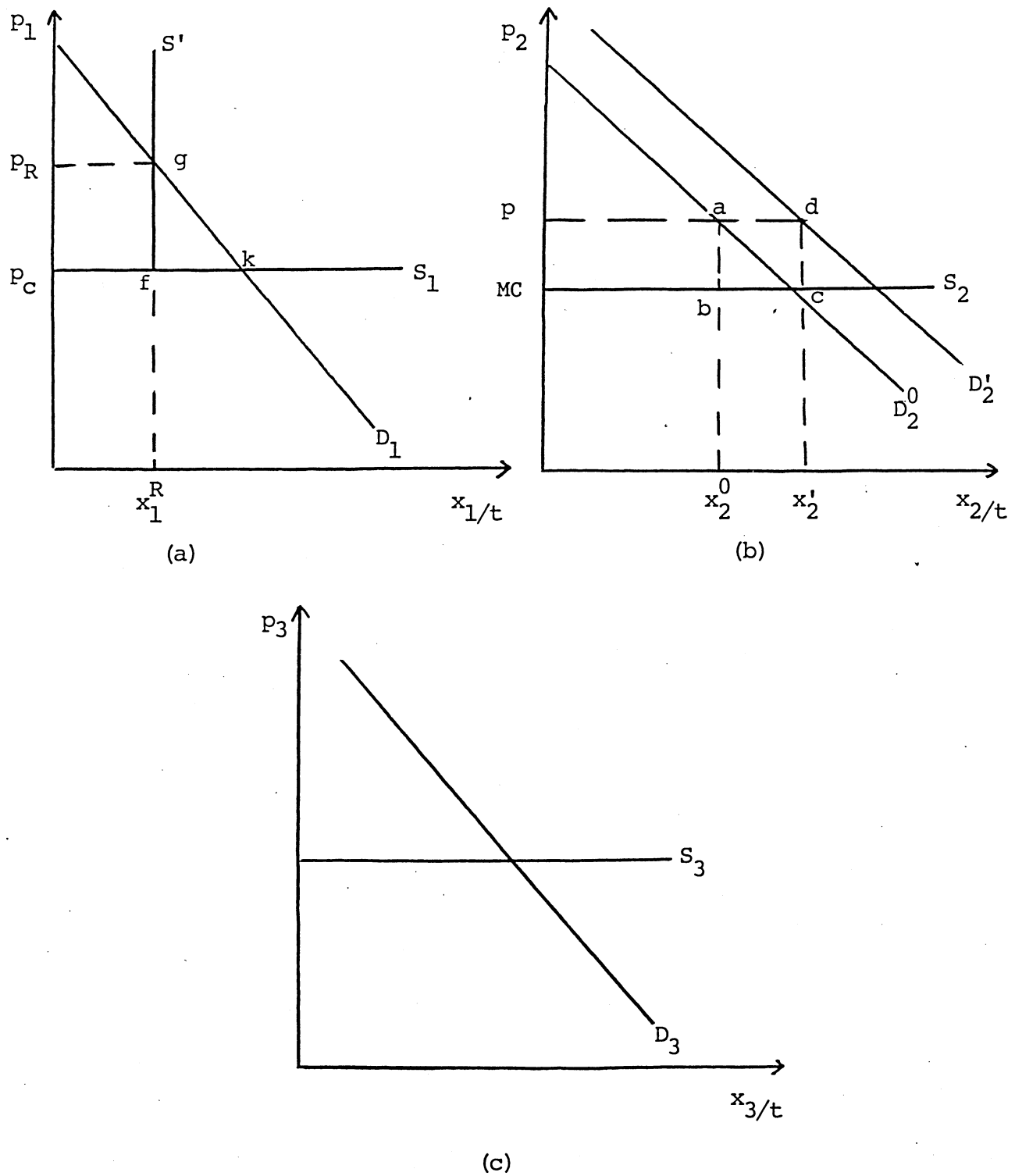


Figure 5.2: Welfare Measurement in a General Equilibrium Setting

irretrievable loss to society. The increase in the price of x_1 may also shift the demand curve in market (c), with the direction of any shift depending on whether x_1 and x_3 are complements, substitutes or independent goods; but there is no welfare loss or gain measurable in that market (Harberger 1971).

Empirical Estimates

Now we want to recast the previous problem in the new framework. That is, we wish to investigate only the costs associated with the 1972 FPMA Act in a general equilibrium framework, given that a distortion exists in the dairy sector. The welfare loss to consumers as measured in the markets for eggs and poultry products--the equivalent of area $(p_c f g p_R + f g k)$ --has already been calculated, and is reproduced in Table 5.3. Recognizing that the market for other food is distorted, we need to measure the cost of the 1972 legislation in this market. For this purpose, we make some simplifying assumptions. Firstly, it is assumed that the magnitude of the distortion is 1.8 percent; that is, we assume that price exceeds marginal cost by 1.8 percent.⁴⁵ Secondly, the empirical estimates of cross-price elasticities from Table 4.3 are used to make one estimate of the welfare change in the other food market. Finally, since empirical data on the cross-price elasticities for other food with respect to eggs and poultry products are non-existent, a

⁴⁵As before, this implies that the market price is \$0.852/kg, while marginal cost price is \$0.837 (see Appendix D).

Table 5.3: Estimated Losses in Consumer Surplus and the Costs of Transferring \$1 to Agricultural Producers in the Poultry and Egg Sectors, Canada

	Scenario Regarding the Values of the Cross-Price Elasticities of Demand				
	1	2	3	4	5
Change in Consumer Welfare (\$/person/year)					
Poultry products	-11.76	-11.76	-11.76	-11.76	-11.76
Eggs	-5.10	-5.10	-5.10	-5.10	-5.10
Other food	-13.84	-4.75	-0.95	0.95	4.75
Total	-30.70	-21.61	-17.81	-15.91	-12.11
Size of Transfer to Producers (\$/person/year)	15.15	15.15	15.15	15.15	15.15
Cost to Consumers of Transferring \$1 to Producers (\$)	2.026	1.426	1.175	1.050	0.799

Source: Appendix D

number of assumptions regarding these cross-price elasticities are made. The results are presented in Table 5.3

The consumer welfare costs calculated in the market for other food (the distorted market) are quite large when the cross-elasticities of demand estimated in the previous chapter (Table 4.3) are employed. The result is a net annual consumer loss of \$30.70/person and a loss to consumers of \$2.03 for each \$1 transferred to producers (Scenario 1). That is, the cost of transferring one dollar to producers is \$1.03, which is a measure of the deadweight loss due to allocative inefficiency. However, the cross-price elasticity between eggs and other food ($e_{EO} = 2.727$) seems excessively high for this case. Therefore, Scenarios 2 to 5 are based on alternative assumptions about the cross-price elasticities, and these are found in Table D.3 of the Appendix.

Scenarios 2 and 3 assume that other food is a substitute for both poultry products and eggs; in Scenario 2 the degree of substitutability is greater than for case 3. In Scenarios 4 and 5, both poultry and eggs are assumed to be complementary with other food, with the extent of complementarity higher in case 5.⁴⁶ The results indicate that, as the degree of substitutability declines, the loss in consumer welfare due to the 1972 FPMA Act also declines. Hence, the cost of transferring income to producers declines from \$0.43 to \$0.18 as the outward shift in the demand for other food due to price increases in poultry and

⁴⁶ Complementarity was found by Andrikopoulos et al. (1984).

eggs is reduced. Complementarity reduces the cost even more since the demand for other food shifts to the left as poultry and egg prices rise. This reduces the cost of the distortion in the other food market since less is purchased. Indeed, if the degree of complementarity is sufficiently high, then the savings in the other food market may be large enough to provide a net welfare gain from the introduction of marketing boards in poultry and eggs. This is indicated by case 5 where consumers only lose \$0.80 for every \$1 transferred to producers.

Alternative Methods of Stabilizing Agricultural Incomes:

Measuring the Consumer Welfare Costs

Since the costs of transferring income from general consumers to agricultural producers is probably higher than desirable, alternative means of making such income transfers, and thereby stabilizing producer incomes, should be considered. In this section, several alternative stabilization schemes are considered. The welfare implications of each scheme relative to the supply-restricting stabilization mechanism will be examined.

Income Transfers

The least cost approach to income stabilization in the poultry and egg sectors is a system of income transfers from general taxpayers to agricultural producers. At one extreme, the government could simply guarantee producers a particular rate of return on their investment or a certain level of income, and let

the market determine price and quantity. If the target rate of return or income level is not attained by a producer, then the public authority simply provides the producer with a lump-sum payment to make up the difference. The major problems with this scheme are that (1) it may be subject to abuse and (2) it may not be politically acceptable.

Alternatively, insurance schemes similar to those which currently exist in grains (e.g., Western Grain Stabilization Program), hogs (e.g., Saskatchewan Hog Assured Returns Program) and beef (e.g., the proposed Beef Stabilization Program) can be used to stabilize producers' incomes and reduce uncertainty. These insurance programs are voluntary and producers are required to contribute to the costs of the programs, albeit only a relatively small proportion.⁴⁷ The insurance programs are subsidized by the federal or provincial governments and, therefore, constitute a transfer payment from general taxpayers to agricultural producers. The advantage of this scheme over the simple income transfer is that the market is permitted to operate, providing incentives to minimize costs and signals regarding when to enter or exit the industry. No impediments to entry or exit exist. The insurance mechanism usually guarantees an income level equal to the average level of net income over the past five (or ten) years.

⁴⁷For a discussion of the Western Grain Stabilization Program and its operation see Koroluk (1985).

It is difficult to determine the welfare costs of such an income stabilizing scheme. This depends on frequency of payouts and the inherent stability (or instability) of the industry in the long run. Research beyond the scope of this report will be required to determine the long-run situation in each industry. If the size of income transfers is no larger than those which occur under the current system, the costs of the program will be smaller as there is no consumer deadweight loss in the relevant market. The main advantage of the simple income transfer scheme is that the income transfers are from taxpayers to producers instead of from consumers to producers. Since the tax system tends to be progressive, a change from a quota mechanism to a simple transfer mechanism results in a redistribution of income toward the poor.

Commodity Price Stabilization

Van Kooten and Schmitz (1985) indicate that, when price instability is the result of vagaries in either supply or demand, social welfare can be enhanced through a program of commodity storage.⁴⁸ If instability is due solely to variability in supply (for reasons such as weather), then producers gain from stability while consumers lose; however, the gain to producers is greater than the loss to consumers. If instability is the result of demand variability and supply is non-random, then consumers gain

⁴⁸The actual costs of storage have not been taken into account in calculating the welfare impacts.

while producers are as well off as before; in this case, commodity price stabilization is Pareto Optimal. Unfortunately, the forgoing results rely on symmetric price variability and nonperishable commodities, and neither of these conditions is likely to be encountered in practice. Further, the results are valid only when the analysis is conducted in a single market framework because Van Kooten and Schmitz rely on CS as the valid measure of welfare. Hence, this scheme for stabilizing incomes in the dairy, poultry, and egg sectors is unlikely to be successful.

Price Supports

Price supports are the most common form of subsidy to agricultural producers in the United States and the European Economic Community (EEC). The support price is generally set above the competitive price. Harvey and Hubbard (1984) urge the implementation of a system of saleable quotas, with the supply restricted to the quantity which will clear the market at the support price. This will increase the welfare of society as can be illustrated with the aid of Figure 5.3.

At the competitive price P_c an amount Q_c is produced and sold; at the support price P_s an amount equal to Q_s is supplied. The loss to consumers under a support price is identical to the loss which would occur under a quota system where supply is restricted to an amount Q_m . However, the government must purchase the excess supply and "dump" it on the export market.

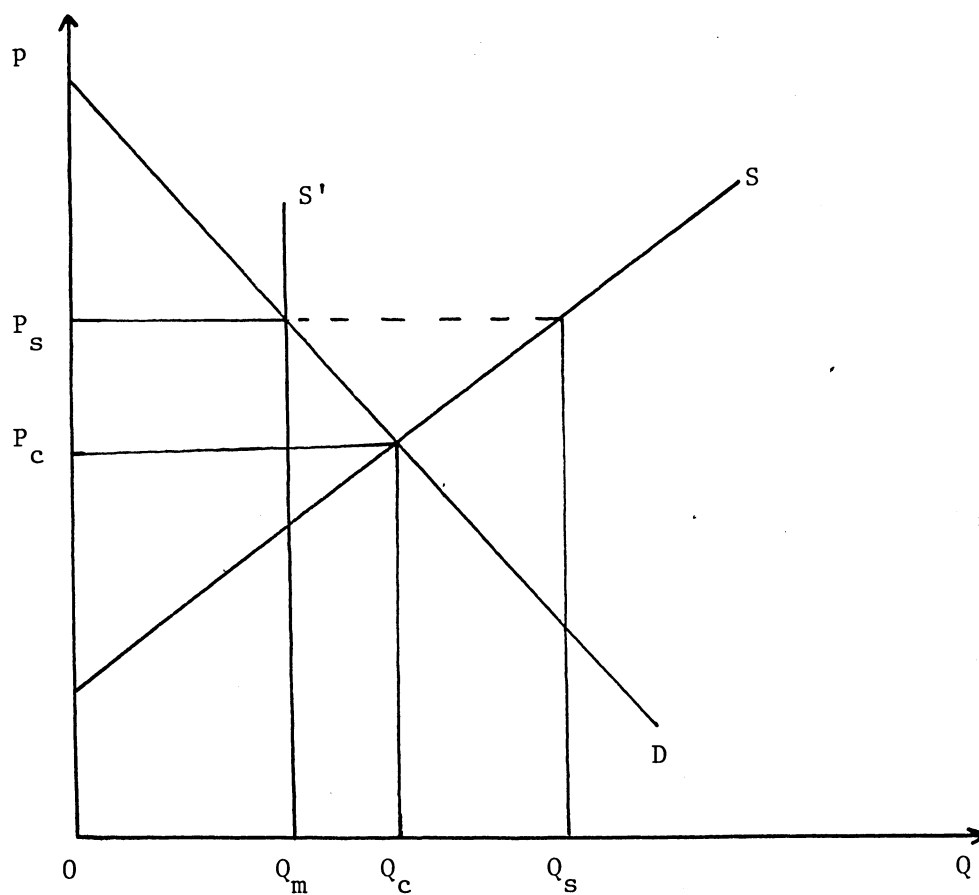


Figure 5.3: Employing a Quota System to Reduce Welfare Costs of Regulation in the EEC.

If the export price is equal to the competitive price, then the cost to the government is equal to $(Q_s - Q_m)$ times $(P_s - P_c)$. Since this cost can be avoided through a supply-restricting mechanism, a quota system is preferred to a support price.

Buy-Only Quota

An intriguing proposal put forward by the Quota Transfer Committee of the Christian Farmers' Federation of Ontario in 1983 was subsequently rejected by the Federation's executive committee. The proposal establishes a mechanism for retaining the stability benefits of controlled supply (such as reduced uncertainty), but also provides potential entrants with ready access to quota. In addition, the buy-only quota proposal avoids the problem that any adjustments in the industry get capitalized into the value of the quota, or some other asset such as buildings. That is, those owning quota when a price increase occurs or when there is a technological advance are able to capitalize the benefits of such developments into the value of their quota. Under the buy-only scheme, all producers would be required to return their quota to the marketing agency when they left the business (e.g., retired).⁴⁹

The proposal also seeks to address another problem. Original quota owners capture much of the windfall from the establishment of a marketing board, while subsequent owners are

⁴⁹ Producers required to quit the industry within a certain period of time (e.g., ten years) would receive some compensation for quota returned to the marketing board.

saddled with the added cost of production resulting from the need to purchase quota. This benefit is lost if producers are no longer able to sell their quota. Hence, this proposal results in a loss, not only to those quota owners who received the initial windfall, but also to those who subsequently purchased quota and may or may not have received a windfall. Obvious, these issues are distributional in nature and need to be addressed from an equity standpoint if a buy-only scheme is implemented.

The buy-only proposal will not affect the results obtained in this study, unless it can be demonstrated that agricultural producers can receive the same income stabilizing benefits at lower prices and higher output. However, it is the distributional consequences of the proposal which need to be investigated further. These benefits may well make the proposal worth further study. However, it should be noted that the CFFO eventually rejected the proposal because there are problems with inter-generational transfers (i.e., from father to son).

CHAPTER 6

SUMMARY AND CONCLUSIONS

The prime purpose of this report was to investigate the consumer welfare impacts of national marketing boards in certain sectors of Canadian agriculture. In particular, the purpose was to investigate measures of consumer welfare in a general equilibrium setting, rather than in the single market framework employed by previous researchers. To some extent, this task has been accomplished. While a method for obtaining better welfare measures has been implemented, the resulting estimates of consumer welfare losses need to be qualified. This is because the aggregate Canadian consumption data do not permit estimation of an appropriate demand system. Hence, estimates of cross-price elasticities of demand obtained in this report, as well as those obtained by other researchers, are not sufficiently reliable to employ in the type of analysis presented here.

Summary

The 1972 Farm Products Marketing Agencies Act established supply-restricting marketing boards in the poultry and egg sectors of the agricultural economy. The supply of dairy products was controlled prior to that by legislation establishing the Canadian Dairy Commission in 1966. Previous studies employed a single market framework to investigate the loss in allocative efficiency due to this form of regulation. In this study, the measurement of consumer welfare losses takes place in a multiple

market or general equilibrium environment, and this is compared to measurement within a single market. Since the demand model is essentially static, it was first assumed that all three marketing boards came into existence at the same time. The consumer surplus measure of welfare was calculated in several ways, and these were compared to each other and to the true measures of welfare change, namely, compensating and equivalent variation. The results indicate that CS calculated in a single market, and using a linear approximation to the true demand curve, is a relatively good measure of the true change in welfare.

Next, it was assumed that marketing boards in poultry and eggs came into existence after the CDC, that is, in 1973 as a direct consequence of the FPMA Act of 1972. Therefore, a market distortion (price to marginal cost ratio of 1.018) was assumed to exist in the market for all other food. In this situation, welfare changes in the distorted market had to be added to the losses in consumer welfare in the poultry and egg markets resulting from regulation in these two markets. The welfare impact in the other food market is significant in this study. Indeed, for the data in this study, the results indicate that, for every dollar transferred to producers, consumers lose about \$2. However, this result is sensitive to the estimates of cross-price elasticities. Indeed, if a relatively high degree of complementarity is assumed (as opposed to substitutability), it is possible to generate welfare gains in the previously distorted market which exceed the losses

in the market currently being regulated.

Conclusions

After investigating several methods for measuring the consumer welfare impacts of government regulation, several conclusions can be drawn.

- (1) Welfare measurement should be conducted in a general equilibrium framework rather than considering one market at a time, as has been done in the past. This is true because distortions exist in markets other than those impacted by a particular policy.
- (2) Compensating and equivalent variation measures of consumer welfare can easily be calculated given the availability of a system of demand functions. With the aid of a computer package, such as MAPLE, it is relatively easy to compute welfare measures from formulae such as expressions (5.1) to (5.4). The major obstacle to making such calculations is the lack of consistent estimates for systems of demand equations. Although the current study provides empirical evidence for the use of consumer surplus as an approximation to the true measures of consumer welfare (EV and CV), CS is not a welfare measure and should be avoided whenever this is possible. However, for public policy purposes, it appears that CS may be a good approximation of the true consumer welfare measures. Indeed, data from this study indicate that CS measures obtained as the area under a linear demand

curve constructed on the basis of elasticity of demand estimates may be reasonable approximations of consumer welfare.

- (3) McKenzie's exact measure of welfare was found to provide a measure of welfare (EV) which falls between the CV and EV values calculated by the expenditure function approach. Further study is required to determine if this is always the case.

Finally, it is necessary to make one recommendation. If serious policy analysis is to be conducted, it will be necessary to make calculations such as those found in this report. One recommendation which seems to follow from this study is that it is necessary to reconsider the system of supply-restricting marketing boards in Canadian agriculture, given that there may be large costs of transferring income. However, this recommendation depends on the reliability of the estimates of the demand system and the assumption made concerning the impact of marketing boards on the prices of other agricultural commodities. Since both the functional form and subsequent parameter estimates are questionable, it is imperative for government to collect the types of data which will provide reliable estimates of demand. This will require the collection and analysis of detailed panel data. It is recommended, therefore, that the government collect panel data on consumer expenditures and that this data be made available to researchers in demand and public policy (welfare) analysis.

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APPENDIX A

FOOD CONSUMPTION AND PRICE DATA

APPENDIX A

FOOD CONSUMPTION AND PRICE DATA

Table A1: Personal Disposable Income, Expenditure on Food, All Items, Food and Non-Food Consumer Price Indexes, and Population, Canada, 1960-1984.

YEAR	PERSONAL PER CAPITA DISPOSABLE INCOME (\$)	PER CAPITA EXPENDITURE ON FOOD (\$)	CONSUMER PRICE INDEX (1981 = 100)			POPULATION ('000s)
			ALL ITEMS	NON-FOOD	FOOD	
1960	1,487	267.26	31.4	33.8	25.8	17,870
1961	1,475	263.79	31.7	34.0	26.2	18,238
1962	1,579	269.55	32.0	34.3	26.7	18,583
1963	1,646	277.69	32.6	34.7	27.5	18,931
1964	1,713	288.44	33.2	35.4	28.0	19,291
1965	1,846	299.58	34.0	36.2	28.7	19,644
1966	1,994	313.46	35.2	37.2	30.6	20,015
1967	2,116	326.09	36.5	38.9	31.0	20,378
1968	2,262	334.52	38.0	40.6	32.0	20,701
1969	2,424	354.51	39.7	42.4	33.3	21,001
1970	2,536	372.02	41.0	44.0	34.1	21,297
1971	2,779	396.58	42.2	45.6	34.4	21,568
1972	3,121	435.31	44.2	47.3	37.0	21,801
1973	3,608	501.38	47.6	49.7	42.4	22,043
1974	4,212	576.32	52.8	54.0	49.4	22,364
1975	4,868	666.93	58.5	59.5	55.8	22,697
1976	5,450	713.96	62.9	65.1	57.3	22,993
1977	5,943	767.89	67.9	70.2	62.0	23,273
1978	6,636	851.04	73.9	74.7	71.6	23,517
1979	7,410	946.44	80.7	80.6	81.1	23,747
1980	8,308	1,068.77	88.9	88.7	89.8	24,043
1981	9,587	1,197.29	100.0	100.0	100.0	24,342
1982	10,391	1,242.58	110.8	111.8	107.2	24,632
1983	10,852	1,293.74	117.2	119.0	111.2	24,885
1984	11,544	1,365.17	121.4	123.8	117.4	25,124

Table A2: Price Indexes for Selected Food Categories, Canada, 1960-1984

PRICE INDEX (1981 = 100)								
YEAR	DAIRY PRODUCTS	CEREALS	FATS & OILS	POULTRY	FISH	RED MEAT	EGGS	FRUITS & VEG- TABLES
1960	27.0	25.1	34.0	33.6	16.8	25.5	41.9	23.4
1961	26.8	25.4	36.4	30.2	17.5	26.5	43.2	23.9
1962	26.1	26.0	35.8	30.9	18.0	28.2	40.9	24.8
1963	26.0	27.2	35.1	31.7	18.4	27.9	44.9	26.2
1964	26.8	28.5	36.0	30.2	18.6	27.2	39.0	27.0
1965	27.5	28.7	39.4	31.1	19.5	28.8	41.7	27.9
1966	29.5	29.4	41.2	33.6	21.4	32.4	49.3	28.0
1967	31.4	29.9	40.4	32.2	21.8	32.2	41.6	27.7
1968	32.6	30.5	38.9	33.1	22.2	32.4	42.8	30.6
1969	33.8	30.9	38.4	33.0	23.8	35.3	47.5	29.9
1970	34.1	31.6	40.2	32.0	26.4	36.0	42.8	30.3
1971	35.4	32.3	41.0	32.9	27.5	34.7	37.8	31.2
1972	37.4	33.4	41.4	37.7	31.6	39.1	41.0	33.4
1973	40.1	36.6	43.6	49.6	38.9	48.0	59.1	39.5
1974	45.7	45.5	63.6	56.3	48.3	51.5	65.4	44.9
1975	57.8	53.7	75.9	61.2	50.0	53.7	65.0	48.7
1976	60.8	54.7	68.6	63.1	55.0	52.9	70.9	50.4
1977	65.3	58.2	73.2	63.3	60.7	54.2	71.7	59.9
1978	70.1	63.3	82.5	72.7	69.2	72.1	72.8	73.7
1979	76.4	74.0	89.2	82.4	76.9	87.8	78.9	80.6
1980	87.3	84.9	95.9	86.1	87.5	93.2	87.1	86.9
1981	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1982	110.1	105.8	103.3	104.4	109.5	104.9	98.7	108.9
1983	116.0	111.0	107.6	107.8	115.0	105.8	101.6	110.2
1984	123.6	116.8	121.6	114.6	120.6	110.8	108.4	121.3
1981*								
price (\$/kg.)	1.4458	1.1690	3.0080	3.1680	10.923	3.7409	1.4026	.9467

*

Price calculated on same per unit basis as quantity is given in Table A.3.

Table A3: Per Capita Consumption of Selected Foods in Canada, 1960-1984

PER CAPITA FOOD CONSUMPTION BY CATEGORY (KILOGRAMS)								
YEAR	DAIRY PRODUCTS	CEREALS	FATS & OILS	POULTRY	FISH*	RED MEAT	EGGS	FRUITS & VEG- TABLES
	---- retail weight ----			evise- rated weight	retail weight	car- cass weight	fresh	equiv- alent
1960	174.05	71.05	17.21	12.56	7.93	62.06	15.63	157.35
1961	170.43	67.25	17.35	14.11	8.03	61.56	15.38	154.63
1962	167.57	68.39	18.35	14.06	8.00	61.85	15.27	157.93
1963	165.15	73.83	18.89	14.94	7.77	63.31	14.58	158.89
1964	164.00	63.29	18.93	15.90	7.17	66.05	14.53	149.29
1965	160.81	77.04	18.35	16.59	7.35	66.28	14.40	155.13
1966	159.21	66.15	19.08	17.84	7.23	65.98	13.93	154.55
1967	155.11	67.24	20.39	18.50	6.89	69.30	14.18	157.48
1968	154.20	67.15	20.82	18.04	7.44	69.86	14.31	153.28
1969	155.67	69.16	20.95	19.55	7.61	68.47	14.55	165.59
1970	150.11	68.86	20.75	20.48	7.01	70.61	14.73	159.98
1971	143.52	65.34	20.59	19.73	8.51	75.22	14.52	162.58
1972	144.06	68.44	21.59	20.16	8.59	77.19	14.04	160.18
1973	135.32	69.52	21.61	20.85	8.25	73.89	13.42	182.99
1974	133.29	68.06	21.98	20.30	8.15	76.14	13.28	175.09
1975	140.93	68.76	22.00	19.00	7.88	77.74	13.20	181.69
1976	135.04	70.86	22.46	20.28	8.89	81.57	13.01	181.83
1977	136.31	69.09	22.38	20.71	8.72	78.67	12.67	178.97
1978	132.74	67.92	22.09	21.35	7.78	76.28	12.47	193.40
1979	131.95	66.69	22.33	22.83	8.04	72.79	12.98	198.74
1980	135.79	70.17	22.31	22.71	7.94	74.92	12.86	198.08
1981	136.74	67.18	22.84	22.52	6.98	74.45	12.68	226.36
1982	140.46	69.80	22.68	22.62	7.13	71.99	12.75	195.01
1983	139.20	67.96	23.58	22.91	6.97	72.53	12.56	192.08
1984	137.83	68.84	22.74	23.54	7.18	70.36	12.02	192.02

* The 1964 and 1984 consumption are unavailable for fish. These are forecasted in Appendix B.

Table A4: Per Capita Food Consumption and Price Indexes for Beef and Pork Consumption Categories, Canada, 1960-1984

YEAR	BEEF		PORK	
	CONSUMPTION carcass weight (kg.)	PRICE	CONSUMPTION carcass weight (kg.)	PRICE
1960	31.66	23.7	23.80	30.7
1961	32.00	23.6	22.82	33.5
1962	32.25	25.9	22.71	34.5
1963	33.71	25.1	23.00	34.5
1964	36.01	24.3	23.49	33.8
1965	37.91	25.3	21.71	37.7
1966	38.11	27.8	21.31	43.6
1967	37.72	29.3	24.73	39.4
1968	38.62	29.8	24.26	39.1
1969	38.85	32.2	23.32	43.7
1970	38.29	33.2	26.65	42.8
1971	40.16	34.0	29.63	36.7
1972	42.91	37.2	28.62	44.3
1973	42.04	44.9	26.88	56.3
1974	43.61	49.5	28.12	57.2
1975	48.28	46.9	24.12	73.3
1976	51.36	43.9	25.10	76.3
1977	48.85	46.7	25.10	74.7
1978	45.73	68.3	25.92	86.3
1979	39.90	89.8	29.05	87.6
1980	39.53	97.5	31.30	86.9
1981	40.69	100.0	30.10	100.0
1982	40.44	99.4	27.84	116.4
1983	40.02	100.1	28.62	116.8
1984	38.32	106.7	27.89	119.0
1981 Price* (\$/kg)	4.167		3.165	

* Price calculated on the same per unit basis as quantity.

APPENDIX B

FORECASTING THE 1964 AND 1984 VALUES OF FISH CONSUMPTION

APPENDIX B

FORECASTING THE 1964 AND 1984 VALUES OF FISH CONSUMPTION

Statistics Canada obtains data concerning per capita fish consumption from the Department of Fisheries. However, this data are unavailable for 1964 and 1984. Hence, they were forecasted for the purposes of this paper. The 1964 figure for consumption was determined as an average of two estimates. The first is obtained by simply extrapolating from the 1963 and 1965 values; this estimate gave 7.13. The second estimate is based on an extrapolation of the 1963 and 1965 fresh water values, which resulted in a fresh water estimate of 1.21. Since the salt water total is available for 1964, the fish consumption estimate is the sum of the salt water total and the fresh water estimate, namely, 7.20. The average of these two estimates is 7.17, the value used in this report.

The 1984 estimate of fish consumption is obtained using a moving average model. The estimate is provided below. It is obtained using the statistical package RATS (Regression Analysis of Time Series) (Doan and Litterman 1984). The following output was obtained from RATS.

```
equation(ma=input) 1 fish
```

```
# 1
```

```
VAR      0      CONSTANT
```

```
VAR     -1      MVG AVGE   LAGS    1 TO    1
```

```
initial 1 1 24
```

INITIAL ESTIMATES

EQUATION 1

DEPENDENT VARIABLE 6 FISH

NO.	LABEL	VAR	LAG	COEFFICIENT
-----	-------	-----	-----	-------------

***	*****	***	***	*****
-----	-------	-----	-----	-------

1	CONSTANT	0	0	7.760833
---	----------	---	---	----------

2	MVG AVGE	-1	1	.0000000
---	----------	----	---	----------

iterate(startup=1) 1 2 24 resid

ITERATIONS TAKEN (ITERATE) 8

OBSERVATIONS 23 DEGREES OF FREEDOM 21

R**2 .33800461 RBAR**2 .30648102

SSR 5.2748599 SEE .50118240

DURBIN-WATSON 1.94837492

Q(11)= 9.61876 SIGNIFICANCE LEVEL .564970

LABEL	VAR	LAG	COEFFICIENT	T-STATISTIC
-------	-----	-----	-------------	-------------

*****	***	***	*****	*****
-------	-----	-----	-------	-------

CONSTANT	0	0	7.706471	41.81837
----------	---	---	----------	----------

MVG AVGE	-1	1	.7682234	5.164045
----------	----	---	----------	----------

forecast(print) 1 1 25

1 fishforc 25

** FORECASTS **

ENTRY FISH

25 7.17830

(1984)

APPENDIX C

EXAMPLE OF A MAPLE PROGRAM FOR CALCULATING WELFARE MEASURES

APPENDIX C

EXAMPLE OF A MAPLE PROGRAM FOR CALCULATING WELFARE MEASURES

The following is a listing of a MAPLE used to calculate McKenzie's exact measure of consumer welfare. Slight modifications to the program can be made to find CV and EV using the expenditure function approach. However, to calculate the area under a curve (i.e., consumer surplus), it was necessary to employ Simpson's Rule, as noted in the text. As a result of memory problems, it was necessary to carry out the calculations using a two-step procedure. The two programs employed in this procedure are listed below

PROGRAM LISTINGS

PROGRAM 1

```
#####
t3:=1/6*t33;
ev:=t1+t2+t3;
g1:=15.68;
g2:=-56.45;
b11:=-.25;
b22:=-.90;
b21:=-1.97;
b12:=-1.97;
bm1:=3.12;
bm2:=-8.02;
bm3:=24.10;
pch:=.01;
cp1:=pch*.599;
cp2:=pch*.442;
cp3:=pch*.015;
#####
sdiv:=1:
for j from 1 to 3 do
    sdiv:=sdiv+bm.j*ln(p.j/m);
od:
w1:= (g1+b11*ln(p1/m)+b21*ln(p2/m)+(bm1-b11-b21)*ln(p3/m))/sdiv
:
w2:= (g2+b21*ln(p1/m)+b22*ln(p2/m)+(bm2-b21-b22)*ln(p3/m))/sdiv
```

```

:
w3:= ((1-g1-g2)+(bm1-b11-b12)*ln(p1/m)+(bm2-b21-b22)*
      ln(p2/m)+(bm3-bm1-bm2 +b11+2*b21+b22)*ln(p3/m))/sdiv :
for j from 1 to 3 do
  x.j := (w.j*m)/p.j ;
od:
t1:=0:
for i from 1 to 3 do
  t1:=t1-x.i*cp.i;
od:
# t1;
t1:
t22:=0:
for i from 1 to 3 do
for j from 1 to 3 do
  t22:= t22+(x.i*diff(x.j,m)-diff(x.i,p.j))*cp.i*cp.j ;
od;
od:
# t2:=t22/2:
t2:=t22/2:
t33:=0:
for i from 1 to 3 do
for j from 1 to 3 do
for k from 1 to 3 do
  t33:=t33+(diff(x.i,p.j)*diff(x.k,m)+diff(x.i,p.k)*
diff(x.j,m)-diff(x.i,p.j,p.k)+ x.i*(diff(x.j,p.k,m)-diff(x.j,m)*
diff(x.k,m)-x.j*diff(x.k,m,m))*cp.i*cp.j*cp.k;
od;
od;
od:
# save 'ev' in maple internal format to facilitate easy use in
# other similar computations in the future.
simplf :=proc(x) option remember;
  if type(x,float) then
    convert(x,rational)
  elif hastype(x,float) then
    map(simplf,x);
  else
    x
  fi;
end;
digits:=5;
a:=simplf(ev);
b:=normal(a);
# evaluate and print results
save b,'temp.m';
done;

```

PROGRAM 2

```

read 'temp.m';
g1:=15.68:

```



```
g2:=-56.45:
b11:=-.25:
b22:=-.90:
b21:=-1.97:
bm1:=3.12:
bm2:=-8.02:
bm3:=24.10:
p1:=2.702:
p2:=1.304:
p3:=0.837:
pch:=1:
cp1:=pch*.599:
cp2:=pch*.442:
cp3:=.015:
m:=1019.09:
    print(m,p1,p2,p3,evalf(b));
done:
```

APPENDIX D

ADDITIONAL CALCULATIONS OF WELFARE CHANGES

APPENDIX D

ADDITIONAL CALCULATIONS OF WELFARE CHANGES

In this Appendix, calculations underlying Tables 5.1, 5.2 and 5.3 are provided. In Table D.1, the initial and supply-restricting quantities are provided. The data in row (3) are derived directly from the estimated demand equations with all prices at their original levels. In row (4), the price in the market under consideration is at the restricted level, while prices in the other markets are kept at their initial level. In row (5), all prices are at their restricted levels. The own-price elasticities are provided in row (6), and these are used to find a linear demand curve based on initial output and price. The supply-restricting quantities for the linear (naive) case are provided in row (7). The calculations were made using MAPLE.

Data in Table D.1 are used to calculate the values found in the first three rows of Table 5.1. They are also used to calculate the transfers from consumers to producers (Table D.2). The data from Table D.2 is required to obtain the values in Table 5.2.

Three scenarios or cases for the values of the cross-price elasticities of demand for eggs and poultry with respect to other food are considered in Table D.3. These cases are as follows:

- (1) The cross-price elasticities estimated in this study and presented in Table 4.3.
- (2) Other food is considered to be a relatively good substitute

Table D.1: Initial (Competitive) and Supply Restricting Prices and Quantities

Item	Sector		
	Poultry	Eggs	Other Food
(1) Initial (competitive) price (\$/kg.)	2.702	1.304	0.837
(2) Supply-restricted price (\$/kg)	3.301	1.746	0.852
(3) Initial (competitive) output (kg)	21.3316	12.5846	1,129.0821
(4) Restricted output (other prices at initial levels) (kg)	17.6565	10.3529	1,108.9580
(5) Restricted output (other prices at restricted levels) (kg)	18.4945	12.5091	1,098.8250
(6) Own-price elasticity	-0.9443	-0.6461	-1.1013
(7) Restricted output for linear demand using (6) at initial price and quantity (kg)	18.8661	9.8286	1,106.7979

Table D.2: Value of Income Transfers and Welfare Loss

Item	Sector		
	Poultry	Eggs	Other Food
\$ / person / year			
(1) Income Transfer from Naive Demand Curve	10.1018	4.3442	16.6020
(2) Welfare or Deadweight Loss	1.3374	0.6091	0.1671
(3) Income Transfer from Estimated Demand Curve			
Row (4) from Table D.1	10.5762	4.5760	16.6344
Row (5) from Table D.1	11.0782	5.5290	16.4824

Table D.3: Estimated Losses in the Market for Other Food as a Result of Supply-Restricting Marketing Boards in Eggs and Poultry Products

Cross-Price Elasticity of Variable on RHS with respect to other food		Percent Change in Quantity of Other Food Demanded	Change in the Quantity of Other Food Purchased After Marketing Boards were Introduced	Change in Consumer Welfare Measured in the Market for other Food
		%	kg.	\$/person/year
<u>Case 1</u>				
eggs	2.727	92.445	922.4657	-13.8370
poultry	-0.484	-10.745		
<u>Case 2</u>				
eggs	0.5	16.95	316.7075	-4.7506
poultry	0.5	11.10		
<u>Case 3</u>				
eggs	0.1	3.39	63.3415	-0.9501
poultry	0.1	2.22		
<u>Case 4</u>				
eggs	-0.1	-3.39	-63.3415	0.9501
poultry	-0.1	-2.22		
<u>Case 5</u>				
eggs	-0.5	-16.95	-316.7075	4.7506
poultry	-0.5	-11.10		

for both eggs and poultry products.

- (3) Other food is considered to be somewhat substitutable for both eggs and poultry products.
- (4) Purchases of other food are considered to be somewhat complementary to purchases of eggs and poultry products.
- (5) Purchases of other food are highly complementary with purchases of eggs and poultry products.

The values of the elasticities are given in Table D.3. The original quantity of other food purchases is assumed to be 1,129.08 kilograms per person per year, while the distortion in the other food market is \$0.015/kg. Finally, the price of other food is assumed not to change as demand increases; the size of the price distortion is also assumed to remain constant.

LIST OF WORKING PAPERS PUBLISHED IN 1987

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