DEVELOPING A MULTIPLE COMPONENT PRICING SYSTEM FOR MILK:

A HEDONIC APPROACH TO COMPONENT VALUATION

by

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Abstract

The dairy industry in British Columbia (B.C.) and elsewhere is facing a change in consumer demand for many milk products. In particular, demand is shifting away from products with high butterfat content and towards those with high protein content. Yet the present system of determining the price of milk in B.C. is based solely on butterfat content. The increase in consumption of low-fat fluid dairy products in B.C. has caused substantial excess butterfat supplies on the fluid side of the market that has required diversion to the industrial milk market, a situation known in the trade as "skim-off". It therefore appears desirable to modify the current milk pricing system from one driven by butterfat alone to a broader, more market-oriented system that values the range of components in milk and conveys changes in consumer preferences to farm producers and processors more directly. Such a system is called a multiple component pricing (MCP) system. Given that component levels can be affected in farm production, shifting to a system where milk is priced by its components could be a "win-win" situation in which there are efficiency gains throughout the milk sector.

The empirical model used in this thesis employs a pooled cross-section time-series data set and involves the econometric method of generalized least squares. A hedonic market approach is used to determine component values from wholesale product prices across a range of retail milk products. It reveals that the current butterfat differential pricing system does not succeed in providing the true market values of the multiple milk constituents produced and demanded in the B.C. market. The results indicate a positive value for each of milk protein, butterfat and the remaining solids including lactose and minerals. Protein is estimated to have a higher shadow value than butterfat in almost all regressions in both the aggregated (fluid and industrial milk) market model, and in the industrial model. The value of "other solids" is, with few exceptions, estimated to be more valuable than butterfat in the aggregated model.

This research indicates that hedonic pricing models are effective in determining market valuations of the individual components and can be done with provincial data. It also indicates that the importance of both protein and other non-fat solids in milk pricing in B.C. has been largely ignored and undervalued. Generalizing from the evidence in this study, we find that in choosing component values, the protein component should be priced no less, per kilogram, than butterfat, and the other non-fat solids should be priced similarly. Because these results are derived from B.C. data, extensions of the quantitative results to other regions should be preceded by further empirical testing with data for those regions.

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CHAPTER 1

1.0 INTRODUCTION

1.1 Problem Statement

The dairy industry in British Columbia (B.C.) is facing a change in consumer demand for many milk products. In particular, demand is shifting away from milk products with high butterfat content and towards milk products with high protein content. Yet the present system of determining the price of milk in B.C. is based solely on butterfat content. The increase in consumption in B.C. of low-fat dairy products, especially in the fluid milk sector[1], has caused substantial excess butterfat supplies in the fluid market that have required diversion to the industrial milk market, a process known as "skim-off". It may therefore be desirable to modify the current system of pricing milk products from a system driven by butterfat content alone to a broader, more market-oriented system that values the range of components in milk and conveys changes in consumer preferences to farm producers more directly. Such a system is called a "multiple component pricing" (MCP) system, and may discourage the production of milk with high fat content and encourage the production of milk with higher levels of protein, if consumer preferences warrant such a shift. The resulting increase in total solids allows processors to achieve higher milk product yields for the same purchased milk volume. Both producer and processor efficiency and equity could be improved under such an arrangement, and consumer products with desired attributes would more readily be provided. Shifting to a system pricing milk by its components could be a "win-win" situation in which there are efficiency gains throughout the milk sector.

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[1] See appendix 5 for details.

This thesis uses a hedonic pricing model to estimate the implicit value of the various components of milk in B.C. The underlying theory of this approach to price determination was developed by Lancaster (1966), although contributions to the theory of consumer behavior in deterministic situations were already set out by a range of researchers[2]. He postulated that goods possess characteristics, and that it is the bundle of characteristics a good provides, not goods themselves, that determine consumer's preferences. The hedonic approach enables us to determine these implicit values of milk characteristics.

Background to the Industry

The existing dairy policy in B.C. and the underlying structure of milk pricing will clearly have some effect on component values. Milk pricing in B.C. is currently based on a butterfat differential pricing system in which the accounting values for all types of milk (other than fluid milk) are determined by the federal support prices of butter ($5.34/kg)[3] and skim milk powder ($3.93/kg), hence on the prices of butterfat and non-fat solids. The implication of this is that since the milk supply in Canada is constrained by quotas, the support prices are minimum values. If there is excess demand for either component at these support prices, the market price for that component will rise above the support price level, whereas if there is excess supply, the support price will hold and some government (CDC) purchases will occur. The quantitative restriction imposed by aggregate industrial milk quotas in Canada makes the situation different from the U.S., where there has been an open-ended offer to purchase the supported end products and where shadow values of the components conform to the support price levels.

[2] Court (1939), Griliches (1939), Lancaster (1957), Johnson (1958), Debreau (1959, 1960), Morishima (1959), Uzawa (1960).

[3] The Western provinces agreed in 1990 to sustain the butterfat price at $5.30/kg at the 1990 level.

The pricing of fluid milk in B.C. values milk only by its butterfat content without specifying the components. However, an average hectoliter of B.C. milk contains approximately 87.4 kg of fluid carrier and 12.6 kg of milk solids. Milk solids are 3.8 kg butterfat, 3.3 kg protein and 5.5 kg other solids (other solids include lactose, minerals and vitamins)[4]. The level of milk solids in milk is crucial for profitability in milk manufacturing since the amount of milk solids determine product yield and contribute to product quality. Furthermore, marginal differences in protein levels in milk can cause great differences in processing efficiency and profit, especially in cheese processing (Emmons et al., 1990). Additionally, both casein and whey (the two constituents of protein) enhance cheese quality (Varnam et al., 1994). The valuation of milk based on protein content, and not simply on casein content, is therefore important[5] (Li-Chan, 1997).

The separability of milk into its constituent parts (particularly the major components: protein, fat, and lactose) allows milk to be valued according to its components (Li-Chan, 1997). Milk constituents can then be optimally allocated to the product or product category where the highest value (indirectly determined by consumer demand) is obtained. In other words, in equilibrium, we expect component values to converge across products, as processors add components to products where the highest component value is obtained, until the marginal costs of adding components just equals the marginal benefit of the added constituent. However, processing constraints are suspected to prevent complete equalization of those values. The divergence in constituent value across product categories might therefore not indicate

[4] All calculations based on B.C. average component tests in 1996.

[5] It should be noted that casein can not be accurately measured and there is uncertainty about casein's effect on cheese chemistry (Butler, 1992).

inefficiency[6].

The hedonic model used in this thesis enables us to determine the market value of not only butterfat but also of the dominant portion of milk solids, namely the multiple characteristics in nonfat solids. This approach will also allow us to test for different shadow values across product categories, as discussed above.

The high correlation between butterfat and protein content in milk raises the question of the efficiency of multiple component valuation. For a MCP system to be efficient (and a hedonic approach useful) milk components must be subject to change by farmers. Component data from MCP systems in California indicate that through changing management practices farmers are able to increase the proportion of nonfat solids in milk and decrease the proportion of butterfat. This is discussed in more detail in chapter 2. In B.C., tests[7] of milk for butterfat content show that butterfat content increased by 3.5 percent between January 1994 and December 1996. This change is due, at least in part, to the butterfat differential pricing system in B.C. In addition, grain prices increased during this period and caused a shift toward using more forages and less grain in the dairy cow diet. Furthermore, the shift to a "single quota" system where quota is determined based on butterfat tests has promoted a "race for base", due to the expectation that if butterfat levels in milk were increased, a larger allocation of the new single quota could be received. The trends in component tests mentioned above indicate that producers respond to changes in policy and payment issues. The price incentives provided by the MCP system are thus consistent with producer behaviour. The increases in protein and

[6] The marginal value of protein or other milk constituents is found to differ between products or product categories in Hillers et al. (1980), Young et al. (1986) and Young et al. (1990). That is, the value of lactose in milk used for cheese production is minimal and may be negative if whey disposal is costly (Young et al. (1986)).
[7] The previous 12 months average component tests.

lactose[8] contents of 2.8 and 3.4 percent respectively during the same period indicate the high correlation between components, but might be a response to the strongly debated MCP issue in the industry since January 1992 (when Ontario implemented the MCP).

Butterfat utilization has historically been higher in the fluid market than in the industrial market in B.C. (the fluid market utilizes approximately 65 percent of all milk produced). As a result of increased consumption of low-fat fluid products, the utilization of butterfat in the fluid market has decreased, and by December 1996, only 43 percent of all butterfat produced was utilized in fluid products[9]. Butterfat is skimmed off the fluid market and substituted with more protein and lactose, and the quantity of nonfat solids in fluid milk thereby increases. In December 1996, approximately 75 percent of all fluid milk consumption is of either 2 percent, 1 percent, or skim milk. The declining demand for butterfat and increasing demand for nonfat solids in the fluid market indicate greater importance of nonfat solids (and less on butterfat) in valuation of fluid products.

The increase in protein imports and the decline in butterfat imports in B.C. between 1992 and 1996 (appendix 6) indicate an increased shortfall in protein production and increased provincial supply of butterfat. Trade data for the cheese sector (the second largest sector after fluid and which utilizes approximately 25-30 percent of all milk produced) indicate improved competitiveness in the B.C. cheese sector in recent years. The MCP is particularly suited to the cheese manufacturing sector (since product yields and profitability are dependent directly on raw milk composition) and will indeed encourage this positive trend. The current butterfat differential pricing system does not have the capacity to reflect the changes in consumers'

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[8] The increase in lactose is calculated from December 1993 to July 1995 (when test of lactose was changed to a test of other solids).
[8] See appendix 1 for details.

preferences. Nor can't it convey preferences to producers by valuing the constituents in greatest demand. The imbalance between production and consumption of components highlights the need for a pricing system that aligns the two more closely.

1.2 Objectives

The objective of this thesis is to determine the implicit value of the multiple milk components in B.C. Such a valuation may foster a system that will allow processors to pay for the components they need, and will allow farmers to change management practices to best meet processors needs. Valuing protein, butterfat and the remaining solids including lactose and minerals may be the best solution to the current skim-off problems in B.C. A hedonic market approach is used in this thesis to determine component values from wholesale product prices. This approach will reveal whether the current butterfat differential pricing system provides the true market values of the milk constituents produced and demanded in this market.

The market for milk products is divided into five product categories: fluid milk, cheese, ice cream, yogurt, and butter. These categories allow us to test the basic aggregated (fluid and industrial) and industrial product models for potential differences in component valuation across product categories, and reveal if constituents are allocated efficiently in processing. Finally, since consumption of low-fat products, particularly in the fluid market, is increasing (and the butterfat skim-off worsening), we want to determine if this consumption trend is reflected in product prices. The basic model is therefore tested for differences in component valuation across time. Conclusions about the efficiency of the current butterfat differential pricing system can then be made.

1.3 Thesis Outline

Chapter 2 presents background information on component valuation in a multiple-component pricing system. The chapter discusses the empirical experiences from component pricing, efficiency gains obtained by valuation of the multiple characteristics in a product, and a review of an analysis employing the hedonic price method in milk valuation. The theoretical considerations in chapter 3 focus on how component values for milk pricing can be determined, previous empirical work, and discussions of the different functional forms in a hedonic approach. An overview of the data of the empirical model, specification of the empirical model, and the methodology employed, are described in chapter 4. Chapter 5 presents the estimation results and interpretations of the regression analysis. This chapter also discusses the implications of the estimated hedonic shadow values for the B.C. milk market. Conclusions are drawn in chapter 6.

CHAPTER 2

2.0 BACKGROUND INFORMATION ON COMPONENT VALUATION

2.1 Multiple Component Pricing

2.1.1 Objectives

Emmons et al. (1990) defined multiple component pricing of milk as "the pricing of milk on the basis of more than one component, such as fat and protein; fat and nonfat solids; or fat, protein, lactose and minerals (p. 1712)." The primary objective of a MCP system, that "prices paid or received for milk reflect as accurately as possible the amount and value of products that can be made from it" is pertinent because milk composition varies seasonally, regionally and from herd to herd. Furthermore, yields of products such as butter and cheese are directly dependent on the content of fat, protein and lactose.

A raw milk pricing system based on MCP will accommodate changes in the relative values of components in response to marketplace conditions and requirements. The component values send signals to producers regarding the relative market values of components, and producers can, by changing farm management practices, increase production of the components for which demand increases. In a MCP system, processors pay for the milk based on components; the pricing system is thus more directly related to product yield. MCP has the potential to encourage the industry to take advantage of marketing opportunities created by changing consumer demand without adversely affecting any particular sector of the industry. It might also lead to greater equity both among and between producers and processors. In other words, shifting to payment by components could provide efficiency gains throughout the dairy sector.

2.1.2 History of Classified Milk Pricing

The dairy industry in North America experienced many of the same adjustment pains in its search to solve butterfat pricing inequities as it has experienced in the present multiple component pricing efforts. A century ago, producers were paid on a volume or weight basis, regardless of the milk's composition. The flat price incentives provided rewards for producers for stretching the fluid volume or weight. Watering and adding various ingredients were not unusual practices. Producers and processors also recognized that butterfat could be skimmed and marketed independently at a higher price (as butter or cream). Nonfat solids pricing proposals have been on the government agenda since 1896, when Babcock proposed paying for cheese milk on the basis of nonfat solids in addition to butterfat. In 1908, he revised his original concept and proposed pricing the non-fat fraction of milk on the basis of its casein content, as measured by a test that he developed.

Multiple component pricing has attracted industry and academic attention since the 1940s. Only with the development of relatively low-cost and accurate procedures for measuring and separating milk components in the 1960s has this pricing method become appropriate feasible (Lenz et al., 1994). Prior to 1972, few significant developments occurred except in Holland and the state of California. Protein testing began in 1958 in Holland, and by the mid 1960's over half of the milk sold in that country incorporated protein as well as butterfat content in its pricing formula (Carr 1980). The state of California has had both nonfat solids (SNF) and butterfat included in its pricing structure since 1962 (Butler, 1992).

Since 1972, there has been greater acceptance of the multiple component pricing concept. Denmark (1972), France (1976), Finland (1978), and Norway (1980) have adopted protein pricing, and the United Kingdom elected to incorporate nonfat solids pricing in 1980. Several independent cooperatives and individual processing plants in the U.S., most notably in Vermont and the intermountain west, initiated programs on their own, also in 1980 (Carr, 1980). Changing a U.S. milk marketing order from pricing milk based on skim and milk-fat to one that prices milk's skim portion based on protein was almost unheard of. Until 1988, there was no market-wide multiple component plan in North America, other than in California. The Great Basin Federal Order in Utah and Nevada adopted a MCP system in 1988, and the acceptance of this program, by giving the right production incentives to the producers, prompted other Federal Orders to follow suit. In 1993, the Middle Atlantic Federal Order in the U.S. established a MCP system, and the milk producers in Eastern Ohio-Western Pennsylvania Federal Order petitioned the USDA for a similar change. Many dairy product processing plants already paid a premium to producers who delivered milk with higher protein and nonfat solids content as a milk procurement procedure (Elbehri et al., 1993). In August 1995, the final decision adopting a MCP plan for five[10] Midwestern federal milk marketing orders in the U.S. was signed. These five orders accounted for 26 percent of all milk pooled under federal orders during 1994 (USDA, 1995). These regions are now pricing milk based on milk fat, protein and other solids. In 1995, 13 of 33 federal milk marketing orders, representing 55 percent of all federal milk, had implemented some kind of MCP (USDA, 1995).

The federal agriculture improvement and reform act of 1996 (farm bill) contained a provision authorizing MCP as part of the current federal order reform procedures. The USDA (December 1996) suggested ten new, consolidated federal orders. Of interest for Canada is the Pacific Northwest Area, which will switch the current MCP system based on butterfat and nonfat solids (SNF) to a program based on butterfat, protein, and other solids, as of February 1, 1997 (as in the five Midwestern federal milk marketing orders). Of the 13 federal orders now with MCP

[10] These were Chicago Regional, Nebraska-Western Iowa, Upper Midwest, Eastern South Dakota, and Iowa.

(Equity Newsletter, 1997), only the Middle Atlantic Order uses the component nonfat solids. All others use butterfat and protein, or butterfat, protein and other solids. This is also the trend in Europe. Equity Newsletter of June 1996 stated that a federal milk market administrator report of May 1995 concluded that MCP was applicable to more than 79 percent of dairy farmers marketing milk in federal milk marketing orders. This includes 18 percent of all federal orders that have implemented MCP, and 61 percent that market their milk to a cooperative or plant that offers a voluntary MCP plan. The report also found that 78 percent of the MCP plans pay on the component protein, 21 percent pay on nonfat solids, and the remaining mostly use cheese yield pricing.

The next two sections discuss the history of MCP in California and Ontario.

California

California was one of the first regions to establish a MCP system (second only after Holland). Hedonic pricing was applied in the fluid market in 1962 and in the industrial market in 1969. Fluid milk valuation is currently based on butterfat, SNF and fluid carrier, while manufacturing milk is based on butterfat and SNF. MCP was born out of a compromise between processors and producers. In the early 1960s, processors wanted statutory authority to market a low-fat milk product in the state, but producers were afraid of what such a product would do to their "class 1" sales of milk fat. Whole-milk SNF standards were therefore gradually increased from 8.15 percent in 1961 to 8.7 percent today (Boynton, 1992), which are higher than federal standards (8.25 percent SNF), and are met by adding or subtracting fats and solids.

California butterfat prices have historically been valued higher than SNF, but a structural shift in consumer preferences of milk constituents, from butterfat to protein content in products,[11] led to a decline in butterfat values starting in 1980. The average class prices of SNF declined until 1988, but has since then increased and stabilized in 1995 at approximately $1.04/lb. The decline in SNF values is due partly to the overall decline in milk prices since 1980 (1996 milk values are approximately 50 percent of values in 1980). Differences in component valuation between classes have been marginal since 1980. These trends are shown in figure 2.1. below.

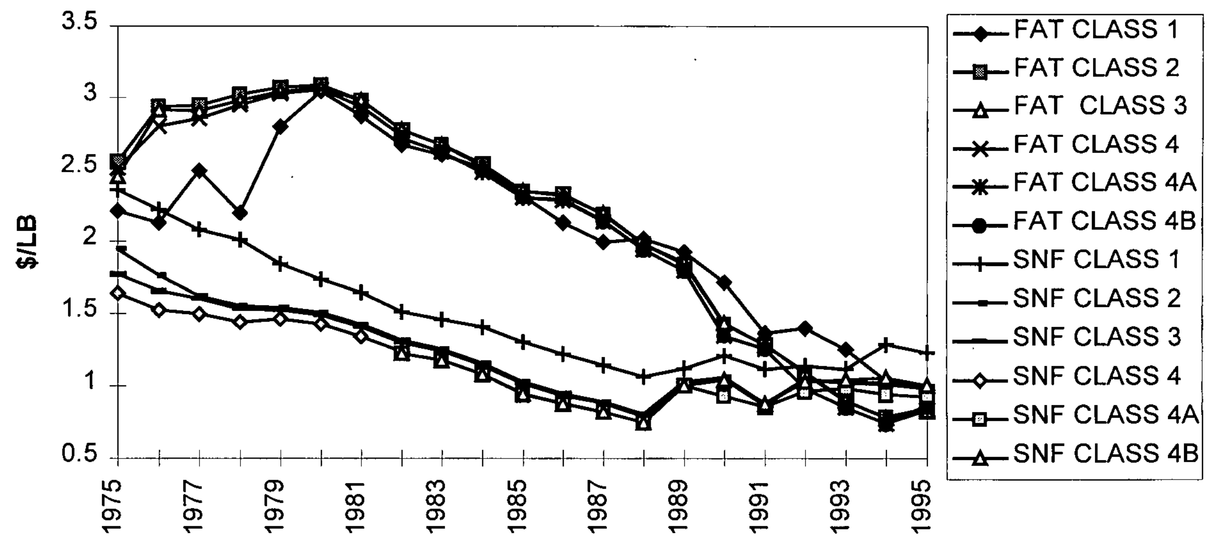

Figure 2.1. California Component Values, CPI adjusted (Dec. 1996=100)[12]
Source: Department of Food and Agriculture, Division of Marketing Services

The valuation of milk based on butterfat and nonfat solids is influenced by the Chicago Mercantile Exchange grade AA butter price, the Commodity Credit Corporation support price for extra grade nonfat dry milk powder, and the National Cheese Exchange 40 pound block cheddar

[11] Cheese production increased by 127 percent between 1985 and 1993 (Dairy Herd Management, 1995).
[12] The class 4 was split into classes 4a) and 4b) effective August 1, 1982.
California milk class definitions (Butler, 1992):
Class 1 Fluid products, yogurt (in-state), sterilized or UHT milk (in-state) and lactose-reduced milk
Class 2 Fluid creams, sour cream, cottage cheese, buttermilk, sterilized creams, yogurt (out-of-state) and UHT milk(out-of-state)
Class 3 Ice cream, ice milk, light dairy dessert, frozen mixes, frozen yogurt, and other frozen products
Class 4a Butter and dried milk
Class 4b Cheese other than cottage cheese

cheese price. These values are combined with data on product yields of butter, whey butter, skim milk powder and cheddar cheese, and various allowances and differentials. In other words, end-use pricing is used in all classes, which is a marginal product pricing method, and according to Butler (1988), a well established economic concept for allocating components of output to the various input values.

Although the cheddar yield of a particular plant will vary from other plants, it is normal in a market for an aggregate value to not reflect the values in each region, each plant, etc. However, Butler (1988) and Shippelhoute (1997) questioned the efficiency of employing a proxy for cheddar yield only, in cheese milk valuation, since the yield of different cheeses varies significantly.

Ontario

Ontario implemented a MCP system based on protein, butterfat and other solids in 1992. Since then the other Canadian provinces have followed its example, except in Saskatchewan and B.C. The move to MCP in Ontario was preceded by the change in allocation of the industrial milk quota (MMQ) from a volume basis to a kilogram of butterfat basis on August 1, 1990. This began the process of reducing the administrative incentive to continuously improve butterfat content. A further change was made when a policy was introduced to make producers fully accountable for butterfat production within fluid quota shipments. The first application of this policy took place August 1992, and individual producer's MMQ was adjusted to reflect any changes in butterfat marketed within fluid shipments. Ontario producers have thus received payment for the kilogram per hectoliter of protein, butterfat and other solids (lactose and minerals) produced, with class premiums for fluid and semi-fluid uses, since January 1992. This system changed in October 1996. The volume premium (previously approximately 18 percent of milk price) was eliminated, and the associated values were placed on the protein and other solids components. The new component values are shown in table 2.1. Values of protein and other solids vary between classes in the new system, while the butterfat value is constant across all milk classes. Protein utilized for cheese processing is now valued twice the class 1a protein price, and 2.5 times the protein utilized in condensed/evaporated milk (class 4b). Other interesting features are that the butterfat value for cheese milk (classes 3a and 3b) is only 60 percent of the protein value, and that other solids are valued at the same level as protein in all classes other than the cheese class.

Table 2.1. Ontario Class Prices ($/kg)[13]

	Butterfat	Protein	Other solids
Class 1a	5.49	4.61	4.61
Class 1b	5.49	4.05	4.05
Class 1c	5.49	4.27	4.27
Class 2	5.49	4.15	4.15
Class 3a	5.49	9.13	0.57
Class 3b	5.49	8.67	0.57
Class 4a	5.49	3.47	3.47
Class 4b	5.49	3.62	3.62
Class 4c	5.49	3.48	3.48
Class 4d	5.49	3.48	3.48

Source: Dairy Farmers of Ontario, 1997

2.1.3 Producer and Processor Efficiency Gains

Numerous analyses[14] have focused on MCP and the factors causing variation in milk composition since the beginning of this century when it was recognized that cheese yield

[13] Effective October 1, 1996. Ontario milk class definitions (Dairy Farmers of Ontario, 1997):
Class 1a Homogenized milk, 2%, 1%, and skim milk
Class 1b Fluid creams
Class 1c Chocolate milk, flavoured milks, buttermilk
Class 2 Ice cream, yogurt, sour cream
Class 3a Fresh cheese, specialty cheese
Class 3b Cheddar cheese
Class 4a Butter and powder
Class 4b Condensed and evaporated milk for retail sale
Class 4c New products
Class 4d Inventory, animal feed

[13] Cerbulis et al. (1974), Hee Song and Hallberg (1982), Cragle et al. (1986), Burton et al. (1986) and Young et al. (1986).

depended on the content of milk fat and casein. These studies can be divided in three types: studies that examine for example changes in components due to 1) cow characteristics, such as breed, (Holsteins versus colored breeds), genetic properties, stage of lactation, and age; 2) changes in management practices, such as change in feed composition of energy, protein, and fiber, fat and oil levels in the ration, chemical additives, and physical form of the feed; and 3) milking frequency, season, and climate. However, not many studies have analyzed the response of component production to price incentives provided by MCP, where the relative change in component levels is necessary for overall efficiency gains. If the value of nonfat solids increases relative to the value of fat, then we expect production of nonfat solids to increase and/or the production of fat to decrease. According to Butler (1997), the relative ratios of fat to SNF in milk may be changed by altering the feeding regime, but only small changes are possible in the short term and relatively limited changes in the longer term. The empirical question of to what degree milk composition will respond to a change in relative component prices is analyzed in Kirkland (1993).[15] The author concluded that in the short run, MCP had only limited abilities to control production of milk components. Butterfat seemed more responsive than SNF, which might according to the author be due to the fact that cows have historically been genetically selected for butterfat production rather than SNF production. Since SNF has been valued highest among components in MCP systems in North America only since 1992, we expect the responsiveness, or elasticity, of SNF to price changes to increase over time.

The change in consumer preferences in California the last decade warranted a shift in the component price ratio of SNF to butterfat. The price ratio doubled from 1988 to 1994 (appendix 4). Contrary to what is suggested in the literature, this was coupled with a corresponding increase

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[14] A simulated linear programming model was used (without validation, using actual farm data) based on a 305-day lactation period and various feeding regimen.

in SNF production (in lbs./cwt.) while butterfat production (in lbs./cwt.) have stabilized or even marginally declined (appendix 3). The data indicate a long run producer capacity to change milk composition due to price incentives provided by MCP, despite "the large correlation between milk components" (Van Vleck, 1984). One could conclude that if component price incentives are substantial then producers will change farm management practices accordingly.

Ontario implemented MCP in 1992, and the protein to butterfat price ratio increased from 1.15 to 1.4 in August 1996 (appendix 4). This increase most likely reflects a shift in consumer demand from products with high butterfat content toward products with high protein content. Although the data covers only a short time period, butterfat production (in kg/hl) has stabilized and even declined marginally in this period. Protein production (in kg/hl) tends to be more volatile after the implementation of MCP, and seem to have declined somewhat (appendix 2). This might correspond to the high correlation between protein and butterfat tests. The seemingly lower protein tests in milk might also suggest that the protein value has not been substantial enough to change feeding practices. This seems particularly true, since feed prices have increased substantially in Ontario in the last few years, and the higher protein values have not covered the increased feed costs required to increase protein production. Due to decades of breeding practices for increased butterfat tests, protein is expected to be less manipulative than butterfat. The higher protein value in a MCP system might therefore change breeding practices to emphasize protein (and SNF) production, and increased protein to butterfat production are, as in California, expected in the long run.

Less influence of federal regulation might provide a change in component values. The support prices in California are not minimum prices, as in Canada, since the products are traded under an open-ended offer to purchase. A hedonic market approach using California data is therefore more likely to reveal these support prices. In Canada, where the milk supply is constrained by quotas, the support prices will be minimum values, and the possibility is raised that component values in the milk product market could be higher than the support price levels.

Product yield factors are important in estimating market values of producer milk (Brog, 1970). Furthermore, the importance of component levels for processor profitability and efficiency, is unquestionable. As discussed in the background to the industry in chapter 1, processors may vary their use of components in various milk products in response to changes in component prices. However, some technological constraints on the separability of components are likely to limit an optimal component allocation. This is discussed further in chapter 5.

Equity Newsletter (1997) stated that "high component milk is more valuable in all markets and that the greatest relative advantage is in markets with competitive cheese industries." Hillers et al. (1980) also found that "the economic advantage of using milk higher in protein (casein) in cheese manufacture is particularly great (p. 322)." Yield of fluid and most class 2 products (yogurt, ice cream etc.) are not influenced by protein and other solids components, but the components have values at retail and wholesale level (based on consumer preferences) (Dairy Farmers of Ontario, 1992).

2.1.4 Hedonic Demand Approach for Milk

The most difficult aspect of multiple component pricing is that milk constituents do not relate directly to consumer demand or to producer supply. The market value of every component is not readily observable. Perrin (1980) suggested "a consumer goods characteristics demand approach to be useful in establishing implicit consumer values also for the multiple milk components (p. 445)." However, using a hedonic analysis of milk component values was largely ignored until Lenz et al. (1994) developed a retail-level hedonic model for analyzing the value of US milk components contained in aggregate dairy product commodities and applied it to household consumption survey data. The use of aggregated data on characteristics, demand and supply factors in component valuation, as examined in the hedonic model for the B.C. market in chapter 5, does not necessarily imply a less suitable approach, although the detail provided by household data would be preferred.

Lenz's findings support Perrin's conjecture that a hedonic approach at the retail level can be used to value milk components. In particular, fat, protein and calcium appeared to have positive implicit values at both retail and farm levels. The model employed in Lenz et al. extended the usual hedonic methodology by characterizing household consumption decisions in terms of quantities consumed, weighted average prices, and characteristics contents of aggregate commodities, rather than in terms of quantities, prices and characteristic content of individual market goods. Other possibly relevant but unobservable and/or subjective characteristics such as packaging, color, taste, aroma, and perceived freshness were suppressed and modeled only implicitly. Lenz et al. assumed that a household choses a food consumption bundle to maximize utility derived from the nutritional and non-nutritional aspects of food consumption, subject to the food expenditure constraint.

Since hedonic price theory suggests neither specific aggregate commodity definitions nor specific functional forms for representing hedonic values, Lenz et al. (1994) suggested that a necessary condition for a market good to be included in an aggregate commodity is that

> the market good's marginal nutrient contribution be combinable with the nutrient contributions of other market goods defining the aggregate commodity when assigning a hedonic valuation to the overall nutrient contribution. To the extent consumers view marginal grams of fat, protein, and calcium obtained from consuming <u>any</u> cheese variety as nutritionally equivalent, then any cheese can be aggregated into a "cheese" commodity for the purpose of nutrient valuation. As a general rule, aggregate commodities should be defined such that variation in the commodity price can be adequately explained in terms of variations in nutrient content and socio-demographic variables (p. 497).

The beverage milk was aggregated and they expected that price variation in this commodity, which would be closely related to the mix of skim, low-fat, and whole milk purchased, can be explained by variation in the commodity's fat content, regional taste and price level differences, meal planner's education, age distribution of family members, and other socio-demographic variables (p. 497).

The model was estimated via nonlinear least squares. The quantity of fat, protein and calcium in each product category were found significant in explaining the retail value of these products. Additional categories of group-common characteristics, including various collections of vitamins and minerals, were initially analyzed, but consistent and significance of estimates of implicit values of these characteristics were not forthcoming. Farm-level value as a percentage of retail-level value were not known for the entire range of products, but a farm-level residual of 50 percent (based on a 1977 report) was used.

Studies by Perrin (1980), Schwart (1985), St-Pierre and Scobie (1987), and Lenz et al. (1994) provide estimates of milk component values, using various methods of derivation, and are presented in table 2.2.

Table 2.2. Alternative Milk Component Values

Variable	Perrin[a]	Schwartz[a]	St. Pierre[a]	Lenz, et al.
$ Protein per kg[16]	8.82	8.50	10.65	5.21
$ Fat per kg	4.02	4.25	2.60	4.07
Protein/fat ratio	2.19	2.00	4.09	1.28

[a] Conversion of SNF to protein values was accomplished using the conversion relationship %SNF=4.74+1.266% protein.

Source: Lenz et al. (1994).

Estimates by Lenz et al., when multiplied with component levels in raw milk, nearly equaled the actual milk price, but by "comparing the two alternative price vectors of fat and protein values, it is clear that they would provide substantially different economic incentives for fat and protein production" (Lenz et al., 1994, p. 502). The butterfat value in the federal milk

[16] Values were converted from value per point to value per kilogram.

marketing orders was 28 percent greater than the fat value derived from the hedonic analysis and lied outside of the 90 percent confidence interval of the hedonic fat value.

CHAPTER 3

3.0 THEORETICAL CONSIDERATIONS

3.1 Hedonic Theory and Empirical Work

The amount of lactose, fat, protein, minerals and vitamins in milk will separately and jointly contribute to the quality and value of dairy products. Explicit values of the raw milk components are not observable in the market, but the implicit values can be retrieved from market values of the fluid and manufactured dairy products. This section summarizes the theory on valuation (shadow values) of product characteristics, and the literature that estimates these values.

Hedonic research was presented by Court (1939) and Griliches (1939). Both were concerned with the automobile industry. General Motors was involved in the work of Court, where he developed hedonic price indexes with automotive examples. An econometric analysis of the value of quality changes in automobiles was then provided by Griliches (1939). Hedonic theory was not well developed at this time. Even thirty years later, Lancaster (1966) stated that

> the current status of consumer theory is still that the intrinsic properties of particular goods, those properties that make a diamond quite obviously different than a loaf of bread, have been omitted from the theory, so that a consumer who consumes diamonds alone is as rational as a consumer who consumes bread alone, but one who sometimes consumes bread, sometimes diamonds, is irrational.

Lancaster's work presented the essence of hedonics, i.e., that "goods possess characteristics, or give rise to multiple characteristics in fixed proportions and that it is these characteristics, not goods themselves, on which consumer preferences are exercised." Lancaster (1957), Johnson (1958), Debreu (1959, 1960) and Uzawa (1960) developed early work in this direction in the theory of consumer behaviour. The work of and Morishima (1959) contributed with an approach similar to that of Lancaster in 1966.

Lancaster (1966) implied that by moving to multiple characteristics, many of the intrinsic qualities of individual goods are incorporated, and the result is a

"model much richer in heuristic explanatory and predictive power than the conventional model of consumer behaviour and one that deals easily with those many common-sense characteristics of actual behaviour that have found no place in traditional exposition."

In general, he suggested that the consumer may have to choose among many paths linking groups of goods with groups of characteristics. In conventional theory of consumer behaviour the principal question whether a particular consumer prefers collection x_1 or collection x_2 no longer has a direct answer, although whether the consumer prefers characteristics collection z_1 or z_2 does have such an answer (Lancaster, 1966). In a complex consumption technology (many goods relative to characteristics) consumers may therefore change goods collections as a result of compensated relative price changes, simply in order to obtain the same characteristics collection in the most efficient manner. The hedonic model enables the multidimensional characteristics of products to be appropriately incorporated, and assumes that consumers regard products to have multiple characteristics. According to Lancaster (1966),

"the relationship between the collections of characteristics available to the consumer which are the direct ingredients of consumer preferences and consumer welfare, and the collections of goods available to the consumer which represent the consumer relationship with the rest of the economy, is not direct and one-to-one, as in the traditional model, but indirect, through an activity vector."

Additionally, consumers weigh the various combinations of characteristics contained in the different products in reaching their buying decisions and determining their willingness to pay for goods. Using hedonics to value the implicit properties or characteristics of products instead of pricing individual goods (independent of composition) from which utility is derived, would therefore provide efficiency gains.

Since the theoretical empirical work of Lancaster (1966), Rosen (1974) concluded that the hedonic price method (HPM) could be applied to any market. Although, the majority of

HPM studies have looked at the real estate market as a reflection of surrounding environmental characteristics. By controlling for the structural, locational, and other characteristics of a house, the effect, which certain environmental characteristics (e.g., air quality) have upon the property price can be isolated, and the implicit price of one characteristic (e.g., air quality) can thereby ascertain. However, this is one example of applying hedonic methods; hedonics are now used in a variety of industries. For example, Melton et al. (1996) illustrated a hedonic application with experimental auction methods to evaluate consumer perceptions and willingness to pay for fresh pork chops.

The method of contingent valuation has received less acceptance than the hedonic price method, and is primarily used in markets without readily observable market values on products (e.g., environmental goods). However, Arrow (1965) used a hedonic approach to value environmental goods. He stated that whereas market prices are operationally revealed in the market, shadow prices must be indirectly estimated. The estimation of shadow prices that represents the value of social, as opposed to private benefits was problematic, since social benefits include the private benefits and the benefits imposed on the environment. Ultimately, he stated that a shadow price is a subjective valuation that must be made by individuals. However, by using a hedonic approach, this can be made a more objective valuation.

In the absence of directly observable component market prices for dairy products, it is necessary to impute the values of the beneficial characteristics of dairy products. This computation necessarily involves decomposing market prices into their constituent parts to determine the implicit value of certain characteristics. In the case of milk components, a hedonic price approach and an associated multiple component pricing system could benefit both producers and processors since it would provide clear information on the pricing of milk components rather than having to derive values from the value of the aggregate commodity. For example, if protein is highly valued by consumers (even if they do not know what component it is that causes them to prefer a commodity), then producers should be encouraged to produce more of the commodity with this characteristic if the marginal cost of provision is not above the incremental value to the consumer.

Rosen (1974) built a model of product differentiation based on the hedonic hypothesis that goods are valued for their utility-bearing attributes or characteristics. He defined hedonic prices as "the implicit prices of attributes and are revealed to economic agents from observed prices of differentiated products and the specific amount of characteristics associated with them." The hedonic prices constitute the empirical magnitudes explained by the model. Using an econometric model, he estimated implicit prices by the first-step regression analysis or ordinary least squares (OLS) (product price regressed on characteristics). The major goal of Rosen's analysis was to present an overview of how price or value of a commodity Z was determined. A class of commodities was therefore described by n attributes (Z_n) or characteristics,

$$Z = (Z_1, Z_2, \ldots . Z_n). \tag{3.1}$$

The components of Z were objectively measured in the sense that all consumers' perceptions of the amount of the characteristics embodied in each good are identical, though of course consumers may differ in their subjective valuations of alternative packages. Rosen assumed a variety of products among which choices could be made. Each product has a quoted market price P(Z), which is determined by the distribution of consumer tastes and producer costs. The price P(Z) is also associated with a fixed value of the vector Z, so the product market will implicitly reveal a function

$$P(Z) = P(Z_1, Z_2, \ldots Z_n) \tag{3.2}$$

relating prices and characteristics. Linear versions of these marginal bid and marginal offer functions are the buyer's (and seller's) equivalent of a hedonic price regression, obtained from comparing prices of brands with different characteristics:

$$\frac{dp}{dz}(Z_i)=W_{ji}=\beta_0+\beta_1 Z_i+\beta_2 X_i+\beta_3 D_{oi}+e_{ji} \text{ and } \frac{dp}{dz}(Z_i)=G_{ji}=\alpha_0+\alpha_1 Z_i+\alpha_2 S_{oi}+u_{ji}, \tag{3.3}$$

where $\frac{dp}{dz}(Z_i)$ is the estimated hedonic marginal price of characteristic Z_i; W_{ji} is consumer j's marginal purchase price for Z_{ij}; X_j is consumer expenditures on commodities other than Z; D_{oi} is a vector of observed demander traits affecting the marginal bid; G_{ji} is firm j's marginal offer price for Z_i; S_{oi} is a vector of observed supplier traits affecting the marginal offer; and e_{ji} and u_{ji} are disturbance terms. In other words, the price of product Z can be written as a function of its multiple characteristics or attributes, and exogenous supply (S) and demand (D) shifters:

$$P(Z_i)=f(Z_1,..Z_n, D_1,..D_n, S_1,..S_n) \tag{3.4}$$

Consumers act competitively in spite the fact that marginal cost of quality, $P_i(Z)$, is not necessarily constant, because as many units as desired of any brand can be purchased without affecting prices. The function P(Z) is assumed to be the same for all buyers and independent of the number of units consumed. The producer plant maximises profit by choosing the optimal number of units and characteristics produced, where unit revenue is given by the implicit price function for characteristics. This gives the market clearing implicit price function P(Z).

Rosen (1974) and Freeman (1979) suggested that two special cases would simplify estimation of marginal bid functions. They both concluded that the inverse marginal bid functions could be consistently estimated by OLS. First, if we assume that the quantities available of each of Z are fixed, then the Z will be exogenous. Second, if we assume that as many units of Z as desired can be obtained at the same prices, and that the marginal bid functions can be inverted to express quantities Z_i as functions of marginal prices, then supply is perfectly elastic. This implies that marginal prices are exogenous and the use of OLS can be supported.

Bateman (1993) attempted to impute a price for an environmental good by examining the effect which its presence had on a relevant market-priced good. He explained the objective of HPM studies as to define the (inverse) demand function relating the quality of the environmental good to individuals' marginal willingness to pay for that good. He outlined a number of assumptions necessary for HPM results to be meaningful. These include:

(i) Willingness to pay is an appropriate measure of benefits.

(ii) Individuals can perceive product quality changes; these changes affect the future net benefit stream of the finished goods, and individuals are therefore willing to pay for changes in these products. In other words, in applying hedonics to milk components, it is not necessary for the consumer to know the exact levels of components in the product in question, but they can identify the quality changes that are important to them, and the quality changes determine their marginal bid value.

(iii) An entire study area can be treated as one competitive market with freedom of access across the market and perfect information regarding product prices and the quality characteristics.

(iv) The product market is in equilibrium, i.e. individuals continually re-evaluate the products, such that their purchased product constitutes their utility-maximizing choice of product given their income constraint.

Freeman (1979) noted that differentiating the equation with respect to characteristics level gives a new expression for the marginal purchase price of characteristics. The implicit marginal purchase price of cheese, for example, will vary according to the ambient level of characteristics prior to the marginal change. The implicit marginal purchase price function describes the price paid for marginal increments of characteristics. However, he stated that it does not necessarily follow that it is the household demand curve for characteristics in the sense that it is unlikely to correspond to households' marginal willingness to pay (inverse demand curve) for characteristics. We can see that empirical observations of implicit marginal purchase prices and corresponding levels of protein (for example) in cheese tell us only about single points on each household's inverse demand curve for this protein. Thus, the implicit marginal purchase price curve can normally be used only to approximate the benefit of marginal changes in protein levels, such as in cheese. Freeman (1979) points out that when households have identical utility functions and incomes, the implicit marginal purchase price curve correctly estimates the benefits of non-marginal changes in product characteristics.

HPM researchers face a fundamental problem in that theory provides no particular expectation regarding the nature of the functional form of the implicit marginal purchase price and inverse demand function (other than that they are unlikely to be linear). The most commonly adopted forms are therefore the double log and semi-log forms. Bartik (1987) suggested that the econometric problem of estimating hedonic demand parameters is not a standard identification problem caused by demand-supply interaction, as has been often assumed. Estimation procedures based on this assumption lead to biased results. This is supported by Epple (1987) who noted that "the hedonic estimation problem is instead caused by the endogeneity of both prices and quantities when household face a non-linear budget constraint (p. 59)." An instrumental variables solution to this problem is suggested using instruments that exogenously shift the budget constraint. Bartik (1987) and Epple (1987) implied that OLS in the Freeman-Rosen approach will be biased because the household's choice of Z and X is positively correlated with the unobserved tastes in the residual. For example, a household with greater tastes for a characteristic will choose greater quantities of that characteristic. This positive correlation should lead to positive bias in OLS estimates of the common slope of two consumers' marginal bid functions. Bartik (1987) found that "a regression of marginal bids on Z_i will result in a straight line through the two observation points, and the slope of this line is more positive than the true marginal bid slope. If we estimate the inverse marginal bid function, regressing Z_i on the marginal price, the result is the same biased least-squares line (p. 81)." Bartik (1987) therefore utilized a semi-log functional form to estimate hedonic price functions. The marginal bid for neighbourhood physical condition was assumed to depend on the quantity of physical condition, non-housing expenditures, and demand shifters. Demand shifters included income, treatment-group dummies, a time trend, a dummy variable for city, and interaction terms between the city variable and demand shifters. The function was estimated using both OLS and the instrumental variable approach. The OLS estimate was greater than the instrumental estimate, consistent with the argument that OLS estimates are positively biased. Epple (1987) found that, "because marginal prices are implicit rather than explicit, hedonic pricing models raise identification and estimation issues beyond those normally confronted in simultaneous models (p. 59)."

Despite Freeman's assertions that all of the assumptions underlying the figures are "plausible," Bateman (1993) supported the finding of Bartik (1987) and Epple (1987), and stated that given that a utility-maximizing explanation of household behavior requires that household inverse demand curves be steeper than the implicit marginal purchase price curve, the assumptions underlying the HPM are all liable to result in overestimation of the benefits of product characteristics improvement (or underestimation of the costs of product quality loss).

To define the value of dairy products, the hedonic price function describes the value of any of the products as a function of product characteristics, and exogenous demand and supply factors. We expect that the value of a product increases with increased amounts of the characteristics in the product. Bateman (1993) argued that the constant marginal purchase price implied by the linear hedonic price function is unlikely to occur in reality. He meant that the amount of a characteristic is likely to be a normal good and exhibit diminishing marginal utility. The hedonic price function is therefore likely to be non-linear. He therefore stated that if we have a multiplicative underlying utility function, then a double log hedonic price function might be appropriate. The shape of net returns (and functional form) should therefore be guided by a data plot of wholesale prices on product characteristics.

The hedonic price method is an well-accepted theory of determining implicit market values of product characteristics. It is used to generate implicit characteristic values for a range of products and sectors. However, the theory provides no particular guidance regarding the functional form of the implicit marginal purchase price and inverse demand function. The following chapter will thus provide a detailed description of the underlying data for the hedonic market analysis where the shadow values of milk constituents are estimated. The empirical model is then specified and an estimation strategy provided, followed by the methodology employed.

3.2 Dummy Variables

The purpose of this section is to consider the role of qualitative explanatory variables in the regression analysis. The introduction of qualitative variables, or dummy variables, allows us to test the null hypothesis that there is no difference in intercept coefficients between product categories. More interesting, it allows us to test the null hypothesis that there is no difference in slope coefficients, or shadow values, between product categories. The definition of each of the dummy variables employed in this thesis is shown in table 4.1.

CHAPTER 4

4.0 DATA AND EMPIRICAL MODEL

The empirical approach and estimating hedonic equation, as theoretically described in chapter 3, are the focuses of this chapter. The objectives are first to provide a description of the data used to estimate the implicit values of milk components, and then to explain the specification and expected signs of variables included in the regression equations that will follow.

4.1 The Data

The testing of the hedonic model is done with pooled cross-sectional and time-series data, from January 1993 to July 1996. The data sources include: wholesale prices from Dairyland Foods Inc. (the main processor in B.C.), nutrient values of dairy goods from e.g., the Dairy Bureau of Canada, the B.C. monthly income data from Statistics Canada, and monthly raw milk prices from the B.C. Milk Marketing Board.

The annual regression estimates (including only nutrient values and not supply and demand shifters) are based on data from January 1993 to December 1996, and are discussed in section 5.1.6. The cross section data (nutrient values of 60 dairy products; 6 fluid products and 54 industrial products), are combined with monthly time series data (the time-based demand and supply shifters), to explain the variability in wholesale prices. In total 2,580 (43*60) observations are employed in the aggregated fluid and industrial products data set, and 2,322 (43*54) observations in the industrial market model. The basic models are then tested using data from 12 monthly observations, each year on 60 and 54 products in the aggregated and industrial market, respectively.

A listing of the variables used in this study, including definitions and descriptive statistics, is presented in tables 4.1 and 4.2. However, a definition of the variables is needed for a clearer understanding of the product characteristics and demand and supply shifters used.

Table 4.1. Definition of Variables

$PRICE_{ijt}$	wholesale price per kg of product *i*, in category *j*, in time period *t*;	
PT_{ijt}	grams of protein per kg of product *i*, in category *j*, in time period *t*;	
$SPTR_{ijt}$	grams of protein per kg of product *i*, squared and divided by 1000, in category *j*, in time period *t*;	
BF_{ijtt}	grams of butterfat per kg of product *i*, in category *j*, in time period *t*;	
$SBFR_{ijt}$	grams of butterfat per kg of product *i*, squared and divided by 1000, in category *j*, in time period *t*;	
OS_{ijt}	grams of other solids (lactose, minerals and vitamins) per kg of product *i*, in category *j*, in time period *t*;	
$SOSR_{ijt}$	grams of other solids per kg of product *i*, squared and divided by 1000, in category *j*, in time period *t*;	
LT_{ijt}	grams of lactose (carbohydrates) per kg of product *i*, in category *j*, in time period *t*;	
CA_{ijt}	grams of calcium per kg of product *i*, in category *j*, in time period *t*;	
MI_{ijt}	grams of other minerals (phosphorous, magnesium, zinc, potassium and sodium) per kg of product *i*, in category *j*, in time period *t*;	
MIN_{ijt}	grams of total minerals (Ca_{ijt}+ MI_{ijt}) per kg of product *i*, in category *j*, in time period *t*;	
VIT_{ijt}	grams of total vitamins (fat-soluble vitamins (vitamin A) and water-soluble vitamins B_6, B_{12}, and riboflavin) per kg of product *i*, in category *j*, time period *t*;	
$PMILK_{jt}$	raw milk price, as processor cost, classified accounting values for product *i*, in category *j*; time period *t*;	
$INCOME_t$	provincial income in time period *t*;	
$PSUBST_t$	wholesale price of orange juice in time period *t*	
	* DUMMY	(=1, if observation is from fluid category); (=0, otherwise);
DFLUID		(=1, if observation is from fluid category); (=0, otherwise);
DPTFLUID	PT * DUMMY	(=1 for protein if observation is from fluid category); (=0, otherwise);
DBFFLUID	BF * DUMMY	(=1 for butterfat if observation is from fluid category); (=0, otherwise);
DLTFLUID	LT * DUMMY	(=1 for lactose if observation is from fluid category); (=0, otherwise);
DVMFLUID	(VIT+MIN) * DUMMY	(=1 for vitamins and minerals if observation is from fluid category); (=0, else);
DVCFLUID	(VIT+CA) * DUMMY	(=1 for vitamins and calcium if observation is from fluid category); (=0, otherwise);
DICE	DUMMY	(=1, if observation is from ice cream/sherbet/sour cream category); (=0, otherwise);
DPTICE	PT * DUMMY	(=1 for protein if observation is from ice cream/sherbet/sour cream category); (=0, otherwise).
DBFICE	BF * DUMMY	(=1 for butterfat if observation is from ice cream/sherbet/sour cream category); (=0, otherwise);
DLTICE	LT * DUMMY	(=1 for lactose if observation is from ice cream/sherbet/sour cream category); (=0, otherwise);
DPTYOG	PT * DUMMY	(=1 for protein if observation is from yogurt category); (=0, otherwise);

Table 4.1. Continued.

DPTIY	PT * DUMMY	(=1 for protein if observation is from ice cream/sherbet/sour cream and yogurt categories); (=0, otherwise);
DCHE	DUMMY	(=1, if observation is from cheese category); (=0, otherwise);
DPTCHE	PT * DUMMY	(=1 for protein if observation is from cheese category); (=0, otherwise);
D956	DUMMY	(=1, if observation is from 1995 and 1996); (=0, otherwise);
DPT956	PT * DUMMY	(=1 for protein if observation is from 1995 and 1996); (=0, otherwise);
DBF956	BF * DUMMY	(=1 for butterfat if observation is from 1995 and 1996); (=0, otherwise);
DOS956	OS * DUMMY	(=1 for other solids if observation is from 1995 and 1996); (=0, otherwise);
e_{ijt}	epsilon, the error disturbance term in product i, in product category j, in time t; $e_{ijt} \sim N(\rho,\sigma^2)$.	

Table 4.2. Descriptive Statistics

VARIABLE	MEAN		ST. DEV.		MIN		MAX	
	AGGRE-GATED MODEL	INDUS-TRIAL MODEL	AGGRE-GATED MODEL	INDUS-TRIAL MODEL	AGGRE-GATED MODEL	INDUS-TRIAL MODEL	AGGRE-GATED MODEL	INDUS-TRIAL MODEL
PRICE	6.18	6.72	3.03	2.70	1.21	2.36	15.42	15.42
PT	108.72	117.07	104.81	107.27	1.00	1.00	500.00	500.00
SPTR	22.80	25.21	39.63	41.07	0.00	0.0010	250.00	250.00
BF	164.89	181.49	186.30	189.20	1.00	1.00	820.00	820.00
SBFR	61.88	68.72	140.44	146.46	0.0010	0.0010	672.40	672.40
LT	111.46	117.51	100.73	104.20	1.00	1.00	304.17	304.17
CA	2.72	2.89	3.04	3.16	0.20	0.20	14.50	14.50
MIN	10.06	10.68	9.61	9.94	0.62	0.62	44.40	44.40
MI	7.34	7.79	6.94	7.17	0.12	0.1186	30.63	30.63
VIT	0.0046	0.0048	0.0041	0.0043	0	0	0.0261	0.0261
OS	121.52	128.20	96.44	99.19	1.81	1.81	306.60	306.60
SOSR	24.07	26.27	28.62	29.33	0.00	0.0033	94.00	94.00
PMILK	49.74	48.02	5.30	1.12	45.78	45.78	67.96	49.77
PSUBST	0.13	-	0.38	-	0	-	1.30	-
INCOME	597.29	597.29	6.78	6.78	587.09	587.09	620.30	620.30
DPT956	48.04	51.73	88.15	92.01	0	0	500.00	500.00
DPTFLUID	3.35	-	10.06	-	0	-	34.75	-
DPTCHE	85.62	95.13	120.28	123.16	0	0	500.00	500.00
DPTICE	11.39	12.66	19.50	20.16	0	0	67.78	67.78
DPTYOG	8.30	9.23	17.81	18.54	0	0	57.27	57.27
DPTIY	19.70	21.89	22.54	22.73	0	0	67.78	67.78
DBF956	72.86	80.19	148.47	154.74	0	0	820.00	820.00
DBFFLUID	1.55	-	5.66	-	0	-	33.50	-
DBFICE	32.30	35.88	58.70	60.82	0	0	180.00	180.00
DOS956	53.70	56.65	88.05	91.67	0	0	306.60	306.60
DLTFLUID	5.69	-	18.34	-	0	-	104.02	-
DLTICE	64.96	72.18	108.55	112.12	0	0	304.17	304.17
DVMFLUID	0.45	-	1.34	-	0	-	4.73	-
D956	0.44	0.44	0.50	0.50	0	0	1	1
DFLUID	0.10	-	0.30	-	0	-	1	-
DCHE	0.38	0.43	0.49	0.49	0	0	1	1
DICE	0.28	0.31	0.45	0.46	0	0	1	1
DYOG	0.18	0.20	0.39	0.40	0	0	1	1
DIY	0.47	0.52	0.50	0.50	0	0	1	1

4.1.1 Product Characteristics

An important feature of the data set is that nutrient values of the product characteristics protein, butterfat and lactose, and minerals and vitamins (aggregated as other solids), are calculated and therefore not actual values or moving averages. We assume that dairy products retain the same nutrient values across time. In other words, component levels, as one part of the right hand side variables in our model, will vary considerably across products, but are constant over time. This may not be entirely accurate. Individual processor data on nutrient values might reveal individuality in nutrient values in products across processors. Individual processor data on nutrient values was requested, but was not provided for confidentiality reasons. The specification of products produced, given the lists of wholesale prices on the different products produced in B.C., was therefore carefully followed, and the literature[17] was searched to allocate the industry standard allotment of nutrient values to each specific product. Various methods were used such that each product was allocated with its converted component values, in grams of each component per kilogram of product (g/kg), for all of the 60 products considered. Each product, with its corresponding wholesale price in dollar-value per kilogram ($/kg) of product, therefore represents one cross-section in our data set. It should also be noted that although the large seasonal variation in the production of raw milk components (in kg/hl milk) might affect the composition of products, it could also be that only production levels are affected. In this thesis, we assume the latter.

It is questionable whether the registered nutrient values of protein include the non-protein fraction of nitrogen (urea). If protein contains urea, shadow values of protein may be over-estimated (Li-Chan, 1997). The registered values of butterfat include saturated fat, and the mineral component (MIN) is the sum of calcium (CA), potassium, sodium, phosphorous, magnesium and zinc. Vitamins (VIT) include fat-soluble vitamins (vitamin A) and water-soluble vitamins (vitamin B_6, B_{12} and riboflavin). Vitamin A activity was expressed in retinol equivalents (RE) in all publications and was translated into metric measure by the following

[17] "Nutrient Values of Dairy Foods" published by the Dairy Bureau of Canada, the 1982 and 1996 issues, and "Bowes and Church's: Food Values of Portions Commonly Used", Pennington (1994), are the primary sources for these calculations.

standards:

1 RE = 3.33 International Units (IU) of retinol;

1 IU = 0.344 μg of all trans vitamin A, such that

1RE = 3.33 IU = 3.33 * 0.344 μg = 1.14552 μg.

The calculated nutrient values in grams per kilogram of product used in estimating the value of milk components are presented in tables 4.3-4.7.

As discussed in chapter 3, the hedonic literature does not indicate the types of market goods that can be aggregated. The more the data is aggregated, the greater the variability in the valuation and use of constituents. This feature is useful for statistical estimation, but may pose difficulties if we force the same shadow value on uses when the actual shadow value may be different. For this reason, the cross-section data is divided into five major product categories: fluid products, cheese, ice cream (including sherbet and sour cream), butter, and yogurt. The categories were designed to contain products that have similar features and anticipated similar shadow values of product characteristics.

To measure individual differences in component shadow values across these product categories, slope dummies can be introduced and tested. The data is aggregated in a model of industrial products and in an aggregated fluid and industrial product model to increase the degrees of freedom and to reduce specification bias.

Table 4.3. Nutrient Values in Cheese[18]

Product Category	PT g/100g	BF g/100g	LT g/100g	CA g/100g	MIN g/100g	VitA[19] g/100g	VitB[20] g/100g
Cheese:							
Hard Cheese							
Cheddar	26.00	34.00	2.00	0.72	1.98	3.48	4.55
Cheddar, reduced fat	31.50	15.00	0.10	0.84	2.28	1.89	6.61
Mozzarella	22.00	24.00	2.00	0.57	1.50	3.14	3.47
Mozzarella, partly skimmed	28.00	18.00	4.00	0.73	1.91	2.20	4.21
Colby	24.07	32.50	2.61	0.69	1.90	3.16	4.61
Farmers	24.07	32.50	2.61	0.69	1.92	3.19	4.58
Edam	25.36	28.21	1.43	0.74	2.46	10.49	15.62
Gouda	25.36	27.86	2.14	0.71	1.98	3.48	4.15
Monterey Jack	24.00	30.00	0.68	0.75	1.84	2.91	4.81
Brick	23.54	30.04	2.82	0.68	1.85	3.46	4.27
Havarti	21.79	37.86	1.07	0.63	1.62	4.36	0.72
White cheese, average	23.40	31.30	0.10	0.56	1.60	3.61	5.61
Soft Cheese							
Parmesan, grated	50.00	33.33	0.10	1.45	4.44	2.10	4.52
Processed cheddar	22.00	32.00	2.00	0.62	2.98	3.32	4.33
Processed Swiss	25.00	25.36	2.14	0.78	3.15	2.63	3.17
Processed spread, cheddar	18.75	18.75	6.25	0.56	3.31	2.15	5.57
Processed spread, with skim milk	25.00	6.25	12.50	0.54	3.61	1.15	4.38
Cream cheese	8.00	34.00	2.00	0.08	0.61	5.02	2.48
Cream cheese light	10.36	16.79	6.43	0.14	1.07	2.06	0.72
Cottage cheese, (4.5 % M.F.)	12.17	4.35	2.61	0.06	0.69	0.55	2.33
Cottage cheese (2% M.F.)	14.06	1.56	3.91	0.07	0.73	0.23	2.64
Cottage cheese (1% M.F.)	12.40	0.78	3.10	0.06	0.50	0.06	8.88
Cottage cheese, (0.4% M.F.)	16.88	0.39	1.30	0.03	0.18	0.09	9.59

Table 4.4. Nutrient Values in Butter[17]

Product Category	PT g/100g	BF g/100g	LT g/100g	CA g/100g	MIN g/100g	VitA[21] g/100g	VitB[22] g/100g
Butter:							
Regular	0.10	82.00	0.10	0.02	0.88	8.71	-
Unsalted	0.10	82.00	0.10	0.02	0.08	8.71	-
Whipped	0.10	77.50	0.10	0.03	0.85	8.31	-

[18] The numbers are rounded for case of readability, but more precise numbers are used in the actual calculations. PT=protein, BF=butterfat, LT=lactose, CA=calcium, MIN=total minerals, VitA=vitamin A, VitB=vitamin B.

[19] Fat-soluble vitamins, as vitamin A, in 10^{-4} g/100g.

[20] Water-soluble vitamins, as vitamin B_6, B_{12} and riboflavin, in 10^{-4} g/100g.

[21] Fat-soluble vitamins, as vitamin A, in 10^{-4} g/100g.

[22] Water-soluble vitamins, as vitamin B_6, B_{12} and riboflavin, in 10^{-4} g/100g.

Table 4.5. Nutrient Values in Ice Cream, Sherbet, and Sour Cream[17]

Product Category	PT g/100g	BF g/100g	LT g/100g	CA g/100g	MIN g/100g	VitA[23] g/100g	VitB[24] g/100g
Ice cream, sherbet, and sour cream:							
French, vanilla, soft serve	4.07	13.02	22.21	0.13	0.50	1.86	0.94
Regular, vanilla	3.48	11.06	23.48	0.13	0.53	1.43	1.06
Regular, strawberry	3.18	8.48	27.58	0.12	0.48	1.10	0.91
Regular, chocolate	3.79	11.06	28.18	0.11	0.57	1.41	0.92
Cookies'n cream	6.78	2.44	28.00	0.17	0.55	1.95	1.00
Haagen Dazs:							
Vanilla	4.44	15.56	21.56	0.10	0.38	1.70	0.33
Strawberry	4.14	14.31	21.98	0.10	0.38	1.65	0.26
Chocolate	4.62	16.37	22.20	0.09	0.47	1.98	0.11
Butter pecan	4.83	15.98	27.36	0.10	0.47	1.68	0.69
Coffee	4.29	14.29	24.02	0.11	0.44	2.19	0.27
Chocolate chip	4.83	16.07	25.39	0.09	0.47	1.64	0.11
Honey vanilla	4.27	15.39	21.01	0.10	0.41	2.02	0.45
Vanilla, Swiss almond	5.13	18.00	22.00	0.10	0.41	1.66	0.38
Sherbet, orange	1.15	1.98	30.42	0.05	0.24	0.26	0.52
Sherbet, fruit flavors	1.24	1.75	28.14	0.05	0.28	0.23	-
Sour cream (14% M.F.)	2.80	13.33	4.25	0.11	0.38	1.53	1.47
Sour cream, light	5.33	4.67	12.00	0.11	0.59	2.66	0.67

Table 4.6. Nutrient Values in Fluid Milk[17]

Product Category	PT g/100g	BF g/100g	LT g/100g	CA g/100g	MIN g/100g	VitA[25] g/100g	VitB[26] g/100g
Fluid milk:							
Homogenized milk	3.30	3.35	4.67	0.12	0.43	0.36	2.05
2% skim	3.33	1.93	4.80	0.12	0.44	0.65	2.10
1% skim	3.36	1.07	4.80	0.12	0.44	0.67	2.10
Skim	3.43	0.16	4.86	0.12	0.45	0.70	1.80
Chocolate milk (2% M.F.)	3.21	1.99	10.40	0.11	0.46	0.65	2.04
Buttermilk (0.8% M.F.)	3.47	0.77	4.63	0.12	0.47	0.09	1.89

[23] Fat-soluble vitamins, as vitamin A, in 10^{-4} g/100g.
[24] Water-soluble vitamins, as vitamin B_6, B_{12} and riboflavin, in 10^{-4} g/100g.
[25] Fat-soluble vitamins, as vitamin A, in 10^{-4} g/100g.
[26] Water-soluble vitamins, as vitamin B_6, B_{12} and riboflavin, in 10^{-4} g/100g.

Table 4.7. Nutrient Values in Yogurt[17]

Product Category	PT g/100g	BF g/100g	LT g/100g	CA g/100g	MIN g/100g	VitA[27] g/100g	VitB[28] g/100g
Yogurt:							
Plain, Swiss style	5.14	2.29	6.86	0.18	0.63	0.23	3.00
Fruit, Swiss style	4.57	1.71	17.14	0.14	0.50	0.27	2.34
Plain, set style, (0.9% to 2% M.F.)	5.14	1.71	6.86	0.18	0.65	0.18	6.58
Yoplait:							
Flavor	4.12	2.35	18.06	0.05	0.24	-	-
Vanilla, set style, low fat	5.29	1.76	17.06	0.05	0.29	-	-
Fruit flavor, low fat	4.71	1.76	18.82	0.05	0.27	-	-
Skim	5.73	0.10	7.93	0.05	0.33	-	-
Fruit flavor, skim	4.12	0.10	18.24	0.05	0.29	-	-
Frozen yogurt, vanilla soft serve	3.89	5.56	24.17	0.14	0.58	0.73	1.25
Frozen yogurt, strawberry	3.09	3.09	20.62	0.05	0.06	-	-
Frozen yogurt, chocolate, soft serve	4.03	9.52	24.86	0.15	0.67	-	1.11

Source: Dairy Bureau of Canada (1996), Pennington (1994), Souci (1994), Macrae (1993), Holland et al.(1991).

4.1.2 Demand and Supply Shifters

Contrary to the structure of component values, which vary across products but not over time, the demand and supply shifters considered (income, milk price and price of substitutes), vary across time, but are constant across products. These variables will therefore capture time-series variation rather than cross-sectional variation. In fact, the nature of the data might cause all time-series changes to be captured by the supply and demand shifters. Interpretation of their effect on milk product prices should therefore be done with caution, since it is uncertain whether it is the time trends or the actual individual variables that are influencing variation in wholesale prices. Since the demand and supply variables are contributing to time-series variation rather than to cross-sectional variation, the "time-series" variables are separable from the component (cross-section) variables. This allows us to drop the demand/supply shifters

[27] Fat-soluble vitamins, as vitamin A, in 10^{-4} g/100g.
[28] Water-soluble vitamins, as vitamin B_6, B_{12} and riboflavin, in 10^{-4} g/100g.

from the regression equation without omitted variable bias. The regressions can then be estimated employing annual data, as discussed in section 5.1.6. However, if the time-series variables pick up changes in milk product values over time (assuming that wholesale price levels and the demand/supply shifters are correlated), then the inclusion of the demand and supply variables will improve the reliability of the component shadow values because there will be less specification bias. The results (i.e. trends in protein and butterfat shadow values) are thus expected to be more reliable in the larger models, i.e. the aggregated model, due to less specification error and higher degrees of freedom.

All demand and supply shifters are adjusted by the all-items consumer price index (December 1996=100). Prices of substitutes (PSUBST) are included to capture exogenous effects on demand for dairy products. Some manufactured products such as cheese, yogurt and ice cream do not have obvious substitutes. The variable PSUBST is therefore considered for fluid products only, and is thus a dummy variable. Data on prices of bottled drinking water, an appropriate substitute for fluid milk, were not accessible. Monthly wholesale values per litre of orange juice and non-dairy creamers such as "Irish cream", were therefore used. The price of complements could also have been used for dairy products, but these are not considered in the model. Further research should explore this option. Monthly income in B.C. (INCOME) is gathered from B.C. Statistics, and employed as a demand shifter to capture exogenous effects on demand in our model. Other exogenous demand factors, such as consumers' preferences for products produced by a particular processor, will not be revealed by this type of data.

The raw milk costs (PMILK) are employed as processor costs in the regression analysis, and is the only exogenous supply shifter considered. Since processor costs can be divided into raw milk costs and non-raw milk costs, the use of PMILK only introduces concerns about cost of technology. Because of the limited availability of processing costs (other than raw milk purchases), the non-raw milk costs are assumed to be similar across products (and across constituents). This assumption implies that the non-raw milk costs do not contribute to the variability in wholesale prices. Fluid milk production involves a relatively fixed coefficient technology with basically fixed proportions (with little input substitution) in terms of non-milk costs and in terms of raw milk costs, but it could be that component levels vary a fair bit, especially in terms of butterfat and lactose (see table 4.3). It is difficult to determine the effect of omitting non-raw milk costs from the model. If they vary across products (likely) and there is correlation between products and components (uncertain), the effect might be picked up by the component levels. It is difficult to assess the magnitude of this potential problem, and it is not clear in which direction omission would biases the estimated component coefficients (shadow values). For this reason, we are confident that omitting non-raw milk costs does not invalidate the results.

Data on raw milk costs is obtained from the B.C. Milk Marketing Board classified accounting milk values, from which processors purchase the milk according to its end use. Since deductions are made from these prices, the prices are not those that are actually paid to producers. The accounting values are determined by a formula involving price of alfalfa hay, an index of 16% dairy feed and farm wages, an index of prices of farm inputs, an index of industry product price, an index of consumer prices, and average weekly wages and salaries in B.C. Because of the regulative nature of the determination of the raw milk price, the price may be capturing cost factors that are in the milk pricing formula rather than just the cost to the processors of raw milk. This is a potential specification bias, and the estimated coefficients should be interpreted cautiously.

Raw milk costs vary across milk products. In the period considered in the hedonic model (1993-1996), milk purchased for fluid purposes is priced 27-40 percent higher than milk used in manufacturing. In January 1993, adjusted fluid milk costs were $64.75/hl, and dropped from $67.32/hl to $61.28/hl between July and August 1995 in an attempt to improve B.C.'s competitiveness in the fluid milk market. The price was $62.98/hl in July, 1996. Only marginal differences exist between the unit raw milk costs of all manufactured milk. The class 2 milk, used in the production of yogurt and ice cream, is priced approximately 2 percent higher than milk for other industrial purposes. Industrial milk costs increased by 3 percent (from $47.85/hl to $49.41/hl) and 5 percent (from $45.99/hl to $48.37/hl) between January 1993 and July 1996 for class 2 and other industrial milk, respectively.

4.1.3 Wholesale Prices

This thesis attempts to detect the sources of variation in wholesale prices, the dependent variable in the estimated regression equations. Wholesale prices of 60 products (product details in table 4.3-4.7) are gathered from Dairyworld Foods Inc., the main processor in B.C. Dairyworld processes approximately 85 percent of all milk produced in B.C. The province is self-sufficient in most dairy products, except cheese, where there are substantial imports (appendix 6). The use of data only from this one processor is thus warranted. If there were several processors and a large quantity of imports in the province, hedonic estimation based on wholesale data from only one processor as a proxy for overall dairy product valuation would be a source of estimation bias. The regulation of the industry, the concentration of the processing market, and the high level of self-sufficiency in most products make it appropriate to use wholesale prices on milk products derived from only one processor. However, this prevents testing for consumer preferences across a wider range of products and component levels.

As briefly explained in the background to the industry in chapter 1, support prices act as floor prices in the wholesale trade of butter and skim milk powder (SMP) and thereby have an indirect effect on wholesale prices of all dairy products. Support prices are currently $5.33/kg and $3.93/kg for butter and SMP, respectively (Dairy Farmers of Canada, 1996). However, farm level butterfat prices have been sustained at $5.30/kg since 1996. Since approximately 820 grams of a kilogram of butter are butterfat, and one kilogram of SMP contains approximately 350 grams of protein, 505 grams lactose and 9.7 grams butterfat (Dairy Bureau of Canada, 1996), support prices can easily be used in component valuation. The estimated shadow values in the hedonic price model presented in tables 5.11 and 5.12, will therefore be compared to the support prices of butterfat and non-fat solids, and will indicate whether support prices reveal the "true" market values of the components. Bearing in mind that support prices indirectly affect all dairy products, the interpretation of wholesale prices as market determined valued must be undertaken with some caution.

Given that the price variation across fluid milk is limited, for any demand or supply shocks, it must be that quantities absorb the adjustment. We are therefore getting limited shadow price information on the components from the fluid market, and rather some data on preferences only. This important difference between the fluid and the industrial milk market, suggests that we aggregate the fluid products with the industrial market data and estimate component shadow values for the whole milk market, testing any differences between it and the fluid market with slope dummies.

In our model, wholesale prices are employed instead of retail prices since the difference between wholesale and retail prices, i.e., the retail margin, is not likely to differ because of differences in component levels. Data at the wholesale level also provides the most direct shadow value of the components. Wholesale prices were generally registered in dollar-value per kilogram of product ($/kg). However, the price of ice cream, frozen yogurt, sherbet, and all fluid products were registered in value per liter of product. Calculations of wholesale prices from litre to kilogram were therefore required to obtain an overall homogeneous measure, in value per kilogram ($/kg). Since nutrient values of most of these product were obtained from the U.S. literature, and measured in cups and pints of product with corresponding weight in grams, cups were converted into litres, employing the following formula (Pennington, 1994):

1 liquid pint = 2 cups of liquid measure = 0.4732 liter

This formula is the basis for the density calculations provided in table 4.8. Product values per liter of product were converted into product values per kilogram of product. Wholesale prices per liter of product in some of the product categories did not change much across products. However, the variability in density of each product caused substantial differences in product prices per kilogram of product. Consequently, a product group that received similar prices per litre would, if of low density, obtain higher price per kilogram compared to high-density products. Finally, since wholesale prices differ according to size and quantity of the products, prices for the most common sales volume levels were utilized.

Table 4.8. Product Density

	Density (Liters * factor = kg)		**Density (Liters * factor = kg)**
ICE CREAM		**FROZEN YOGURT**	
French vanilla, soft serve	0.7270	Frozen yogurt, strawberry	0.8199
Vanilla, regular	0.5579	Frozen yogurt, vanilla soft serve	0.6086
Strawberry	0.5579	Frozen yogurt, chocolate, soft serve	0.6086
Chocolate	0.5579		
Cookies'n cream	0.7608	**FLUID:**	
Haagen Dazs:		Homogenized milk	1.032
Vanilla, swiss almond	0.6762	2% skim	1.032
Vanilla	0.7608	1% skim	1.032
Strawberry	0.9806	Skim	1.036
Chocolate	0.7692	Chocolate milk (2% M.F.)	1.056
Butter pecan	0.7354	Buttermilk (0.8% M.F.)	1.036
Coffee	0.9467	Sour cream (14% M.F.)	1.000
Chocolate chip	0.7523	Sour cream, light	1.000
Honey vanilla	0.7523		
SHERBET			
Sherbet, orange	0.8115		
Sherbet, fruit flavors	0.8199		

Source: Primary calculations

4.1.4 Procedures

Component values are strongly interdependent, and as some variables are highly correlated (appendix 7), estimation procedures were undertaken with caution to avoid multicollinearity. The basic model includes the product characteristics protein (PT), the squared term of protein (SPTR), butterfat (BF), the squared term of butterfat (SBFR), and other solids (OS), and the demand and supply shifters. This model was estimated for the aggregated industrial and fluid product markets, and for the industrial product market only.

Various tests of this basic model were then undertaken. To allow for different shadow values across product categories, slope dummy variables were introduced (together with intercept dummy variables). This was done first in the fluid milk category, and then in other product categories. Since component values are constant over time, and vary substantially across products, regressions within years will account for cross-section variation, but will miss any drift in product valuation within year. Slope dummies were therefore tested for structural shifts in shadow values in the latter half of the data (1995/96). In another test, the supply/demand shifters were left out and annual regressions (as explained in section 4.2.1) estimated. These tests indicate if component values are increasing or decreasing over time. The trends in these two tests can then be compared. The fluid market is not presented separately because of the limited variability in both the protein component and wholesale prices across fluid products. Given the small level of variation in fluid milk product prices, it was advisable to estimate an aggregate model and introduce the fluid milk market by slope (and intercept dummy-variables) for milk components here. This allows for different component shadow values in fluid milk. Because of the consumption trends in the fluid market, the implicit value of nonfat solids is expected to be higher in the fluid market than in the industrial market.

4.2 The Empirical Model

The econometric model employed to estimate the implicit milk component values in B.C. is specified in this section. The guiding principle in this approach to component valuation is to determine the components that processors utilize and value, and indirectly, the components that are valued by consumers. The rationale of the hedonic approach is employed to determine how different constituent levels affect the wholesale selling price of the product, holding everything else constant. We focus on the economics of the potential explanatory factors for causing variability in wholesale values, such as the probabilistic assumptions made about the dependent and the explanatory variables, and the functional form of the empirical model.

The model we estimate is the hedonic price regression for the marginal product estimates of raw milk constituents. The model must include product characteristics and demand and supply shifters, as discussed in chapter 3. The two basic empirical models for product type i are:

$$PRICE_{ijt}=\beta_0+\beta_1 PT_{it}+\beta_2 BF_{it}+\beta_3 OS_{it}+\beta_4 PMILK_{jt}+\beta_5 PSUBST_t+\beta_6 INCOME_t+\varepsilon_{ijt} \quad (4.1)$$

which is linear both in parameters (the ß's), and in variables, and

$$PRICE_{ijt}=\beta_0+\beta_1 PT_{it}+\beta_2 PT_{it}^2+\beta_3 BF_{it}+\beta_4 BF_{it}^2+\beta_5 OS_{it}+\beta_6 PMILK_{jt}+\beta_7 PSUBST_t+\beta_8 INCOME_t+\varepsilon_{ijt} \quad (4.2)$$

which is linear in the parameters but non-linear in the variables.

The employed variables are defined in table 4.1, and the subscript "ijt" on the applicable RHS variables specifies dairy product or product type *i*, in product category *j*, in time *t*;

(i = 1,..60, products);

(j = 1,..5, product categories);

(t = 1,..43, months for each product i).

4.2.1 Model Specification and Strategy

Product Characteristics

The levels of all milk solids: protein, butterfat, and other solids (lactose, minerals and vitamins) are hypothesized here to positively contribute to the variability in wholesale prices in the dairy products studied. If levels of components did not contribute to price variability, there would be incentives to processors to remove and eliminate constituents with negative shadow values. Lactose is reduced in some fluid milks because of lactose intolerance, butterfat consumption is declining significantly, and vitamin A and D are often added to fluid milks. This is likely a response to consumer preferences and therefore changing shadow values of components. In equilibrium, components might flow between products, and be allocated to products where the highest value is obtained. The marginal implicit values of constituents might merge in equilibrium, but there may be processing constraints that prevent complete equalization of those values, as discussed in chapter 1. Slope dummies are introduced into the model to test for the potential differences in shadow values across product categories.

Protein, butterfat, and to a certain extent, lactose, contribute to product yields, quality and taste, discussed in chapter 2, and are therefore anticipated to contribute positively to the variability in wholesale prices. Lactose, minerals, and vitamins can be treated separately or aggregated into the category of "other solids". To provide comparability to the situation in other jurisdictions, the aggregated component of other solids is of major importance in the basic model. Inclusion of the separate variables of minerals/calcium and vitamins assume there are consumer preferences for these components and processor awareness of these preferences. If minerals (calcium) and fat-soluble and water-soluble vitamins, which do not contribute to the taste of the final product, are to have a positive effect on consumer demand at retail, they would have a measurable effect at wholesale level only in a competitive market. If there is no effect at wholesale, then there are no options to convey this consumer valuation to producer and wholesale supply. The *a prior* predictions of the significance of these variables are therefore uncertain.

Component plots of butterfat and wholesale prices suggest diminishing marginal net returns to butterfat. The functional form of the model might therefore be linear in the parameters, the β's, but non-linear in the butterfat variable. Consequently, in addition to using a linear functional form in both variables and parameters, squared terms on component variables of both protein, butterfat and other solids (SPTR, SBFR and SOSR) were employed in the estimation procedure. The plots of protein and other solids and wholesale price did not offer *a prior* predictions of the signs of the coefficients of SOSR and SPTR; their effect on explaining the variability in wholesale prices is therefore unclear. Consumer marginal willingness to pay for additional butterfat is expected to decrease as butterfat levels increase, which supports the hypothesis that there is a lower and diminishing marginal net return to butterfat, and a negative sign on the estimated coefficient of SBFR.

A Box-cox test can be useful in the specification process, although Box-cox transformations in the regressions do make interpretations challenging. Logarithmic functional forms of the estimation equation were considered, given the suggestions in the literature discussed in chapter 3. However, the logarithmic form limits the already marginal variability in some of the variables (especially in the fluid market), and the estimations using this functional form was not successful. A linear functional form allowing for diminishing returns (squared terms of constituents) has therefore been used in all reported regressions.

Although our special concern is estimating the shadow values of raw milk components, the effects of the variables on wholesale prices may differ across different groups of products. For example, the effect of the variables on prices may be different for cheese products and fluid products. To capture these differences we introduce interaction terms between certain product categories and the certain components. Intercept dummies indicate how milk product values are higher or lower than the estimated equation would predict, holding all right-hand-side variables constant. Slope dummy variables capture the potential difference in shadow values across product categories. If all parameters are the same, then there are no behavioral differences across product categories, and the data can be treated as one sample.

Constituent interdependence and therefore high simple correlation between butterfat and the squared term of butterfat, and protein and the squared term of protein, caused some instability in estimated coefficients, and caution had to be taken to prevent multicollinearity. This was a problem in the testing of the basic model, since the dummy variables are calculated from variables on nutrient values. Separate tests of the basic models were therefore required. To capture the potentially different implicit shadow values of components in the fluid market, slope and intercept dummies were introduced in the fluid category in the aggregated model. The values of butterfat, protein and lactose in fluid milk are of special interest, given the skim-off problems of butterfat, and that more protein and lactose (and less butterfat) are consumed in fluid milk as the consumption of low-fat products increases (tables 4.3-4.7). The sign of the slope dummy for butterfat in the fluid category (DBFFLUID) is therefore hypothesized to be negative; the slope dummy for protein in fluid milk (DPTFLUID) is hypothesized to contribute positively to the value of protein in fluid milk.

Because of lactose intolerance, consumer preferences for no-lactose products might suggest that increasing levels of lactose in fluid milk would decrease the milk's value. The *a priori* expectation of the sign of DLTFLUID is therefore negative, although uncertain because the consumption of lactose in fluid milk is increasing (since consumption of low-fat milk is increasing). Calcium (CA) and vitamins (VIT) are hypothesized to play a more important role in valuation of fluid milks, giving that these constituents are currently added to beverage milk. In other words, consumer willingness to pay for the "wholesome" fluid beverage, i.e. the willingness to pay for protein, calcium/minerals and vitamins is expected to be higher in fluid milks than in manufactured dairy products. These product constituents are hypothesized to contribute positively to wholesale prices and are therefore separately tested with slope dummies.

The shadow values of protein, butterfat and lactose are then tested for different values in other product categories. The *a prior* expectations of the signs of the component coefficients are uncertain. We will therefore not try to anticipate values to be positive (higher than average) or negative (lower than average). The problems of multicollinearity, or highly correlated variables, were severe, but because of the importance of the fluid market, the slope dummy for protein in fluid milk (DPTFLUID) is included in many of the regressions.

In addition to testing slope dummies for component values in certain product categories, slope dummies are employed to allow the shadow values to change over time. This allows us to test for a structural change in component valuation over time. A slope dummy for the 1995/96 period is tested to determine whether the component values differ in this latter period compared to the previous period. All other potential dummy variables are left out. The *ex ante* expectation is not clear. However, the increasing dimensions of skim-off from the fluid to the industrial sector in B.C. reflect changes in consumer preferences. The value of butterfat is therefore expected to have declined the last years. Consumption data by component in B.C. revealed that consumption of all milk components, not only butterfat but also protein and other solids, have flattened out and even declined since the beginning of 1995 (appendix 5). Although the distribution pattern of the allocation of these components is somewhat unclear, the consumption data might indicate that shadow values are overall declining.

As discussed in section 4.1.2, component levels in each milk product vary across products but not over time, while the demand and supply shifters vary over time but not across products. The time-series variables are therefore separable from the component (cross-section) variables. The supply and demand shifters are thus left out of the model and component values are estimated using data for separate years. This provides a complimentary test of the previously explained test of component valuation across time. The annual regression estimates, one for each 12 months in a year, are first employed with only the product characteristics. The slope dummy variable, DPTFLUID, and the intercept dummy variables DFLUID and DICE are then included.

Exogenous Demand and Supply Factors

Milk input prices affect milk product values in a competitive market. An increase in feed costs would encourage substitution to other feeds and might result in lower production. This decrease in supply would have a positive effect on milk prices, and we should therefore consider cost in our milk pricing equation. However, the situation in B.C. is more constrained. Fluid milk prices in B.C. are determined by a formula using historical data. The present situation is only a marginal factor. Current prices are therefore not affected significantly by changes in current input prices. We therefore do not include it in the regression equation.

Component levels at the farm level are seasonal, with a maximum reached in the period between November and February, and a minimum in mid-summer. Higher component tests of protein and butterfat might determine greater product yields, and consequently contribute to efficiency gains in milk processing of these products. However, production quantity should capture the variation in component tests, and seasonality is not considered.

Processor costs are hypothesized to be an important explanatory factor in explaining variability in wholesale prices. The raw milk costs (PMILK) are therefore employed.

However, as was previously discussed, processing costs are not employed and are assumed to be constant across products (and component levels). If PMILK captures the effect of processing wage rates, for example, the effect of wage rates is to increase costs and the price of milk products, and should have a positive sign.

The exogenous demand factor, INCOME, is hypothesized to positively contribute to wholesale prices of all product categories, since higher monthly income will provide incentives to increase product prices. "Normal" dairy products are theoretically income inelastic, while the income effect on luxury products is stronger. Cornick, et.al. (1994) found that skim milk expenditures are positively related to income, and that whole milk is an inferior good and negatively related to income. However, the different conditional/unconditional expenditure responses across milk types are not of major interest in this analysis.

Another exogenous effect on demand, the price of substitutes for fluid milk (PSUBST), is hypothesized to contribute positively to wholesale prices in a perfectly competitive market.. Since PSUBST is highly correlated with the raw milk price, however, PSUBST was omitted, and is not discussed in the results.

Calculating Shadow Values

The wholesale values are measured in value per kilogram of product (\$/kg). The component values in the data set are measured in grams per kilogram of product (g/kg). The estimated coefficients of the components are therefore the wholesale level shadow values in value per gram (\$/g). This can be illustrated with an example of how the value of β_1 is determined:

$$\begin{aligned} &\text{Equation:} && PRICE_{ijt} && = \beta_0+\beta_1 PT_{it}+\beta_2 PT_{it}^2+\beta_3 BF_{it}+\beta_4 BF_{it}^2+\beta_5 OS_{it} \\ & && PRICE_{ijt} && = \beta_1 PT_{it} \\ &\text{Measure:} && \$/kg && = \beta_1 * g/kg \\ & && \beta_1 && = \$/g \end{aligned} \tag{4.3}$$

To convert the implicit component values into values in \$/kg (instead of the estimated value in \$/g), the estimated shadow values should be multiplied by 1,000.

The farm-level residual of wholesale values is assumed to be 40 percent, and calculated from the estimated coefficients (shadow values in \$/kg). The derivative of the raw milk price with respect to, for example, butterfat, which is the estimated shadow, or marginal value, of butterfat, is calculated as shown below:

$$PRICE = \beta_1 BF + \beta_2 SBFR + \beta_3 DBFFLUID$$

$$\partial PRICE/\partial BF = \beta_1 + 2\beta_2 BF + \beta_3 \qquad (4.4)$$

Butterfat in the basic model is linear in the variables. The first term, β_1, is calculated as the derivative of β_1BF. Since the term for marginal net return of butterfat, β_2SBFR, is BF squared, the derivative is $2\beta_2$BF. The butterfat value in fluid milk is tested with a slope dummy variable. Since DBFFLUID is the butterfat value in fluid products, the derivative of PRICE with respect to β_3DBFFLUID is β_3.

4.3 Methodology

The determination of statistical significance of the various endogenous and exogenous characteristics hypothesized to influence wholesale price of B.C. dairy products is undertaken using the econometric software SHAZAM. The empirical models used in this thesis (equation 4.1 and 4.2) use a pooled, cross-sectional time-series data set. With this type of data, there is a risk of heteroscedasticity (unequal variance of the error terms) and autocorrelation (correlation between the error terms over time) if ordinary least squares (OLS) estimation is used. Autocorrelation and heteroscedasticity violate two of the critical, basic assumptions of the classical linear regression model (best linear unbiased estimator), where :

$E(\varepsilon_{it}^2) = \sigma_i^2$ heteroscedasticity;
$E(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij}$ autocorrelation.

If there is heteroscedasticity or autocorrelation, the use of OLS yields estimators that are linear-unbiased, as well as consistent, but not efficient (not even asymptotically efficient (i.e., minimum variance)), the variance-covariance matrix of the disturbance vector is incorrect. The variance is no longer a minimum variance; hence "the confidence intervals based on it will be unnecessary wide and the test of significance less powerful" (Gujarati, 1988, p. 342). In this thesis, the model was first estimated by OLS, and as expected, the null-hypothesis that there is no positive autocorrelation was rejected at less than the 5 percent significance level, given the computed d-value in the Durbin Watson d-statistics. Furthermore, the null-hypothesis of homoskedasticity was rejected, given the upper percentage point of the chi-square distribution. The estimated DW statistic suggested that there is positive correlation in the estimated residuals. The observed correlation simply reflects the fact that some variable(s) that belongs in the model are captured by the error term and need to be introduced as explanatory variables.

The lack of efficiency in OLS makes the usual hypothesis-testing procedure of dubious value. One remedial measure is to employ generalized least squares (GLS). In GLS, any additional information (e.g., the nature of the heteroscedasticity or autocorrelation) is incorporated directly into the estimation procedure by transforming the variables. In OLS, such additional information cannot be directly incorporated. Hence, instead of minimizing the sum of squared residuals, an appropriately weighted sum of residuals is minimized (Gujarati, 1988). The pooling technique (the POOL command in SHAZAM) employs a set of assumptions on the disturbance covariance matrix that give a cross-sectional heteroscedastic and time-wise autoregressive model (White, 1993, pp.245-247):

$E(\varepsilon_{it}^2) = \sigma_i^2$ heteroscedasticity;

$E(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij}$ for $i \neq j$, cross-section independence; and

$\varepsilon_{it} = \rho_i\varepsilon_{i,t-1} + v_{it}$ autocorrelation.

An estimation for the coefficients β is obtained by a GLS procedure, and proceeds with the following steps:

Step 1: Estimate β by OLS and obtain estimated residuals e_{it}.

Step 2: Use the estimated residuals to compute ρ_i hat as estimates of the ρ_i.

The SAME option is specified and forces use of the same autoregressive parameter for all cross-sections.

Step 3: The ρ_i hat is used to transform the observations and OLS is applied to the transformed model. The error variance and covariance are estimated from the regression residuals of the transformed model.

Step 4: The GLS estimator is obtained. The default estimation method of the POOL command is to use a diagonal PHI matrix. The SAME command in SHAZAM forces the ρ_i to be the same for each of the cross-sectional units.

CHAPTER 5

5.0 RESULTS AND INTERPRETATIONS

Section 5.1 presents the results of the empirical analysis of milk component valuation in B.C. The results of the basic model and tests of alternative variables are presented and discussed first. The focus then turns to tests of model specification, i.e., if dummy variables for different shadow values in the various product categories are necessary, and whether component values have changed over time. This involves testing the significance of the variables included. The models for the industrial and the aggregated industrial and fluid markets are presented. The shadow values themselves are presented in section 5.2. This section focuses mainly on the application of the estimated shadow values and should be of interest to readers interested in the more practical implications of the estimation process.

5.1 Regression Analysis

5.1.1 Statistical Issues

The high correlation between milk components led to multicollinearity between variables. Inclusion of more and different dummy variables increased the volatility in coefficient estimates and coefficient signs. Separate regressions for various dummy variables were therefore necessary.

The basic model is designed to explain the variation in wholesale prices (PRICE) of milk products in both the aggregated industrial and fluid market, and the industrial product market by product characteristics, e.g., by protein content, butterfat content and other solids content, and by demand and supply shifters, as discussed in chapter 4. Two variations of the basic model are tested, one in which linearity in both parameters and variables is assumed, and one in which we assume linearity in parameters, but non-linearity in variables. Non-linearity in variables was assumed by including squared terms of components. This allows for changing marginal net returns of components, or different functional forms, as discussed in section 4.2.1. The marginal product prices differ considerably, regardless of whether the squared term of butterfat is included. The results are therefore divided into two types: The type 1 model is linear in both parameters and variables, and/or includes the squared term of components of protein and/or other solids. The type 2 model includes squared terms of butterfat and/or protein. The squared term of other solids (SOSR) was initially included, but the coefficient on the variable was insignificant in all regressions, and therefore omitted.

One of the demand shifters, the variable for the price of substitutes (PSUBST) in fluid milk, was highly correlated (0.97) with the raw milk price (PMILK) variable, causing multicollinearity. This variable was therefore omitted in the final model. PMILK and monthly income (INCOME) are the only demand and supply shifters considered throughout all estimates.

5.1.2 The Basic Model

The basic model includes the product characteristics and the demand and supply shifters in explaining the variability in wholesale prices. Dummy variables for testing for changes in component values over time and across product categories, are not introduced here.

Aggregated Market Model

The results of estimating the basic hedonic model in the aggregated market of fluid and industrial milk products are presented in table 5.1. Both product characteristics, supply and demand factors are consistently significant (at 5 percent level) in explaining wholesale price variability. On the demand side, the positive effects of both protein, butterfat, and other solids levels on wholesale price variability suggest that consumers' willingness to pay for a dairy product is determined by its composition. That is, increases in any of these components in milk products increase the wholesale price of the products. Although consumers might not be aware of the actual amount of each component in each product, the quality and taste differences are likely determining factors in the consumers choice of, or willingness to pay for, a particular product. Since taste and quality of milk products depend on the portion of components in products, the hedonic results illustrate in fact, that the level of the three main components in milk products determines product valuation.

On the supply side, milk is delivered at the processing plant with certain proportions of milk solids and water carrier. The constitution of the milk influences product yields and processing efficiency. We hypothesized wholesale prices to be determined by product characteristics. Thus, component levels are important for both the supply and demand side in valuation of milk components and should not be ignored. In other words, the results are consistent with expectations, and provide great support in valuing the multiple raw milk components, not merely the butterfat component, which is the current practice in B.C.

We will in the following focus on the details of the results. The coefficient on the squared term of protein (SPTR) is significant and negative in the type 1 model, and suggests diminishing marginal net returns to protein as protein level increases. However, the coefficient on SPTR is insignificant in the type 2 model. This indicates that there is not a change in marginal willingness to pay for protein as protein level increases. Rather, the marginal value of protein is consistent across the level of production. Because the coefficient on SPTR is insignificant in the type 2 model, it is left out of the models without causing changes in the shadow values of the existing component variables.

The coefficient on the squared term of butterfat (SBFR), introduced in the type 2 model, is consistently significant and negative in all regression estimates. This result supports the hypothesis of diminishing marginal net returns to butterfat, as suggested in section 4.2.1. In other words, the marginal value of butterfat declines as the level of butterfat increases, which is consistent with the current declining trend in butterfat consumption, and consumer awareness of high-fat products. This result is also interesting given the current debate between producers and processors on the skim off issue. Producers have proposed to increase the production of high fat (36% fat) whipping cream (the regular whipping cream contains 32% fat) to reduce or eliminate the skim off. Processors are reluctant to this and expect their returns on butterfat to be higher in

Table 5.1. Basic Model: Aggregated Market Model[29]

		PT	SPTR	BF	SBFR	OS	PMILK	INCOME	CONST.
Type 1 Model									
Reg. 1									
	coeff.	0.0229		0.0101		0.0180	-0.0011	0.0007	-0.6
R2=0.8425	t-ratio	(48)		(43)		(22)	(-1.2)	(5)	(-4)
F=1017.49	st. error	0.0005		0.0002		0.0008	0.0010	0.0001	0.1
	elast.	0.40		0.27		0.35	-0.01	0.07	-0.10
	value ($/kg)	22.9		10.1		18.0			
Reg. 2									
	coeff.	0.0230		0.0102		0.0184		0.0006	-0.7
R2=0.7944	t-ratio	(41)		(37)		(19)		(5)	(-6)
F=970.99	st. error	0.0006		0.0003		0.0010		0.0001	0.1
	elast.	0.40		0.27		0.36		0.06	0.12
	value ($/kg)	23.0		10.2		18.4			
Reg. 3									
	coeff.	0.0287	-0.0171	0.0104		0.0182	-0.0012	0.0006	-0.9
R2=0.8374	t-ratio	(21)	(-4)	(44)		(22)	(-1.4)	(5)	(-6)
F=927.33	st. error	0.0014	0.0042	0.0002		0.0008	0.0008	0.0001	0.1
	elast.	0.51	-0.06	0.28		0.36	-0.01	0.06	-0.14
	value ($/kg)	25.0		10.4		18.2			
Type 2 Model									
Reg. 1									
	coeff.	0.0171		0.0209	-0.0147	0.0164		0.0006	0.6
R2=0.7964	t-ratio	(19)		(17)	(-9)	(17)		(5)	(4)
F=783.70	st. error	0.0009		0.0012	0.0016	0.0010		0.0001	0.1
	elast.	0.30		0.56	-0.15	0.32		0.06	-0.09
	value ($/kg)	17.1		16.1		16.4			
Reg. 2									
	coeff.	0.0170		0.0209	-0.0149	0.0159	-0.0011	0.0007	-0.4
R2=0.8541	t-ratio	(24)		(22)	(-12)	(20)	(-1.1)	(5)	(-3)
F=906.56	st. error	0.0007		0.0010	0.0013	0.0008	0.0010	0.0001	0.1
	elast.	0.30		0.56	-0.15	0.31	-0.01	0.07	-0.07
	value ($/kg)	17.0		16.0		15.9			
Reg. 3									
	coeff.	0.0185	-0.0043	0.0206	-0.0145	0.0157	-0.0011	0.0007	0.4
R2=0.8676	t-ratio	(12)	(-1.09)	(22)	(-12)	(21)	(-1.0)	(5)	(-3)
F=824.80	st. error	0.0015	0.0039	0.0009	0.0012	0.0007	0.0010	0.0001	0.15
	elast.	0.32	-0.02	0.55	-0.15	0.31	-0.01	0.07	-0.07
	value ($/kg)	18.5		15.8		15.7			

other products. They therefore want producers to pay for the potentially added butterfat in high-

[29] PT=protein, SPTR=squared protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, PMILK=raw milk price, INCOME=monthly income.

fat whipping cream. The consistency in significance and sign of the coefficient on the squared term of butterfat suggests that the marginal value of butterfat declines as more butterfat is added. This diminishing marginal net returns to butterfat can provide helpful information in this debate. Three variables were initially used to capture different elements of demand and supply conditions in determining the variability in wholesale prices: the raw milk price (PMILK), the price of substitutes for fluid products (PSUBST), which was omitted because of high correlation with PMILK, and monthly income (INCOME). The coefficient on the supply shifter (PMILK) is negative and insignificant in this aggregated model. This contradicts our expectation of a positive and significant coefficient. The coefficient on PMILK is positive and significant in the industrial model, and suggests that the negative sign arises from some characteristics of or interactions within the fluid market. The issues of whether wholesale prices of the different types of fluid milk are technologically determined, and the non-raw milk cost in the fluid market compared to the industrial market, do not contribute to an explanation of this occurrence.

The demand shifter (INCOME) yielded positive and significant coefficients. This finding was throughout all estimates. As explained in chapter 4, the component values for each product vary considerably across products, but do not over time. The demand and supply shifters, however, change only over time, and not across products. In other words, all the time-series changes are captured by INCOME and PMILK, making it difficult to interpret their effect on milk product prices.

The significance of the component coefficients did not vary between the type 1 model and the type 2 model, with the exception of the coefficient on the squared term of protein (SPTR), which became insignificant in the type 2 model. However, the shadow values changed considerably when the squared term of butterfat (SBFR) was included. Overall, protein is consistently valued higher than butterfat and other solids, but by including the squared term of butterfat (the type 2 model), this difference is almost eliminated and all component values become closer. The large and positive coefficient on other solids (OS) shows support for valuing other solids. In the type 1 model, the shadow value of OS is higher than that for butterfat, but the shadow values are relatively similar in the type 2 model. Protein (PT) in the type 1 model consistently generates the largest elasticity of all component variables. This suggests that milk prices are more sensitive to changes in protein content than to changes in other solids or in butterfat. The elasticity of other solids is surprisingly higher than the elasticity of butterfat, but this changes in the type 2 model. Here the elasticity of OS and PT is similar, and butterfat has the highest elasticity (but usually the smallest shadow value).

The coefficient of determination, the adjusted R^2 value, measures the goodness of fit of the regression lines to the data. The R^2 is high for all regression estimates (0.79-0.86), but does not give any conclusive evidence as to which of the models, type 1 or type 2, provides the best fit for the data set. Both models will therefore be considered in testing the basic models. However, the statistical significance of the coefficient on the squared term of butterfat (SBFR) should not be understated, and the estimated coefficients in the type 2 model are more similar to component valuation in other MCP jurisdictions (see Ontario component values in table 2.1).

For testing the overall significance of the estimated regression, the F test was employed, and the null-hypothesis that the true slope coefficients are simultaneously zero was strongly rejected.

Industrial Market Model

The data on the industrial market separates the fluid market data from the aggregated model. The degrees of freedom are reduced, since the six fluid products are eliminated, and the number of observations falls from 2,580 to 2,322. The individual variables become more collinear and their variation across the sample is reduced. Although the variability in the industrial model is substantial, we expect the reduced sample to give us less significant and more unpredictable results.

The coefficients of the variables included, their significance levels, coefficient estimates, and elasticity and goodness of fit, are generally consistent with the aggregated market model. Furthermore, the variables have the predicted signs. However, the smaller sample reveals a few differences from the aggregated model, which we will here examine. High correlation between the squared terms of protein and butterfat, SPTR and SBFR respectively, caused multicollinearity and unusually large estimated coefficients. It was therefore necessary to estimate the coefficients on these two variables by separate regressions. The inclusion of the squared term of butterfat to allow for changes in the marginal net return of this component, is estimated by again dividing the models into two types, the type 1 and the type 2 models.

Examining the results in table 5.2 by variable shows that the component levels of protein, butterfat and other solids have a consistently positive and significant effect (at the 5 percent level) on wholesale price variability. This supports the general finding in the aggregated model, and again provides support for valuing the multiple raw milk components, not only the butterfat component of milk solids. The coefficient on the squared term of protein (SPTR) is insignificant and suggests a linear relationship between wholesale prices and protein (i.e., not a declining marginal net return of protein). The coefficient on the squared term of butterfat (SBFR) is also here negative and significant, and suggests declining marginal net returns of butterfat, as predicted. The significance of the coefficient on SPTR in the aggregated type 1 model, however insignificant in the type 2 model, might indicate marginal net return of protein in the fluid market. However, the instability of this result makes it difficult to reach a definitive conclusion. The coefficient on the squared term of other solids (SOSR) was insignificant and caused multicollinearity when introduced with SBFR. It was therefore omitted in the final results.

Table 5.2. Basic Model: Industrial Market Model[30]

		PT	SPTR	BF	SBFR	OS	SOSR	PMILK	INCOME	CONST.
Type 1 Model										
Reg. 1	coeff.	0.0187		0.0079		0.0117		0.0060	0.0010	0.8
R2=0.8270	t-ratio	(28)		(22)		(10)		(3)	(6)	(3)
F=222.96	st. error	0.0007		0.0004		0.0012		0.0021	0.0002	0.3
	elast.	0.32		0.21		0.22		0.04	0.09	0.12
	value ($/kg)	18.7		7.9		11.7				
Reg. 2	coeff.	0.0178	0.0027	0.0077		0.0116		0.0059	0.0010	0.9
R2=0.8255	t-ratio	(9)	(0.5)	(20)		(10)		(3)	(6)	(3)
F=184.40	st. error	0.0019	0.0051	0.0004		0.0012		0.0021	0.0002	0.3
	elast.	0.31	0.01	0.21		0.22		0.04	0.09	0.13
	value ($/kg)	17.8		7.7		11.6				
Reg. 3	coeff.	0.0183	0.00195	0.0078		0.0125	-0.0008	0.0059	0.0009	0.8
R2=0.7822	t-ratio	(10)	(0.4)	(17)		(3)	(-0.1)	(3)	(5)	(2)
F=90.78	st. error	0.0019	0.0052	0.0004		0.0046	0.0162	0.0022	0.0002	0.4
	elast.	0.32	0.01	0.21		0.24	-0.00	0.04	0.08	0.13
	value ($/kg)	18.3		7.8		12.5				
Type 2 Model										
Reg. 1	coeff.	0.0138		0.0182	-0.0143	0.0099		0.0060	0.0009	0.9
R2=0.8458	t-ratio	(15)		(16)	(-10)	(9)		(3)	(6)	(4)
F=218.45	st. error	0.0009		0.0011	0.0014	0.0011		0.0021	0.0002	0.3
	elast.	0.23		0.49	-0.15	0.19		0.00	0.08	0.14
	value ($/kg)	13.8		13.0		9.9				

The coefficient on the raw milk price variable (PMILK) is significant and positive, and consistent with theory, as discussed in chapter 4.2.1. A similar description can be made for the monthly income variable (INCOME). However, all time series changes are captured by the demand and supply variables, and interpretations of their effect on milk product prices should therefore be made cautiously.

The shadow values are consistently larger in the aggregated fluid and industrial market model than in the industrial market model. The larger degrees of freedom in the aggregated model suggest that this model provides the most reliable results. It indicates that all components

[30] PT=protein, SPTR=squared protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, SOSR=squared other

are more valuable in the fluid market. This is likely true for protein. However, tests of the basic models later in this analysis indicate that both butterfat and other solids are valued lower in fluid products.

Protein (PT) in the type 1 model for industrial milk products consistently generates the largest elasticity (and the largest shadow values) of all component variables, as was also observed in the aggregated model. The elasticity of other solids (OS) is very similar to the elasticity of butterfat. This changes considerably in the type 2 model, as in the aggregated model, where the elasticity of OS and PT is generally similar, and butterfat (BF) possesses the highest elasticity.

The coefficient of determination, the adjusted R^2 value, of the multiple industrial market regression is high (0.78-0.84), although smaller than in the aggregated market model. The type 2 model has a higher goodness of fit estimate, but the small difference provide no conclusive suggestions for which of the models, type 1 or type 2, represents the best fit for the data set. As in the aggregated market model, both models are included in the following tests. The F test was also used to test the overall significance of the regression estimates. The null-hypothesis of no joint effect of the variables on prices was again rejected, indicating that the true slope coefficients are not simultaneously zero.

5.1.3 Test: Different Shadow Values in Fluid Milk

Aggregated Market Model

As a test for differences in shadow values of components utilized in fluid milk products, various slope dummy variables were introduced to distinguish the fluid products from the aggregated products. Multicollinearity is causing instability in the model's estimated coefficients, especially in the type 2 model. This made the inclusion of many dummy variables difficult. The

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solids, PMILK=raw milk price, INCOME=monthly income.

incorporation of relatively few dummy variables only marginally changed the estimated dummy-coefficients in both the type 1 and type 2 models. The trends in significance and coefficients of the dummy variables are consistent across the two models. The estimates are therefore provided with primary focus on the type 1 model. This does not limit the importance of the type 2 models.

In the first approach, the basic model (the product characteristics, and the demand and supply shifters) is tested by implementing various slope and intercept dummy variables for fluid milk. The results are presented in table 5.3.

The coefficients on the milk components are also here positive and significant. The coefficient on the squared term of butterfat is consistently significant and negative. The inclusion of dummy variables changes the significance level (but not the negative sign) of the raw milk price (PMILK). The negative and significant (at 5 percent level) coefficient is expected to be rooted in the fluid market, as explained in section 5.1.2. Income is again consistently positive and significant.

The coefficient on the intercept dummy variable, DFLUID, is significant and negative in both the type 1 and the type 2 models, both when included separately and together with dummy variables for components in fluid products. This suggests that the intercept of the estimated regression line for fluid products is significantly lower than the intercept of the regression lines in the rest of the model. The negative sign is surprising but might be a result of the expected lower values of butterfat in fluid milk.

Table 5.3. Test: Dummy Variables in Fluid Products (A)[31]

		PT	BF	SBFR	OS	PMILK	INCOME	DFLUID	DPTFLUID	DBFFLUID	DLTFLUID	DVCFLUID	CONST.
Type 1 Model													
Reg. 1													
	coeff.	0.0185	0.0077		0.0108	-0.0014	0.0004	-8.3	0.1924				1.6
R2=0.8224	t-ratio	(28)	(22)		(10)	(-3)	(5)	(-5)	(4)				(7)
F=936.92	st. error	0.0007	0.0003		0.0011	0.0005	0.0001	1.6	0.0497				0.2
	elast.	0.33	0.20		0.21	-0.01	0.04	-0.13	0.10				0.26
	value ($/kg)	18.5	7.7		11				192.4				
Reg. 2													
	coeff.	0.0182	0.0074		0.0095	-0.0013	0.0004	-1.8		-0.0078			1.8
R2=0.8216	t-ratio	(28)	(22)		(9)	(-3)	(5)	(-11)		(-1.9)			(8)
F=927.14	st. error	0.0007	0.0003		0.0010	0.0005	0.0001	0.2		0.0040			0.2
	elast.	0.32	0.20		0.19	-0.01	0.04	-0.03		-0.00			0.29
	value ($/kg)	18.2	7.4		9.5					-7.8			
Reg. 3													
	coeff.	0.0186	0.0078		0.0116	-0.0014	0.0004	-1.3			-0.0092		1.5
R2=0.8227	t-ratio	(28)	(22)		(10)	(-3)	(5)	(-6)			(-4)		(7)
F=938.85	st. error	0.0007	0.0004		0.0012	0.0005	0.0001	0.2			0.0022		0.2
	elast.	0.33	0.21		0.23	-0.01	0.04	-0.02			-0.01		0.24
	value ($/kg)	18.6	7.8		11.6						-9.2		
Reg. 4													
	coeff.	0.0187	0.0078		0.0116	-0.0014	0.0004	1.72	-0.04	-0.01	-0.0111	-1.17	1.48
R2=0.8228	t-ratio	(28)	(22)		(10)	(-3)	(5)	(0.1)	(-0.1)	(-0.3)	(-0.6)	(-0.2)	(6)
F=657.94	st. error	0.0007	0.0004		0.0012	0.0005	0.0001	0.3	0.4925	0.0278	0.0199	6.132	0.2
	elast.	0.33	0.21		0.23	-0.01	0.04	0.03	-0.02	-0.00	-0.01	-0.02	0.24
	value ($/kg)	18.7	7.8		11.6								
Type 2 Model													
Reg.1													
	coeff.	0.0136	0.0171	-0.0129	0.0100	0.0004	-0.0013	-1.30			-0.0087		1.62
R2=0.8310	t-ratio	(15)	(15)	(-9)	(9)	(5)	(-3)	(-6)			(-4)		(7)
F=1601.07	st. error	0.0009	0.0011	0.0014	0.0011	0.0001	0.0005	0.23			0.0080		0.22
	elast.	0.24	0.46	-0.13	0.20	0.04	-0.01	-0.02			-0.01		0.26
	value ($/kg)	13.6	12.8		10.0						-8.7		

[31] PT=protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, PMILK=raw milk price, INCOME=monthly income, DFLUID=dummy variable for the fluid milk category, DPTFLUID=dummy variable for protein in fluid milk, DBFFLUID=dummy variable for butterfat in fluid milk, DLTFLUID=dummy variable for lactose in fluid milk, DVCFLUID=dummy variable for vitamins and calcium in fluid milk.

We hypothesized a positive sign on the coefficient on protein (DPTFLUID), a negative sign on butterfat (DBFFLUID), and we did not have any expectations of the sign of the other solids (DOSFLUID) in fluid milk. The slope dummy variables for protein, butterfat and lactose in fluid milk were separately tested for in both the type 1 and type 2 models. The coefficient on DPTFLUID is significant and positive, as expected. This suggests that protein is more valuable in fluid milk than in other product categories. Given that the fluid milk price is based on butterfat, and that processors are reluctant to base the valuation of fluid milks on protein levels, the finding is interesting. The estimated shadow value is large, perhaps unrealistically so, but is consistently positive throughout the analysis.

Both the coefficients on DBFFLUID and on the dummy variable for lactose in fluid milk (DLTFLUID) were significant and negative. DBFFLUID was significant at 10 percent level in the type 1 model and at 5 percent level in the type 2 model. The size of the estimated shadow value of butterfat suggests that butterfat has only limited value in fluid milk. High-fat products, such as whipping cream and 10% cream, are not considered in the data set used in this analysis, but the inclusion of these products is likely not to change this result. The result is interesting given the fast declining butterfat consumption in fluid milk, which provided expectations of declining butterfat values. But the high marginal value, as indicated in this test, may be unrealistic.

The significantly negative estimate of the coefficient on DOSFLUID is also somewhat surprising. DOSFLUID was substituted with DLTFLUID to test the importance of lactose in fluid milk. The significance, sign, and estimated shadow values of the coefficients of these two variables are almost identical, and suggest that the value of lactose in fluid milk is only marginal. This might be a result of processors responding to the needs of lactose intolerant consumers. We hypothesized higher values for calcium and vitamins in fluid milk than in other milk products, but our expectations of lactose valuation in fluid milk compared to its valuation in other product categories was not clear. However, the negative estimated coefficient on both butterfat and lactose again suggest the somewhat surprising implications of this analysis, namely that protein has great importance in milk valuation, and in fluid milk valuation in particular. Since the large fluid sector in B.C. has been a major factor in the "delayed" implementation of MCP here, these consistent findings throughout the model should not be understated. Processors are reluctant to acknowledge the value of nonfat solids in fluid milk, and they request to consolidate the current butterfat differential pricing system. But if the butterfat value is declining and the value of nonfat solids increasing (consumption increased till 1995-96, appendix 5), there are obvious financial reasons for this reluctance.

In an estimate of the model that includes DFLUID, DPTFLUID, DBFFLUID, DLTFLUID and DVCFLUID, the coefficients on all the dummies are insignificant (regression 4). Insignificant variables are usually an expected result when variables are highly correlated, and might be explained by multicollinearity.

The same procedure was followed in the type 2 model, and the estimated dummy coefficients are different, but the trends in coefficient estimates, when introduced separately and combined, were consistent with the type 1 model estimates. The results of only one type 2 model are thus sufficient.

In a second approach, we hypothesized that calcium, other minerals, vitamins, and lactose might have a different value in the fluid market than in the industrial market. For this reason, we tested the basic model including several of the other solids (not only OS, as in the previous analysis). We also included slope dummy variables of vitamins and minerals, both separately and combined with other dummy variables in the fluid market. The results are presented in table 5.4.

The coefficients on protein, butterfat and lactose are all consistently significant and positive throughout this exercise, again suggesting the importance of valuing these components in milk. A variable for "total minerals" (MIN) was introduced to test whether the total sum of minerals had a significant effect on milk prices. But the coefficient on this variable was significant only at the 10 percent level and, the sign was negative. This result is surprising, since the negative marginal value of minerals should provide incentives to processors to remove the minerals that are unwanted in the market.

To distinguish between the various minerals, calcium (CA) was subtracted from total minerals, since calcium provides a wholesome contribution to milk and dairy products. The coefficient on this variable also turned out to be insignificant. The coefficient on the variable total vitamins (VIT) was also insignificant. The insignificance of the coefficients on minerals and vitamins, when separately included as substitutes to other solids, suggests that valuing milk based on protein, butterfat and other solids is a more appropriate measure than breaking down the individual components in other solids to price these separately. The coefficient on PMILK and INCOME continue to be significantly negative and positive, respectively, as before.

Different dummy variables were introduced separately to allow different intercepts and slope coefficients in the fluid market. In particular, we were interested in whether the shadow values of protein (DPTFLUID), vitamins and minerals (DVMFLUID), and vitamins and calcium (VCFLUID) are different in the fluid market. One should interpret the results of these tests with caution because of the instability in significance and sign of these individual dummy variables.

The coefficient on the intercept dummy variable in fluid milk was again significant and negative. We hypothesized greater value of vitamins and minerals in fluid milk than in other milk products, but the coefficient on DVMFLUID was insignificant in all regressions. Calcium and vitamins were hypothesized to have greater shadow values in fluid products than in manufactured products. As predicted, the coefficient on DVCFLUID is positive and significant. This suggests that vitamins and calcium have additional value in fluid milk products, but since the coefficient on DVMFLUID was insignificant, we have to be careful with interpretations. Both the coefficients on DPTFLUID and DVCFLUID are positive and significant when tested together, as hypothesized, and support the findings in the first approach, which suggested that the shadow value of protein is higher in fluid products than in industrial products. This should provide processor incentives to allocate more protein to fluid milk products.

Although some of the dummy coefficients are large, the elasticities are quite small. The elasticity for protein suggests that milk product prices are more sensitive to changes in protein content than to changes in other solids or in butterfat. The elasticity for butterfat is similar to the elasticity for other solids.

The adjusted R^2 is high (approximately 0.82), as it is for all regression estimates in this analysis, and changes only marginally across the estimated regressions. The adjusted R^2 does not suggest which regression model provides the best fit of the data set, but does indicate that a high percentage of the variance in the dependent variable results from changes in the independent variables. Finally, the F test leads us to reject the null hypothesis that the coefficients on the independent variables are jointly zero.

Table 5.4. Test: Dummy Variables in Fluid Products (B)[32]

		PT	BF	LT	VIT	MIN	CA	PMILK	INCOME	DFLUID	DPTFLUID	DVMFLUID	DVCFLUID	CONST.
Type 1 Model														
Reg. 5														
	coeff.	0.0209	0.0077	0.0103	8.2017	-0.0188		-0.0013	0.0004	-2.3		0.10838		1.7
R2=0.8303	t-ratio	(17)	(21)	(10)	(0.8)	(-1.8)		(-2.5)	(5)	(-2.0)		(0.4)		(8)
F=764.33	st. error	0.0012	0.0004	0.0011	9.8862	0.0102		0.0005	0.0001	1.16		0.26		0.2
	elast.	0.37	0.20	0.19	0.01	-0.03		-0.01	0.04	-0.04		0.0079		0.27
	value ($/kg)	20.9	7.7	10.3		-18.8								
Reg. 6														
	coeff.	0.0214	0.0078	0.0111	7.5623		-0.0698	-0.0013	0.0004	-6.1			3.6882	1.5
R2=0.8264	t-ratio	(10)	(20)	(10)	(0.8)		(-1.1)	(-3)	(5)	(-4)			(3)	(6)
F=747.66	st. error	0.002113	0.0004	0.0011	9.858		0.0672	0.0005	0.0001	1.43			1.2280	0.2
	elast.	0.3759	0.2095	0.2008	0.0056		-0.0316	-0.0108	0.0405	-0.10			0.0715	0.24
	value ($/kg)	21.4	7.9	11.1									3688.2	
Reg. 7														
	coeff.	0.0220	0.0081	0.0124	10.3031		-0.0827	-0.0014	0.0004	-10.9	0.19127		2.3556	1.3
R2=0.8274	t-ratio	(10)	(20)	(10)	(1.0)		(-1.2)	(-3)	(5)	(-6)	(4)		(1.9)	(5)
F=682.32	st. error	0.002121	0.000399	0.001189	9.884		0.0672	0.0005	0.0001	1.9	0.0508		1.2180	0.2
	elast.	0.3875	0.2171	0.2242	0.0076		-0.0365	-0.0110	0.0398	-0.18	0.1038		0.0457	0.21
	value ($/kg)	22.0	8.1	12.4							191.3		2355.6	

[32] PT=protein, BF=butterfat, LT=lactose, VIT=vitamins, MIN=minerals, CA=calcium, PMILK=raw milk price, INCOME=monthly income, DFLUID=dummy variable for the fluid milk category, DPTFLUID=dummy variable for protein in fluid milk, DVMFLUID=dummy variable for vitamins and minerals in fluid milk, DVCFLUID=dummy variable for vitamins and calcium in fluid milk, DLTFLUID=dummy variable for lactose in fluid milk, DVCFLUID=dummy variable for vitamins and calcium in fluid milk.

5.1.4 Test: Different Shadow Values in Specific Product Categories

Aggregated Market Model

To allow the estimated regression lines to shift slope and intercept we employed dummy variables in the various categories. The protein value was tested separately and combined with dummy variables in fluid milks, in the ice cream category, in yogurt and in cheese products. The *a prior* expectations of protein valuation in the different industrial product categories are uncertain. The results are presented in table 5.5.

As in all other estimates, protein, butterfat, and other solids contribute significantly to the variability in wholesale prices. The coefficient on the squared term of butterfat (SBFR) is also included here, as previously, and is negative and significant. This indicates declining marginal net returns to butterfat. INCOME still positively influences wholesale prices, while the coefficient on PMILK is significantly negative, as in the previous aggregated market model.

The coefficient on DFLUID is consistently significant and negative. The negative sign is surprising. Both the coefficients on DBFFLUID and DLTFLUID are again negative and significant when introduced with various dummy variables in other product categories. This supports the previous finding that butterfat and lactose might have lower (or marginal) values in fluid milk than in other categories.

Because of multicollinearity, the inclusion of a series of dummy variables often caused great instability in the estimated coefficients, or shadow values. It was therefore necessary to introduce the various dummy variables separately. Even then the test results were not consistent. However, the coefficient on protein in yogurt and cheese is consistently negative. The often large and significant coefficients of the dummy variables, when both separately introduced and combined with other variables, indicate that component values might differ between product categories. This may suggest inefficiency in processing of dairy products.

The explanatory power of the model as measured by the adjusted R^2 is good (0.81-0.86), but is not conclusive in regard to which model provide a better fit to the data set. For testing the overall significance of the estimated regression, the F-test was employed, and the null-hypothesis, that the true slope coefficients of the regressions estimates provided in table 5.5 are simultaneously zero, is also rejected in this model.

Table 5.5. Test: Dummy Variables in Various Product Categories - Aggregated Market[33]

		PT	BF	SBFR	OS	PMILK	INCOME	DFLUID	DPTFLUID	DPTICE	DPTYOG	DPTCHE	CONST.
Type 1 Model													
Reg. 8	coeff.	0.0194	0.0074		0.0077	-0.0013	0.0004	-6.2	0.1339	0.0339			1.6
R2=0.8135	t-ratio	(27)	(20)		(6)	(-3)	(5)	(-4)	(2.5)	(6)			(7)
F=763.72	st. error	0.0007	0.0004		0.0012	0.0005	0.0001	1.7	0.0530	0.0058			0.2
	elast.	0.3413	0.1986		0.1510	-0.0108	0.0405	-0.0999	0.0727	0.0625			0.26
	value ($/kg)	19.4	7.4		7.7				133.9	33.9			
Reg. 9	coeff.	0.0176	0.0072		0.0104	-0.0014	0.0004	-8.3	0.18310		-0.0102		2.0
R2=0.8197	t-ratio	(23)	(18)		(9)	(-2.7)	(5)	(-5)	(4)		(-2.3)		(7)
F=802.43	st. error	0.0008	0.0004		0.0011	0.0005	0.0001	1.7	0.0505		0.0045		0.3
	elast.	0.3096	0.1922		0.2046	-0.0109	0.0401	-0.1342	0.0993		-0.0137		0.32
	value ($/kg)	17.6	7.2		10.4				183.1		-10.2		
Type 2 Model													
Reg. 1	coeff.	0.0337	0.0208	-0.0141	0.0149	-0.0011	0.0007					-0.0148	-0.9
R2=0.8610	t-ratio	(7)	(22)	(-11)	(18)	(-1.1)	(5)					(-3)	(-4)
F=776.45	st. error	0.0049	0.0010	0.0013	0.0008	0.0011	0.0001					0.0043	0.2
	elast.	0.5936	0.5556	-0.1417	0.2937	-0.0089	0.0688					-0.2053	-0.15
	value ($/kg)	33.7	16.2		14.9							-14.8	
Reg. 2	coeff.	0.0229	0.0174	-0.0133	0.0096	-0.0014	0.0004	-9.9	0.2430			-0.0084	1.3
R2=0.8285	t-ratio	(4)	(15)	(-9)	(9)	(-2.6)	(5)	(-6)	(5)			(-1.6)	(4)
F=767.20	st. error	0.0060	0.0012	0.0149	0.0011	0.0005	0.0001	1.6	0.0502			0.0052	0.3
	elast.	0.4028	0.4747	-0.1331	0.1880	-0.0109	0.0396	-0.1603	0.1318			-0.1167	0.21
	value ($/kg)	22.9	17.4		9.6				243.0			-8.4	

[33] PT=protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, PMILK=raw milk price, INCOME=monthly income, DFLUID=dummy variable for the fluid milk category, DPTFLUID=dummy variable for protein in fluid milk, DPTICE=dummy variable for protein in the ice cream category, DPTYOG=dummy variable for protein in the yogurt category, DPTCHE=dummy variable for protein in the cheese category.

Industrial Market Model

Various dummy variables were included in modeling the industrial product market to capture potential dynamics and different shadow values across product categories. The results are presented in table 5.6. The variables of product characteristics in the basic part of the model are all consistently significant and positive, and both the coefficients on INCOME and PMILK are positively significant, as expected. The coefficient on protein in the ice cream category and in the combined ice cream and yogurt category is found positive and significant. The coefficient on the intercept variable for cheese (DCHE) regressed with various slope dummy variables was consistently insignificant, and therefore left out of the regressions.

The estimations in the type 2 model were particularly inconsistent, and do not provide any clarifications as to whether component values vary across products. Highly correlated variables and fewer degrees of freedom are likely the sources of these difficulties. The sign of the coefficient on the dummy variable for protein in cheese (DPTCHE) changed, depending on the combination of variables included, and caused instability in the model. The same instability is found when the dummy variable for butterfat in cheese (DBFCHE) is included. However, the coefficients on the dummy variable for butterfat in the ice cream category (DBFICE) and the dummy variable for lactose in the ice cream category (DLTICE) are consistently positive and significant, although this consistency is not found in the aggregated data set. The finding in the industrial market model suggests that butterfat and lactose have higher values in ice cream than in the rest of the model. In other words, butterfat and lactose might not be allocated efficiently. By adding these two components to products in this category, processors can potentially improve profitability. However, these results should be interpreted with caution.

Somewhat higher estimates on the adjusted R^2 are assessed in the industrial market model than in the aggregated model. However, this may be caused by multicollinearity. The F-test was again employed; the test of overall significance of the estimated regression was rejected.

Table 5.6. Test: Dummy Variables in Various Product Categories - Industrial Market[34]

Type 1 Model		PT	BF	OS	PMILK	INCOME	DCHE	DICE	DBFICE	DPTICE	DLTICE	DPTIY	CONST.
Reg. 1													
	coeff.	0.0186	0.0067	0.0056	0.0055	0.0009	0.2	-5.4	0.0273	0.0569	0.0065		1.3
R2=0.8980	t-ratio	(20)	(23)	(4)	(2.5)	(5)	(1.0)	(-10)	(12)	(6)	(3)		(5)
F=247.06	st. error	0.0009	0.0003	0.0013	0.0022	0.0002	0.2	0.5	0.0023	0.0100	0.0019		0.2
	elast.	0.3242	0.1818	0.1068	0.0395	0.0815	0.01	-0.25	0.1460	0.1072	0.0703		0.20
	value ($/kg)	18.6	6.7	5.6					27.3	56.9	6.5		
Reg. 2													
	coeff.	0.021324	0.008433	0.008608	0.006026	0.000967		0.9012				0.0161	0.1
R2=0.8521	t-ratio	(25)	(22)	(7)	(2.8)	(6)		(4)				(3)	(0.5)
F=194.03	st. error	0.0008	0.0004	0.0012	0.0021	0.0002		0.2				0.0049	0.30
	elast.	0.3716	0.2278	0.1643	0.0431	0.0859		0.04				0.0523	0.02
	value ($/kg)	21.32	8.43	8.61								16.1	

Type 2 Model		PT	BF	SBFR	OS	PMILK	INCOME	DCHE	DICE	DBFICE	DPTCHE	DLTICE	CONST.
Reg. 1													
	coeff.	0.0225	0.0180	-0.0136	0.0098	0.0060	0.0009				-0.0081		0.6
R2=0.8321	t-ratio	(4)	(15)	(-9)	(8)	(2.8)	(6)				(-1.5)		(1.9)
F=169.47	st. error	0.0060	0.0012	0.0015	0.0012	0.0021	0.0003				0.0053		0.32
	elast.	0.3913	0.4876	-0.1387	0.1862	0.0427	0.0840				-0.1144		0.09
	value ($/kg)	22.46	13.13		9.76						-8.1		
Reg. 2													
	coeff.	0.015156	0.0139	-0.0097	0.0061	0.0058	0.0009	-0.1	-5.6	0.0220	0.060478	0.0061	1.4
R2=0.8890	t-ratio	(14)	(12)	(-7)	(5)	(2.7)	(5)	(-0.3)	(-9)	(8)	(6)	(3)	(6)
F=190.60	st. error	0.001085	0.001133	0.001431	0.001344	0.002134	0.000171	0.2	0.6	0.002706	0.011010	0.0020	0.25
	elast.	0.2641	0.3764	-0.0987	0.1168	0.0411	0.0830	-0.00	-0.26	0.1174	0.1139	0.0659	0.21
	value ($/kg)	15.16	10.43		6.12					22.0	60.5	61.4	

34 PT=protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, PMILK=raw milk price, INCOME=monthly income, DCHE=dummy variable for the cheese category, DICE=dummy variable for the ice cream category, DBFICE=dummy variable for butterfat in the ice cream category, DPTICE=dummy variable for protein in the ice cream category, DLTICE=dummy variable for lactose in the ice cream category, DPTCHE=dummy variable for protein in the cheese category.

5.1.5 Test: Different Shadow Values in 1995/96

Aggregated and Industrial Market Model

To capture the potential changes in component values over time, slope dummies were introduced in the 1995/96 time series data. The results are presented in table 5.7.

Based on the recent trend of dairy products being selected for their components, we hypothesized an overall decline in component values. As predicted, the coefficient estimates for the 1995-96 time period revealed significantly negative values on both the coefficients on protein, butterfat and other solids. "Other solids" was estimated with the largest decline, followed by protein and butterfat, with a per kilogram decline of $0.14, $0.13 and $0.07, respectively. However, when all dummy variables were combined in one regression estimate, the significance levels were reduced, (although the coefficient signs are still negative).

A similar analysis was employed in the industrial market. The results are presented in table 5.8. The significance, signs and coefficients on the dummy variables for protein in 1995-96 (DPT956), the dummy variable for butterfat in 1995-96 (DBF956), and the dummy variable for other solids in 1995-96 (DOS956), were almost identical to these estimations in the aggregated market model. This supports the claim of an overall decline in component values in 1995/96.

Table 5.7. Test: Dummy Variables in 1995/96 - Aggregated Market[35]

		PT	BF	SBFR	OS	PMILK	INCOME	DPT956	DBF956	DOS956	D956	CONST.
Type 1 Model												
Reg. 1												
	coeff.	0.0229	0.0101		0.0180	-0.0012	0.0007	-0.0001				-0.6
R2=861.11	t-ratio	(49)	(43)		(22)	(-1.3)	(5)	(-4)				(-4)
F=970.99	st. error	0.0005	0.0002		0.0008	0.0010	0.0001	0.0000				0.1
	elast.	0.4038	0.2705		0.3538	-0.0099	0.064	-0.0010				-0.09
	value ($/kg)	22.94	10.13		17.98			-0.13				
Reg. 2												
	coeff.	0.0229	0.0102		0.0180	-0.0012	0.0007		-7E-05			-0.6
R2=0.8420	t-ratio	(48)	(43)		(22)	(-1.3)	(5)		(-3)			(-4)
F=847.056	st. error	0.0005	0.0002		0.0008	0.0009	0.0001		0.0000			0.1
	elast.	0.4026	0.2718		0.3547	-0.0095	0.0645		-0.0008			-0.10
	value ($/kg)	22.9	10.2		18.0				-0.07			
Reg. 3												
	coeff.	0.0229	0.0101		0.0180	-0.0013	0.0007			-0.0001		-0.6
R2=0.8480	t-ratio	(49)	(44)		(22)	(-1.3)	(5)			(-2.9)		(-4)
F=878.73	st. error	0.0005	0.0002		0.0008	0.0010	0.0001			0.0000		0.1
	elast.	0.4025	0.2704		0.3545	-0.0101	0.0649			-0.0012		-0.09
	value ($/kg)	22.9	10.1		18.0					-0.14		
Reg. 4												
	coeff.	0.0229	0.0101		0.0180	-0.0012	0.0007				-0.0164	-0.6
R2=0.8388	t-ratio	(48)	(42)		(21)	(-1.3)	(5)				(-4)	(-4)
F=821.27	st. error	0.0005	0.0002		0.0008	0.0009	0.0001				0.0046	0.1
	elast.	0.4023	0.2706		0.3547	-0.0098	0.0637				-0.0012	-0.09
	value ($/kg)	22.9	10.1		18.0							
Type 2 Model												
Reg. 1												
	coeff.	0.0171	0.0209	-0.0149	0.0159	-0.0011	0.0007	-0.0001				-0.4
R2=0.8563	t-ratio	(25)	(22)	(-12)	(20)	(-1.2)	(5)	(-4)				(-2.9)
F=789.53	st. error	0.0007	0.0010	0.0015	0.0008	0.0010	0.0001	0.0000				0.1
	elast.	0.3003	0.5572	-0.1492	0.3128	-0.0093	0.0649	-0.0011				-0.1
	value ($/kg)	17.1	16.0		15.9			-0.13				
Reg. 2												
	coeff.	0.0170	0.0209	-0.0149	0.0159	-0.0012	0.0007	-0.00009	-0.00003	-0.00005		-0.4
R2=0.8609	t-ratio	(25)	(22)	(-12)	(21)	(-1.2)	(5)	(-2)	(-1.7)	(-0.9)		(-2.8)
F=632.75	st. error	0.0007	0.0009	0.0012	0.0008	0.0010	0.0001	0.00004	0.00002	0.00006		0.1
	elast.	0.2996	0.5582	-0.1496	0.3123	-0.0097	0.0648	-0.0007	-0.0004	-0.0005		-0.1
	value ($/kg)	17.0	16.0		15.9			-0.09	-0.03			

[35] PT=protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, PMILK=raw milk price, INCOME=monthly income, DPT956=dummy variable for protein in 1995 and 1996, DBF956=dummy variable for butterfat in 1995 and 1996, DOS956=dummy variable for other solids in 1995 and 1996, D956=dummy variable for 1995 and 1996.

Table 5.8. Test: Dummy Variables in 1995/96 - Industrial Market[35]

Model		PT	BF	SBFR	OS	PMILK	INCOME	DPT956	DBF956	DOS956	D956	CONST.
Type 1 Model												
Reg. 1	coeff.	0.0188	0.0078		0.0116	0.0056	0.0009	-0.00013				0.8
R2=0.8361	t-ratio	(29)	(23)		(10)	(2.7)	(6)	(-4)				(3)
F=201.87	st. error	0.0006	0.0003		0.0011	0.0021	0.0002	0.00003				0.3
	elast.	0.327	0.2119		0.2214	0.0402	0.0835	-0.0010				0.12
	value ($/kg)	18.76	7.84		11.61			-0.13				
Reg. 2	coeff.	0.0187	0.0079		0.0116	0.0057	0.0009		-0.00006			0.8
R2=0.8322	t-ratio	(29)	(22)		(10)	(2.7)	(6)		(-3)			(3)
F=195.02	st. error	0.0007	0.0004		0.0012	0.0021	0.0002		0.00002			0.3
	elast.	0.3255	0.2128		0.2222	0.0408	0.0841		-0.0007			0.12
	value ($/kg)	18.7	7.9		11.6				-0.06			
Reg. 3	coeff.	0.0188	0.0079		0.0117	0.0057	0.0009			-0.00015		0.8
R2=0.8447	t-ratio	(30)	(24)		(11)	(2.7)	(6)			(-2.8)		(3)
F=218.42	st. error	0.0006	0.0003		0.0011	0.0021	0.0002			0.00005		0.2
	elast.	0.3269	0.2127		0.2228	0.0406	0.0838			-0.0012		0.12
	value ($/kg)	18.8	7.9		11.7					-0.15		
Reg. 4	coeff.	0.0187	0.0078		0.0116	0.0055	0.0009				-0.0233	0.8
R2=0.8329	t-ratio	(29)	(22)		(10)	(2.6)	(6)				(-4)	(3)
F=195.48	st. error	0.0007	0.0003		0.0012	0.0021	0.0002				0.0058	0.3
	elast.	0.3253	0.2116		0.2217	0.0395	0.0831				-0.0015	0.13
	value ($/kg)	18.7	7.8		11.6							
Type 2 Model												
Reg. 1	coeff.	0.0133	0.0183	-0.0143	0.0100	0.0056	0.0009	-0.00013				0.9
R2=0.8617	t-ratio	(17)	(18)	(-11)	(10)	(2.6)	(5.4)	(-4)				(4)
F=218.58	st. error	0.0008	0.0010	0.0013	0.0010	0.0021	0.0002	0.00004				0.2
	elast.	0.2324	0.4931	-0.1463	0.1890	0.0398	0.0817	-0.0010				0.14
	value ($/kg)	13.3	13.0		9.9			-0.13				
Reg. 2	coeff.	0.0133	0.0183	-0.0144	0.0099	0.0054	0.0009	-0.000081	-0.00003	-0.00005		0.9
R2=0.8673	t-ratio	(17)	(18)	(-11)	(10)	(2.6)	(5)	(-1.9)	(-1.6)	(-0.9)		(4)
F=173.95	st. error	0.0008	0.0010	0.0013	0.0010	0.0021	0.0002	0.00004	0.00002	0.00006		0.2
	elast.	0.2323	0.4948	-0.1469	0.1889	0.0388	0.0809	-0.0006	-0.0004	-0.0005		0.14
	value ($/kg)	13.3	13.1		9.9			-0.08	-0.03	-0.05		

5.1.6 Test: Different Shadow Values - Annual Regressions

Aggregated Market Model

As a complimentary test to the previous test of component valuation across time presented in section 5.1.5, annual regressions (with monthly data for each of the four years) were estimated. As discussed in chapter 4, the "time-series" variables are left out in this test, without causing additional specification bias. However, estimation bias is likely to increase in the annual regression estimates because of lower degrees of freedom. We also expected multicollinearity to cause estimation problems in this smaller data sample. The results are therefore anticipated to be less reliable in this model.

Both the basic model and a model with the inclusion of various dummy variables were estimated. The dummy variables were included only in the type 2 model, since the trends in component valuation across years did not change between the type 1 and type 2 models. As expected, the inclusion of various dummy variables caused multicollinearity in the model, and the trend of the estimated shadow values across years are not as conclusive as in the previous test, where all component values were found to be substantially lower in 1995/96 compared to in 1993/94. However, the estimated shadow values of protein are lower in 1995 and 1996 than in 1993 and 1994 in both models. This result is similar to the previous finding, although the values tend to increase between 1993 and 1994. The trend in other solids valuation differs in this test, and suggests that the value of other solids has increased consistently since 1993. Finally, the test suggests that the butterfat value is declining in the type 2 model. This is consistent with expectations and previous findings. The shadow value of butterfat is marginally increasing in the type 1 model, which contradicts the hypothesis and the findings in the previous test.

Estimates of the 1995 and 1996 data set were not successful in the type 2 and type 1 models, respectively, due to failure of the autocorrelation correction procedure. The small sample is not likely to provide sufficient variability to correct for the highly correlated variables and residuals in this data sample. Results are therefore presented only for year 1993, 1994 and 1995 in the type 1 model, and for year 1993, 1994 and 1996 in the type 2 model. This indicates the overall shortcoming of the data set, i.e., the problem of apparently high degrees of multicollinearity, which make it difficult to obtain robust results.

Table 5.9. Test: Annual Regressions - Aggregated Market[36]

		PT	BF	SBFR	OS	CONST.
Type 1 Model						
Reg. 93						
	coeff.	0.0233	0.0093		0.0128	0.4
R2=0.9520	t-ratio	(37)	(29)		(19)	(2.9)
F=940.02	st. error	0.0006	0.0003		0.0007	0.1
	elast.	0.4122	0.2509		0.2525	0.06
	value ($/kg)	23.3	9.4		12.8	
Reg. 94						
	coeff.	0.0233	0.0100		0.0142	0.1
R2=0.9387	t-ratio	(42)	(37)		(13)	(0.7)
F=887.40	st. error	0.0006	0.0003		0.0011	0.2
	elast.	0.4161	0.2707		0.2844	0.02
	value ($/kg)	23.3	10.0		14.2	
Reg. 95						
	coeff.	0.0231	0.0100		0.0179	-0.2
R2=0.8727	t-ratio	(25)	(21)		(16)	(-1.3)
F=488.59	st. error	0.0009	0.0005		0.0011	0.2
	elast.	0.4022	0.2646		0.3487	-0.04
	value ($/kg)	23.1	10.0		17.9	
Type 2 Model						
Reg. 93						
	coeff.	0.0172	0.0211	-0.0163	0.0099	0.5
R2=0.9502	t-ratio	(19)	(19)	(-11)	(15)	(4)
F=694.17	st. error	0.0009	0.0011	0.0014	0.0007	0.1
	elast.	0.3049	0.5653	-0.1642	0.1954	0.08
	value ($/kg)	17.2	15.7		9.9	
Reg. 94						
	coeff.	0.0176	0.0207	-0.0155	0.0112	0.3
R2=0.9403	t-ratio	(21)	(17)	(-10)	(13)	(2.3)
F=666.11	st. error	0.0008	0.0012	0.0015	0.0009	0.1
	elast.	0.3135	0.5618	-0.1578	0.2228	0.05
	value ($/kg)	17.6	15.6		11.2	
Reg. 96						
	coeff.	0.0154	0.0184	-0.00001	0.0117	1.0
R2=0.9682	t-ratio	(33)	(15)	(-7)	(18)	(9)
F=743.28	st. error	0.0005	0.0012	0.0019	0.0007	0.1
	elast.	0.2642	0.4772	-0.1330	0.2249	0.15
	value ($/kg)	15.4	13.9		11.7	

Table 5.9. Test: Annual Regressions, cont.[37]

		PT	BF	SBFR	OS	DFLUID	DICE	DPTFLUID	CONST.
Reg. 93									
	coeff.	0.0136	0.0192	-0.0161	0.0050	-7.7	-0.1	0.1781	2.0
R2=0.9631	t-ratio	(14)	(17)	(-11)	(6)	(-7)	(-0.5)	(5)	(11)
F=1112.04	st. error	0.0010	0.0011	0.0014	0.0008	1.1	0.1	0.0333	0.2
	elast.	0.24	0.51	-0.16	0.10	-0.13	-0.00	0.10	0.32
	value ($/kg)	13.6	13.8		5.0			178.1	
Reg. 94									
	coeff.	0.0136	0.0183	-0.0150	0.0066	-8.4	-0.3	0.1938	2.0
R2=0.9465	t-ratio	(13)	(14)	(-9)	(6)	(-6)	(-1.3)	(4)	(10)
F=1041.71	st. error	0.0010	0.0013	0.0016	0.0012	1.5	0.3	0.0458	0.2
	elast.	0.24	0.50	-0.15	0.13	-0.14	-0.01	0.11	0.33
	value ($/kg)	13.6	13.4		6.6			193.8	
Reg. 96									
	coeff.	0.0129	0.0179	-0.0146	0.0085	-10.011	-0.6	0.2450	2.1
R2=0.9770	t-ratio	(27)	(13)	(-7)	(14)	(-6)	(-4)	(5)	(19)
F=1332.39	st. error	0.0005	0.0014	0.0020	0.0006	1.6	0.1	0.0479	0.1
	elast.	0.22	0.46	-0.14	0.16	-0.16	-0.03	0.13	0.33
	value ($/kg)	12.9	13.0		8.5			245.0	

Industrial Market Model

A similar analysis was developed for manufactured dairy products. The results are presented in table 5.10. Again, the coefficients on all milk components are significant and contribute positively to wholesale prices. The estimated coefficients of other solids are small compared to earlier regression estimates, but are increasing significantly, as in the aggregated market model. This is the single largest difference from the analysis in section 5.1.5, where all component values declined in 1995/96. Butterfat values overall are declining, although the shadow values increase between 1993 and 1994 in the type 1 model. This supports the findings in the aggregated market model, where butterfat values declined. The estimated shadow values of protein are declining in the type 1 model, and between 1994 and 1996 in the type 2 model. This is consistent with the results in the regression estimates of the aggregated market.

[37] PT=protein, BF=butterfat, SBFR=squared butterfat, OS=other solids, DFLUID=dummy variable for the fluid category, DICE=dummy variable for the ice cream category, DPTFLUID=dummy variable for protein in the fluid category.

Table 5.10. Test: Annual Regressions - Industrial Market[38]

		PT	BF	SBFR	OS	CONST.
Type 1 Model						
Reg. 93						
	coeff.	0.0202	0.0077		0.0071	1.8
R2=0.9620	t-ratio	(33)	(22)		(9)	(12)
F=695.19	st. error	0.0006	0.0003		0.0008	0.2
	elast.	0.3530	0.2087		0.1369	0.27
	value ($/kg)	20.15	7.68		7.14	
Reg. 94						
	coeff.	0.0195	0.0079		0.0082	1.9
R2=0.9527	t-ratio	(31)	(24)		(7)	(8)
F=392.14	st. error	0.0006	0.0003		0.0012	0.2
	elast.	0.3448	0.2159		0.1596	0.28
	value ($/kg)	19.5	7.9		8.2	
Reg. 95						
	coeff.	0.0191	0.0078		0.0115	1.6
R2=0.9136	t-ratio	(20)	(15)		(8)	(5)
F=227.22	st. error	0.0009	0.0005		0.0014	0.3
	elast.	0.3298	0.2081		0.2162	0.24
	value ($/kg)	19.1	7.8		11.5	
Type 2 Model						
Reg. 93						
	coeff.	0.0129	0.0198	-0.0171	0.0043	2.1
R2=0.9596	t-ratio	(13)	(18)	(-12)	(5)	(11)
F=449.79	st. error	0.0010	0.0011	0.0014	0.0008	0.2
	elast.	0.2255	0.5377	-0.1760	0.0829	0.32
	value ($/kg)	12.9	13.6		4.3	
Reg. 94						
	coeff.	0.0137	0.0184	-0.0152	0.0053	2.1
	t-ratio	(14)	(15)	(-10)	(5)	(10)
	st. error	0.0010	0.0012	0.0015	0.0010	0.2
	elast.	0.2430	0.5048	-0.1583	0.1030	0.31
	value ($/kg)	13.7	12.9		5.3	
Reg. 96						
	coeff.	0.0136	0.0163	-0.0127	0.0079	2.1
	t-ratio	(29)	(13)	(-7)	(12)	(18)
	st. error	0.0005	0.0013	0.0019	0.0006	0.1
	elast.	0.2305	0.4281	-0.1261	0.1472	0.30
	value ($/kg)	13.6	11.7		7.9	

The Chow Test

The Chow test (Gujarati, pp. 443-446) is a method of testing for differences between two regression estimates. The regression estimates using the 1995/96 data and the regression estimates using the 1993/94 data in the basic type 2 model were employed. This model indicated overall declining shadow values from 1993/94 to 1995/96. We also tested whether these two

[38] PT=protein, BF=butterfat, SBFR=squared butterfat, OS=other solids.

estimates are significantly different from each other. The type 1 model did not provide regression estimates due to the failure of the autocorrelation correction procedure, and only the regression estimates in the type 2 model were tested.

The chow test is based on these assumptions:

(a) $u_{93/94} \sim N(0,\sigma^2)$

$u_{95/96} \sim N(0,\sigma^2)$

(b) $u_{93/94}$ and $u_{95/96}$ are distributed independently

In words, the disturbances in the two regression estimates are assumed to be distributed normally with a zero mean and constant, or homoscedastic, variance σ^2, which is independently distributed.

The Chow test suggests that the regression estimates employing 1993/94 data are significantly different than the estimates using data from 1995/96. This supports the findings in the tested regression employing the 1993/94 data and the 1995/96 data separately, and the findings in the test provided in section 5.1.6, suggesting that component values are declining overall. Given the sudden (and surprising) decline in the consumption of all components (not only butterfat) in 1995/96, an overall decline in component values was hypothesized. The test results are therefore consistent with our expectations, and indicate changing consumption patterns of dairy foods as well as a structural change in component valuation where not only the value of butterfat is declining.

5.1.7 Test: Functional Forms

As suggested in hedonic theory discussed in chapter 3, linear regression models such as the type 1 model, which is linear in the parameters and explanatory variables, have a tendency to overestimate component coefficients. This potential specification bias might be caused by the diminishing marginal net returns to butterfat, and can be corrected for by choosing the "right" model for empirical analysis, as discussed in section 4.2. The squared terms of butterfat, protein and other solids were therefore introduced. The coefficient on the squared term of butterfat was significantly negative in all the type 2 models and therefore used throughout this analysis. Other functional forms of regression models with variables linear in parameters but nonlinear in the variables are double-log or constant-elasticity models. However, the logarithmic models did not succeed in the aggregated nor in the industrial market models. The introduction of terms in natural logarithmic form reduces variability in the variables that might already have limited variability. This might help explain the failure of this estimation procedure.

5.2 Summary and Evaluation of the Hedonic Shadow Values

The estimated wholesale level protein, butterfat and other solids values are translated into retail level by assuming that the farm level residual is 40 percent of the wholesale values for all dairy products. This is based on suggestions in Lenz et al. (1994) who employed a farm margin of 50 percent in their analysis of the 1977 US dairy basket. The raw milk costs in different products given product yield formulas were also calculated and compared to wholesale prices. These calculations suggest a farm margin of 40-50 percent of wholesale prices.

Farm-level shadow values of milk components as estimated in the regression analysis of the basic model and its tests, discussed in section 5.1, are presented in tables 5.11 and 5.12. The first three columns show the shadow values of the components. The far column, the calculated milk value (in $/hl), show these values multiplied by their respective average component levels in 1996. The average component test levels in 1996 were 3.28 kg/hl of protein, 3.83 kg/hl of butterfat, and 5.45 kg/hl of other solids (or 4.8 kg/hl of lactose). The other columns show the estimated shadow values of dummy variables in different product categories. For example, a negative value on a dummy variable should be subtracted from the related component shadow value in one of the three first columns to find the component shadow value in the specific product category.

To evaluate the shadow values, the calculated milk prices should be compared to the actual milk price. The CPI-adjusted (Dec. 1996=100) actual milk prices in July 1996 were \$62.98/hl for fluid milk, \$49.41/hl for class 2 milk (yogurt, ice creams etc.), and \$48.37/hl for class 3 milk (cheese). Details regarding the determination of the actual milk prices is provided in section 4.1.2. It becomes obvious that our estimates are high given the levels of current milk prices. The use of the 40 pegated and

the industrial model. The value of other solids is, with few exceptions, estimated as higher than butterfat in the aggregated market. This indicates that the importance of both protein and other solids in milk pricing in B.C. have been largely ignored.

In all the type 1 models, which are linear in both parameters and variables, protein is valued 2.3-2.8 times higher than butterfat, and other solids is valued 0.8-1.8 times the butterfat value. Although the estimated values are higher in the aggregated model, the ratio between them is relatively similar in the two market models. The high value of other solids is unexpected, given the recent attention to lactose intolerance in milk products. In the type 2 models, butterfat values are higher and protein values lower than in the type 1 models. Furthermore, are protein values above but close to butterfat values, and other solids also usually close to butterfat values. Protein is generally valued highest of the three components considered. The protein to butterfat ratio is estimated at 1.0-1.7, with one exception where protein is valued 2.1 times the butterfat value. Butterfat is valued equal to or higher than other solids, and the other solids to butterfat ratio is estimated at 0.3-1.0. The high value of other solids is supported in current component valuation in Ontario, established October 1, 1996 (table 2.1), and in suggestions from the Canadian Milk Supply Management Committee. Protein, butterfat and other solids in these systems are valued relatively similarly in all product categories.

The significance of the coefficients on the slope dummy variables in the tests of the basic model indicates consumer preferences for certain components in certain products, but also that milk constituents might not be efficiently allocated across products at the processor level. The estimated shadow values of the slope dummies are unusually large and difficult to explain. This is especially true for the coefficients on the dummy variable for protein in fluid milk (DPTFLUID), the dummy variable for vitamins and calcium in fluid milk (DVCFLUID), and the dummy variable for protein in the ice cream category (DPTICE). Despite the large magnitude of the coefficients, the significance and signs of the coefficients on protein, vitamins and calcium in fluid milk, are significantly positive, and negative for butterfat and lactose in fluid milk, throughout this analysis. The values of protein, vitamins and calcium are therefore suggested to be of great importance in fluid milk valuation. The size of the coefficient on the dummy variable for butterfat in fluid milk (DBFFLUID) suggests that butterfat has only marginal value in fluid milk. The consumption of low-fat milk products, such as skimmed, "1 percent" and "2 percent" milk has increased rapidly in the last few years, and these products account for approximately 75 percent of all fluid milk consumption (February 1997). The finding of declining butterfat value in fluid milk, and diminishing marginal net returns to butterfat in both the industrial and aggregated market models are therefore not surprising. The negative coefficient on DLTFLUID also suggests that lactose has only marginal value in fluid milk.

The significance and signs of the coefficients on the dummy variables for components in product categories other than in fluid milk were not consistent. The highly correlated variables caused instability in the model. However, the coefficients on the dummy variables for protein in the yogurt category (DPTYOG) and the dummy variable for protein in cheese products (DPTCHE) were consistently significant and negative, suggesting that the protein in yogurt and cheese is less valued than in the rest of the model. This raises the question of whether it would be profitable to the processor to remove protein from these products and allocate it to those products where protein has a higher value.

The overall decline in component values in the latter part of our data set (in 1995/96) support the somewhat surprising hypothesis in this project, that the valuation of all components have declined the last two years. The declining consumption of butterfat in the fluid market, and the resulting skim-off problems, and the unexpected decline in consumption of all components starting in 1995, lead to the hypothesis of overall declining component values. This hypothesis was supported in the test of the basic model. A decline in butterfat and protein values was also estimated in the annual regressions, but other solids increased. The lower degrees of freedom in this test allowed us to downplay the relevance of this estimated increase. The Chow-test allowed us to reject the hypothesis that the type 2 regression estimates employing 1993/94 and 1995/96 data separately were the same, and support the general finding of overall declining component values. However, the magnitude of the coefficients on all the slope dummy variables should be interpreted with caution.

Although there is some variation in the estimated component values across regressions, the shadow values give a fair indication of the range of the values of each component and serve as a guide to applying a MCP system in B.C. Most important is the support these results give to establishing a pricing regime that values each of milk protein, butterfat and other solids. The importance of considering all three categories in milk pricing cannot be overstated. Although the shadow price estimates are similar to the actual milk prices, it is erroneous to infer that pricing milk on a fat differential basis provides the same milk supply incentives to producers as in a multiple component pricing system.

The current butterfat differential pricing system values butterfat at $5.34/hl, which is the federal support price for butter. This is in the upper range of the hedonic butterfat estimates, and indicates that the federal support price for butter is over-priced. The declining butterfat consumption and the increased butterfat skim-off from the fluid market supports this statement (indicating declining value of butterfat, particularly in fluid milk). Pricing milk based on butterfat encourages increased butterfat production, which is inefficient given current market requirements. The federal support price for skim milk powder (SMP) at $3.93/kg can be used as a measure of the protein value, and is low, and much below the estimated range of our estimates. The sum of the estimated values of protein and other solids, in other words, the nonfat solids value, overshadows the butterfat value in milk. This brings into question the efficiency of the federal support prices, and the market incentives they provide. Since there is no open-ended support price in Canada, the support prices are minimum values, and the possibility is raised that component values in the milk product market could be higher than the support price levels. This is precisely what our hedonic price estimations for nonfat solids values show.

Comparing the current valuation of components in B.C. with the hedonic estimates, where aggregated protein and other solids values are higher than the butterfat value, it is obvious that a MCP system would provide substantially different economic incentives for fat, protein and other solids production. Since the results suggest a higher value on protein and other solids, and lower butterfat value, establishing a MCP system may be the best solution to handle the current skim-off problems in B.C. Such a system may also reverse the trend of over-supply of butterfat for which demand is declining. Shifting to payment by component is a "win-win" situation, with efficiency gains throughout the milk sector.

Table 5.11. Shadow Values: Aggregated Market Model[39]

	PT	BF	OS	LT	DPTFLUID	DBFFLUID	DLTFLUID	DVCFLUID	DPTICE	DPTYOG	DPTCHE	DPT956	DBF956	DOS956	MILK VALUE
Type 1 Model															
Basic	9.2	4.1	7.2												84.8
	9.2	4.1	7.4												86.0
	10.0	4.1	7.3												88.4
Dummy - fluid	7.4	3.1	4.3		77.0										59.4
	7.3	3.0	3.8			-3.1									56.1
	7.5	3.1	4.6				-3.7								61.6
	8.5	3.1	4.5					1475.3							64.3
	8.8	3.3		5.0	76.5			942.2							65.2
Dummy - various	7.8	3.0	3.1		53.6				13.6						53.6
	7.0	2.9	4.2		73.2					-4.1					56.8
Dummy - 1995/96	9.2	4.1	7.2									-0.05			84.8
	9.2	4.1	7.2										-0.03		84.9
	9.2	4.1	7.2											-0.06	84.8
Annual - 1993	9.3	3.7	5.1												72.7
Annual - 1994	9.3	4.0	5.7												77.0
Annual - 1995	9.2	4.0	7.2												84.7
Type 2 Model															
Basic	6.8	6.4	6.6												82.8
	6.8	6.4	6.4												81.4
	7.4	6.3	6.3												82.7
Dummy - fluid	5.3	5.3	3.9		103.5										59.0
	5.0	5.3	3.2			-7.2									54.5
	5.5	5.1	4.0				-3.5								59.22
Dummy - various	13.5	6.5	6.0								-5.9				101.5
	9.2	6.9	3.8		97.2						-3.4				77.5
Dummy - 1995/96	6.8	6.4	6.4									-0.05			81.5
	6.8	6.4	6.4									-0.04	-0.01		81.4
Annual - 1993	6.9	6.3	4.0												68.2
Annual - 1994	7.0	6.3	4.5												71.3
Annual - 1996	6.2	5.5	4.6												66.5
Annual - 1996	5.2	5.2	3.4		98.0										55.4

[39] PT=protein, BF=butterfat, OS=other solids, LT=lactose, DPTFLUID=dummy for protein in fluid milk, DBFFLUID=dummy for butterfat in fluid milk, DLTFLUID=dummy for lactose in fluid milk, DVCFLUID=dummy for vitamins and calcium in fluid milk, DPTICE=dummy for protein in the ice cream category, DPTYOG=dummy for protein in the yogurt category, DPTCHE=dummy variable for protein in the cheese category, DPT956=dummy for protein in 1995 and 1996, DBF956=dummy for butterfat in 1995 and 1996, DLT956=dummy for lactose in 1995 and 1996, DOS956=dummy for other solids in 1995 and 1996.

Table 5.12. Shadow Values: Industrial Market Model[40]

	PT	BF	OS	DPTICE	DBFICE	DLTICE	DPTYOG	DPTIY	DPTCHE	DPT956	DBF956	BOS956	MILK VALUE
Type 1 Model													
Basic	7.5	3.1	4.7										61.9
	7.1	3.1	4.6										60.4
	7.3	3.1	5.0										63.3
Dummy - various	7.4	2.7	2.2	22.8	10.9	2.6							46.9
	8.5	3.4	3.4					6.4					59.7
Dummy - 1995/96	7.5	3.1	4.6							-0.05			61.9
	7.5	3.2	4.7								-0.02		62.0
	7.5	3.2	4.7									-0.06	62.1
Annual - 1993	8.1	3.1	2.9										53.8
Annual - 1994	7.8	3.2	3.3										55.6
Annual - 1995	7.7	3.1	4.6										62.0
Type 2 Model													
Basic	5.5	5.2	4.0										59.8
Dummy - various	9.0	5.3	3.9			-3.2							70.9
	6.1	4.2	2.5	8.8		24.2		24.6					49.2
Dummy - 1995/96	5.3	5.2	4.0							-0.05			59.1
	5.3	5.2	4.0							-0.03	-0.01	-0.02	59.1
Annual - 1993	5.2	5.4	1.7										47.1
Annual - 1994	5.5	5.2	2.1										49.4
Annual - 1996	5.4	4.7	3.2										53.0

[40] PT=protein, BF=butterfat, OS=other solids, DPTICE=dummy variable for protein in the ice cream category, DBFICE=dummy variable for butterfat in the ice cream category, DLTICE=dummy variable for lactose in the ice cream category, DPTYOG=dummy variable for protein in the yogurt category, DPTIY=dummy variable for protein in the ice cream and yogurt category, DPTCHE=dummy variable for protein in the cheese category, DPT956=dummy variable for protein in 1995 and 1996, DBF956=dummy variable for butterfat in 1995 and 1996, DOS956=dummy variable for other solids in 1995 and 1996.

CHAPTER 6

6.0 CONCLUSIONS

6.1 Summary and Conclusions

This thesis used a hedonic approach to determine the implicit market value of milk components. This work was motivated by several factors, including the apparent change in consumer preferences away from butterfat toward protein, the increasing surplus of butterfat in fluid milk demand (the skim-off issue), and the desire to make milk pricing more market responsive. The goal of the study was to explain the variability in wholesale milk product prices using the nutrient (component) levels of dairy foods and exogenous demand and supply shifters in an economic framework, with particular attention to capturing the influence of all major constituents in raw milk. This is in contrast to the current pricing system in B.C. which values only butterfat.

The estimated coefficients of each component variable considered in the empirical model are the marginal constituent values, or shadow prices, at wholesale level. Cross-sectional data from January 1993 to July 1996 were used to test the hypotheses. We used a generalized least squares approach to estimate the model.

The main variables used to explain the differences in milk product values (the three major components (butterfat, protein, and the aggregate of other solids (lactose, calcium and other minerals)) and two demand/supply shifters), are considered in detail in two markets, the aggregated fluid and industrial product market, and the industrial product market. Slope dummy variables were introduced to test for different component shadow values in fluid milk and in other product categories. The basic model was then tested for structural change in component valuation over the last two years, and between each year. Most importantly, the results strongly suggest that butterfat, protein and other solids are all crucial factors in explaining variability in wholesale prices, and should therefore all be considered in valuation of raw milk in B.C.

The time-based demand and supply parameters were measured by the explicit income and raw milk price. Both were expected to have a positive effect on the price of milk products. Income proved to be important and positively affect wholesale prices. The coefficients on the variable for raw milk costs were negative and insignificant in the aggregated product market. This result was unanticipated and cannot easily be explained. However, the coefficient on the raw milk costs were significantly positive in the industrial market and suggest that the cost of raw milk is an important factor in determining wholesale prices, as expected.

The significantly positive coefficients on protein, butterfat, and other solids in explaining variability in wholesale prices, support the implementation of a multiple component pricing system in milk valuation in B.C. based on these three components. Generally, protein was found to be the most important component in milk valuation, and the estimated protein values ranged from just slightly above to twice the value of butterfat. In the regressions where the butterfat variable was allowed to have a non-linear effect (e.g., diminishing marginal values), the value of protein and butterfat converged to where protein was only slightly higher in value than butterfat. The estimated shadow value of "other solids" was found to be surprisingly important, higher than the butterfat value in the type 1 model, and lower than (but similar to) the butterfat value in the type 2 model. The importance of a declining marginal value for butterfat (its value falls as more butterfat is included), but not for protein and other solids, reflects the origins of butterfat skim-off from the fluid sector.

Possibly because of high correlation between the cross-sectional component variables and the dummy variables, estimates allowing for different shadow values in certain product categories were often surprisingly large. However, the often significant coefficients on the slope dummies suggest that milk constituents may not be efficiently allocated between product categories. Technology constraints in the separability of components might partly explain this. Protein was shown to have a higher value in milk utilized for fluid purposes than in other milk, which is surprising given some processor perceptions that protein does not add to the value of fluid milk. On the other hand, these tests suggest that both butterfat and lactose have a marginal value in fluid milk. Since approximately 75 percent of all fluid milk is utilized in low fat products such as "2 percent", "1 percent" and skim milk, and this trend is continuing, the model suggests that protein, calcium and vitamins are important factors in fluid milk valuation.

To test for time trends in component valuation, intercept dummy variables for the latter half of the data set (1995-96) were introduced. The coefficients on the dummy variables were significantly negative, indicating an overall declining trend in component valuation in B.C. The declining trend in butterfat consumption, previously mentioned in reference to the skim-off issue, leads one to expect a declining butterfat value. However, the estimated decline over this brief period from 1993 to 1995 in both protein and other solids was surprising.

This research is the first step in estimating milk component values in B.C. based on a hedonic approach, and the results are supportive of the theoretical model used. Valuation of milk based on butterfat only fails to provide producer incentives to produce more of those components high in demand, and thereby improve processor profitability. A MCP system could be a useful tool in managing the changing consumer preferences for milk and milk products and could lead to efficiency gains for processors, producers and consumers.

The hedonic component values estimated in this analysis can also be reviewed in the context of (minimum) federal support prices. The estimated butterfat value is similar to (actually in the upper range of) the hedonic butterfat estimates, a result that has also been found in the U.S. (Lenz et al, 1994). However, the situation in B.C. is different for protein and other non-fat solids.

Here, the market situation is such that the estimated non-fat component values exceed the support price for skim milk powder (at $3.93/kg) by a wide margin. The minimum federal support price appears to be non-binding, with market values of protein and other non-fat solids rising above that level, given consumer demand and the fixed supply of raw milk determined by quota levels.

The research procedures and results could be improved by extending the data set to include processor data from other provinces. Using nutrient values of products from individual processors and including processing costs in each product category would likely improve the results. An extended model would also enable us to test for differences in component values across provinces. However, the aggregated data set in this hedonic price model is an important first step in estimating component values.

This research also raises the question of nutritional labeling of milk products. With increased consumer valuation of non-fat milk solids, one might expect labeling of those component levels to be increasingly sought by consumers. Improved labeling of nutritional composition of dairy foods could contribute positively to this trend of increased valuation of non-fat solids and potentially increase consumer perceptions of dairy product composition.

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APPENDIX 1: B.C. Component Production

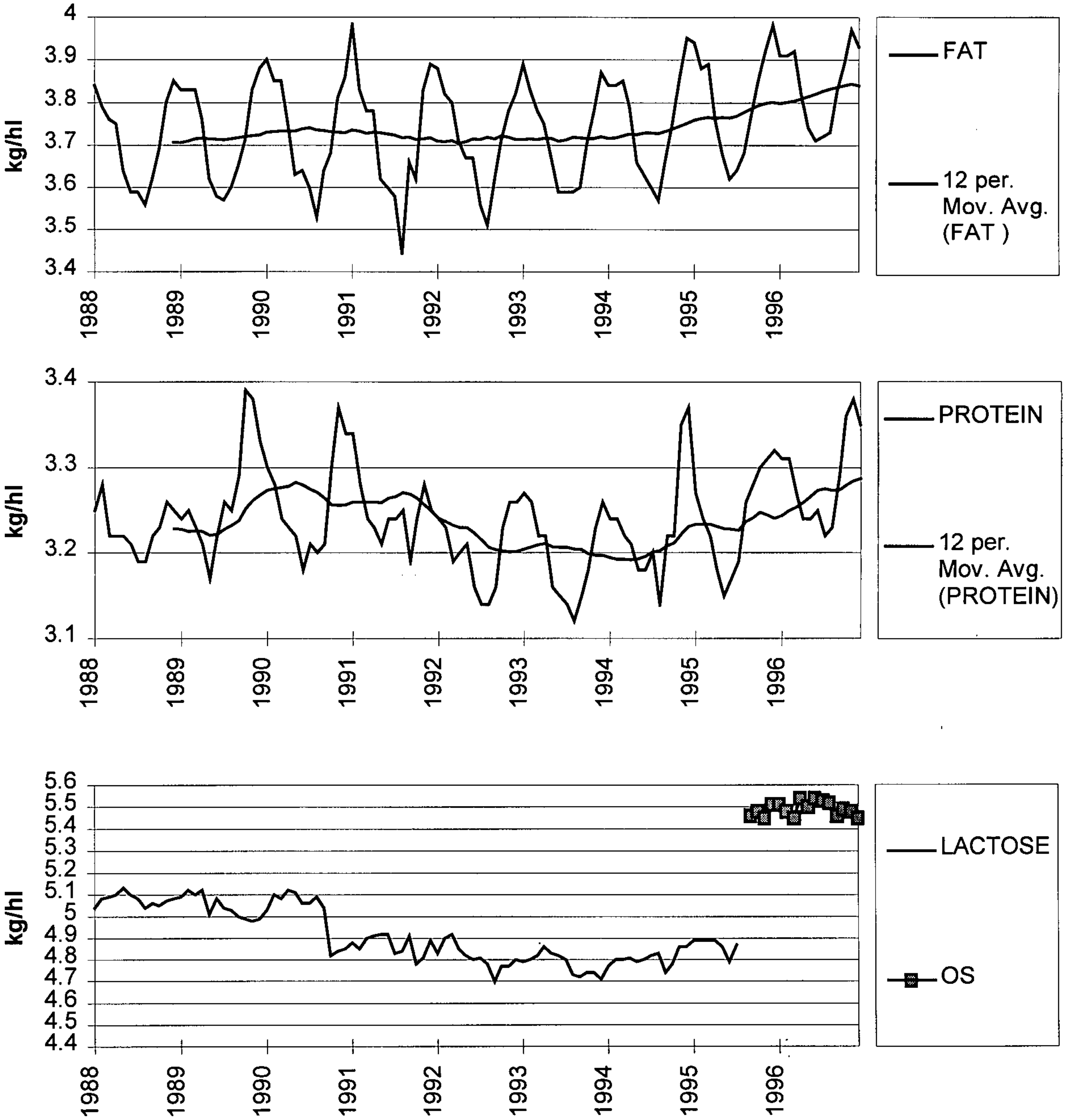


Figure A.1.1: B.C. Component Tests
Source: B.C. Milk Marketing Board

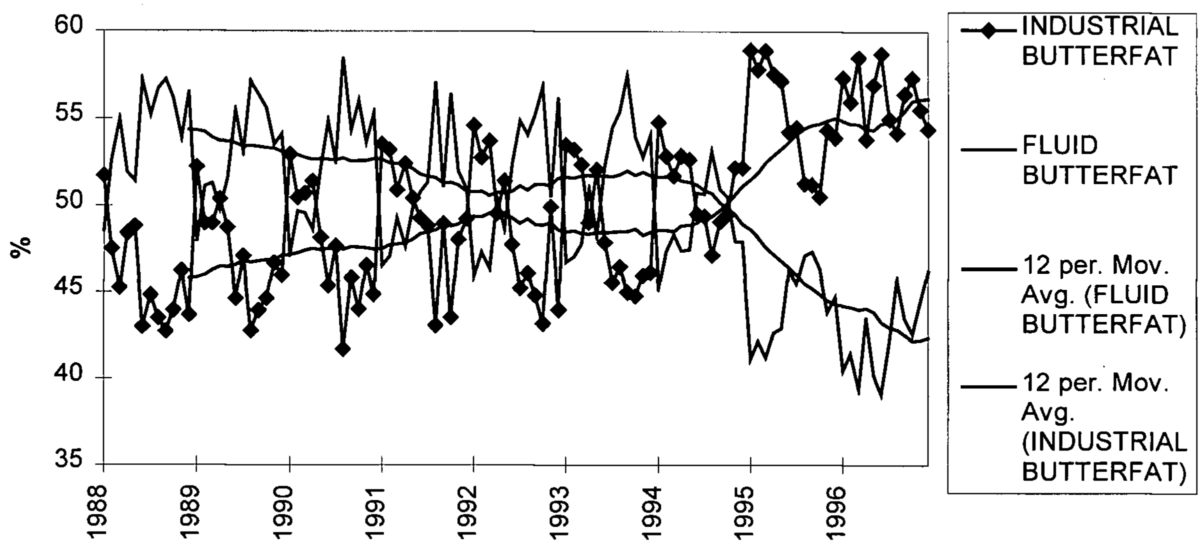


Figure A.1.2: B.C. Butterfat Distribution, Industrial and Fluid Purposes
Source: B.C. Milk Marketing Board

APPENDIX 2: Ontario Component Production

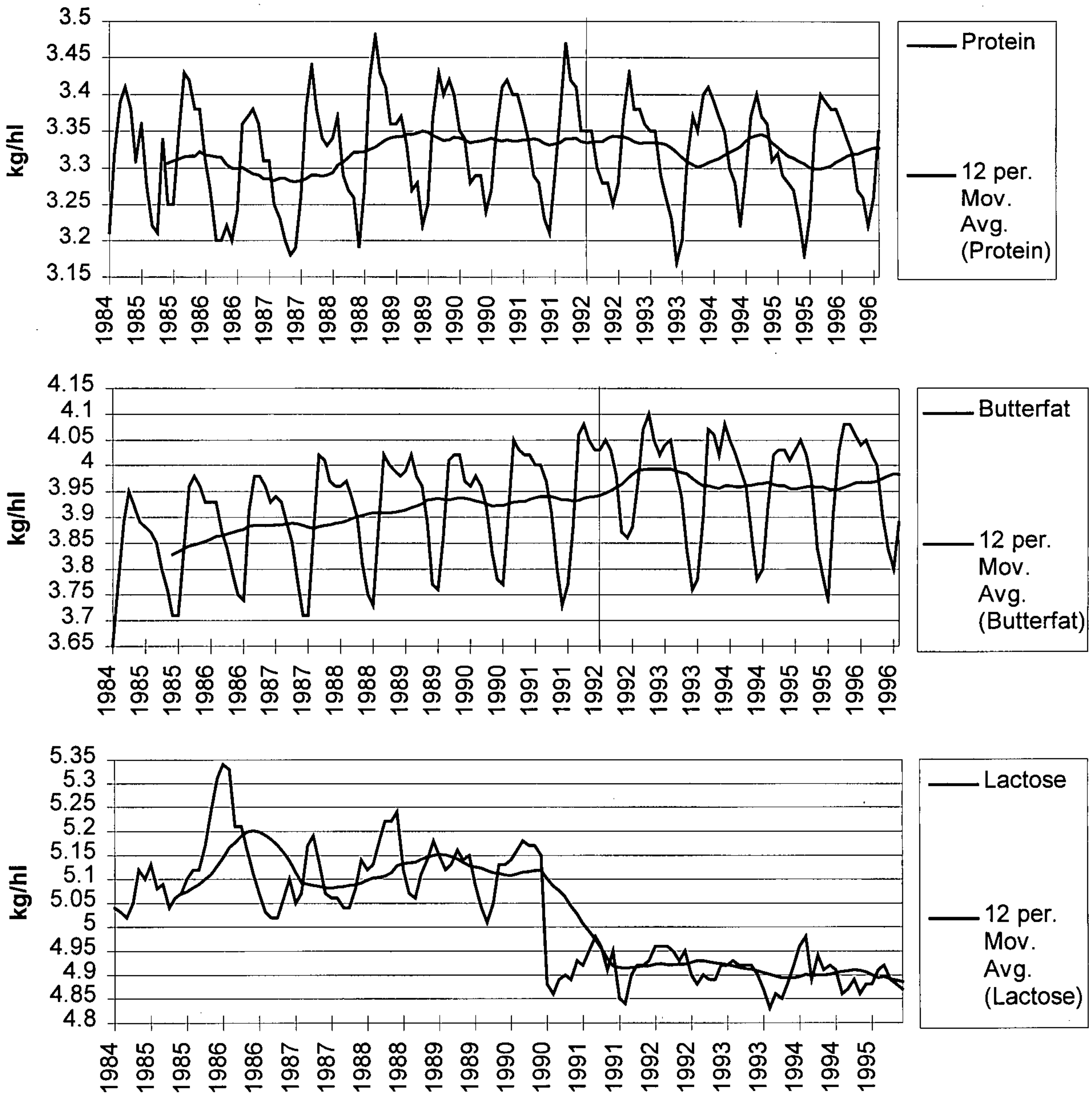


Figure A.2.1: Ontario Component Tests

Source: Dairy Farmers of Ontario

APPENDIX 3: California Component Production

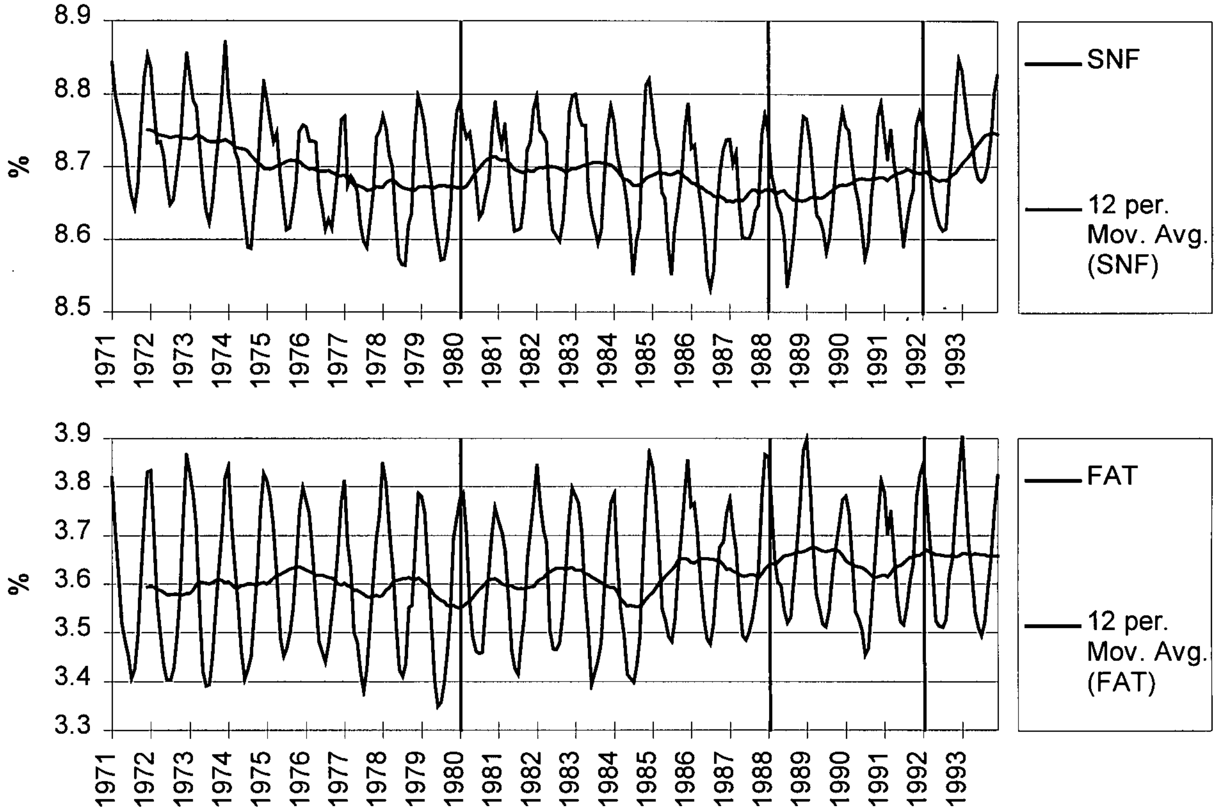


Figure A.3.1: California SNF and Butterfat Tests
Source: California Department of Food and Agriculture, Division of Marketing Services

APPENDIX 4: Ontario and California Component Price Ratio

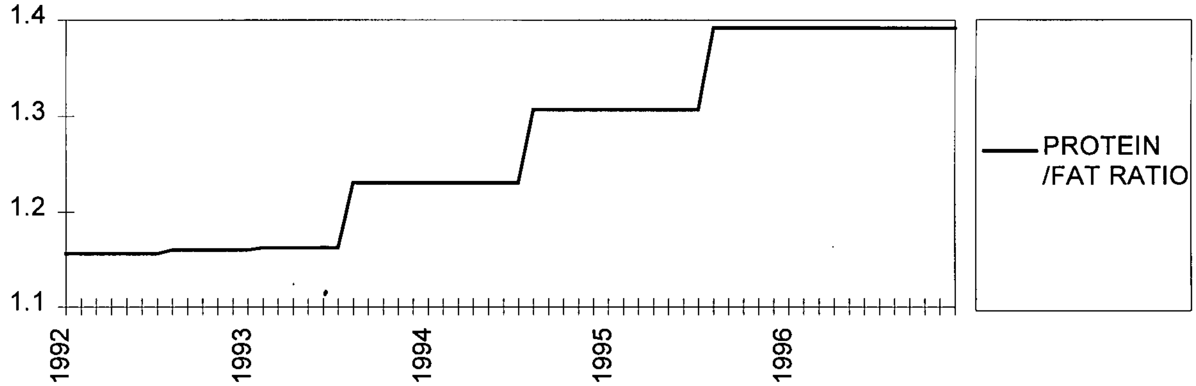


Figure A.4.1: Ontario Protein/Butterfat Ratio

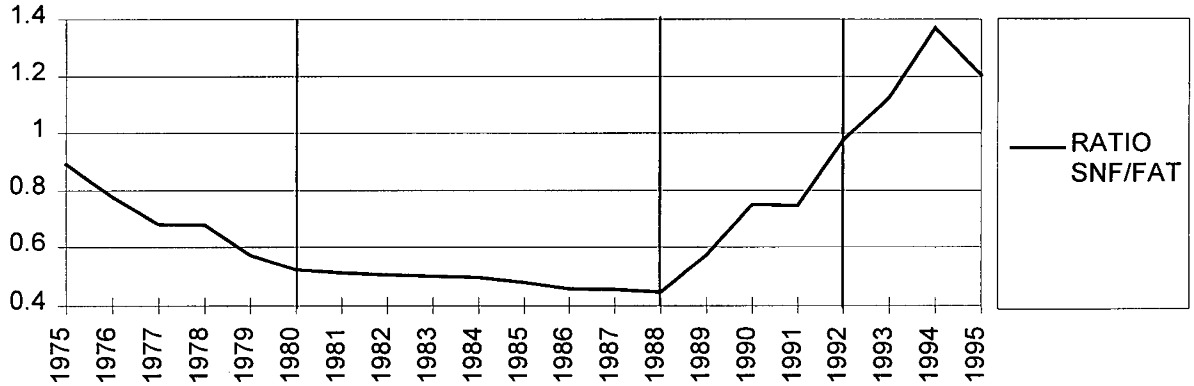
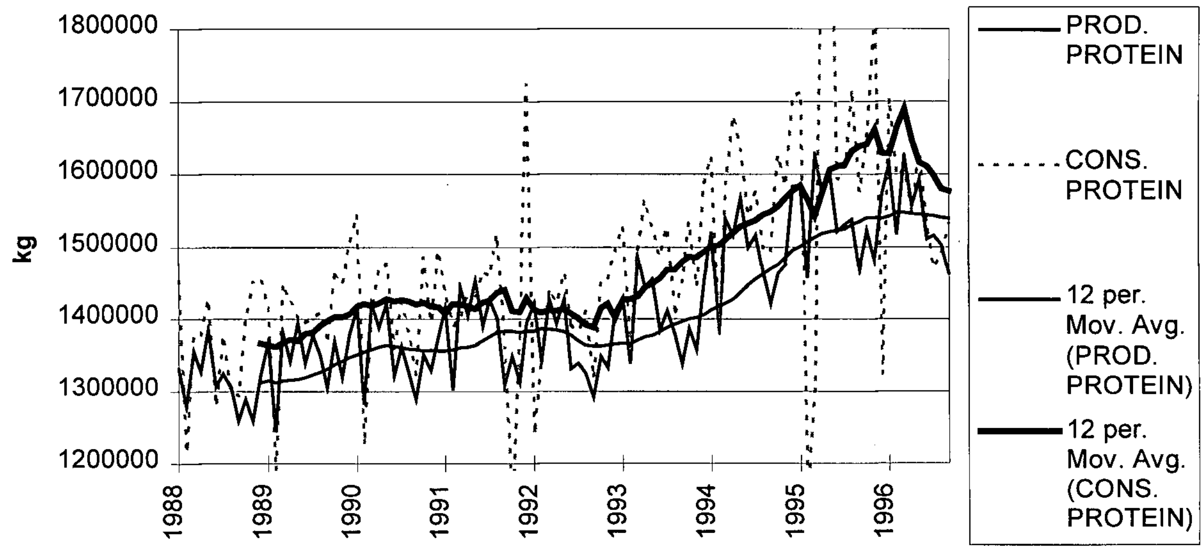
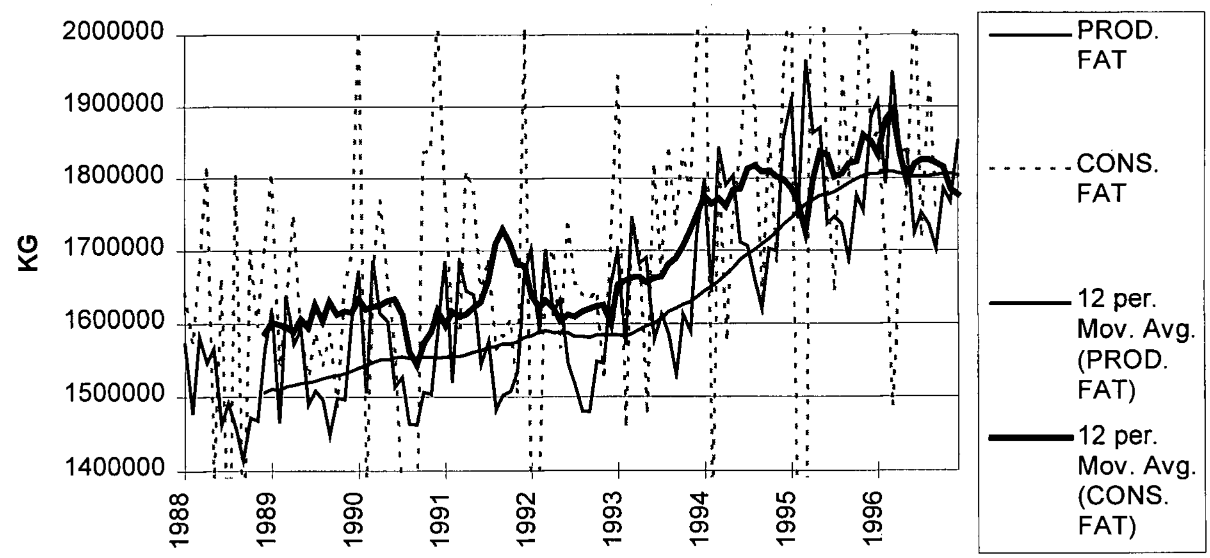


Figure A.4.2: California SNF to Butterfat Price Ratio[41]

[41] The ratio is calculated from weighted average fat and SNF prices by classes.

APPENDIX 5: B.C. Consumption and Production of Components





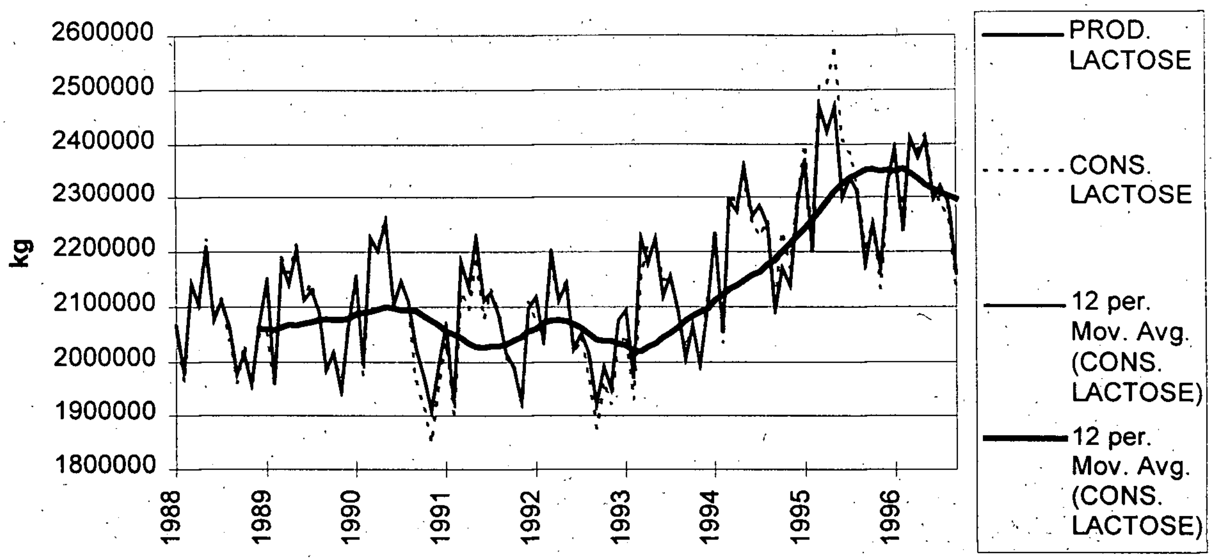


Figure A.5.1: BC Consumption and Production of Components

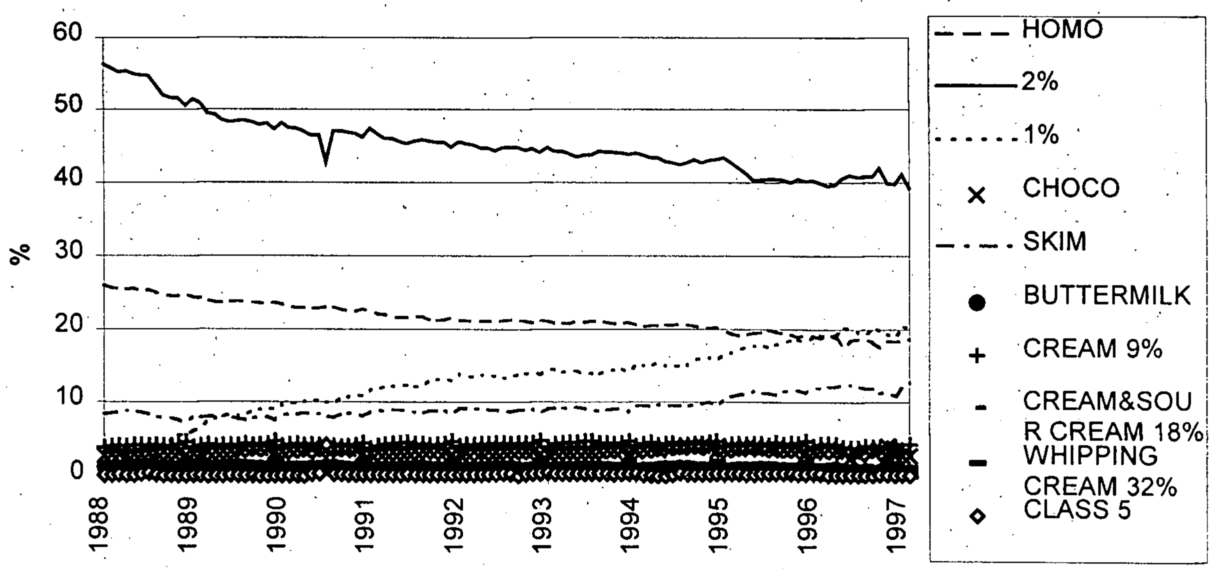
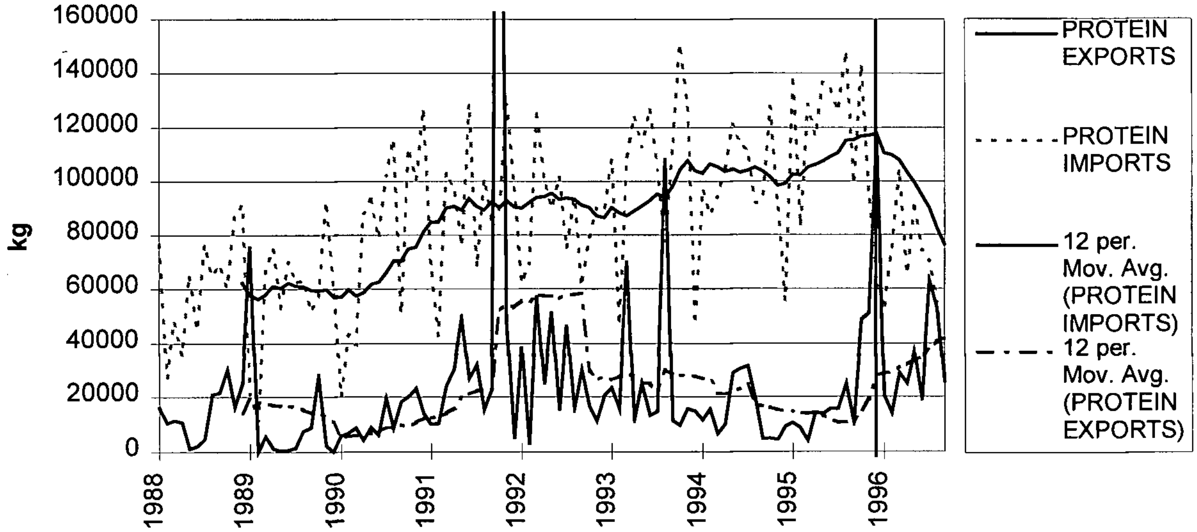
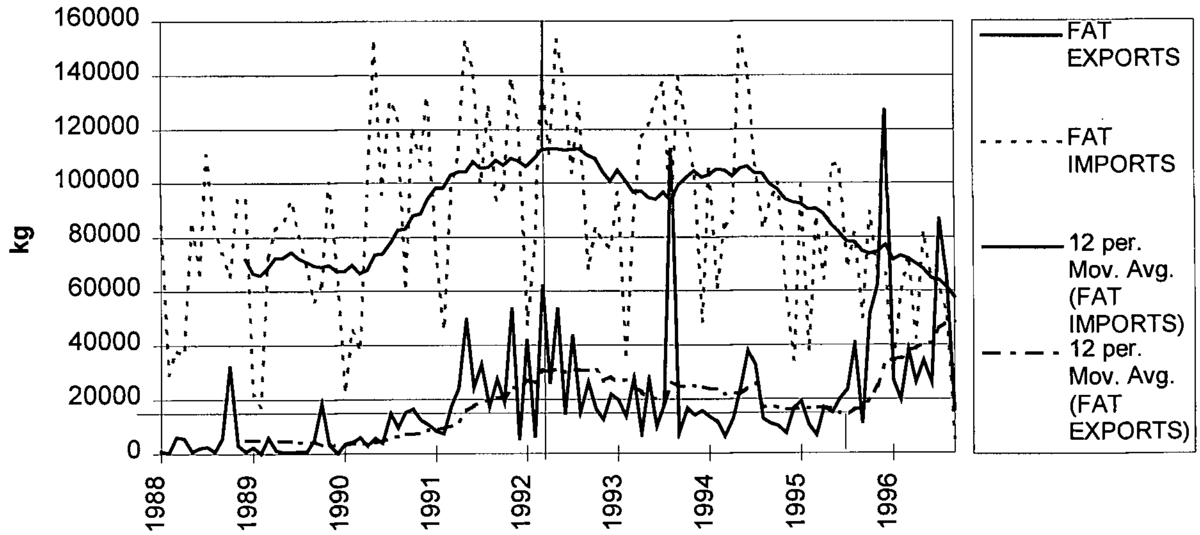


Figure A.5.2: BC Fluid Consumption and Production, % of total liters

APPENDIX 6: B.C. Component Trade





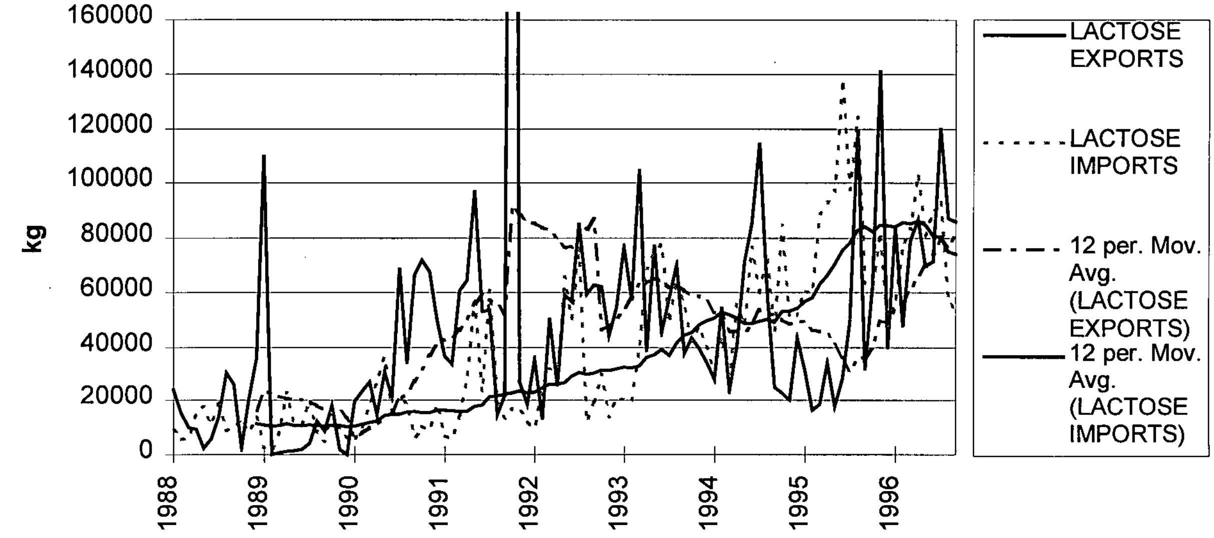


Figure A.6.1: BC Trade in Components[42]

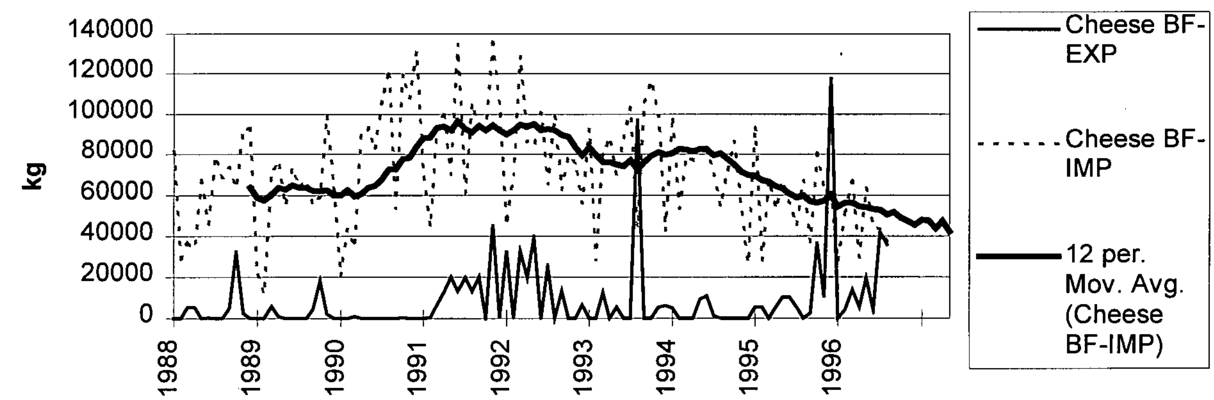


Figure A.6.2: BC Trade in Cheese Components[43]

[42] In January 1989, 109,000 kg of lactose in skim milk powder was exported from BC. The peak in October 1991 is due to export of 515,000 kg of lactose in skim milk powder, resulting in total lactose exports of 546,000 kg.

[43] The trade in cheese components is represented by the butterfat component, since the traded cheese contains similar amounts of butterfat, protein and lactose.

APPENDIX 7: Correlation Matrix

Table A.7.1: Aggregated Market Model

	PRICE DPTFLU	PT DPTCH	SPTR DPTICE	BF DPTYOG	SBFR	LT DBF956	CA DBFFLUID	MI	VIT DOS956	OS DLTFLUID	SOSR	PMILK DVMFL	PSUBST DVCFL	INCOM D956	DPT956 DFLUID
PRICE	1,00														
PT	0,68	1,00													
SPTR	0,66	0,93	1,00												
BF	0,55	0,23	0,26	1,00											
SBFR	0,27	-0,03	0,04	0,92	1,00										
LT	-0,25	-0,56	-0,47	-0,44	-0,38	1,00									
CA	0,67	0,95	0,92	0,30	0,02	-0,50	1,00								
MI	0,60	0,82	0,78	0,31	0,10	-0,45	0,83	1,00							
VIT	0,46	0,55	0,45	0,51	0,37	-0,57	0,53	0,50	1,00						
OS	-0,20	-0,49	-0,41	-0,42	-0,39	0,99	-0,43	-0,37	-0,54	1,00					
SOSR	-0,17	-0,48	-0,39	-0,33	-0,29	0,98	-0,41	-0,38	-0,46	0,98	1,00				
PMILK	-0,60	-0,33	-0,26	-0,35	-0,20	-0,08	-0,26	-0,29	-0,24	-0,11	-0,14	1,00			
PSUBST	-0,54	-0,24	-0,18	-0,27	-0,15	-0,18	-0,17	-0,19	-0,16	-0,21	-0,23	0,97	1,00		
INCOME	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,00	1,00	
DPT956	0,35	0,53	0,49	0,12	-0,02	-0,29	0,50	0,43	0,29	-0,26	-0,25	-0,11	-0,13	0,36	1,00
	1,00														
DPTFLUID	-0,54	-0,24	-0,18	-0,27	-0,15	-0,18	-0,17	-0,19	-0,17	-0,21	-0,23	0,97	0,99	0,00	-0,13
	1,00														
DPTCHE	0,67	0,99	0,91	0,29	0,04	-0,61	0,93	0,82	0,59	-0,54	-0,52	-0,33	-0,24	0,00	0,52
	-0,24	1,00													
DPTICE	0,05	-0,36	-0,30	-0,14	-0,19	0,67	-0,31	-0,32	-0,30	0,67	0,67	-0,12	-0,19	0,00	-0,19
	-0,19	-0,42	1,00												
DPTYOG	-0,29	-0,28	-0,24	-0,35	-0,20	0,21	-0,26	-0,28	-0,34	0,19	0,09	-0,10	-0,16	0,00	-0,14
	-0,16	-0,33	-0,27	1,00											
DBF956	0,31	0,13	0,14	0,55	0,51	-0,24	0,17	0,17	0,28	-0,24	-0,18	-0,13	-0,15	0,32	0,49
	-0,15	0,16	-0,08	-0,19		1,00									
DBFFLUID	-0,44	-0,20	-0,15	-0,21	-0,12	-0,14	-0,14	-0,16	-0,13	-0,16	-0,19	0,80	0,82	0,00	-0,10
	0,81	-0,19	-0,16	-0,13		-0,12	1,00								
DOS956	-0,06	-0,24	-0,20	-0,21	-0,19	0,48	-0,21	-0,18	-0,26	0,48	0,47	0,14	-0,10	0,40	0,14
	-0,10	-0,27	0,32	0,09		0,12	-0,08		1,00						
DLTFLUID	-0,50	-0,22	-0,17	-0,24	-0,14	-0,14	-0,16	-0,18	-0,15	-0,17	-0,20	0,91	0,93	0,00	-0,12
	0,92	-0,22	-0,18	-0,14		-0,14	0,80		-0,08	1,00					
DVMFLUI	-0,54	-0,24	-0,18	-0,27	-0,15	-0,18	-0,17	-0,19	-0,17	-0,21	-0,23	0,97	0,99	0,00	-0,13
	0,99	-0,24	-0,19	-0,16		-0,15	0,81		-0,10	0,93		1,00			
DVCFLUID	-0,54	-0,24	-0,18	-0,27	-0,15	-0,18	-0,17	-0,20	-0,16	-0,21	-0,23	0,97	0,99	0,00	-0,13
	0,99	-0,24	-0,19	-0,16		-0,15	-0,16		-0,10	0,92		0,99	1,00		
D956	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,58	0,61
	0,00	0,00	0,00	0,00		0,55	0,00		0,69	0,00		0,00	0,00	1,00	
DFLUID	-0,54	-0,24	-0,18	-0,27	-0,15	-0,18	-0,17	-0,19	-0,16	-0,21	-0,23	0,97	0,99	0,00	-0,13
	0,99	-0,24	-0,19	-0,16		-0,15	0,82		-0,10	0,93		0,99	0,99	0,00	1,00
	PRICE DPTFLU	PT DPTCH	SPTR DPTICE	BF DPTYO	SBFR DPTIY	LT DBF956	CA DBFFLU	MI DBFICE	VIT DOS956	OS DLTFLU	SOSR DLTICE	PMILK DVMFL	PSUBST DVCFL	INCOM D956	DPT956 DFLUID

Table A.7.2: Industrial Market Model

	PRICE	PT	SPTR	BF	SBFR	LT	CA	MI	VIT	OS	SOSR	PMILK	INCOME
	DPT956	DPTCHE	DPTICE	DPTIY	DBF956	DBFICE	DOS956	DLTICE	D956	DCHE	DICE		
PRICE	1,00												
PT	0,67	1,00											
SPTR	0,68	0,93	1,00										
BF	0,50	0,17	0,22	1,00									
SBFR	0,23	-0,07	0,02	0,93	1,00								
LT	-0,42	-0,63	-0,52	-0,51	-0,42	1,00							
CA	0,69	0,95	0,92	0,27	0,00	-0,54	1,00						
MI	0,60	0,81	0,77	0,27	0,08	-0,51	0,82	1,00					
VIT	0,45	0,53	0,43	0,49	0,35	-0,62	0,52	0,48	1,00				
OS	-0,38	-0,57	-0,46	-0,51	-0,43	0,99	-0,48	-0,43	-0,60	1,00			
SOSR	-0,36	-0,57	-0,45	-0,42	-0,34	0,98	-0,47	-0,45	-0,52	0,98	1,00		
PMILK	-0,45	-0,48	-0,42	-0,46	-0,32	0,50	-0,50	-0,49	-0,43	0,47	0,44	1,00	
INCOME	0,01	0,00	0,00	0,00	0,00	0,00	-0,80	0,00	0,00	0,00	0,00	0,42	1,00
DPT956	0,34	0,52	0,48	0,09	-0,04	-0,32	0,49	0,42	0,27	-0,30	-0,29	0,09	0,37
	1,00												
DPTCHE	0,67	0,99	0,91	0,24	0,01	-0,68	0,93	0,81	0,57	-0,63	-0,61	-0,52	0,00
	0,51	1,00											
DPTICE	-0,07	-0,42	-0,35	-0,20	-0,22	0,66	-0,36	-0,37	-0,34	0,65	0,66	0,35	0,00
	-0,22	-0,49	1,00										
DPTIY	-0,43	-0,64	-0,54	-0,52	-0,38	0,74	-0,56	-0,59	-0,61	0,71	0,63	0,53	0,00
	-0,33	-0,74	0,63	1,00									
DBF956	0,27	-0,09	0,12	0,54	0,50	-0,28	0,14	0,15	0,26	-0,28	-0,23	0,08	0,41
	0,48	0,13	-0,11	-0,28	1,00								
DBFICE	0,04	-0,41	-0,34	-0,13	-0,19	0,59	-0,34	-0,36	-0,31	0,59	0,57	0,33	0,00
	-0,21	-0,46	0,87	0,53	-0,07	1,00							
DOS956	-0,14	-0,27	-0,22	-0,24	-0,21	0,48	-0,23	-0,21	-0,28	0,48	0,47	0,53	0,41
	0,12	-0,30	0,31	0,34	0,11	0,28	1,00						
DLTICE	-0,18	-0,46	-0,37	-0,24	-0,23	0,80	-0,38	-0,39	-0,36	0,80	0,84	0,36	0,00
	-0,24	-0,50	0,87	0,51	-0,13	0,79	0,38	1,00					
D956	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,49	0,58
	0,63	0,00	0,00	0,00	0,58	0,00	0,69	0,00	1,00				
DCHE	0,53	0,85	0,66	0,19	-0,03	-0,74	0,72	0,69	0,58	-0,71	-0,68	-0,50	0,00
	0,44	0,90	-0,54	-0,83	0,10	-0,51	-0,34	-0,55	0,00	1,00			
DICE	-0,19	-0,49	-0,39	-0,24	-0,24	0,73	-0,40	-0,41	-0,38	0,72	0,74	0,38	0,00
	-0,25	-0,52	0,93	0,55	-0,13	0,87	0,34	0,95	0,00	-0,58	1,00		
	PRICE	PT	SPTR	BF	SBFR	LT	CA	MI	VIT	OS	SOSR	PMILK	INCOME
	DPT956	DPTCHE	DPTICE	DPTIY	DBF956	DBFICE	DOS956	DLTICE	D956	DCHE	DICE		