High Hill Yak Cheese Production in Nepal:

An Analysis of Privatization Policy Incorporating the Impacts of Market Failures

for Agro-Industries in Developing Countries

by

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Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

IN

AGRICULTURAL AND APPLIED ECONOMICS

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July 8, 1997

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(ABSTRACT)

In recent years the development community has pressured LDCs to privatize agro-industries. This pressure stems from poor public enterprise performance and an ideological shift. However, public enterprises mitigate market failures. The major objective of this study is to measure the impact of privatizing the Nepalese yak cheese industry. To achieve the objective, public and private behavior are determined. The impacts of privatization stem from changes in monopsony behavior and institutional constraints that differ between the public and private sectors. The Dairy Development Corporation (DDC) of Nepal produces yak cheese. The DDC's mandate is to provide a "fair" price to consumers and producers. Private producers of cheese have emerged in recent years. Milk shed structures include: single DDC factories, single private factories, multiple private factories, and mixed production.

Market performance is evaluated using partial equilibrium models that include the yak cheese and milk markets. Economic surplus measures are used for evaluation. Herder producer surplus is the most important criterion because herders are the poorest beneficiaries. The impact of privatization is determined through comparison of observed DDC and predicted private equilibria. Private equilibrium is predicted using a simultaneous equation system developed for this research. The equations ensure that supply and demand balance at the aggregate and individual milk shed levels. The Lerner index is incorporated to model monopsony behavior. Private monopsony parameters used in the system are estimated econometrically. A private equilibrium is also predicted with a modified firm cost structure reflecting reduced impacts of institutional constraints.

Findings show that private and public firms are exercising monopsony power. DDC privatization can be advocated because it increases herder producer surplus by 15.4%. Total surplus falls slightly because private cheese is lower quality. DDC privatization decreases herder welfare in milk sheds that support only a single firm. The simultaneous equation system developed to predict the private market equilibrium for post agro-industry privatization has the potential to be extended to solve a broader range of economic problems. The equation system can be adapted to applications where there are multiple production regions and monopsony behavior varies by regional characteristics.

ACKNOWLEDGMENTS

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Chapter 1. Introduction

1.1 Introduction

In recent years, international development efforts have emphasized free markets, privatization of public enterprises, and elimination of parastatal purchasing boards in least-developed countries (LDCs). This emphasis follows a growing body of evidence that central economic controls and public enterprises have had poor financial performance and have not met social objectives (Jones *et al*. 1990).

Privatization gained momentum in Britain during Margaret Thatcher's administration and spread to developing nations with the support of the United States and the international donor community, which has become increasingly hostile to state interventions in the economy (Martin 1993). For LDCs facing fiscal crises brought on by oil shocks in the 1970s, there was additional pressure to privatize to reduce government expenditures (Walle 1989).

However, public enterprises do serve broad functions in LDCs including the mitigation of market failures. Public enterprises are also utilized to achieve social objectives including employment goals, provision of subsidized products and other transfers to the poor, establishment of key industries and initiating entry into international markets. The existence of market failures and the fact that social objectives are pursued through public enterprises makes the impact of privatization on efficiency an open empirical question (Jones *et al*. 1990).

Nepal is an extremely poor LDC with 55 public enterprises (World Bank 1996). A plurality of Nepal's public enterprises' are involved in processing and marketing agricultural products (Spotlight, August 1996). Nepal has been under pressure from the donor community to liberalize its economy and privatize its public enterprises (World Bank 1996). Pressure to privatize stems from extremely poor financial performance of government corporations. Only six Nepalese government corporations showed profits in 1995 (Kathmandu Post, November 5, 1995).

The Dairy Development Corporation (DDC) of Nepal is a public enterprise charged with providing a market outlet for dairy producers and ensuring that Nepal's urban consumers pay a "fair" price. The DDC has been targeted for restructuring by reducing government equity and decision authority though the public sale of stock and providing stock to employees. The DDC's yak cheese production component has been targeted for outright privatization through asset sale to private parties (NZFHRC 1994). The donor community perceives that privatization of yak cheese production could serve as an effective example since its profitability should facilitate successful privatization. Despite strong donor community pressure that is manifest in warnings that international aid supporting the DDC will end, a series of Nepalese governments have been

unable to privatize the DDC. However, since 1992 the government has allowed private producers of dairy products, including yak cheese.

In the mid-1980s, Nepal embarked on a structural adjustment program with support from the IMF and IDA. While this program helped to achieve macro-economic stabilization, only limited progress was achieved in structural reforms and market liberalization (World Bank 1996). Since the emergence of democracy in 1991, successive Nepalese governments have both nominally supported and strongly opposed the privatization of public enterprises.

1.2 Problem Statement

Agro-industry privatization programs need to be evaluated based on a variety of criteria including economic efficiency, the distribution of welfare gains between industry participants and consumers, and impacts on social goals pursued by the targeted public enterprise. However, the perceived poor performance of public enterprises has led the international development community to promote agro-industry privatization with only limited analysis of their impacts (Jones *et al*. 1990). To a large extent, privatization is being justified based on a comparison of efficiency between public enterprises and private firms in ideally competitive markets rather than with realistic assessments of private behavior in markets that are fraught with market failures. Given these market failures, increased efficiency is not guaranteed, and impacts of privatization on other social goals is an empirical question.

This dissertation estimates the impacts of privatizing the yak cheese component of the DDC on industry participants, yak cheese consumers, and on alternative social goals. It includes assessment of impacts stemming from market power associated with industry structure and firm behavior. Additionally the impacts of *institutional constraints* (defined below) that differ between public and private sectors are introduced into the analysis.

1.2.1 Market Power

During the period 1962 to 1993, the DDC was the sole significant producer of yak cheese in Nepal. It possessed potential market power in the yak cheese output and milk input markets. The DDC's objectives as stated in its charter are to provide a "fair price" to raw milk producers and to yak cheese consumers based on the costs of production. The DDC's actual performance with respect to these objectives is an empirical question; little is known about its effectiveness in achieving stated goals.

Private yak cheese producers have emerged in the Nepalese high hills following recent legalization of private dairy production in Nepal. Currently, private firms produce approximately half of all yak cheese. Private producers face a competitive output market but

have potential monopsonistic power over milk producers in their milk shed. Yak milk sheds currently exhibit a variety of structures including production by multiple private factories, single private factories, single DDC factories and a mix of private and DDC production.

1.2.2 Institutional Constraints

Institutional constraints can have differential impacts on the public and private sectors. Policy makers must consider these differential impacts when examining DDC privatization. The term *institutional constraint* is used to refer to restrictions on firms that prevent them from adopting technologies, employing organizational structures that would improve profitability, and from conducting transactions (or making transactions costly). Hoff, Braverman and Stiglitz 1987 define institution in this context as a system of rules (formal and informal) along with available information. These rules define the types of exchanges that can be made and help structure the incentives of exchange.

LDC institutional constraints are more pronounced compared to those found in developed economies. Developed economies tend to have more effective institutions. These constraints affect the appropriateness of the neoclassical economic paradigm where institutions are not given a prominent role. An example of the impact of institutional constraints could be the inability of a firm to integrate distant marketing and production activities due to distrust of sales employees in accurately reporting sales revenue. The institutional constraints in this case would include a weak legal system that would not punish the sales employee even if caught, poor market price information systems, poor communications, and costly monitoring. A more basic institutional constraint in many developing nations is the inability to make forward contracts due to a weak legal system that does not adequately enforce contracts.

The impacts of institutional constraints depend on industry and market characteristics. Three specific problems for private yak cheese producers stemming from institutional constraints are apparent (Colavito 1994). The problems caused by institutional constraints include: (1) sub-optimal product quality, (2) sub-optimal firm organization and (3) the inability of private producers to adopt generic advertising. The specifics of these problems are detailed in chapter two. Sub-optimal is defined as a deviation from apparent profit maximizing choices and associated welfare losses.

It should be stressed that most of the institutional constraints are problems only for private cheese producers. Though the DDC is not subject to these problems, it is subject to management inefficiencies and inconsistencies associated with public enterprises (see chapter 3). It is important to recognize that institutional constraints create incentives for adopting different production systems as a response to different economic environments.

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1.3 Research Objectives

The primary objectives of the research are to measure the economic impacts of privatizing the yak cheese industry of Nepal and assessing the market power behavior of the DDC and private producers. Economic impacts are measured in terms of economic efficiency and efficiency in pursuing alternative social goals. Impacts are evaluated using economic surplus measurements for cheese consumers, cheese producers, and milk suppliers. The distribution of welfare is examined for the following market structures: observed DDC behavior, predicted private behavior, predicted private behavior with reduced institutional constraints, and for the baseline market equilibria.[1] Alternative social goals of cheese production to be evaluated include: generation of foreign exchange, cross-subsidization of DDC milk purchasing and employment generation which is a function of cheese quantity produced.

DDC performance and private performance are directly compared by predicting private producer equilibrium from market data for a year of sole DDC production. This comparison helps evaluate the impact of DDC yak cheese privatization. There are two major research steps to assess private firm monopsony power and predict equilibrium that would result given private production:

1. Determine private monopsony behavior based on characteristics of private firms and the milk sheds, and

2. Predict private market equilibrium based on the determined private monopsony behavior.

The efficiency impact of institutional constraints though sub-optimal product quality, and sub-optimal firm organization are also introduced into the analysis. The goal is to calculate the impact of institutional constraints on the cost structure of private cheese production and to estimate the resulting impacts on market performance. DDC market power behavior is utilized to evaluate the nature of the DDS's objective function and its consistency with stated objectives.

1.4 Justification of the Research

Policy makers need to know which groups benefit from policies and under which market conditions. They also need to know how to structure institutions to best meet social goals. Findings in this dissertation provide specific information for Nepal to help in understanding and addressing the impacts of DDC yak cheese privatization and agro-industry privatization. Some of these results can be generalized and may improve understanding of privatization for the Indian subcontinent and, to a certain degree, across LDCs.

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[1] Baseline equilibria refer to predicted competitive equilibria for the DDC and private firms and an equilibrium where the DDC exercises full monopoly and monopsony power.

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It is important to understand public enterprise market power behavior, management objectives, and efficiency in achieving social goals when making decisions on public enterprise restructuring. The market behavior of private agro-processing firms in LDCs should be considered when evaluating the need to encourage competition and promote cooperatives.

Evaluation of the effectiveness of the DDC in achieving alternative social goals would provide policy makers important information on the impacts of privatization. Estimating the impact of institutional constraints on the private yak cheese industry provides insights into the role of institutional constraints. These constraints affect industry in Nepal and in similar LDCs. Simple verification of observable impacts from institutional constraints would be a contribution to the "efficient market hypothesis" debate framed by Olson (1996).

Applied empirical methods are used to predict private producer market equilibria. These empirical tools will improve the ability of researchers to provide policy makers information needed for decisions.

The research helps to assess the reliability of benefit forecasts that have been made by privatization proponents. Overly optimistic benefit forecasts have given opponents of privatization a populist political issue. Privatization in general and DDC privatization in particular has become an important political issue in Nepal. Disappointment with the results of privatization policies partially accounted for the defeat of the Nepalese Congress Party in 1994 by a communist coalition that opposes liberal economic policies.

1.5 Methods

Partial equilibrium models that include the yak milk and cheese markets are used to measure market performance. The models are constructed from estimated yak milk supply and yak cheese demand functions. Following Tomek and Robinson (1990) cheese supply is derived by estimating the cost of processing milk into cheese and adding this margin to the milk supply curve.[2]

Yak cheese demand is econometrically estimated using monthly data (1988 to 1993) on wholesale prices and sales. An Almost Ideal Demand System (AIDS) for fresh cheeses produced in Nepal is used to estimate yak cheese demand. Milk supply is estimated using panel data (1983 to 1993) by factory site. A direct Nerlovian single equation model is used since input prices but not quantities are known. Yak cheese supply is derived based on a processing margin calculated from detailed economic-engineering models of public and private cheese production (appendix A).

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[2] It is assumed that over the relevant ranges of production that the unit processing cost is constant.

The market power behavior of cheese producers is measured using Lerner indexes of market power. These indices reflect firms' perceived marginal revenue (MR) and marginal expenditure (ME) functions. The output market Lerner index is $L_O = (P_O - MC)/P_O$, where P_O is the market price of output and MC is the marginal cost of production. Under a pure monopoly, the Lerner index is $L_O = -1/\eta_d$, where η_d is the elasticity of demand. Similarly, the Lerner index for an input is $L_i = (MVP_i - P_i)/P_i$, where P is the price of the input and MVP_i is the marginal value of the input (Pindyck and Rubinfeld 1989). Under monopsony $L_i = 1/\eta_s$ where η_s is the elasticity of supply.

A nonparametric test based on the approach pioneered by Varian (1982) and applied for market power by Love and Shumway (1994) is used to estimate DDC market power behavior. The test is based on *The New Empirical Industrial Organization* school (NEIO) that focuses on firm conduct within an industry (Love and Shumway 1994).

Private firm monopsony behavior is determined from market data by milk shed for the years 1994 and 1996. The nonparametric approach used to estimate the Lerner index cannot be used for private firms due to data constraints. Microeconomic relationships based on work by Scherer and Ross (1990) and Love and Shumway (1994) are derived to yield an equation to calculate the Lerner index from available data for each observation of private behavior.

The relationship between private firm monopsony behavior[3] and the number of firms in a milk shed is theoretically derived and econometrically estimated. A system of equations is estimated that accounts for the endogenous relationships among market power behavior, market size and the number of firms. The market power relationship is stated in terms of the Lerner index and the number of cheese processors in a given milk shed.

Private market equilibria are predicted as the solution to a system of simultaneous equations. The system includes equations representing the relationship between the Lerner index and the number of firms in a milk shed, the relationship between milk shed size and number of firms, and equations representing the conditions for a market equilibrium. Baseline market equilibria are similarly obtained.

DDC and private performance are directly compared through estimation of market performance criteria from a partial equilibrium model for observed DDC behavior in 1991 and for predicted private behavior using the 1991 market data. The welfare results are compared at an aggregate market level and for individual milk sheds. The DDC and predicted private performance results are compared to baseline market equilibria results.

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[3] Measured by the calculated Lerner indexes.

The hypotheses that private production results in sub-optimal product quality and sub-optimal firm organization are validated using a two-part approach. Markets are shown to be competitive for private producers. This competitiveness indicates that the higher DDC cheese price results from a difference in quality. The impact of institutional constraints on private firm cost structure are determined from participatory appraisals with private producers and cheese experts.

1.6 Overview of the Research

Extensive background of the research problem is provided in chapter two. Economic and social conditions in Nepal are described. The yak cheese industry production and marketing systems are described in detail to establish the background needed to understand the institutional constraints and market structure. There is a discussion of the institutional constraints literature relevant to LDC development and of the constraints asserted to be present for the yak cheese industry. Descriptions of the DDC and the public enterprise sector of Nepal are also presented.

Chapter three presents a review of literature on public enterprise issues and relevant economic theories. The reasons for the establishment of public enterprises and the current policy debate concerning privatization in LDCs are explored. Implications of DDC behavior are examined. There are sections on positive and normative theories of public enterprise behavior.

Chapter four presents theory and methods used in the research. The emphasis in presentation of theory is to support the methods developed to address the research problems. There is a discussion for selection of welfare analysis in a partial equilibrium framework as the method for evaluating market performance. The Lerner index is derived for market and firm characteristics to provide the basis for the nonparametric test of DDC monopsony power and the econometric estimation to characterize private behavior. The method for predicting the market equilibrium after DDC privatization is presented.

Results are presented in chapter five. Yak cheese wholesale demand, yak milk supply and the relationship between the Lerner index and milk shed characteristics are estimated econometrically. The econometric models are subjected to a battery of misspecification tests as suggested by Spanos (1986) and developed by McGuirk, Driscoll and Alwang (1993). Processing costs for the DDC and private firms are estimated from economic-engineering models. The impacts of institutional constraints causing sub-optimal cheese quality and sub-optimal firm organization on private producer cost structure are also estimated. Market equilibria for private and DDC market structures are predicted. Partial equilibrium models are then constructed to compute market performance criteria. Chapter six presents an overview of the study, a summary of findings, policy implications of findings, and recommendations for future research.

Chapter 2. Background

The objective of this chapter is to provide a foundation for understanding how the political-economic conditions of Nepal impact the research problem. A detailed country description is presented to develop an understanding of institutional constraints in Nepal. The yak cheese industry is described to help understand the impact of institutional constraints on the industry. Nepal's public enterprise sector and the DDC are described to supply context for the research problem.

2.1 Description of Nepal

Nepal's strikingly beautiful landscapes and rich cultures stand in stark contrast to the severe poverty of its people. Nepal remains one of the poorest and least developed countries in the world despite 40 years of intensive development efforts and a relatively stable political history. Over half of Nepal's 20.4 million citizens live in absolute poverty. Per capita income is only $210 and more than 40% of the population is undernourished (USAID 1997). Nepal has a highly skewed income distribution. The top 10% of the population receives 47% of total income. The bottom 20% of the population receive less than 5% of the total (USAID 1997).

Agriculture is the primary occupation for over 80% of Nepal's economically active population (see section 2.1.5 for a description of Nepalese agriculture). Nepal's poor are predominately rural subsistence farmers. Rapid population growth contributes to a difficult development environment.[4] For the past decade GDP, has been growing at 4.6% but due to the high population growth rate per capita income has increased slowly.

2.1.1 Geography, Climate and Peoples

Nepal stretches 885 km east to west and is an average of 193 km wide. It is a landlocked, predominately mountainous nation that is situated between the Tibetan region of China and India (Figure 2.1). Nepal has three distinct regions. A strip of land on the country's southern border referred to as the *Terrai* is an extension of the Indian alluvial plain ranging in width between 26 and 32 kilometers. Most of the country is *Pahad* or mid-hills (70%) which range from 500 to 3,000 meters. The *Pahad* includes the *Mahabharat* range, high *Himalayan* foothills and fertile midland tectonic valleys the largest and most fertile of which is the Kathmandu valley (351 km^2). Nepal's high *Himalayas* are extremely rugged and include eight of the world's ten highest peaks.

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[4] Population grew at 2.5% annually in 1996 (USAID 1996).

Nepal has a monsoon climate. The country averages 2,000 mm of rain annually, with 80% falling during the monsoon season between June and September. Nepal's varied topography results in a wide range of temperature conditions, ranging from sub-tropical in the *Terrai* and lower *Pahad* to extreme cold at higher elevations.
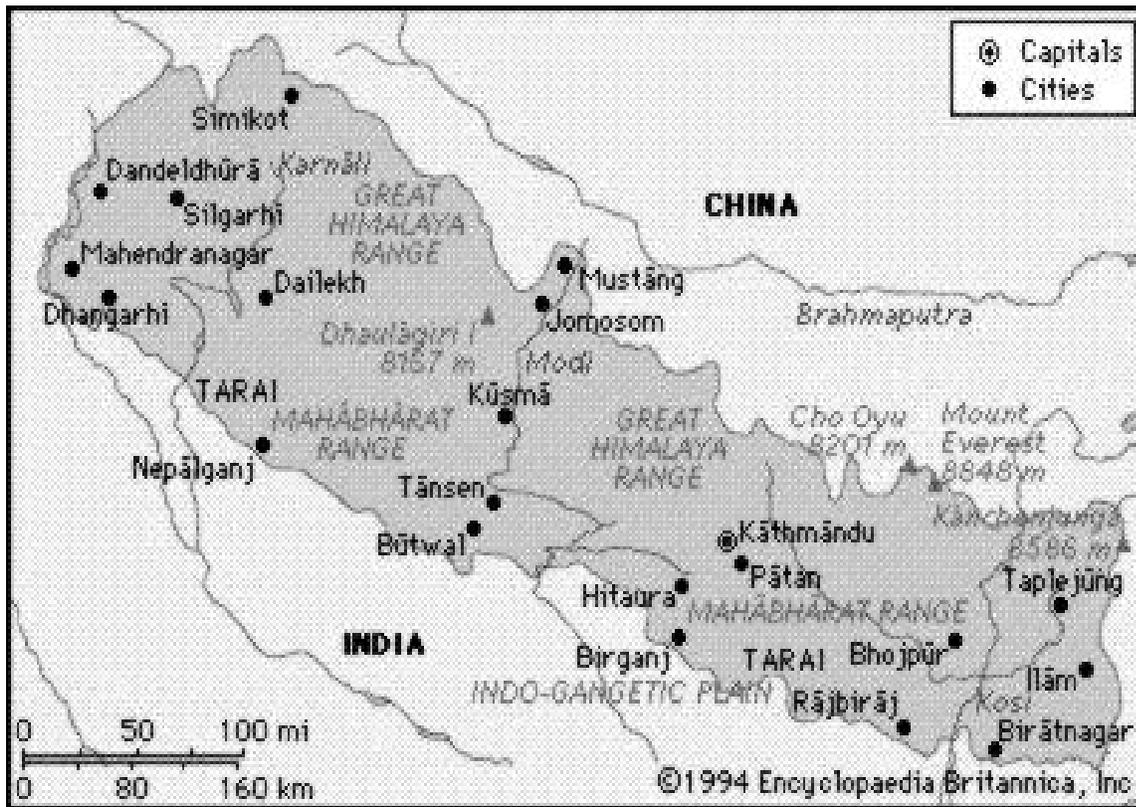
Figure 2.1. Map of Nepal.

Within Nepal there are numerous ethnic and cultural groups. Nepal's ethnic groups originate from Indo-Aryan Hindu groups that fled India during the Moghul invasions and more indigenous Tibeto-Burman Buddhist groups. Indo-Aryan groups predominate in the *Terrai* and have settled up to middle elevations of the *Pahad*.[5] Tibeto-Burman groups predominate at higher elevations.[6] A number of Ethnic groups have cultural roots in both traditions and have primarily settled in middle altitudes.[7] Recent estimates reveal that 80% of Nepalese are Hindu and 15% are Buddhist. However, Nepal's cultures defy easy classification. Many groups share common beliefs yet retain important differences.

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[5] Including Brahmin, Chettri, untouchable castes, and a number of indigenous *Terrai* peoples.
[6] Including Sherpa, Tamang and Bhotia (who are culturally Tibetan).
[7] Including Rai, Limbu, Magar, Newar and Gurung.

Though the caste system no longer has the force of law, it remains important, particularly in rural Nepal. For almost all ethnic groups in Nepal, subsistence farming is the primary occupation. However, important positions in government and society are dominated by Brahmins and Chettris, high-caste Hindu groups. Newar's dominate business activity particularly in Kathmandu, the commercial center of Nepal.

2.1.2 History

Pritivi Narayan Shah unified Nepal though conquest in 1768 and became its first King. Despite British pressure, Nepal retained its sovereignty during the colonial era. In the 1850s the country came under the domination of a hereditary series of Rana family prime ministers. The Rana's were extraordinarily exploitative and harsh. They ensured that the bulk of Nepalese remained feudal subsistence farmers through their suppression of all education, industry, and commerce undertaken by anyone except their family members and close supporters.   The Shah dynasty and the Nepalese congress party overthrew the Rana regime with the support of India. In 1961 the Nepalese king Mahendra dissolved parliament and banned political parties. The King retained political control though domination of the single party allowed under the *Panchayet* system.

In 1990, a coalition of communist parties and the Nepalese Congress party united to overthrow the *Panchayet* system and introduce multi-party democracy. The present King Birendra Bir Bikram Shah acceded to the demands for a constitutional monarchy after a brief struggle. The Nepali Congress Party gained control of the parliament in the first elections held in 1991. They started great number of economic reforms. However, in 1994 they lost their parliamentary majority due to an internal power struggle. The communists gained power through their opposition to unpopular structural reform, Congress' failure to improve the economy, and criticism of privatization programs. They proceeded to roll back the reform process.

2.1.3 Foreign Assistance and Economic Reform

Foreign aid has supported Nepal's development efforts over the past 40 years. Donors have been providing approximately $400 million annually, with the greatest contributions coming from Japan, the World Bank, and the Asian Development Bank (World Bank 1996). The United States has reduced assistance in recent years and currently provides about 5% of all assistance to Nepal.

Assistance has contributed substantially to Nepal's development. It has established a base of physical and human capital needed for economic progress and contributed to improvements in human welfare. However, there is a widespread perception that Nepal has not used aid effectively and that it has become too dependent on donors (World Bank 1996). Aid flows

currently account for 10% of GDP and for nearly 60% of the government's investment budget (World Bank 1996).

In the 1980s, Nepal departed from central planning policies and adopted a structural adjustment program supported by the IMF and World Bank. The program achieved macroeconomic stabilization but very limited progress in structural reforms. In 1991, the newly elected Congress government launched a comprehensive reform program, supported by an IMF Enhanced Structural Adjustment Facility (ESAF). Dramatic reforms were enacted under the Congress government (1991 to 1994). Trade, industrial, and foreign exchange policies were improved significantly.

The Congress government also made a strong start toward public enterprise reform and privatization. USAID and other donors assisted the Congress government with tax reform, privatization of parastatals and streamlining of business licensing procedures (USAID 1997). However, since the communist defeat of the Congress Party in 1994, privatization programs have been interrupted, while subsidies to public enterprises have increased (World Bank 1996).

Donors have had difficulty implementing projects in Nepal due to weak institutional capacity, wavering government commitment, and fragmented authority among ministries (World Bank 1996). There is also poor coordination between donors despite recent attempts to define jurisdiction. Nepal was able to fund questionable projects by playing donors off against each other. Donors have also launched major projects without an understanding of Nepal's institutional constraints leading to poor results (World Bank 1996). Despite the problems implementing structural reform, the economy has been liberalized to an extent. It is now possible for entrepreneurs to start medium sized-businesses with less government interference.

2.1.4. The Economy and Economic Development

Agriculture accounts for about half of Nepal's GDP. Crop production is 60% of agricultural output. Livestock and forestry's share of output are 30% and 10% respectively. Though the Terrai is just 17% of Nepal's area and has only 40% of the population, it produces 60% of agricultural output. Nepal's formal manufacturing industries are poorly developed and account for only 8% of GDP (World Bank 1996). The majority of Nepal's industrial activity is limited to processing agricultural products including jute, sugarcane, tobacco, leather, oil seeds, and grain. Export of textiles and carpets have expanded in recent years. Tourism and remittance earnings are also important to the economy. Tourism accounts for 4% of GDP. Nepal received 322,749 non-Indian tourists in 1995. Over 100,000 Nepalese are working in the Middle East, Korea, Taiwan and Japan (Kathmandu Post, June 8, 1995) with many more working for low wages in India.

Many factors contribute to Nepal's poverty. The labor force has poor skills, 73% of the population are illiterate, and labor management is costly (World Bank 1996). The country has only 3,082 km of paved roads. Nepal's port facility is over 800 difficult kilometers away in Calcutta, India. Nepal also suffers from a poor resource endowment, under-developed physical and social infrastructure, a weak administrative system, and poor management of public resources.[8] Due to these problems, and competition from India, foreign investment prospects remain poor. The population density of 600 people per km^2 of arable land is one of the highest in the world. The result is pressure on natural resources leading to low productivity, deforestation, environmental degradation, and poverty.

2.1.5 Agricultural Development

In recent years, there has been growing dissatisfaction with the performance of Nepal's agricultural sector among Nepalese policy makers. There is increasing emphasis on strategies to develop agro-industries that can generate income and break the cycle of rural poverty. The *Agricultural Perspective Plan* (1995) emphasizes development of high-value crops and livestock products for the nation's hill and mountain regions.[9]

Enterprise budgets have shown high returns to non traditional high-value agricultural products. The hill regions also have a comparative production advantage in a variety of high-value products over the Terrai and India. The products identified include a variety of vegetables, fruits, seeds, dairy products, spices and specialty crops. However, there are many constraints to farmers adopting high-value crops including poor skills, input shortages, poor market infrastructure, and institutional constraints.

The traditional nature of relations between producers and traders is another constraining factor. Business relationships in Nepal depend on close personal ties, often through kinship. These ties reduce opportunistic behavior and permit services such as credit to be provided in a poor business environment. These conditions limit production of high-value products. New market entrants do not have the relationships needed for market participation. Weaknesses in storage and grading systems limit the types of products sold.

Dairy products are particularly important high-value products in Nepal. Almost all farmers in Nepal's various regions maintain dairy animals.[10] The bulk of dairy production is for home consumption. However, dairy products account for a substantial share of cash income for farm families (Joshi 1990). In the majority of the country where markets are remote it has been traditional to market milk surplus in the form of clarified butter and other storable products.

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[8] Nepal does have vast hydro-power potential but has been unable to exploit this resource.
[9] The APP is the principal planning document for agriculture of Nepal's government.
[10] Cows, water buffaloes or yak/yak-cattle hybrids.

Only along the limited highway network is it possible to collect and market milk to urban centers or to India.

The task of collecting and marketing milk has primarily fallen to the DDC. Since 1969 the DDC has produced cheese and a variety of other dairy products including pasteurized milk, ice cream, butter, ghee, and yogurt (see sections 2.6 and 3.6 for descriptions of the DDC). Only in milk sheds in proximity to urban centers have small private dairies emerged to market milk and compete with the DDC. Similarly the DDC produces most cow, buffalo and yak cheese and has only recently faced competition from private cheese producers.

2.2 Description of the Yak Cheese Industry

Yak cheese is the popular name for a cheese produced from yak and yak cattle-hybrid milk. These animals can exploit pastures from 6,000 to 18,000 ft. The first yak cheese factory was built in 1952 (Schulthess 1986). Yak cheese production began as a way to use surplus milk after the Tibetan market was closed to Nepalese due to the Chinese invasion (Dubach 1986). The Food and Agriculture Organization and Swiss cheese makers assisted in establishing the industry. Yak cheese factories are in remote high hill areas of Nepal. It takes from 2 to 4 days to transport cheese from these factories to Kathmandu. The primary market of yak cheese is foreign tourists and ex-patriots living in Nepal.

DDC yak cheese production has declined with the emergence of private yak cheese producers. DDC production fell from 79 tons in 1994 to 31 tons in 1996 (Table 2.1). Private cheese production rose from 31 tons in 1994 to 55 tons in 1996. The DDC has only allowed private production of yak cheese since the emergence of democracy and economic liberalization measures of the early 1990s. The DDC resisted permitting private yak cheese producers, but with the emergence of democracy entrepreneurs felt empowered and were able to overcome DDC objections.[11]

Table 2.1. Yak cheese production trends.

Firm Type	No. of Factories 1994	No. of Factories 1996	Production 1994 (tons)	Production 1996 (tons)
DDC	9	6	79	31
Private Firms	8	13	31	55
Total	17	19	110	105

Source: Based on data obtained from a USAID project consultancy report (Colavito 1994) and Thapa (1996).

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[11] The first private producers simply ignored DDC injunctions against production challenging the DDC to invoke police action which it was unable to do.

There has been considerable pressure to privatize the DDC due to recurring loss (HMG/DANIDA 1991). USAID during the period of Congress party control (1991-94) was actively assisting the government to privatize the DDC. USAID supported early privatization of the yak cheese component of the DDC due to its profitability that would facilitate privatization. However, when the communist government came to power in 1994 they halted DDC privatization.

2.2.1 Importance of the Yak Cheese Industry

The sale of yak cheese generated an estimated Rs 31,982,000 in revenue and $494,000 in foreign exchange for 1994 (Table 2.2). Approximately 4,000 people are directly dependent on the industry for their livelihood. This figure does not include the farmers that produce dairy animals for sale or secondary effects. Income for industry participants is estimated to be Rs 15,518,000. Retailer revenue from yak cheese sales in 1994 is estimated to be Rs 5,139,920.[12]

Table 2.2. Direct importance of yak cheese production (1994).

Item	DDC	Private	Total
Herder families[b]	247	114	361
Dairy animals[b]	3,102	1,659	4,762
Factory workers[a]	104	54	158
Factory-employed marketers[b]	17	5	22
Full-time porters that carry cheese[c]	17	11	28
Villagers hired by industry workers[b,d]	64	33	97
Industry dependents (including family members)[b]	2,585	1,410	3,995
Earnings of above workers (Rs)[b]	10,190,248	5,327,267	15,517,515
Revenue from yak cheese (Rs)[b]	-	-	31,981,175
Foreign exchange earnings (USD) (Based on 90% foreign consumption)[e]	-	-	493,900
Revenue for cheese retailers (Rs)[f]	-	-	5,139,920

Source: Based on data obtained from a USAID project consultancy report (Colavito 1994).
[a] Estimate obtained by direct survey.
[b] Obtained both by direct survey and calculation based on an estimated production relationship.
[c] Calculated based on an estimated production relationship.
[d] The number of villagers hired by herders to farm their land.
[e] The official exchange in 1994 was USD 1 = Rs 49.
[f] Marketing costs for cheese retailers are not deducted due to data constraints.

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[12] This figure is derived from the retail margin and does not account for the cost of retailing.

The development of the yak cheese industry is consistent with the agricultural strategy of Nepal. Yak cheese is a high potential product for the following reasons:

- Yak cheese has an established market in Kathmandu and other tourist areas of Nepal;
- Yak cheese has a high value to weight ratio, making it one of the few products well suited to Nepal's remote high-altitude areas where poverty is particularly severe;
- There is high potential to increase yak cheese value though advertising, better packaging and improved processing (Colavito 1994);
- Yak cheese has market expansion possibilities in the Indian subcontinent, in Nepal with increased advertising and in other foreign countries with improved product quality;
- The industry suffers from institutional constraints and market structure problems that could be alleviated though development assistance (Colavito 1994).

Clearly the yak cheese industry is a relatively small agro-industry. The key to justifying interventions to develop agro-industries such as yak cheese is the high-value of output compared to subsistence agriculture outputs.

2.2.2 Yak Milk Production

Yak cheese is produced in high altitude areas in districts bordering Tibet by traditional people of Tibeto-Burman origins. These districts have little road and communications infrastructure. Travel times from herding areas to Kathmandu are generally between two to five days. Livestock production is much more important in these regions than in the rest of Nepal. Seventy percent of Nepal's pasture land lie in these areas (Miller 1993). These areas have 43% of Nepal's area but only 7.8% of its population (Miller 1993). The remoteness and a lack of political involvement in these areas have led to little development effort and severe poverty in the region.

Yak and yak-cattle hybrid management can be characterized as a traditional transhumanance system.[13] As temperature rises in the spring the animals are brought to progressively higher pastures. During the monsoon (June to September), the herds reach the highest alpine pastures. Families living in a transportable shelter tend the animals. Herders remain in one area for about two weeks. The stock is brought back to home villages for the winter and early spring. In the winter and early spring the animals are fed turnips, crop residues, leaf fodder, and small amounts of maize flour. Yak management has remained traditional because of illiteracy, remoteness, and a lack of government services. Herders have virtually no access to veterinary care or extension services. Due to these problems, the productivity of yaks is very low.

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[13] The female yak is called a *nak* and the yak cattle-hybrid is a *chauri*. The *Chauri* can tolerate lower elevations than yaks.

Yak herders carry their milk up to five hours to cheese factories for sale. In areas without yak cheese factories herders produce ghee (clarified butter) and a storable by product called *chhurpi*. Despite the high value of yak cheese, returns to yak herding are low (Table 2.3). Herders share of yak cheese industry profits are low because of their limited ability to organize. Herders have been unable to form cooperatives to produce cheese or bargain for milk price despite a number of efforts. Farmers' illiteracy, mistrust and social fragmentation, help explain the failure of such efforts (Colavito 1994). However, individual yak farmers are the entrepreneurs that have started private yak cheese production in recent years.

Table 2.3. Returns to yak milk production.[a]

Item	Butter Producer	Milk Sold to the DDC	Milk Sold to a Private firm
Herd Milk Production (kg/year)	7,182	7,182	7,182
Effective Milk Price (Rs/kg)	10.55	9.8	10.53
Milk Revenue (Rs/year)	74,071	70,886	75,612
Chauri Salvage Value (Rs/year)[b]	4,583	4,583	4,583
Advance Value (Rs/year)[c]	0	6,380	6,805
Total Revenue(Rs/year)	80,341	81,849	87,001
Total Cost(Rs/year)	74,911	74,708	74,905
Break-even cost (Rs/ cheese kg)	11.02	10.40	10.43
Return (Rs/ milk kg)	0.76	0.99	1.68
Annual Return (Rs)	5,430	7,141	12,095
Annual Wage Value (Rs)[d]	19,440	19,440	19,440

Source: Based on data obtained from a USAID project consultancy report (Colavito 1994).
[a]   All calculations based on a herder family with 20 milking animals and 1 bull.
[b]   Based on meat value at the end of animal productive life.
[c]   The interest value of an advance payment. Ghee producers receive no advance.
[d]   The wage value of family labor based on village wage rates.

2.2.3 Yak Cheese Production

DDC yak cheese factories consist of a central building compound to process butter, cure cheese, house staff, and produce cheese when herders are near.[14] Most cheese is produced at mobile branch factories that are set up along the herders' grazing routes. Permanent DDC branch factories were established in several locations.

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[14] Butter or ghee are by-products of cheese production.

Private cheese producers have not invested in central factory compounds. They use mobile branches similar to DDC branches. However, private firm branches are of inferior quality. Private branches lack infrastructure such as sleeping facilities and water proof roofs needed to attract well-trained cheese makers. Private firms store cheese in village houses that are not rodent proof. The private cheese producers that have emerged are local yak herders that have either learned to produce cheese through observation or have hired lower-level DDC staff. It is practically impossible for an entrepreneur from outside a locality to independently start a yak cheese factory due to social constraints and the poor business environment. Outsiders essentially do not receive legal protections in Nepal. An example is a Kathmandu-based dairy that invested in a yak cheese factory only to have its equipment confiscated by local workers (Colavito 1994).

Yak cheese production is based on a Swiss recipe for a hard type *Guerre* cheese adapted to Nepal's conditions. Cheese production requires only a limited investment in equipment. Major equipment required are a 300 liter copper pot, a milk separator, milk cans, cheese hoops, cheese cloth, brine tank, various tools and shelter. Cheese production also requires running clean cool water and two inputs that must be purchased from outside Nepal: starter culture and rennant (see section 5.5 and appendix A for an economic-engineering model of yak cheese production).[15] Cheese production also requires firewood to heat the cheese milk. To collect firewood in Nepal commercial enterprises must obtain permission from the Forestry Department. Private producers are forced to pay higher fees than the DDC to the Forestry Department to obtain operating permission and are subject to rent seeking behavior by Forestry Department officials.

Though not complex, cheese production requires completing a series of precise steps. Private cheese quality is substantially inferior to DDC quality. Poor quality private cheese stems from production shortcuts to save costs. The following are some of the specific reasons and causes for poor quality private cheese production:

- Farmers supply low quality milk contaminated with bacteria due to poor sanitary practices. This causes bacterial bloat (dangerous to health), poor cheese taste and poor storing properties. Private producers do not perform DDC-type checks on milk quality.

- To save firewood, private firms do not properly pasteurize cheese milk. This may result in disease transmission (TB and Brucellosis) as well as bloat and poor taste.
- Contamination of cheese milk from poorly cleaned cheese making tools.

- The use of inferior starter culture and rennet to save money and/or the improper storage of these inputs results in poor cheese taste and storage properties.

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[15] The yak cheese recipe is designed for starter culture and rennant produced in Denmark.

- Making cheese in small quantities results in improper processing and poor quality.

- The use of inferior equipment including homemade cheese hoops, cheese presses and cheese cloth (mosquito netting is substituted) to save money causes extra moisture resulting in poor taste and shelf life.

- Improper storage of cheese including failure to provide daily salt curing treatments (needed for taste and to prevent fungal infections), lack of cheese racks to air the cheese, and exposure to rodents.

- Private producers market green cheese. Cheese must be stored at cool, higher altitudes for at least four months to develop flavor and storage qualities. Private producers do not have access to official low cost official credit and market cheese too soon to save interest costs.

- Some private producers lower the cheese milk fat percentage to make more butter resulting in degraded cheese quality.

- Poor treatment during transportation and marketing including, stacking, mishandling, exposure to flies and poor climate control degrades quality.
- A major problem is that private producers do not hire qualified staff because they lack facilities to house qualified staff.

Yak cheese production exhibits increasing returns to scale in a technical sense for the production levels found in Nepal's milk sheds. Cheese production capacity of individual production units depends on the size of the copper milk pot used to make cheese. All factories are observed to be using a standard 300 liter capacity copper pot. Even in markets with multiple factories, cheese factories are observed not to be using their 300 liter copper pots at capacity indicating that they have not achieved an efficient size in a technical sense. This is not efficient in a technical sense because up to the capacity of the 300 litter pot total processing costs should under normal circumstances rise only slightly. Increased production would allow fixed costs to be spread over a greater quantity resulting in decreased average cost. Minimum efficient size (MES) in the economic sense refers to a firm producing at a level where average costs are at a minimum. The observed private factory size represents an optimally sized firm because of institutional constraints that raise production costs dramatically at higher levels of production. The costs stemming from institutional constraints include employee monitoring costs that increase dramatically at higher levels of production (see section 4.5.1 for a detailed discussion concerning private firm size).

2.2.4 Yak Cheese Marketing

Yak cheese is primarily marketed to foreign tourists and ex-patriates living in Nepal. Cheese is mainly sold directly to consumers from small cold shops and department stores in Kathmandu.[16] Tourist restaurants also use yak cheese in western food. A very small percentage of yak cheese is marketed to Nepalese and exported to India.

The DDC transports yak cheese from its factories to a central store in Kathmandu. It then markets the cheese primarily to retailers from two sales offices in Kathmandu. Private yak cheese is sold to retailers and small private wholesale dairies. These dairies do not store large amounts of cheese for extended periods. Private producers frequently bring cheese to Kathmandu in small amounts, typically between 100 to 500 kg per trip. The cheese is brought by both factory owners and independent traders. In Kathmandu, the cheese is stored in hotel rooms and rented rooms for short periods of time. These rooms are not suited for storage of cheese. Marketing costs for private producers are relatively high compared to the DDC's costs because of expenses from their frequency marketing trips.

Private producers are also charged a transportation tax called an *octroi tax* by local governments that control the moterable roads to Kathmandu. The tax is collected by local governments that stop all vehicles at check points and charge 1-2% of the "value" of commercial products. This system creates opportunities for rent seeking behavior by the collection officials. Frequently yak cheese producers are forced to pay bribes to expedite clearance.

Buffalo and cow cheese are the only other fresh cheeses in Nepal.[17] A variety of processed cheeses are marketed but they are predominately consumed by Nepalese. Yak cheese is considered the highest quality cheese, followed by cow cheese and then buffalo cheese. Quality is reflected in the retail cheese prices which were Rs 240, Rs 215, and Rs 190 in 1994.[18] The retail prices varied only marginally across establishment types.

Poor quality private yak cheese is a major problem for the industry. The retail price of high and low quality cheese is currently the same due to poor consumer information. However, wholesale price does incorporate cheese quality and is substantially lower for private cheese. If low quality yak cheese continues to be marketed, yak cheese may get a bad name and result in lower industry revenue. The impact on industry revenue of poor private production practices could be substantial if consumers become aware of potential health effects from consuming low quality cheese.

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[16] Colds shops are small stores in Nepal that have refrigerators and sell a variety of snack food primarily to tourists while department stores are large and market cheese primarily to ex-patriots.

[17] The DDC and private firms produce both types of fresh cheese.

[18] The exchange rate in 1994 was Rs 49 = $1.

Results from a consumer survey conducted by Colavito (1994) indicate that the yak cheese market is already suffering from the sale of low quality private cheese. The rating of yak cheese quality is variable which reflects the difference between DDC and private cheese quality. The product received low ratings (38% of survey respondents ranked yak cheese only as okay or poor). Five percent of respondents indicated that they found quality so poor they would not consume it again. Respondents also directly indicated that variable quality was a problem (53%).

Currently, there is no formal advertisement of yak cheese beyond in-store displays. There are strong indications that yak cheese would benefit from an advertising campaign targeted at tourists. This is indicated by the time (9 days) relative to average stay (10 days) that it takes consumers to discover yak cheese. The value of advertising is also directly revealed because 89% of individuals surveyed who had not heard of yak cheese said they would like to try it. It was also found that it takes wealthy tourists longer to discover yak cheese.[19] The DDC fails to advertise due a flawed perception that since they are able to market all their cheese there would be no profit from advertisement.

2.3 Institutional Constraints

There is a growing body of literature emphasizing the importance of institutional constraints as a major cause of underdevelopment. Bromley (1993) stresses the basic but often overlooked point that capitalism does not work well without institutions designed to reduce transaction costs. According to Bromley (1993) it is critical that there be social legitimacy to institutions. Bromley (1993) stresses the role of the legal system in establishing the social legitimacy needed for free markets to work well. Institutional constraints are associated high transaction costs that inhibit choices. Factors contributing to institutional constraints present in LDCs include:

- low levels of human capital that limit organizational complexity and increase opportunities to engage in opportunistic behavior (Hoff, Braverman and Stiglitz 1987),

- poorly functioning capital markets that limit access to capital for small firms even for highly profitable activities (Hoff, Braverman and Stiglitz 1987),

- poorly functioning and absent risk markets that increase the risk of new production activities (Hoff, Braverman and Stiglitz 1987),

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[19] Tourists spending more than Rs 500 per day took an average of 13 days to discover yak cheese while tourists spending less than Rs 500 took 7 days. This difference is statistically significant.

- extreme information asymmetries between contracting parties resulting in opportunistic behavior (Hoff, Braverman and Stiglitz 1987),

- a poor business environment leading to uncertainty about whether contract conditions will be fulfilled (Bromley 1993),

- a poorly functioning legal system that makes contract enforcement difficult and costly (Bromley 1993),

- poorly developed regulatory systems that result in little faith in product quality (Bromley 1993), and

- a number of factors including easy entry into markets that results in low returns to reputation leading to "sub-optimal" product quality (Esfahani 1991).

2.4 Yak Cheese Industry Institutional Constraints

There are three problems for private yak cheese producers stemming from institutional constraints that are readily apparent. The problems include: (1) sub-optimal product quality, (2) sub-optimal firm organization and (3) the inability of private producers to pool resources for generic advertising (Colavito 1994).[20] The impact of failure to advertise is not estimated due to data constraints. The material related to advertising is presented in this section to establish the pervasive nature of a variety of institutional constraints in Nepal. It should be stressed that industry problems caused by the institutional constraints presented below are problems faced only by private producers. Although the DDC is not subject to these problems, it is subject to management and objective inconsistencies associated with public enterprises.[21]

2.4.1 Yak Cheese Quality

The quality of yak cheese depends closely on the use of costly inputs including, trained personnel, rennant, starter culture, production equipment, and infrastructure. There are low cost substitutes for these inputs, the use of which results in lower quality cheese. Low quality cheese has a decreased storage life and is subject to spoilage (Scott 1990).

It is asserted that the current level of cheese quality is sub-optimal from an industry profit maximizing perspective. The market failure mechanism is similar to the one first proposed by

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[20] See chapter one section 1.2.2 for a definition of sub-optimal in this context.
[21] As outlined in the section, many private institutional constraints stem from the inability of private firms to vertically integrate production and marketing. The DDC is able to operate a vertically integrated firm. DDC vertical integration allows for internalization of the cheese quality decision.

Akerloff (1970) in his seminal work on used car lemons. It is costly for yak cheese purchasers to inspect cheese and quality can only assessed imperfectly at the time of purchase. In particular it is extremely difficult to determine the storage properties of the cheese from an initial inspection. Compounding this problem are the poor skills of the retail purchasers. The weak legal system also prevents cheese producers from leaving cheese on consignment due to fear that their cheese will be stolen.

The result of inability to accurately determine cheese quality at the time of purchase is cheese price based on industry average quality as in the Akerloff (1970) model for used cars. Cheese wholesalers do not know the quality of cheese at the time of purchase but they are able to base price on the average quality of cheese they have purchased. This situation represents a form of market failure associated asymmetric information. If all firms could increase cheese quality, firm profits would increase, but as in a typical prisoner's dilemma problem a cheating firm would be able to reap windfall profits.

The ability to develop a reputation would increase incentives to produce quality cheese. However, as Esfahani (1991) points out, a number of factors including ease of market entry and high variability of product quality limit the rewards to establishing reputation in LDC markets. In Nepal, and particularly in the yak cheese market, establishing a reputation is problematic. Yak cheese factories experience high variation in product quality and are distant from Kathmandu. These factors make factory inspection by retailers impossible. Typically, businesses in Nepal that gain a reputation almost invariably exploit this reputation for short-term gain.

There are three major observable impacts from sub-optimal quality cheese production on the industry. There is a wholesale price gap between DDC and private cheese. Also due to short shelf life wholesalers buy only limited amounts of private cheese per transaction which forces producers to make numerous costly marketing trips. Retailers charge the same price for DDC and private cheese.

2.4.2 Firm Organization

The inability of wholesalers to detect cheese quality at the time of purchase would favor a vertically integrated firm like the DDC. The DDC produces and markets cheese from a permanent facility in Kathmandu. A vertically integrated firm produces cheese of optimal quality because it has perfect information about the quality of the cheese it produces. However, in Nepal it is extremely difficult and costly for private firms to manage operations in distant locations due to the cost of monitoring hired labor. The extreme remoteness of the areas where yak cheese is produced compounds the monitoring problem because firm owners and family members are unwilling to live and travel to these areas. A vertically integrated firm that

produced optimal cheese quality would also be able to reduce its marketing costs. Such a firm would be able to transport cheese in larger shipments since it knows that the cheese would not spoil in storage.

The market failure for cheese quality also results in under investment in cheese factories by private firms. DDC-type factories are needed to produce good quality cheese. The DDC maintains a permanent central factory to staff qualified staff, produce butter, store cheese, store and maintain equipment. However, private cheese producers cannot justify investment in DDC factories since they receive the price for only the average quality of cheese. The limited investment by private cheese producers in equipment to produce quality cheese will result in erratic progress toward market privatization and may presage future industry decline. Private firms will be unwilling to follow Nepalese privatization guidelines that require paying engineering cost estimates for buildings. A number of DDC factories have closed because of private competition. However, due to DDC policy inflexibility and quality problems, private cheese producers will not pay for the closed DDC factories. The closed factories are deteriorating rapidly and the laid-off trained personnel are leaving yak cheese production to the long-run detriment of the industry. The private firms are unable to provide quality housing for qualified master cheese producers that were trained in Switzerland through the DDC.

2.4.3 Advertising

There is survey evidence that yak cheese demand could be substantially increased by advertising (see section 2.2 for marketing survey results). However, private cheese producers have been unable to organize a generic advertising campaign. Due to pervasive mistrust and weak management skills, private cheese producers are unable to pool resources for generic advertising or even agree to requesting government to serve a facilitating role.

2.5 Description of the Public Enterprise in Nepal

During the Rana period (1850s-1950s) the few industries in Nepal were essentially monopolies granted to family members and close political allies. Public enterprise began in modern Nepal with the nationalization of Nepal Bank Limited in 1953. By 1989, the number of public enterprises reached a high of 62. The importance of public enterprises in Nepal can be seen from the fact that in 1992 the Nepalese government's investment in public enterprises amounted to more than 20% of GDP (Spotlight, August 1996). Foreign aid has served an important role in establishing public enterprises in Nepal (Ramanadham 1991). Pant notes in *The Flow of Funds in Nepal* (1995) that many public enterprises were established to use foreign assistance smoothly and wryly comments that Nepal had no funds of its own to establish the public enterprises.

Public enterprises were seen as being critical to Nepal's development since entrepreneurs were unable to establish even basic light industries. There are a variety of agro-industrial public enterprises processing and marketing agricultural products in Nepal including sugar, jute, tea, cotton, leather, ghee, tobacco, turpentine, rice, cooking oils, herbs, seeds, spices, forest products and dairy products. Ramanadham (1991) notes that Nepal's small markets have resulted in public enterprises that have the potential for market power. He reports the following market structures for Nepal's public enterprises: 47% monopoly, 23% duopolies, and 18% oligopolies.

With only a few important exceptions, public enterprises have performed poorly in Nepal. In the ten year period from 1985 to 1994, the public enterprise sector has been in loss for five years and the losses far outweigh the surpluses (Table 2.4). The manufacturing sub-sector has also performed poorly with losses in six of the last ten years. Out of 45 public sector enterprises monitored closely in 1995, 21 were in loss and of 14 industrial enterprises 12 were in loss (Spotlight, August 1996). Total public enterprise losses in 1995 were Rs 738 million (Spotlight, August 1996).[22] Public utilities are the primary exceptions to the poor performance of Nepalese public enterprises.

Poor public enterprise performance is popularly seen in Nepal as the result of poor management due to political interference. Pant (1995) attributes overstaffing and resulting inefficiency to the political appointment of general managers. Public enterprise losses have also be attributed to the political nature of pricing and production decisions to satisfy both urban consumers and rural producers (Joshi 1990).

Table 2.4. Performance of Nepalese public enterprises.[a]

	Gross Profits									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Manufacturing	40	27	55	-96	-58	-133	-171	81	-114	-205
Trading	-108	-59	145	-79	-204	-498	-257	-1087	-307	-376
Services	-	-	-	-	49	25	-181	59	5	12
Social	-	-	-	-	2	-6	-4	11	-13	-17.9
Public Utilities	-92	98	-4	78	148	169	-865	-415	431	565
Financial	11	39	159	156	25	197	-394	206	144	420
Total	-149	105	355	59	-39	-245	-1872	-1146	146	398

[a] Source: Economic Survey 1993/94, Ministry of Finance.

The international donor community has brought considerable pressure on Nepal to privatize public enterprises (World Bank 1996). In Reaction to this pressure, the Congress government launched a privatization program upon coming to power in 1991. The Congress government privatized six public enterprises and targeted ten addition public enterprises for privatization

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[22] Exchange in 1995 was Rs. 49 = $1.

(World Bank 1996). However, with the collapse of the Congress government in 1994, the privatization program was halted. Since 1994 there has been only one additional privatization.

The communist party seized a plurality in Nepal's parliament in 1994 campaigning against economic liberalization and privatization. The communists stressed that there was corruption during the privatization process and that privatized firms have raised prices and decreased product quality. They campaigned on improving the management of public enterprises and accused the Congress party of gross mismanagement of the enterprises.

There is a widespread perception that public enterprise assets were undervalued in privatization programs due to bribes paid by Nepalese businessmen backed by Indian nationals. This is a serious charge in Nepal due to fears of Indian domination. The Nepalese government needs to directly sell public enterprises due to the lack of a well functioning stock market. Sale to wealthy individuals leads to increased opportunities for corruption.

Nepal has virtually no domestic constituency in favor of privatization. Even the Congress party, though nominally responsive to the donor community, has deep antipathy to privatization stemming from its roots as a socialist party. A recent statement by the Congress party vice president Shailaja Acharya reflects this "Economic liberalization and privatization are alien and meaningless to a country like ours..is incongruous in a society like ours which is based on compassion and cooperation rather than on the cut-throat competition that this policy demands" (Kathmandu Post, December 8, 1995, economy section). The hostility to privatization is also reflected in the low esteem in which private businessmen are held. They are associated with corruption and seen as opportunistic, taking all opportunities to cheat customers through misrepresentation of products and market power.[23]

There is also little domestic pressure to reduce expenditures on public enterprises since taxes are low and over 60% of Nepal's development budget is financed by foreign aid. There are strong constituencies for the public enterprises. The nonexistent domestic support for privatization places the donor community in a delicate position. Though the donors have substantial leverage to force privatization they run the risk of encouraging anti-market forces and appearing to attack national sovereignty.

2.6. Description of the Dairy Development Corporation (DDC)

The Dairy Development Corporation of Nepal (DDC) was established as a government corporation in 1969. The DDC replaced the Dairy Development Board in managing a dairy

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[23] Businessmen are required to obtain a variety of operating licenses for which public officials demand bribes. There is a widespread perception that this system results in market power.

processing plant in Kathmandu and yak cheese factories in the hills. The DDC's mandate is (HMG/DANIDA 1991):

- to provide a reliable market outlet and a fair price to milk producers

- to supply pasteurized milk and other dairy products to urban consumers at a reasonable price

- to organize, promote and extend milk collection and production to meet demand, and

- to organize and promote Milk Producer Associations (MPAs).

Inherent in this mandate to pay a "fair" price to farmers and charge a "reasonable" price to consumers is the potential for conflict in pricing policy. In practice the DDC has set prices and promoted policies that create losses. These losses have been covered with donor counterpart funds, the governments central budget and poor accounting practices (HMG/DANIDA 1991).

2.6.1 Dairy Development Corporation Organization

The DDC's operation is organized into six regional milk supply schemes (MSSs) that encompass the national milk grid.[24] Each scheme conducts all aspects of the DDC operation within its region including the processing of raw milk into various products, milk collection, the operation of chilling centers, support to MPAs and sales. However, the schemes have not been given budgetary authority and all important decisions are made by the DDC center (HMG/DANIDA 1991). The bulk of DDC milk is transferred from regional milk supply schemes to the Kathmandu milk supply scheme (KMSS) for sale. The transferring of milk to KMSS to maintain supply for the Kathmandu market at subsidized prices causes high transportation costs. All DDC prices for milk purchased and products sold are uniform across Nepal and do not change with seasonal conditions.

The DDC has also failed both financially and organizationally to separate its commercial and development activities. The primary development goal of the DDC is to expand its milk production grid by providing farmers with training and facilities for forming MPAs and cooperatives.

2.6.2 Scale of DDC Operations

For the Nepalese 1996 fiscal year, the Dairy Corporation marketed 1,470,000 Liters of milk collected from 60,000 farmers and estimates marketing 1,620,000 liters from 90,000 farmers in 1997 (Kathmandu Post, July 12, 1996). In a recent speech the DDC manager

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[24] In 1989 a separate cheese supply scheme was merged into the regional milk schemes.

stressed the extent to which the DDC is expanding its operation (Kathmandu Post, July 12, 1996). He noted that the DDC was adding four milk distribution centers and had recently added six centers in the Mountain region including two in Ilam, a district on Nepal's eastern border. He also stressed that the DDC was conducting training programs to convert MPAs into cooperatives capable of running DDC milk production centers.[25]

The DDC has over 1,100 staff of which 60 % are technical staff and 40% are planners and administrators assigned to the company headquarters in Kathmandu. The DDC operates four dairy processing plants, 16 cheese and butter processing plants, 46 chilling centers and 295 milk collection centers.

2.6.3 DDC Performance

The DDC's present financial situation is critical. Operating losses have occurred in almost every year since its establishment (except in the first years 1969-75). Accumulated losses in 1991 exceeded Rs. 60 million (HMG/DANIDA 1991). The amount of HMG subsidies is estimated to be around RS 38 million which is insufficient to balance the accumulated losses.[26]

The DDC has developed a negative equity (HMG/DANIDA 1991). Losses have eroded its depreciation fund so that the DDC no longer has funds to replace machinery required for continued of its operation. The DDC has covered its losses by changing its depreciation policy and counting counterpart funds obtained from the sale of food aid received from WFP and USAID as DDC assets (HMG/DANIDA 1991). However, these funds can only be used for specified development activities and cannot be used to cover operation losses. The funds should be consider a debt by the DDC.

HMG/DANIDA (1991) attribute DDC's losses to two main causes:

•   Insufficient autonomy and decision making authority in the commercial operation, and

•   Political considerations have often take priority over commercial considerations when deciding on producer and consumer prices and on investments in collection and processing facilities.

These two failures have contributed to a series of DDC problems including:

•   Provision of services to organize farmers into MPAs' that the DDC cannot financially justify.

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[25] The cooperatives running the milk collection centers are supported financially by the DDC.
[26] 1997 exchange rate is Rs. 49 = $1.

- Establishment of milk collection in high cost areas distant from markets.

- Low utilization of existing plant capacity and high fixed costs resulting due to the milk production cycle in Nepal.

- Providing low consumer prices due to political pressure.

Sapkota (1991) notes that although DDC costs increased dramatically during the 1980s, the amount of milk processed increased only marginally. The increased costs stem from expansion of milk collection to distant areas with low productivity. DDC's pricing policy is also constrained from addressing seasonal changes.[27] Due to Nepal's monsoon climate, milk production is much higher during the summer and lower during late winter and spring. However, the DDC maintains constant prices that result in milk rationing in the winter months and the need for milk holidays during the monsoon when milk collection is suspended.

2.6.4 DDC Restructuring and Yak Cheese Privatization

The stated objective of HMG's 10 year dairy development plan is to "establish a cost efficient organizational framework which is conducive to raising the productivity in the diary sector and to improving the conditions of the diary farmers" the plan goes on to stress "An important policy objective will be to increase competition and thus improve efficiency....monopoly situations with milk trade and processing result in high consumer prices and/or low producer prices" (HMG/DANIDA 1991).

However, the plan emphasizes the importance of DDC commercialization to improve efficiency. The DDC is targeted to become a commercial dairy through distribution of ownership between the government, MPAs/cooperatives, DDC employees and sale to the public. The DDC would still be involved in development activities but in the role of a consultant against a fee. The plan also recognizes that the current DDC milk grid is not commercially viable and that a number of present and future milk collection points need to be subsidized. The justification given for the subsidy is the need to provide a market to farmers to raise incomes and to stimulate the adoption of more production diary animals and dairy technologies.

The original Dairy sector plan did not call for the outright sale of the yak cheese component of DDC. However, as part of the Dairy Enterprise Support Project, USAID made an agreement with HMG to assist the DDC and to assist in privatizing the Yak cheese component of the DDC (NZFHRC 1994). USAID stressed that given its profitability the yak cheese component of the DDC would be easy to privatize.

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[27] In Nepal there is strong social and government pressure to maintain constant commodity prices. There is a perception that increasing price at periods of shortage is simply price gouging.

Although the "10 Year Dairy Development Plan" is still the principal planning document for HMG's dairy development efforts, the DDC has not been restructured and the yak cheese component of DDC has not been privatized. The current government of Nepal is resisting international pressure to privatize government corporations. Due to changes in Nepal's commitment to dairy sector reform, USAID has canceled the Dairy Enterprise Support Project and assistance to the DDC. Currently, the DDC is primarily being subsidized directly from the governments central budget and from DANIDA.

Chapter 3. Public Enterprise

This chapter presents a review of issues related to public enterprises and relevant economic theories. Reasons for the establishment of public enterprises, the role of such enterprises in the economy and the current policy debate concerning privatization in LDCs are explored (sections 3.1, 3.2 and 3.3). Normative and positive economic theories of public enterprise behavior are also presented. The section on normative theory outlines the conditions under which public enterprises maximize societal welfare (section 3.4). The positive theory section presents models of public enterprise behavior incorporating organizational failures (section 3.5). The objectives of the DDC and its yak cheese component are explored in the context of the theories presented (section 3.6).

3.1 Introduction

A public enterprise is a hybrid organization that shares characteristics of government units and private firms. The labels "public" and "private" evoke radically different images even though there are deep similarities between the forms. Both forms exhibit substantial delegation of authority. Delegation of authority in both cases is a natural response to the problems of imperfect information (Sappington and Stiglitz 1987). Both organizations also suffer from difficulties in measuring performance and goal conflicts among managers, employees, and owners. For public enterprises, "owners" are the government officials that control the organization. In a democracy these officials would have to be accountable to the public. However, the accountability of public officials is imperfect because of the public's limited ability to monitor and influence their actions.

Public enterprises are found in both developed and developing nations. Historically they have been important in LDCs. Thousands of public enterprises were created in LDCs between the 1960s and the early 1980s (Walle 1989). By the early 1980s, they accounted for over a quarter of LDC capital formation (Walle 1989). Public enterprises have been used in all sectors of LDC economies including manufacturing, services, utilities and financial institutions. Though often associated with heavy industry, public enterprise agro-industries are common in LDCs. These forms are particularly common in the South-Asian countries of Nepal, India, Pakistan, Bangladesh, Sri Lanka, and Bhutan (Ramanadham 1991).

3.2 Public Enterprise Privatization

Since the mid 1980s, there has been a wave of privatizations due to the perceived poor performance of public enterprises. Privatization programs are being undertaken across the world in countries with markedly different economic systems and levels of development (Jones *et al*.

1990). From 1988 to 1993, there were 2,700 privatizations in 95 countries (Harris 1995). The wave of privatization is due to poor financial performance and to ideological shifts hostile to public enterprise that started in the United States and Great Britain (Martin 1993). The ideological shift away from public enterprises is now widely reflected in international donor policies (Walle 1989).

With some exceptions, public enterprise financial performance has been poor, particularly in LDCs (Walle 1989).[28] For example, in South Asia more than half of India's public enterprises had accumulated deficits by 1987 and in Nepal, public enterprise deficits have eroded 30% of the government's equity capital (Ramanadham 1992).

The poor performance of public enterprises has been traced to two related causes: (1) poor management and (2) poorly defined and conflicting objectives that make evaluation of management difficult. Alternative objectives of public enterprise such as training activities, efforts to improve income distribution through subsidization, and efforts to address market failures, are difficult to quantify. It is widely recognized that in all large business organizations, management, employee and owner interests may differ. Difficulty in measuring outputs compounds problems of divergent management, employee and owner interests. Under these circumstances, owners are unable to judge the behavior of their managers. Without a direct link between development-type public enterprise objectives and managerial benefits, performance is likely to suffer (Jones *et al.* 1990). Further, politicians in LDCs have set public enterprise objectives to serve short term political needs that result in poor financial performance and create economic distortions (Ramanadham 1991).

The major criticisms of LDC privatization programs have focused on the negative impacts associated with the dislocation of workers and the inability of infant private sectors to absorb workers (Bromley 1993). Unemployment caused by privatization can result in economic shocks that have severe consequences throughout the economy. Opponents of privatization also perceive negative effects on the poor. Privatization impacts the poor because public enterprises play a key role in maintaining subsidized prices. The negative impact on the poor also stems from the role that public enterprises have in controlling market power and in forcing cross-subsidization (Sappington and Stiglitz 1987). More subtle objections, based on post-privatization market structure and private market institutional constraints addressed by public enterprises, have been less widely raised (Bromley 1993).

Criticisms of privatization based on its initial negative impacts on the economy are seen as valid to an extent. However, proponents of privatization assert that such economic pain represents the cost of introducing an economic system consistent with long-term growth. Privatization

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[28] An exception in Nepal has been the relatively good financial performance of utilities (see section 2.5).

proponents also argue that temporary programs to mitigate negative impacts for the poorest segments of the populations can be more efficient without public enterprises.

Opponents of privatization in the development community have lost the public debate due to the historical evidence of inefficient public enterprises and a reliance on outdated economic arguments for state interference in the economy (Bromley 1993). Critics of public enterprise see resistance to privatization as a means of maintaining rent-seeking behavior (Bromley 1993).

Bromley (1993) notes that the ideological nature of the privatization debate has created a vacuum for policy debate. Jones *et al.* (1990), in their guidelines for selling public enterprises, state that privatization programs lack objective criteria for the decision to privatize and for the operational details of privatization. They point out that there is a strong need for future research to incorporate market failure analysis into any evaluation of public enterprise. Baumol (1980) comments that the increasing ideological nature of the privatization debate obscured common ground concerning appropriate roles for public enterprises and fundamental differences that exist between developed and developing nations.

3.3 The Role of Public Enterprise

A key question for economists studying LDCs is to determine the basis by which economic activity is partitioned into the public and private sectors. There are four possibilities: (1) ideological preference, (2) acquisition though nationalization, (3) historical heritage with inertia, and (4) as a pragmatic response to underlying economic conditions (Jones *et al.* 1982). LDC public enterprises consistently tend to produce about 7-15% of GDP (Jones *et al.* 1982 and Aharoni 1986). Public enterprises in LDCs are generally present in industries with some of the following characteristics: large in scale relative to product and factor markets, capital intensive, high forward linkages, high rent and natural resource exports, and produce standardized products. Findings that public enterprises are common in these sorts of industries are consistent across a wide spectrum of countries and suggest that public enterprise can at least in part be understood as the response of pragmatic governments facing similar problems in the development process. Even in nations as ideologically different as Korea and India, the public enterprise sectors were found to be similar in relative size and structure (Jones *et al.* 1982).

Public enterprise can be one tool for addressing market failures. Such failures can cause profit-maximizing private firm behavior to be incompatible with social welfare maximization. Alternative intervention mechanisms include: taxes, subsidies, antitrust action, regulation, informal administrative guidance and acceptance of the private outcome. The selection of intervention approach should be based on cost effectiveness in achieving goals. Costs to control market failures are increased by organizational failures associated with intervention mechanisms. For instance, with a public enterprise it may be possible to achieve marginal cost pricing but at

the cost of an organizational form that fails to minimize costs. The dichotomy between private and public firms faced with market failure is between two types of economic signals that result in sub-optimal outcomes: (1) incorrect external signals of economic opportunity to private unregulated firms and (2) incorrect internal responses because of organizational failure that creates non-maximizing behavior for public enterprises (Leroy et al. 1982).

Formation of public enterprises has often been justified based on a need to control the exercise of market power by private firms. The ability of private firms to achieve market power is enhanced by the small size of markets in LDCs such as Nepal. Small markets permit production by only a limited number of firms due to technology-based economies of scale. The presence of only a limited number of competing firms leads to conditions conducive to the exercise of market power. The impact of market- power related price distortions can be more severe in LDCs where for the poor even small changes in prices have major impacts on living conditions (Sadoulet and de Janvry 1995).

In LDCs, many public enterprises are found in the agricultural sector, where they are involved in processing and marketing raw agricultural products. Factors that contribute to conditions leading to market power in LDC agro-industries include:

- bulky and perishable raw products with high transportation cost results in cost savings by processing in the region of production,

- low farmer productivity resulting in raw product purchase from a large area, and

- processing equipment with large minimum capacity relative to available raw product.

A recurrent theme in the development literature has been the need to increase national savings by extracting agricultural sector surplus for use in building infrastructure and providing capital needed for industrialization (Mellor 1966). Public enterprises in the agricultural sector have been justified as a device to extract producer surplus. Due to administrative deficiencies in LDCs, public enterprises are used as an alternative tax collection device (Meirer 1990).

Public enterprises have also been promoted by a variety of arguments that are now discredited. Public enterprises were seen as a mechanism to execute the economic plans of central economies that are prevalent in many LDCs. One role of public enterprise in these economies is to administer prices (Srinivasan 1980). Public enterprises were also justified as a way to limit the power of wealthy families that dominate industrial activity in LDCs. However, there is now a perception that public enterprises have actually served to increase the power of such families (Ramanadham 1991). Political-economic goals now discredited also pursued through public enterprises include, nationalization of industries, increasing industry size to enter international

markets, a means to control foreign joint venture capital (Ramanadham 1991), to provide jobs, to promote the prosperity of particular ethnic groups and modernization to enhance national prestige (Myrdal 1972).

LDC public enterprises can also help to overcome institutional constraints that inhibit the development of large complex private firms. Such firms are required to establish key industries needed for broader economic development. The existence and consequences of institutional constraints are often difficult to test empirically (Hoff, Braverman and Stiglitz 1993). Stiglitz and Sappington (1987) note that public enterprises in LDCs have arisen in part due to poorly developed capital and stock markets that prevent risk spreading. Without these markets the cost of capital is driven up and risk increases. In fact, the establishment of many pubic enterprises in developing countries by foreign aid donors stems from a perception that key industries needed for economic development were not being set up by the private sector. The justification by donors for establishing LDC public enterprises is similar to arguments made by Lucas (1988) that particular industries contribute external effects to the economy including the development of human capital.[29]

Sappington and Stiglitz (1987) note that the recent trend of privatization reflects judgments by policy makers in developed countries that previous economic sector assignments for public enterprises were incorrect. They see the selection of which goods and services to be publicly produced as a central question. They developed the fundamental privatization theorem. The theorem establishes conditions under which government involvement cannot improve upon the performance of private markets (the conditions are defined below). They focus on the transaction costs associated with interventions to address market failures.

Direct government intervention is cheaper under public production because the government has direct access to information about the firm (Sappington and Stiglitz 1987). However, under certain conditions, private firms can be induced to act optimally. Sappington and Stiglitz (1987) envision an ideal auction process that leads to welfare-optimal private production without requiring complete knowledge by the government. The auction is a bidding process that allocates the right of private firms to produce a good or service for the government. The private firms receive payoffs that are set by a predetermined valuation function V(z). In essence, the private firms are bidding to become regulated firms. If V(z) can be linked to the sum of consumer surplus and revenue, the firm will maximize the sum of consumer and producer surplus. The result is technological and allocative efficiency.

The auction will fail to produce the optimal outcome under four conditions: (1) if the contractor is risk adverse and rent acquisition by the government is imperfect, (2) firms have limited

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[29] One external effect Lucas (1988) models is learning by doing, where labor in selected industries improves its productivity as part of the production process.

liability and can renege on contract terms, (3) information problems exist such as the government not knowing its valuation function, (4) contract implementation problems arise due to a separation of firm ownership and management (or government decisions and its bureaucracy). The conditions reveal a list of privatization failures. The presence of these conditions makes the best choice of intervention to address market failures an empirical one. These conditions are likely to be more severe in LDCs that have weak market institutions and legal systems. Aharoni (1986) notes that development economists have long held that public enterprises are relatively more effective in addressing market failures in LDCs than regulation regimes for private firms.

3.4 Normative Theory: How Public Enterprises Should Behave.

Normative theory concerns judgments on how public enterprises should behave and what goals they should have. There are a variety of objectives that governments set for public enterprises. Rees (1984) breaks possible objectives into four categories:

1. technical and allocative economic efficiency,
2. profitability,
3. effects on income distribution, and
4. relationships with macro economic policy.

The economic basis for these public enterprise objectives is derived from a welfare economic approach. Under this approach the government is seen to maximize a welfare function with the utility of all citizens as the arguments. Such a function is represented by the Bergson-Samuelson welfare function (equation 3.4.1):

(3.4.1) $$W = W[U^1(C_1, C_2,...,C_n), U^2(C_1, C_2,..., C_n), ...U^H(C_1, C_2,..., C_n)].$$

Where U^h is an individual household utility function in terms of consumption and H is the number of households (U^h = 1, 2...H). Dinwiddy and Teal (1996) point out that the Bergson-Samuelson welfare function represents a set of value judgments not a means to aggregate individual choices to derive a ranking of social choices. Arrow (1963) showed that decision rules cannot be derived from welfare functions such as the Bergson-Samuelson because in such functions utility is defined using ordinal preferences. Ordinal preferences do not allow for interpersonal comparisons of welfare. However, as Dinwiddy and Teal 1996 indicate, the insight derived from equation 3.4.1 is that in a general equilibrium framework consumption levels define aggregate welfare. They also point out that welfare functions such as the Bergson-Samuelson function can be weighted to reflect societal preferences to increase the welfare of the poor.

Welfare economic theory as set forth above should be used to set objectives for public enterprises. However, there are empirical difficulties in relating the variables that public enterprises directly control such as prices, quantities and product quality with societal consumption levels (Vogelsang 1990). The setting of public enterprise objectives can be restricted to a partial equilibrium framework or a simplified multi-market framework given certain conditions. In particular, the public enterprise under consideration should not have "substantial" linkages to other sectors of the economy. Alternatively, Harberger showed even in a general equilibrium approach only the market under consideration and markets with distortions need to be considered. Distortions include both market failures and tax related distortions (Dinwiddy and Teal 1996). Vogelsang (1990) recommends restricting primary analysis of public enterprise performance to a partial equilibrium framework and introducing interactions with other markets only when the links are strong and important. Vogelsang's approach is adopted for this exposition of normative public enterprise theory because the yak cheese industry is relatively small and is not expected to have a broad impact on overall societal consumption levels. Dinwiddy and Teal (1996) note that partial equilibrium measures are by definition equivalent to general equilibrium measures if all effects are captured in one market. This can be see from their differential measure of general equilibrium welfare effects:

(3.4.2) $dW = -\ C_i dp_i + dY.$

Where p_i are prices faced by consumers and Y is income. When all welfare effects are captured in a single market equation 3.4.2 reduces to:

(3.4.3) $dW = -C_1 dp_1 + dY.$

Equation 3.4.3 represents consumer surplus plus producer surplus (dY is the change in producer surplus)

Vogelsang (1990) recommends that a public enterprise should attempt to maximize consumer and producer surplus (i.e., $W[P] = CS[P] + PS[P]$) for its product market. To justify estimation of consumer surplus from the Marshallian demand function he assumes that the industry is small enough so that income effects are negligible. To maximize total economic surplus (i.e., unweighted consumer and producer surplus) for the public enterprise's product market it needs to follow the competitive pricing rule of setting price equal to marginal cost (P = MC). However, a natural monopoly public enterprise using the marginal cost pricing rule will incur budget deficits. This is because natural monopolies are decreasing cost industries implying that marginal cost is below the average cost.

Though subsidies to natural monopolies to maintain marginal cost pricing are theoretically optimal these subsidies have potential efficiency costs. Subsidies can causes rent-seeking and/or

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x-inefficient behavior (see section 4.1). An extreme example would be bribes paid by public enterprise employees to civil servants who check the validity of the firm's claims for subsidization. Subsidies may also induce economic distortions through their financing. To subsidize the public enterprise, the government must either decrease spending on other possibly more beneficial expenditures or raise revenue from taxation, borrowing, and/or increases in the money supply. Vogelsang (1990) stresses that subsidies must convey substantial benefits to be justified otherwise a budget constraint should be imposed on the public enterprise.[30]

Governments frequently adopt a balanced budget constraint for public enterprises to avoid the negative consequences of subsidization. Though a balanced budget constraint may not lead to an optimal outcome it reduces opportunities for rent seeking behavior given the incomplete nature of information typically available to policy makers. The budget constraint helps policy makers in negotiations with the public enterprise. This is because without cost information it is hard to judge whether the public enterprise deficit is the result of efficient marginal cost pricing or wasteful spending. A balanced budget constraint also prevents taxpayers from subsidizing goods they do not consume.

Maximization of unweighted consumer and producer surplus implies that changes in welfare levels for different demographic groups are neutral. Vogelsang (1990) asserts that this is unrealistic because distributional goals may have an important role in public enterprise objectives. Society may prefer to favor certain groups served by the public enterprise, such as the poor. There are a number of approaches a public enterprise can use to target assistance to the poor: (1) the government can subsidize prices for the poor, (2) the public enterprise can cross-subsidize prices for the poor and (3) the public enterprise market power behavior can be modified. For instance monopoly market power can be constrained to improve the welfare of consumers or allowed to yield profits that can be used to improve the welfare of selected groups.

An alternative to a budget constraint to solve distributional issues is to adopt a weighted social surplus function for the public enterprise to maximize. The weighting of social surplus by relevant groups would induce the firm to efficiently engage in cross-subsidization which commonly characterizes public enterprise goals. However, like the direct economic welfare approach, implementation problems prevent public enterprise from explicitly basing their behavior on a weighted social surplus function. In actuality, distributional issues are often treated similarly to finance issues. They are embedded in constraints. An example would be a constraint on a telephone utility to provide access to phone service below cost to assist the poor.

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[30] A potential benefit of a subsidy would be the production of a good with external benefits or improvements in income distribution.

A prevalent second-best approach to public enterprise pricing is to charge Ramsey prices. Ramsey prices are theoretically derived by imposing a balanced budget constraint on a natural monopoly that maximizes welfare. A Ramsey pricing public enterprise maximizes:

(3.4.4) $W[P] = CS[P] + (1+\mu) \Pi)$.

Where $\mu \geq 0$ is the Lagrangian multiplier associated with a balanced budget constraint. Ramsey pricing for a public enterprise producing a single product results in average cost pricing (Vogelsang 1990). The value of Ramsey pricing is that it maximizes consumer surplus (Vogelsang 1990).

For a public enterprise that produces multiple products whose demands are independent of each other Ramsey pricing leads to the inverse elasticity pricing rule. The inverse elasticity pricing rule states that prices should deviate inversely proportional to the demand elasticity from marginal cost (Vogelsang 1990). For products with equal marginal cost the price of the product with elastic demand should be lower than the price of a product with inelastic demand. Equation 3.4.5 is a quantity approximation that represents the Ramsey optimality condition (Vogelsang 1990).

(3.4.5) $$p - \frac{\partial C}{\partial q} \cdot \frac{\partial q}{\partial p} = \frac{q\mu}{(1+\mu)}$$

Where $q = (q^1,..., q^n)$ is a vector of quantities and $p = (p^1,...,p^n)$ is a vector of prices. This is a system of equations because $\partial q / \partial p$ is an n×n matrix. Vogelsang (1990) states that in behavioral terms the Ramsey pricing a public enterprise inflates all demand elasticities by a common factor and otherwise behave like an unconstrained profit maximizing monopolist.

3.5 Positive Theory: How Public Enterprises Actually Behave

For the discussion of normative public enterprise theory it was assumed that firm managers and employees would adopt the public enterprise welfare maximization goals chosen by policy makers. However, it is not clear why the managers and employees should follow the objectives chosen by policy makers for the public enterprise. Even for private enterprises there is extensive evidence that the objectives of managers, employees and owners diverge (Rees 1984). For public enterprises there is greater reason to expect a divergence of owner, manager and employer objectives to manifest itself. This expectation is due to difficulty in measuring the types of goals likely to be set for public enterprises (Sappington and Stiglitz 1987).

The problem of owner, manager and employee interactions can be viewed in the principal-agent framework. For public enterprise the principles' objective should be to maximize welfare while the agents' objectives are to maximize own utility. A second problem is that the public enterprise principal in the form of the government may not have social welfare maximization as its actual objective. Politicians that control public enterprises may use them for pecuniary goals such as providing employment to supporters. This divergence of interests leads to the issue of who the principle agent is for a public enterprise. Vogelsang (1990) suggests the following groups as candidates for being the principles of public enterprises: the electorate, consumers, tax payers, and public enterprise employees.

Vogelsang (1990) points out that a full theory of public enterprise behavior that accounts for the influence of multiple groups and objectives is yet to be developed. He notes that such a pluralistic theory might make it impossible to design a consistent public enterprise objective function based on the preferences of its stockholders. Current theories are monistic in that they emphasize single goals of particular agents and derive predictions about public enterprise behavior.

Economists have long recognized the possibility that even private firms may have objectives other than pure profit maximization. The basic paradigm used in neoclassical economics is the owner managed firm where the owner makes decisions and is able to ensure that decisions are carried out. However, large modern firms are owned by shareholders who often have little to do with running the company. Like public enterprises, private stock companies also have a separation of ownership and management. Major decisions are made by a board of directors and implemented by managers and workers. This separation of ownership and management leads to specification of alternative firm objectives based on the nature of manager utility functions. George and Joll (1981) outline three important models of alternative firm objectives that are relevant to private joint-stock companies and public enterprises: (1) maximization of sales, (2) maximization of growth and (3) maximization of discretionary spending.

3.5.1 General Theories of Alternative Firm Objectives

Alternative firm objective models typically have a profit constraint that managers must satisfy because managers are judged by their firm's profitability. The issue addressed by the models is how managers are likely to behave given some discretionary decision authority. Studies of manager behavior have found that managers are concerned with their income, status, power, security and the avoidance of uncertainty (George and Joll 1981). These types of manager objectives indicate that managers may be more concerned with maximizing measures of firm size at the possible expense of profits. This concern for size is because a manager's status is closely related to firm size and firm size has also been found to be an important determinant of manager income (George and Joll 1981).

The alternative firm objective of sales revenue maximization was first put forward by Baumol. The basic model is depicted in figure 3.1. Firm profit (π) in figure 3.1 is the difference between total revenue (TR) and total cost (TC). A profit maximizing firm would produce at output level M. A sales revenue maximizing firm with the profit constraint π_1 would produce at output level N. If the profit constraint for the firm manager was raised from π_1 to π_2 the firm would produce at output level S. The essential feature of the model is that the sales revenue maximizing firm chooses a higher output level than a profit maximizing firm as long as the managers profit constraint is below the maximum profit level. The model in figure 3.1 can be extended into a dynamic sales revenue maximization model. The basic insight that a sales revenue maximizing firm produces a higher level of output remains valid for the dynamic sales revenue maximization model (George and Joll 1981).
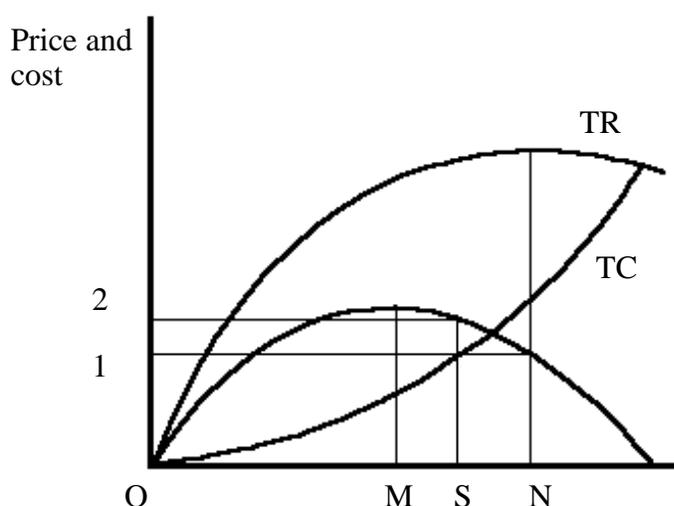
Figure 3.1 Sales revenue maximization.

It has also been argued that maximization of a company's growth rate is a possible objective of firm managers. There is evidence that managers pay and prestige also depends on firm growth rate (George and Joll 1981). The essential feature of such models is that managers will reinvest profits at the expense of dividend payments (George and Joll 1981).

An alternative firm objective of particular relevance to public enterprise behavior is the Williamson discretionary spending model (Hay and Morris 1979). In this model, managers aim to maximize a utility function that contains categories of firm expenditures. Candidates for preferred spending categories for managers include (Hay and Morris 1979):

1. manager monetary compensation,

2. manager perquisites (company cars, lavish offices, and items not need for the firm's operation),

3. control over investment of the firm's funds, and

4. number staff reporting to the manager and their quality.

As in the sales revenue maximization model, managers are also subject to a profit constraint to reflect the fact that they are at least partially evaluated based on firm profitability. The model is depicted in figure 3.2 for the tradeoff between profit and staff expenditure. The model assumes that a utility function can be represented by a "normal" indifference map with indifference curves representing the tradeoff between firm discretionary profit (Π_D), which is net profit more than the minimum required to meet the constraint, and manager preferred spending (George and Joll 1981). Firm equilibrium in figure 3.2 is at point b where the highest manager indifference curve (I_3) is tangent to the profit-staff curve. The model shows that managers with this type of utility function will always spend more on staff than a profit maximizing firm. Such a manager controlled firm also has a higher output, lower price and lower profits then an owner managed firm.
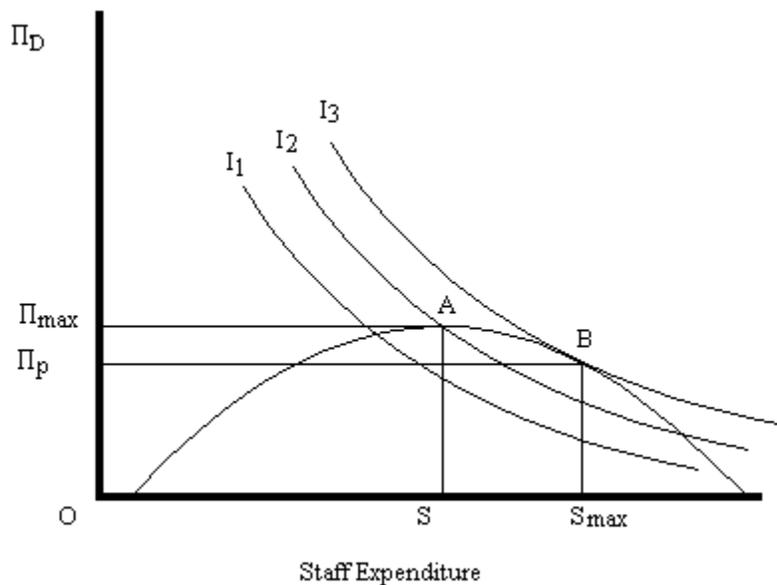
Figure 3.2. Staff expenditure maximization.

3.5.2 Theories of Public Enterprise Behavior

Theories of public enterprise behavior are very similar to the theories for alternative objectives of private firms outlined above. One difference between public and private firms that affect theories of public enterprise behavior is the ability of public enterprises to incur operating losses for extended periods of time. Public enterprises are able to sustain operating losses due to government reluctance in closing public enterprises and the use of public enterprises to subsidize goods and services.

Since public firms can incur sustained operating losses, a variant of Baumol's sales maximization model has been developed for public enterprises. Similar to the private firm case, it is postulated that a manager's utility depends on the size of the public enterprise they manage. A number of economists have found that as in the case of private firms, public enterprise manager pay and perquisites are closely linked to firm size (Vogelsang 1990). However, size of the public enterprise should be measured by the size of its budget or the level of its expenditures on inputs rather than on its sales revenue. This new definition of size is required because a public enterprise's budget consists of revenue from sales and from government subsidies.

Sherman developed the first variant of the Baumol model of sales revenue maximization for public enterprises (Vogelsang 1990). In the model, a multi-product public enterprise maximizes its budget subject to the constraint that its budget is exactly equal to sales revenue and given government subsidies. The firm has the following Lagrangian:

(3.5.1) $£ = E(\mathbf{Q}) + \mu(\mathbf{PQ} - E(\mathbf{Q}) + B)$,

where $E(\mathbf{Q})$ is the firm's expenditure per period, $\mathbf{P}$ is a vector of output prices, $\mathbf{Q}$ is a vector of outputs and B is the allowed budget deficit of the enterprise. Maximization of the Lagrangian (equation 3.5.1) implies the following pricing behavior for the case of independent demands:

(3.5.2) $(p_i - [(\mu - 1)/\mu](\partial E/\partial q_i))/p_i = -1/\epsilon_i$,

and the following pricing behavior for the general case of interdependent demands:

(3.5.3) $(p - [(\mu - 1)/\mu](\partial E/\partial q))/p = -\epsilon$

The Lagrangian multiplier (μ) for equation 3.5.2 is:

(3.5.4) $\mu = (\partial E/\partial q_i)/[(\partial E/\partial q_i) - MR_i]$,

where MR_i is the marginal revenue of good q_i. The Lagrangian multiplier μ is above one for elastic demands implying that the firm prices like a profit maximizer who is understating its true marginal costs (Vogelsang 1990). The overall result is similar to the sales revenue maximization model. The model predicts an output level above the level a profit maximizing firm would produce. However, the result is more extreme for the public enterprise with subsidies. Maximization of the expenditure function leads to the result that the public enterprise produces even above the revenue maximum level.

Another important difference between theories of private and public firm behavior is that many models of public enterprise behavior incorporate the ability of managers to engage in unproductive expenditures. These models are again similar in flavor to Baumol's sales maximization model except instead of a minimum profit constraint public enterprises are assumed to have a maximum constraint for unproductive expenditures. Since the expenditure maximization goal can only be justified if the government is imperfectly informed, a logical next step in modeling is to assume that the government can detect waste only imperfectly. Such unproductive expenditures can be direct waste or expenses require to maintain a rent earning position.

The properties rights approach pioneered by Alchian postulates that public enterprise behavior is determined by the lack of property rights (Vogelsang 1990). Proponents of the property rights approach stress that public enterprises will consistently have higher costs than a private firm producing the same good or service. The reason asserted to cause the higher costs is the dispersion of public enterprise ownership resulting in a free rider problem. Citizens individual stake in a public enterprise is simply too small to justify their effective monitoring of public enterprise costs. Other reasons cited by proponents of the property rights school for the inefficiency of public enterprises include: (1) the fact that public enterprises are not traded so they do not have to be efficient to prevent corporate raiding and (2) public enterprises rarely go bankrupt reducing pressure on management and workers from bad financial performance.

However, despite the general negative view of public enterprise performance found in models of public enterprise behavior, many economists do see important roles for public enterprises in addressing market failures (see discussion in section 3.3). Aharoni (1986) points out that many development economists believe that developing nations are not capable of developing and enforcing regulations that would be required to replace many public enterprises with private firms.

3.6 Dairy Development Corporation Behavior

For this dissertation, characterization of the behavior of the yak cheese component of the DDC is important for selecting methods and interpreting results. Overall DDC behavior is important to the extent that it sheds light on its management of yak cheese production.

There is substantial evidence that overall DDC management behavior can be related to several of the theoretical models of firm behavior discussed above. Expenditure and staff expenditure maximization models are particularly relevant to understanding DDC behavior. Since the early 1980's, the DDC has undergone a rapid increase in size as measured by both employee numbers and corporation expenditures (Sapkota 1991). However, DDC output levels have increased only modestly during this time (Sapkota 1991).   Concurrent with the increase in size the DDC has accumulated mounting deficits that are being financed with donor aid, loans and questionable accounting (HMG/DANIDA 1991).

Sapkota (1991) who is a DDC employee reports that the DDC overstaffs and that this overstaffing problem has increased in recent years. It is also widely believed that DDC managers use their position for personal enrichment and that in exchange for this enrichment, they offer employment to the friends of powerful bureaucrats, businessmen and politicians. The Kathmandu post (October 26, 1994) reports that this practice is even worse since the emergence of democracy and that the DDC general manager was involved in corruption with regard to awarding corporation contracts.

Based on the above anecdotal evidence maximization of expenditures on staff is likely to be a strong objective of DDC managers. This is further supported by the fact that the bulk of DDC's expenditures besides raw milk costs is for employee salaries. Many of the DDC's capital costs have been paid for directly by donors and currently the DDC has used its depreciation fund for operating costs and will be unable to replace needed equipment (HMG/DANIDA 1991).

There is also a confluence of donor community, DDC manager and local politician interest in expanding the DDC's milk collection grid to new areas. The donor community has stressed the need to expand the milk collection grid to encourage the adoption of improved livestock and milk production methods even if this requires subsidizes to DDC (HMG/DANIDA 1991). This expansion effort allows DDC managers to increase the number of employees and develop relationships with politicians seeking the addition of their locality to the DDC milk grid. Sapkota (1991) reports that the addition of new areas to the milk grid that have limited milk production capacity is the major reason for rising DDC deficits.

However, there is strong reason to believe that DDC management of yak cheese production differs substantially from its management of the liquid milk operation. The number of yak

cheese factories remained stable during the 1980s and early 1990s.[31] The number of DDC employees relative to yak cheese production levels has also risen at a much lower rate than for the DDS's liquid milk operation (Sapkota 1991).

It is also reported that DDC managers do not use the yak cheese unit to the same extent as the liquid milk operation for rewarding friends with employment because these jobs are not considered desirable. Jobs related to the yak cheese industry at DDC headquarters are desirable (discussed below) but jobs at yak cheese factories are not desirable for a variety of reasons including:

1. yak cheese factories are in extremely remote areas,

2. yak cheese factories are distant from even district centers and local villages,

3. yak cheese factories are located in areas where indigenous ethnic groups predominate while jobs are primarily awarded to members of high caste Brahmin and Chettri groups,

4. more senior jobs require specific education that Swiss development projects have provided on a merit basis,

5. living costs are high in the remote areas due to transportation costs, and

6. school facilities near yak cheese factories are either poor or non-existent.

DDC managers are also not pressured by local politicians to expand yak cheese production. This lack of pressure from local politicians is due to the marginal nature of these regions. Indigenous ethnic groups predominate in the yak cheese production regions while the Nepalese political structure is dominated by high caste Brahmin and Chettri groups from lower elevation areas. The donor community, since the withdrawal of Swiss and American support for the industry, has also taken no interest in expanding yak cheese production. The Swiss ceased their historic role in developing the industry in the early 1980s while America withdrew its minimal support after the failure of Nepal's government to proceed with DDC privatization in 1994.

The DDC has used profits from yak cheese production to subsidize its liquid milk operation (Sapkota 1991). Faced with mounting demands for expansion of its milk grid by local politicians and withdrawals of donor support, profits from yak cheese production are even more important to the DDC. Further, the political weakness of yak herders also prevents them from effectively lobbying the DDC to raise yak milk price and yak cheese production levels.

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[31] The number of DDC factories has declined since the emergence of private producers.

Due to the relatively low desirability of yak cheese industry jobs, limited pressure to expand production (from local politicians and yak herders), and the need for earnings to subsidize its liquid milk production, there are strong reasons to believe that the DDC would manage the yak cheese industry like a private profit maximizing firm. The only caveat to this assertion is that DDC yak cheese output pricing is inconsistent with profit-maximization. DDC yak cheese prices are low in the peak fall season resulting in shortages during the spring and early summer (Sapkota 1991). The maintenance of a constant price though the year stems partially from strong cultural beliefs that prices should not be raised during periods of peak demand (Sapkota 1991). The under-pricing policy also favors rent seeking behavior by DDC sales employees who develop relationships with wholesalers and notify them when the DDC receives yak cheese shipments during shortage periods. This rent opportunity also reveals that yak cheese jobs at the DDC headquarters are desirable. The test and interpretation of DDC market power behavior take account of these stylized facts of DDC yak cheese production (see section 4.3).

Chapter 4. Theory and Methods

Relevant theory and methods used to achieve the research objectives are presented in this chapter. These objectives are to measure DDC and private firm market power, the impact of DDC privatization, and the impact of institutional constraints on performance under different market structures. The emphasis of the chapter is on presenting methods developed and extended for this research effort, and the theory to support the methods used.

In section 4.1, the theoretical basis for the overall approach to the research problem is presented. Sections 4.1.1 and 4.1.2 present the basis for using a partial equilibrium framework and economic surplus criteria to evaluate market performance. Section 4.1.3 is an overview of methods. Theoretical relationships between market characteristics, firm conjectures about rivals and the Lerner index used to represent market power are derived in section 4.2. Theory behind the nonparametric test of DDC monopsony behavior is presented in section 4.3. In section 4.4, the method to predict private equilibrium is derived. Section 4.5 presents theory for econometric estimation of private producer behavior. In section 4.6, methods to predict DDC behaviors are shown.

4.1 Introduction

The major objective of the research is to compare performance between two stylized markets: DDC production and private production. Economic theory establishes that the competitive outcome maximizes technical efficiency and social welfare (Nicholson 1989). This result rests on an assumption that all markets in the economy are competitive. Technical efficiency occurs when no reallocation of resources permits more production of one good without decreasing production of another good. Social welfare in theory can be measured as the sum of welfare for individuals in a society. However, it is impossible to directly compare the welfare of different individuals. In practice, economists commonly use consumer and producer surplus to measure welfare (see section 4.1.2).

The competitive outcome does not optimize social welfare when market failures are present. Sources of market failures include imperfect competition, public goods, and externalities. The theory of the second best shows that a market failure in even a single sector of the economy invalidates the optimality of competitive behavior in remaining markets. This finding indicates that policy makers must analyze each situation to develop policies (Nicholson 1989).

In practice, when imperfect competition is present the competitive outcome represents an ideal that policy makers strive to attain. Policies that structure markets are judged on the degree to which they induce producers to behave competitively. However, the distribution of social

welfare resulting from a competitive market with no market failures may still not satisfy society's preferences.

To compare market performance under different assumptions about market structure, it is necessary to analyze both the yak cheese and yak milk markets. The milk factor market is included in the analysis for two reasons: (1) the markets are closely linked and (2) the yak cheese industry was established to improve the welfare of yak milk producers.

Ideally, a computable general equilibrium (CGE) model would be used to analyze the impact of DDC privatization. CGE models improve analysis because they allow for linkages between all markets in an economy. Incorporating these linkages allows for feed-back effects from related markets in the economy and estimation of societal consumption levels. Ultimately, changes in societal consumption levels (possibly weighted by demographic variables) should be the basis for evaluating policy options (Dinwiddy and Teal 1996). Section 3.4 provides a review of economic welfare theory concerning the evaluation of policy changes. However, because the yak cheese industry is relatively small and has limited linkages with other major markets in the economy, analysis can be restricted to the cheese and milk markets (see section 4.1.1). A partial-equilibrium model is used to model the two markets.

DDC and private performance vary because of different degrees of exercise of market power and different production cost structures faced by the two types of firms. Use of market power differs between the DDC and private producers for two reasons: (1) DDC objectives may not be to maximize profit (both in the past and currently) and (2) unlike when the DDC was the only producer of cheese in Nepal, there are multiple private firms leading to competitive conditions in the cheese output market. Cost structures vary between the types of firms for two reasons: (1) institutional constraints facing the DDC and private producers are different and (2) the DDC may not be minimizing its costs.

Welfare outcomes under DDC production can be determined using a partial equilibrium model calibrated with observed price-quantity data. Market performance under private production cannot be examined ex post. Instead, market equilibria must be predicted and the welfare outcomes measured. The private market equilibria are predicted based on forecasts developed from observed private behavior.

An important feature of the yak cheese industry is that there are multiple factory locations that define milk sheds. These milk sheds have distinct characteristics including size differences. This feature is incorporated into the analysis by measuring impacts between market structures for producers by individual milk shed.

4.1.1 Partial Equilibrium Analysis

Partial equilibrium models give a dependable first-order approximation of policy effects that is seldom overwhelmed by feedback effects and general welfare effects (Sadoulet and de Janvry 1995). There are however, theoretical weaknesses associated with partial equilibrium models. Partial equilibrium models offer an approximation of policy impacts but do not allow for the impact of all linkages with related markets, unlike CGE models. For instance, price changes in a market may affect equilibria in markets for related products which in turn will alter the calculated equilibrium.[32] However, partial equilibrium models that contain multiple related markets can capture important feed-back effects. Partial equilibrium models are also not capable of estimating changes in societal income (and consumption) levels from policy changes unlike CGE models.

Partial equilibrium models can be extended to incorporate a variety of secondary effects including exchange rate changes, private investment behavior, and welfare gains associated with the investment of public revenue (Sadoulet and de Janvry 1995). For complete analysis of a markets performance tax induced welfare losses need to be balanced by accounting for the benefits of government expenditures. The issue of who benefits from government expenditures is relevant for analysis of the yak cheese industry because profits from the yak cheese industry are used to subsidize the DDS's liquid milk operation.

Despite its weaknesses, a partial equilibrium framework is widely used for evaluating the performance of public enterprises (Vogelsang 1992). Similarly, the use of such a framework has been widely used to evaluate the effects of more general policies and development programs (Sadoulet and Janvry 1995, Alston, Norton and Pardey 1995). For this effort a partial equilibrium model containing the yak cheese and milk markets is used. The model is extended to partially measure impacts beyond the yak cheese and milk markets. In addition to the economic surplus criterion, alternative evaluation criteria are incorporated in the partial equilibrium model analysis used for evaluation of DDC privatization (see section 4.1.2 for a description of these alternative criteria).

Certain aspects of the yak cheese industry also mitigate some of the general weaknesses associated with a partial equilibrium approach. In particular, producers of milk and cheese consume virtually none of their own product, implying that income effects are negligible.[33] Consumers spend a small proportion of their total budget on yak cheese. This spending pattern also minimizes potential income effects. There is also a clear separation of markets for inputs between yak cheese and other fresh cheeses due to the remoteness of the yak cheese production

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[32] Related products include production inputs, substitutes and complements.
[33] This is true for yak cheese which is consumed predominately by foreign tourists but to a somewhat lesser extent for yak milk which even if not used to produce cheese is mostly marketed in the form of local products.

regions that limits feed-back effects. Also limiting feed-back effects is the fact that clarified butter (the alternative use of yak milk) is primarily produced from cows' milk.

Another factor indicating that partial equilibrium analysis is appropriate stems from the finding that yak cheese production levels remain relatively constant post DDC privatization (see section 5.6 for the predicted private market equilibrium). This stability does limit complicating effects from other fresh cheese markets and from markets for inputs used in cheese production.

4.1.2 Market Performance Criteria

Consumer and producer surplus are commonly used by applied researchers to measure the impacts of policy changes on a market's performance (Sadoulet and de Janvry 1995, and Alston, Norton and Pardey 1995). For evaluation of yak cheese market performance under different market structures, consumer surplus, cheese producer surplus, and total surplus are used. For evaluation of yak herder welfare under different market structures, milk producer surplus is used. Figure 4.1 graphically depicts the surplus measures for the competitive and market power equilibria for the yak cheese and yak milk markets.

Additional market performance criteria used in this study include: foreign exchange earnings and total output for the yak cheese industry. Nepal suffers from a chronic lack of foreign exchange. Though the yak cheese industry is relatively small in size, it represents a steady, significant source of foreign exchange because up to 90% of yak cheese is sold to foreigners from countries with hard currencies. Total industry output acts as a partial proxy for impacts on agents closely connected to the industry. Such agents include businesses that herders patronize, cheese porters and other input suppliers for production of yak milk and cheese.
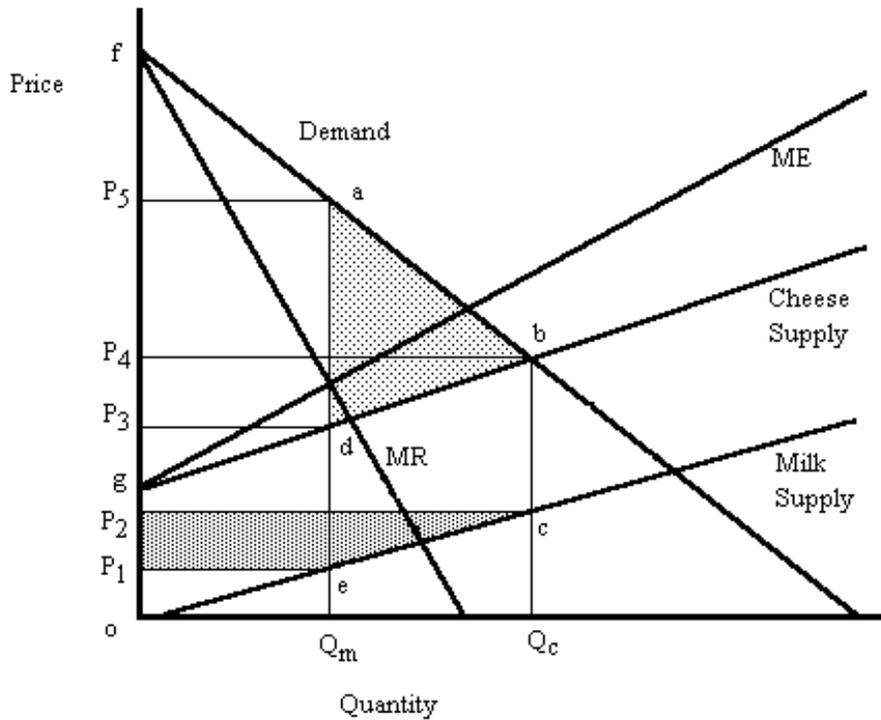
Figure 4.1 Partial equilibrium modeling and measures of market efficiency.[a, b]

[a] Two contrasting equilibria are depicted in the figure: (1) pure competition (P_5-Q_c) and
  (2) profit maximization by a firm with monopoly and monopsony power (P_6-Q_m).

[b] Welfare measures for the two market equilibria.

	Consumer surplus	Cheese producer surplus	Milk producer surplus
Competitive	fbP$_5$	P$_4$bg	P$_2$co
Market power	faP$_5$	P$_3$dg	P$_1$eo
Changes in welfare	P$_5$abP$_4$ (Loss)	P$_5$adg (Gain) Dark Shaded Area	P$_2$ceP$_1$ (Loss)
Dead weight loss	abd Light Shaded Area		

Consumer surplus, cheese processor surplus, and herder surplus are measured as defined in
equations 4.1.1 to 4.1.3 for the yak cheese and milk market participants:

$$(4.1.1) \qquad CS = \int_0^{Q_e} D_c(Q)dQ \; - \left(P_e \; Q_e\right)$$

$$(4.1.2) \qquad PS = \left(P_e \; Q_e\right) - \int_0^{Q_e} S_c(Q)dQ$$

$$(4.1.3) \qquad PS_m = \left(P_{me} \; Q_e\right) - \int_0^{Q_e} S_m(Q)dQ$$

where Q_e is the equilibrium quantity of cheese/milk in cheese units, P_e is the equilibrium price of cheese, P_{me} is the equilibrium price of milk (in cheese units), $S_c(Q)$ is cheese supply function, $S_m(Q)$ is the milk supply function and $D_c(Q)$ is the Marshallian (income constant demand curve).

There are theoretical limitations to the use of surplus measures. Ideally consumer welfare would be evaluated directly from changes in the consumer's utility level:

$$(4.1.4) \qquad u = v(p_1, y_1, z_1) - v(p_0, y_0, z_0),$$

where $v(\cdot)$ is the indirect utility function, p represents the prices of available goods, y is a budget constraint and z are personal characteristics (Sadoulet and de Janvry 1995). However, utility functions are ordinal relationships that cannot directly yield monetary measures. The alternative widely adopted measure of consumer welfare is consumer surplus. Consumer surplus is an attractive measure of consumer welfare because it can be interpreted as the consumers willingness to pay above the actual product price. It is also simple to computed because it is based on the elasticity of demand.

A criticism of consumer surplus is that a change in a good's price affects the consumers income which changes their demand.[34] However, if the budget share of the good is small, this income effect is also small. This is the case for the yak cheese industry.

Producer surplus is an analogous measure to consumer surplus for producer welfare. It is calculated as the area above the supply curve and below the equilibrium price (see figure 4.1 and equation 4.1.2). Producer surplus is related to the concept of profit and can be interpreted as returns to fixed or quasi-fixed inputs (Sadoulet and de Janvry 1995). In partial equilibrium analysis, producer surplus is treated as equivalent to economic profits produced from market power (Vogelsang 1990). However, producer surplus does not have the negative phenomena of x-inefficiency and rent seeking behavior associated with economic profit.[35]

Similar to the use of consumer surplus there are concerns related to income effects in using the producer surplus measure. When producers consume the product they produce, changes in the

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[34] See Appendix B for a discussion of the alternative consumer surplus measures of equivalent and compensatory variation.
[35] X-inefficiency is a tendency for firms, without the full pressure of competitive rivals to not control costs effectively (Scherer and Ross 1990). Firms with market power may also spend considerable resources on activities to maintain that power through the political system.

product price will affect them through the cost of consumption. For the cheese industry, these income effects are relatively unimportant because producers of milk and cheese consume very little of their products. Herders and processors produce milk and cheese for sale.

Typically consumer and producer surplus are computed from linear partial equilibrium models based on econometric estimates of demand and supply price elasticities. A number of concerns have been raised regarding this approach (Alston, Norton and Pardey 1995). Econometric estimation of elasticities requires the specification of functional forms for supply and demand. Misspecification of the underlying functional forms for supply and demand can bias the elasticity estimates. Economic theory provides little assistance in determining the correct functional forms. For this effort, flexible functional forms are used to estimate supply and demand elasticities. The use of flexible functional forms limits misspecification bias. Error in measuring economic surplus is also introduced in a linear partial equilibrium model by using linear supply and demand functions to approximate functions that may not be linear. For this effort, the supply and demand functions are linearly projected from the observed DDC price-quantity equilibrium based on the estimated elasticities (see section 4.4). Errors in measuring surplus changes using linear approximations around an equilibrium have been found to often be relatively small (Alston, Norton and Pardey 1995).

The aggregation of individual supply and demand curves to obtain market supply and demand curves also introduces a source of error in estimating welfare impacts. The problems associated with aggregation are relevant to partial-equilibrium models and to CGE models which also require the use of aggregate functions. In order for aggregated functions to retain theoretical properties, it must be assumed that tastes, incomes and prices of other goods are constant across individuals in the economy (Alston, Norton and Pardey 1995). However, Alston, Norton and Pardey (1995) note that these, assumptions also characterize alternative measures of welfare and, though, not correct, are not worse than other simplifications.

Overall industry efficiency is measured by the change in total surplus which is the sum of consumer and processor producer surplus. However, total surplus for the yak cheese industry excludes yak herder producer surplus which is also an important market performance criterion. A critical fact is that *ceteris paribus* the presence of market power will result in a deadweight welfare loss (figure 4.1). Reduction in consumer welfare for the yak cheese industry is not a major concern since consumers are foreign or wealthy. However, reduction in output implied by market power will decrease the welfare of yak milk producers.

No attempt is made to develop an explicit weighting scheme for the distribution of economic surplus. Vogelsang (1992) notes that such schemes are confounded by empirical difficulties in assigning weights. These problems are also discussed by Alston, Norton, and Pardey (1995).

However, it should be noted when judging the distribution of welfare that there may be strong grounds to favor milk producers. They are the only group of market participants to suffer from pervasive poverty. The tourist consumers, the retailers (wholesalers in the models), and cheese producers are wealthy by Nepalese standards. The industry was also explicitly established with foreign support to increase the incomes of yak herders. The only potential reason not to favor the welfare of yak milk producers is that the DDC uses profits from yak cheese production for cross-subsidization. The DDC is attempting to expand its liquid milk collection grid to remote areas as part of its development objectives. The DDC also subsidizes urban milk consumption. However, the yak herders' poverty is more severe than the poverty of the groups these policies benefit (Miller 1993).

The additional performance criterion of foreign exchange earnings is calculated based on the model equilibria.[36] Market performance criteria are also evaluated at the milk shed level to capture impacts on cheese processors and milk producers that vary with milk shed size and market power behavior.

4.1.3 Overview of Methods

To evaluate the impact of DDC yak cheese privatization, the equilibria under private production have to be predicted for each milk shed. The data used to calibrate the partial equilibrium models are from a year when the DDC was the only producer of yak cheese. Performance under different market structures is compared using welfare measures calculated with the models. The impacts of institutional constraints are measured by solving for private market equilibrium using a modified cost structure. This modified cost structure reflects reduced institutional constraints. Changes in market performance criteria are then computed.

The year selected for the comparison of DDC and private production is 1991. This is a year that precedes private production and falls within the period for which yak cheese demand and yak milk supply are econometrically estimated. This approach requires that only private producer equilibrium be predicted, since the DDC equilibrium can be directly observed. This approach decreases error in the comparison. Monopsony behavior by private cheese firms is determined from estimated parameters representing private behavior for the years 1994 and 1996. Six partial equilibrium models are constructed to compare performance across different market structures. The models and the method used to obtain the models' price-quantity equilibria are presented in table 4.1. The observed DDC, predicted private, and reduced institutional constraint equilibria are also compared to baseline market structures imposing competitive and pure market power behavior on the DDC and private firms.

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[36] Foreign exchange earnings are estimated using market parameters estimated by Colavito (1994).

Table 4.1 Models used for measuring performance.

Scenario	Market Structure	Equilibrium Solution
1. DDC (observed 1991)	Sole DDC production	The observed price and quantities produced in 1991 by the DDC.
2. DDC (Competitive)	Sole DDC production	Competitive DDC behavior imposed with solution of a simultaneous equation system calibrated with 1991 DDC data.
3. DDC (Market power)	Sole DDC production	Market power DDC behavior imposed with solution of a simultaneous equation system with 1991 DDC data.
4. Private Predicted (Estimated Conjectures)	Production by multiple private firms	Private equilibrium solved using a simultaneous equation system with 1991 DDC market data and estimated private producer monopsony behavior.
5. Private Predicted (Competitive Conjectures)	Production by multiple private firms	Private equilibrium solved using a simultaneous equation system with 1991 DDC market data and imposing competitive conjectures on private producers.
6. Private Predicted (Reduced Inst. Constraint impact)	Production by multiple private firms	Private equilibrium solved using a simultaneous equation system with 1991 DDC market data, estimated private producer market behavior and a modified cost structure. The modified cost structure reflects decreased impact of institutional constraints.

4.1.3.1 Prediction of Private Producer Equilibrium

A multi-step method is used to predict the private market equilibrium. The method maximizes the use of available information by incorporating restrictions derived through economic theory. The private price-quantity equilibria are derived using the estimated firm cost structure and private monopsony behavior observed in milk sheds where private production existed.[37] The cost structure is determined from an economic-engineering model of private production. Monopsony power exercised by private cheese producers varies by milk shed because the number of private firms depends on the size of the milk shed. The conditions for monopsony power depend upon a firm's beliefs about the behavior of rivals. These beliefs depend on the number of cheese producing firms in a milk shed.

The private equilibrium is the solution to a simultaneous equation system. The system represents equilibrium in a single milk shed, and includes equations representing the exercise of monopsony power. Identities ensure that cheese demand is equal to the sum of supplies from all

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[37] Firm cost structure is estimated from 1994 data and private behavior is estimated from 1994 and 1996 data.

milk sheds. The demand and supply elasticities used in the system come from models estimated using market data. Observed DDC price and quantity values are used to calibrate the models.

Two types of equations are used to define monopsony power in the milk sheds. An equation for each milk shed specifies the relationship between the Lerner index and the number of firms present in a milk shed. An equation for each milk shed specifies the relationship between milk shed size and the number of firms. The parameters for these equations are estimated econometrically. Econometric estimation is required for three reasons: (1) there is a relationship between the Lerner index and the number of firms in a milk shed, (2) it permits statistical validation of relationships, and (3) it allows for separation of effects between the number of firms and the proximity of a DDC factory on the Lerner index.[38]

To estimate the equation system, the Lerner index is calculated for each milk shed that has private firms. The Lerner index for each such milk shed is computed using an estimated cheese supply function, processing cost, and observed price and quantity data. Equations used to estimate the system are derived from the theoretical relationship between the variables. The theoretical relationship between the number of firms in a milk shed and the Lerner index is derived from the first-order conditions of a profit-maximizing firm with partial monopsony power. The relationship between shed size and the number of firms is based on a minimum efficient firm size argument.

The method for predicting private equilibria is presented in section 4.4. In section 4.5, a theoretical justification is made for estimation of private behavior. The method to compute the Lerner index is also derived in section 4.5. Solution methods for DDC baseline market structures are shown in section 4.6. The method for determining DDC output market behavior is also derived in section 4.6.

4.2 Modeling Private Firm Behavior Given Monopsony Market Power

The Lerner index is used to model private firm monopsony power. The Lerner index is a unit-free measure of a firm's ability to lower input price (defined below). The following derivation draws on the work of Scherer and Ross (1990) and Love and Shumway (1994). The derivation assumes a certain market structure in the private yak cheese industry consistent with observations. Oligopsonistic yak cheese producers purchase yak milk from competitive producers and are price takers in the output market. A profit-maximizing firm with no output market power but with potential input market power has the following objective function:

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[38] Proximity to a DDC factory induces private behavior closer to a competitive outcome (see section 4.6).

$$(4.2.1) \quad \text{Max} \, (\pi_{ij}) = P \cdot y_{ij} - C_{ij}(y_{ij}, \overline{P}_j, q_{ij}) - P_{mj}(Q_j) \cdot q_{ij} - FC_{ij}$$
$$\text{wrt:} \, y_{ij}, q_{ij}$$

Where P is cheese price, y_{ij} is the output of firm i in milk shed j, q_{ij} is milk purchased by firm i in milk shed j, $\overline{P}_j$ is a vector of input prices excluding milk price, P_{mj} is milk price in milk shed j, FC_{ij} is the fixed costs of firm i in milk shed j and Q_j is the total amount of milk purchased in milk shed j, (i.e., $Q_j = \sum_{i=1}^{N_j} q_{ij}$ where N_j is the number of firms in milk shed j),. The function $P_{mj}(Q)$ is a price-dependent positively sloped agricultural supply function for milk in milk shed j.[39] The firms' conditional cost function $C_{ij}(y_{ij}, \overline{P}_j, q_{ij})$ is defined as: $C_{ij}(y_{ij}, \overline{P}_j, q_{ij}) = \min\{ \overline{P}_j \cdot \overline{q}_{ij} : F_{ij}(\overline{q}_{ij}, q_{ij}) \geq y_{ij}\}$ where $F_{ij}(\overline{q}_{ij}, q_{ij})$ is firm i's production function in milk shed j and $\overline{q}_{ij}$ is a vector of inputs excluding milk (q_{ij}).

The use of the conditional cost function $C_{ij}(y_{ij}, \overline{P}_j, q_{ij})$ is justified in the yak cheese industry. Although there is a fixed conversion rate of yak milk to yak cheese, the amount of marketable cheese produced depends on the levels of other inputs. For example, labor and labor quality affect the amount of cheese lost. The loss rate for the DDC and private producers is observed to vary over a narrow range. In the partial equilibrium models, an average loss rate is used since these models are specific to a particular year.

Taking the partial derivatives of equation 4.2.1 with respect to y_{ij} and q_{ij} yields the first-order conditions for firm i's profit maximization problem (equations 4.2.2 and 4.2.3).

$$(4.2.2) \quad \frac{\partial \pi_{ij}}{\partial y_{ij}} = P - \frac{\partial C_{ij}()}{\partial y_{ij}} \stackrel{\text{set}}{=} 0$$

$$(4.2.3) \quad \frac{\partial \pi_{ij}}{\partial q_{ij}} = -P_{mj} - \frac{\partial P_{mj}(Q_j)}{\partial Q_j} \cdot \frac{\partial Q_j}{\partial q_{ij}} \cdot q_{ij} - \frac{\partial C_{ij}()}{\partial q_{ij}} \stackrel{\text{set}}{=} 0$$

Since the firm has no output market power, equation 4.2.2 is the basic marginal cost pricing rule for firms in a competitive industry.[40] The next step is to obtain an expression of input market power in terms of the Lerner index and the firm's conjectures with respect to the supply response of rivals. Mathematically the firm's conjectures are measured by the conjectural variation term

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[39] The use of a separate variable name for output (y_i) is restricted to this section for exposition purposes. In the remaining sections of chapter four a market margin approach (Tomek and Robinson 1990) is taken where the raw input and final output are equated by an implicit conversion factor.

[40] Milk input terms cancel out to yield equation 4.2.2 by application of an envelope theorem result.

$\dfrac{Q_j^*}{q_{ij}}$ where Q_j^* is the amount of the input used by the other j firms in the production region.

The conjectural variation term measures the degree of coordination between firms (both collusive and Cournot non-collusive) that results in economic profit. Multiplying the second term of equation 4.2.3 by an equivalent of one $\dfrac{Q_j}{P_{mj}}\ \dfrac{P_{mj}}{Q_j}$ yields equation 4.2.4.

$$(4.2.4) \qquad 0 = -P_{mj} - \frac{P_{mj}}{Q_j}\ \frac{Q_j}{P_{mj}}\ \frac{Q_j}{q_{ij}}\ \frac{P_{mj}}{Q_j}\ q_{ij} - \frac{C}{q_{ij}}$$

Regrouping terms in equation 4.2.4 yields:

$$(4.2.5) \qquad 0 = -P_{mj} - \frac{P_{mj}}{Q_j}\frac{Q_j}{P_{mj}}\ \frac{Q_j}{q_{ij}}\ \frac{q_{ij}}{Q_j}\ P_{mj} - \frac{C}{q_{mj}} = 0 .$$

Equation (4.2.5) can be rewritten as:

$$(4.2.6) \qquad 0 = -P_{mj} - \frac{1}{\varepsilon_{sj}}\ \frac{Q_j}{q_{ij}}\ S_{ij}\ P_{mj} - \frac{C}{q_{ij}} = 0 ,$$

$$(4.2.7) \qquad \frac{P_{mj} + \dfrac{C}{q_{ij}}}{P_{mj}} = -\ \frac{S_{ij}}{\varepsilon_{sj}}\ \frac{Q_j}{q_{ij}}$$

where S_{ij} is the market share of firm i for milk used in milk shed j and ε_{sj} is the elasticity of supply for milk. The elasticity of milk supply may vary between milk sheds. Noting the relationships in equations 4.2.8 and 4.2.9 equation 4.2.10 can be obtained (Love and Shumway 1994):

$$(4.2.8) \qquad \frac{Q_j}{q_{ij}} = 1 + \frac{Q_j^*}{q_{ij}} ,$$

$$(4.2.9) \qquad -\frac{C}{q_{ij}} = MVP_{mij} ,$$

where MVP_{mij} is the marginal value product of firm i for the milk input. Note that a profit-maximizing firm equates marginal value product for an input with the marginal factor cost of the input.

Equation 4.2.7 can be now be rewritten as equation 4.2.10.

$$(4.2.10) \qquad L_{ij} = \frac{\left(MVP_{mij} - P_{mj}\right)}{P_{mj}} = \frac{s_{ij}}{\epsilon_s}\left(1 + \frac{Q_j^*}{q_{ij}}\right).$$

The Lerner index (L_{ij}) in equation 4.2.10 represents a unit-free measure of a profit maximizing firm's ability to lower the price of an input (milk in this case). The Lerner index in equation 4.2.10 is firm specific, and conditions for when the Lerner index defined in 4.2.10 represents a market value are defined below. The Lerner index is related to the input supply function through the own-price elasticity of milk supply (ϵ_s). Equation 4.2.10 shows that a firm's monopsony market power depends on its conjectures $\frac{Q_j^*}{q_{ij}}$ about the behavior of rivals. When a firm has non-collusive Cournot-type conjectures (i.e., $\frac{Q_j^*}{q_{ij}} = 0$) and all firms face identical marginal costs, equation 4.2.10 becomes equation 4.2.11.

$$(4.2.11) \qquad L_{ij} = \frac{1}{N_j \, \epsilon_s}$$

When $\frac{Q_j^*}{q_{ij}} = -1$, a firm has Bertrand competitive conjectures and would have no market power (i.e., $L_{ij} = 0$). For a monopsonist $\frac{Q_j^*}{q_{ij}} = 0$ (there are no rivals), and $S_{ij} = S_j = 1$ which implies:

$$(4.2.12) \qquad L_j = \frac{1}{\epsilon_s},$$

in the case of a monopsonist.

In an agricultural context, monopsony power occurs naturally when the minimum efficient size (MES) for a processing firm in a production region permits a single or limited number of firms to

operate at the minimum of long-run average cost.[41] However, even in an agricultural market with a single processing firm there are factors that can limit the exercise of monopsony power. Baumol developed a theory of market contestability where the threat of entry by a rival seeking economic profits would deter a firm from taking full advantage of its monopsony power (Scherer and Ross 1991). However, the threat of entry is only credible when either an additional firm at MES can enter the market or theoretically there exist no fix costs that cannot be recovered when the firm leaves the market. Low fixed costs given high economic profits may not inhibit new entrants. It should also be noted that if fixed costs such as equipment can be resold at purchase value less depreciation, firms would not be inhibited from entry. Producers may also exert pressure on the monopsonistic processor through the formation of, or threat to form a cooperative for bargaining on price or to process the product.

For the yak cheese industry, private firm size is observed to be essentially equal in the milk sheds. When firms are of equal size market share can be expressed in terms of number of firms in a milk shed (N_j) (i.e., $S_{ij} = \dfrac{1}{N_j}$). Processing firms in the yak cheese industry are observed to be of equal size because of spatial forces. New entrants to a milk shed essentially choose location to split the milk shed with existing firms. Under the condition of equal firm sizes equation 4.2.10 becomes:

$$(4.2.13) \qquad L_{ij} = \left[\frac{1}{N_j} \right]_s \left[1 + \frac{Q_j^*}{q_{ij}} \right] .$$

By equation 4.2.13, increases in firm numbers will decrease a firm's ability to exert monopsony power. This result depends on the assumption that the value of the conjectural variation term remains constant or decreases. There are strong reasons to expect that the conjectural variation term $\dfrac{Q_j^*}{q_{ij}}$ will decrease in value as the number of firms in a milk shed increases. There is a body of empirical work indicating that collusive behavior is more difficult when the number of firms in an industry increases, hence it is highly unlikely that firms' conjectural variation term would increase with the number of firms in an industry (Scherer and Ross 1990).

The Lerner index in equation 4.2.13 can be interpreted as a measure of monopsonistic power at the regional market level with the assumption that all firms have identical conjectures. This assumption is justified because the major determinant of conjectures is the firms' market share and the cost structure of firms in the market (Scherer and Ross 1990). For the yak cheese

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[41] Alternative sources of monopsony power are the granting of purchasing/processing rights by government.

industry, milk shed market share is equal. Firm cost structures are also identical. Equation 4.2.13 can be written at the milk shed level as:

$$(4.2.14) \qquad L_j = \frac{1}{N_{j\ s}} \left[1 + \frac{Q_j^*}{q_j} \right].$$

The theoretical negative relationship between number of firms and the exercise of market power used in econometric estimation of this relationship. Results from this estimation help predict market equilibrium for private yak cheese production (see sections 4.4 and 4.5)

4.3 Nonparametric Method to Test DDC Milk Market Monopsony Power.

This section contains the theoretical basis for a nonparametric test of DDC monopsony power.[42] The purpose of estimating DDC market power behavior is to establish that positive economic rents were being earned in the yak cheese industry. The nonparametric test is a direct application of an approach developed by Love and Shumway (1994) based on the seminal work of Varian (1982). The test recovers the firm's perceived impact on price in a particular factor market by estimating the Lerner index of market power. The following presentation of the theoretical basis of the test directly follows Love and Shumway (1994).

The Love and Shumway test is predicated on an assumption of profit maximization. However, it allows for the possibility that firms do not take full advantage of their market power. There are two basic reasons a firm would not take full advantage of its market power: (1) it does not perceive its market power correctly (i.e., a monopsonist perceives input elasticity to be higher than it actuality is), and (2) there is an external constraint forcing the firm to limit its use of potential market power. In the case of the DDC there is a mandate not to use market power. However, there is no effective mechanism to stop the DDC from using market power in the yak milk markets. The test assumes cost minimization but allows for the possibility of negative technical change which can be utilized to determine if the DDC is engaging in outright unproductive expenditure.

Section 3.6 presents a review of expected DDC objectives for its overall operation and its management of yak cheese production. The major finding is that the DDC has strong incentives to manage the yak cheese industry for profit to allow for expansion of its milk collection grid. It is also reported that DDC managers provide employment opportunities to patrons. However, yak

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[42] See section 4.7 for a description of how the output market Lerner index is obtained from the nonparametric estimate of monopsony power and observed DDC equilibrium. See section 5.7.3 for the estimation of DDC output market power.

cheese industry jobs are generally considered undesirable for this purpose. The nonparametric test can capture negative technical change associated with the use of unproductive labor.

A firm's maximization problem as expressed in equation (4.2.1) can be restated as equation (4.3.1).

(4.3.1) $\quad \text{Max} (\pi_{ij}) = P\ y_{ij} - \sum_{k=1}^{z} P_k\ q_{kij} - P_m(q_{ij} + Q_j^*)\ q_{ij}$
$\quad\quad\quad \text{wrt:} y_{ij}, q_{ij}$

Where k is an index for k input prices excluding the milk input, q_{kij} are the quantities of inputs other than milk (q_{ij}) that firm i uses in milk shed j.[43] All other variables are as defined in section 4.2.

Since the firm is maximizing profits, discreet changes in input and output levels imply that:

(4.3.2) $\quad \Delta\pi_{ij} = P\ \Delta y_{ij} - \sum_{k=1}^{z} P_k\ \Delta q_{kij} - P_m\ \Delta q_{ij} - q_{ij}\ \Delta P_m \geq 0$

Equation 4.3.2 can be written in terms of observations in two periods: t and s. Equation 4.3.3 imposes the restriction indicated by profit maximization that no set of feasible input and output quantities chosen at observation s can result in higher profit using the prices of period t.

(4.3.3) $\quad P^t (y_{ij}^s - y_{ij}^t) - \sum_{k=1}^{z} P_k^t\ (q_{kij}^s - q_{kij}^t) - P_m^t(q_{ij}^s - q_{ij}^t) - q_{ij}^s(P_m^s - P_m^t) \leq 0$

Where the superscripts t and s specify the value of the data for observations t and s (note t ≠ s). If the firm is competitive in all markets the last term in equation 4.3.3 ($q_{ij}^s(P_m^s - P_m^t)$) drops out because the firm does not effect any prices by changing quantities bought and sold. Equation 4.3.3 is then equivalent to the Weak Axiom of Profit Maximization (Varian 1984). When input supply is upward sloping and $q_{ij}^t \geq q_{ij}^s$, equation 4.3.3 becomes a more rigorous condition than WAPM.[44] Equation 4.3.3 is a more rigorous condition than WAPM because it implies that a corresponding increase in the input price over which the firm has monopsony power from observation s to t implies that the last term in equation 4.3.3 is positive (Love and Shumway 1994).

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[43] Note that $\overline{P}$ defined in section 4.2 is the vector of to P_k s (i.e.., $\overline{P} = P_k$ where k=1 to z).
[44] A firm with monopsony power perceives its input supply curve to be upward sloping.

Equation 4.3.3 depends on the assumption that the supply curve does not shift and there is no inflation (Love and Shumway 1994). Prices are deflated to avoid spurious shifts in the input supply and demand functions. The input supply curve may shift due to changes in a firms' technology. Love and Shumway (1994) also allow for the possibility of technical change in their monopsony power test. Hicks-neutral positive and negative technical changes are introduced into the model (equation 4.3.4).

(4.3.4) $y_i^t = Y_i^t - a_i^{t+} + a_i^{t-}$

Where y_i^t is redefined as "effective" by Love and Shumway (1994), Y_i^t is now observed output, a_i^{t+} is positive neutral technical change, and a_i^{t-} is negative neutral technical change. Love and Shumway (1994) note that shifts in the input supply function not compensated for by shifts in the input demand curve lead to movements in prices and quantities in opposite directions. Monopsony power may not cause these movements therefore observations with this occurrence are not used in the Love and Shumway test. When $P_m^t - P_m^s$ ^{s} $q_i^t - q_i^s$ where ^{s} means different signed observations must be deleted.

The presence of monopsony power can be determined by directly checking equation 4.3.3 for each s and t in the data set. Assuming no technical change, if it is found that equation 4.3.3 holds for all s and t then the firm has exercised positive monopsony power in all periods (Love and Shumway 1994). Assuming no technical change, if it is found that equation 4.3.3 does not hold for all s and t then the firm has no monopsony power. Love and Shumway (1994) develop an alternative test from which the monopsony power Lerner index can be recovered and a parameter of technical change can be determined. Love and Shumway (1994) specify a linear programming model that embeds equation 4.3.3. Dropping the index for milk shed (j), the test for monopsony power for a single production region is defined by equation 4.3.5:

(4.3.5) Objective $= \min(a_i^{t+}, a_i^{t-}, m_i^{ts}) \quad \sum_{t=1}^{T} b^{t+} a_i^{t+} + b^{t-} a_i^{t-} + \sum_{s} \sum_{t=1}^{T} c^{ts} m_i^{ts}$

Subject to constraints (i) to (iv):

(i) $P^t \left[(Y_i^t - a_i^{t+} + a_i^{t-}) - (Y_i^s - a_i^{s+} + a_i^{s-}) \, m_i^{ts} \right] - \sum_{k=1}^{z} P_k^s \, (q_{ki}^t - q_{ki}^s) - m_i^{ts} \, (q_i^t - q_i^s) \quad 0$

(ii) a_i^{t+} 0 t

(iii) a_i^{t-} 0 t

(iv) m_i^{ts} 0 $t \; s$

Where m_i^{ts} represent monopsony power terms and t is an index of observations of which there are T. In equation 4.3.5 subscript i is an index of firms present in the market place. The terms

b^{t+}, b^{t-} and c^{ts} are weights that can be introduced given a priori knowledge. The LP model is solved using all observations where s ≠ t except when $P_m^t - P_m^s$ ≥ s $q_i^t - q_i^s$.

The linear programming model defined in equation 4.3.5 determines the existence of monopsony power through determination of a monopsony power parameter (m_i^{ts}) that solve the model for the tested data. The model also yields technical change parameters (a_i^{t+} and a_i^{t-}) that solve for the tested industry data. The monopsony power parameter (m_i^{ts}) relates to the Lerner index as indicated in equation 4.3.6 (Love and Shumway 1994):

$$(4.3.6) \qquad L_i^{ts} = \frac{m_i^{ts}}{P_m^t} \ ,$$

or for the case where there is a single processing firm:

$$(4.3.7) \qquad L^{ts} = \frac{m^{ts}}{P_m^t} \ .$$

The test determines a Lerner index value for each observation pair. When $L^{ts} > 0$ monopsony power is indicated. When L^{ts} (and by implication m^{ts}) is positive equation 4.3.3 holds for observations s and t. Average firm monopsony conduct over the tested observations is determined by averaging L^{ts} values (Love and Shumway 1994).

4.4 Method to Predict Private Market Equilibrium

Equilibria for private markets need to be predicted to compare performance under different market structures. Welfare levels under DDC production can be obtained by using a partial equilibrium model calibrated with the observed DDC price-quantity equilibrium. However, a private equilibrium must be predicted. These market equilibria are predicted from market data for a year that only the DDC produced cheese and from empirical estimations of firm market power behavior (see section 4.1 for an overview). The data required include DDC cheese price, quantities of cheese produced in the milk sheds, and supply and demand elasticities.

The private market equilibrium is determined as the solution to a system of simultaneous equations that represent market conditions. The sum of quantities from individual milk sheds is consistent with the price and quantity relationship defined by the aggregate cheese demand function. Equilibrium in each milk market is ensured because each shed cheese supply is directly determined from the shed milk supply function. Monopsony behavior in the milk markets is represented through equations relating the number of firms in a milk shed to milk shed size. The Lerner index of monopsony power is tied to the number of firms in the milk shed.

The model used to predict private market equilibrium is linear.[45] The models cheese supply and demand are linear functions determined from econometric estimation of own price elasticity. The model used to predict private market equilibrium also functions as the partial equilibrium model to estimate market performance criteria.

4.4.1 The Cheese Market Demand Function

Wholesale yak cheese demand (equation 4.4.1) is represented in the model using a linear functional form (see above for discussion of linearity). The demand function is calibrated from the observed DDC price-quantity equilibrium and the elasticity of wholesale yak cheese demand that was estimated using market data.

(4.4.1) $P = S_d Q + b_d$

where P and Q are the price and quantity of marketable yak cheese. The slope (S_d) and intercept (b_d) are parameters calculated based on geometrical relationships defined by the estimated milk demand elasticity (ϵ_d) and observed price-quantity equilibrium (see equations 4.4.2, 4.4.3 and figure 4.2). The intercept term (b_d) incorporates the difference between private and DDC cheese quality.

(4.4.2) $S_d = \dfrac{P^*}{Q^*} \quad \dfrac{1}{\epsilon_d}$

(4.4.3) $b_d = b_d^* - (P^* - P^{**})$.

In equation 4.4.3 , b_d^* is the intercept for demand for DDC-quality cheese as defined in equation 4.4.4.

(4.4.4) $b_d^* = P^* + S_d Q^*$

P^* and Q^* are the observed price and quantity of marketed DDC yak cheese for 1991. The elasticity of demand for yak cheese (ϵ_d) is estimated using an AIDS model (see section 5.1 for the estimation of yak cheese demand and the computation of yak cheese demand elasticity). Note the slope for demand for DDC and privately produced cheese are assumed to be equal and

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[45] The error from using a linear model is limited because the predicted private equilibrium quantity of cheese sold is close to the observed quantity of cheese sold by the DDC.

$(b_d^* - P^*)= S_d Q^*$ (see figure 4.2). P^{**} is the price of privately produced cheese, and is calculated as follows:

(4.4.5) $$P^{**} = P^* \; \frac{P^{**}_{94}}{P^*_{94}}$$

The price difference between DDC and private cheese is due to quality differences. This difference is accounted for in the wholesale demand function by a downward shift of demand by the price difference $(P^*- P^{**})$. The use of a downward shift in demand to account for the quality difference is based on the observation that wholesalers are indifferent between DDC-produced and private cheese at the lower price. The cheeses can be treated as perfect substitutes in the final retail market because the price for both cheeses is the same. The price gap can be interpreted as a marketing cost to cheese retailers due to the lower quality and associated poor storage qualities of private yak cheese. These problems result in higher losses of privately produced cheese.
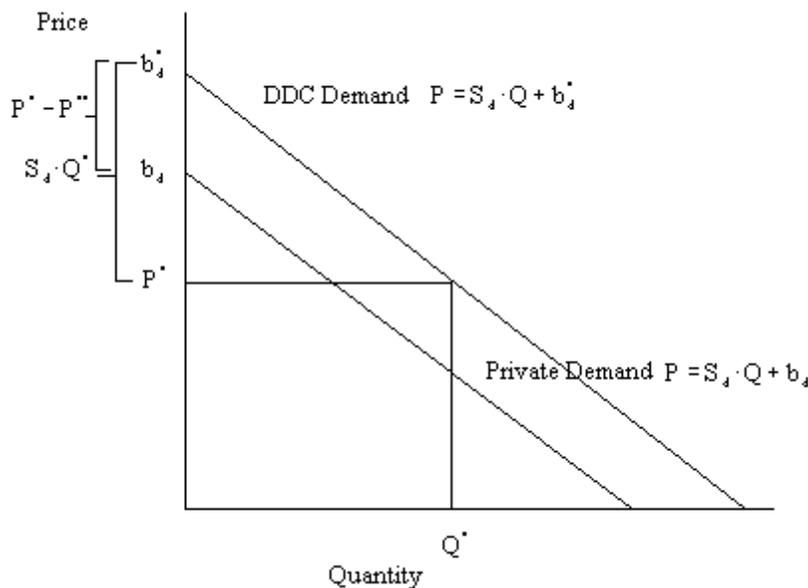
Figure 4.2. Yak cheese wholesale demand.

4.4.2 The Cheese Supply and Marginal Expenditure Functions by Milk Shed

For each of the nine milk sheds where the DDC was operating in 1991, a cheese supply function is defined. Because of data constraints in estimating elasticities for individual milk sheds, the elasticity of milk supply used in the models is constant across milk sheds. Average

transportation cost is included in the processing cost. Transportation cost differences between milk sheds are not entered into the models because these costs are small and are relatively similar across the milk sheds. The cheese supply functions are derived from milk supply functions based on the observed DDC price-quantity equilibrium and estimated elasticity of yak milk supply (equation 4.4.6).

$$(4.4.6) \qquad P_{mj} = S_{msj} Q_{mj} + b_{msj}$$

where: P_{mj} and Q_{mj} are the price and quantity of yak milk for milk shed j. P_{mj} and Q_{mj} are expressed in terms of the amount of milk used by the DDC to produce one kg of marketable cheese. The milk supply slope (S_{msj}) and intercept (b_{msj}) parameters are calculated based on geometric relationships defined by the estimated milk supply elasticity ($_s$) and observed price-quantity equilibrium (equations 4.4.7 and 4.4.8). The geometric relationships are the same as the ones used for estimation of demand slope and intercept (see equations 4.4.2, 4.4.3, 4.4.5 and figure 4.2).

$$(4.4.7) \qquad S_{msj} = \frac{P_m^*}{Q_{mj}^*} \quad \frac{1}{_s}$$

$$(4.4.8) \qquad b_{msj} = P_m^* - S_{msj} Q_{mj}^*.$$

Where P_m^* and Q_{mj}^* are the observed price and quantity of DDC yak milk for milk shed j in 1991. It should be noted that DDC milk price is the same for all sheds. Elasticity of milk supply is also the same across milk sheds.

Supply functions (equation 4.4.9) for privately produced cheese in each milk shed are derived from the milk supply functions by adding a processing cost and an upward shift in the supply function to account for the higher rate of cheese loss in private production:

$$(4.4.9) \qquad P = S_{msj} Q_j + b_{msj} + M_{pr} + PL_{pr}$$

The processing cost (M_{pr}) is calculated from the economic-engineering model of private yak cheese production at the mean of observed private factory production levels (see section 5.6 and appendix A). The price of cheese (P) is the same for firms in all milk sheds. The upward shift (PL_{pr}) accounting for the higher production loss of private producers is calculated as follows:

$$(4.4.10) \qquad PL_{pr} = S_{msj} (Q_{mj}^* - Q_{mrj}^* (1 - Loss_p))$$

where Q_{mrj}^{*} is the raw amount of cheese produced by the DDC in milk shed j before accounting for its losses, and $Loss_p$ is the percentage of cheese lost by private producers (see figure 4.3).
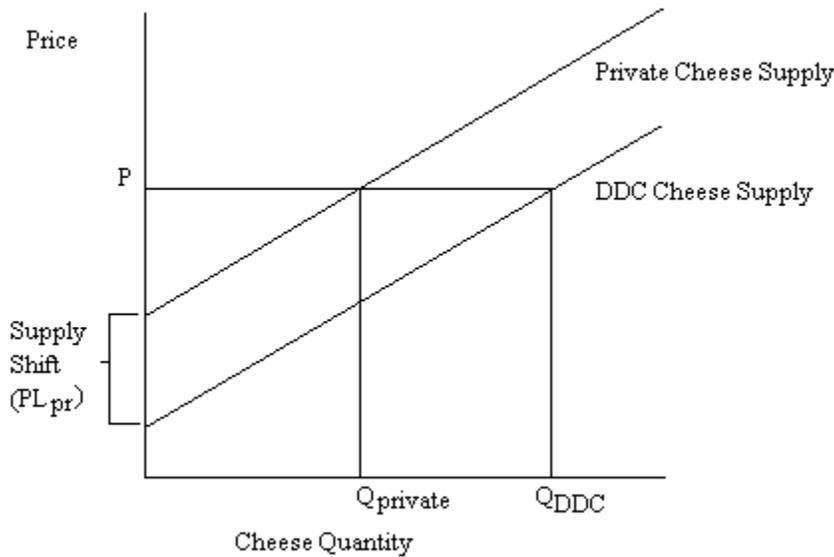
Figure 4.3. Supply shift accounting for higher loss of private producers.

A private firm with monopsony power makes its production decisions based on the marginal expenditure (or marginal outlay) function, which is an increasing function of the input quantity purchased. The marginal expenditure function for the yak milk input in milk shed j ($ME_{Q_{mj}}$) can be expressed as (Nicholson 1989):

$$(4.4.11) \qquad ME_{Q_{mj}} = \frac{\partial (P_{mj} \; Q_{mj})}{\partial Q_{mj}} = P_{mj} + Q_{mj} \; \frac{\partial P_{mj}}{\partial Q_{mj}} .$$

For the linear milk supply functions, the private marginal expenditure functions for yak milk of pure monopsonists are obtained by applying the definition (equation 4.4.11),

$$(4.4.12) \qquad ME_{mj} = P_{mj} + Q_{mj} \; S_{msj}$$

Substituting the definition of P_{mj} (equation 4.4.6) into equation 4.4.12 yields equation 4.4.13:

$$(4.4.13) \qquad ME_{mj} = (S_{msj} \; Q_{mj} + b_{msj}) + Q_{mj} \; S_{msj}$$

Simplifying equation 4.4.13 yields:

$$(4.4.14) \qquad ME_{mj} = 2\, S_{msj}\, Q_{mj} + b_{msj}.$$

The marginal expenditure functions for cheese production are obtained by summing the cheese processing costs and introducing the upward supply shift to reflect the higher cheese loss rate of private producers,

$$(4.4.15) \qquad P = P_j = 2\, S_{msj}\, Q_j + b_{msj} + M_{private} + PL_{pr}$$

where P, as before, is the price of yak cheese, and Q_j is the quantity of marketable yak cheese from milk shed j (note that $ME_{Q_{mj}}$ is equated to cheese price by the monopsonist). The price of yak cheese (P) is equal for all milk sheds (i.e., $P = P_j$). For the case where private producers have constrained market power, the effective marginal expenditure function for a milk shed becomes:

$$(4.4.16) \qquad P = P_j = (1 + {_s}L_j)\, S_{csj}\, Q_j + b_{csj}$$

where L_j is the Lerner index of monopsony power in milk shed j, $S_{csj} = S_{msj}$, and $b_{csj} = b_{msj} + M_{private} + PL_{pr}$ for milk shed j. Under the observed market structure, firm Lerner indexes and shed Lerner indexes are equal (i.e., $L_{ij} = L_j$).[46] Note that when L_j reaches its maximum value (i.e., $L_j = 1/{_s}$) the expression $(1 + {_s}L_j) = 2$. Solving for cheese quantity in equation 4.4.16 yields equation:

$$(4.4.17) \qquad Q_j = \frac{P - b_{csj}}{\left(1 - {_s}L_j\right)S_{csj}}$$

Equation 4.4.17 defines the quantity of cheese produced from a particular milk shed based on the demand function-defined price of yak cheese.

4.4.3 Private Market Equilibrium Equation System

In this section, the system used to predict the private market price and quantity equilibrium is developed. The demand, supply, and marginal expenditure functions introduced in sections 4.1.1 and 4.1.2 are incorporated into the equation system. Monopsony behavior in the milk markets is represented by two equations introduced for each milk shed. The relationship between the

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[46] Lij = Lj because the firms are observed to have similar cost structures, equal market shares and are assumed to have identical conjectures (see section 4.2 for a discussion).

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Lerner index and number of firms in a milk shed is defined in equation 4.4.18. The number of firms in a milk shed is related to milk shed size by equation 4.4.19.

$$(4.4.18) \qquad L_j = a + b \; \frac{1}{N_j}$$

$$(4.4.19) \qquad N_j = c + d \, Q_j$$

L_j is the Lerner index of monopsony power in milk shed j and N_j is the number of firms in milk shed j. The parameters in equations 4.4.18 and 4.4.19 a, b, c, and d are estimated using an equation system that accounts for the endogeneity of the number of milk producers in each milk shed, milk shed size and the Lerner index (see section 4.5 for the theoretical basis for this relationship and section 5.3 for estimation of the relationship).

The simultaneous system can now be defined as follows in equations 4.4.20 to 4.4.24 (also see Table 4.2 in section 3.7 for a summary of the system):

Demand Equilibrium Equations:

$$(4.4.20) \qquad P = S_d \, Q - b_d \qquad \qquad \text{(Wholesale demand in Kathmandu)}$$

$$(4.4.21) \qquad Q = \sum_{i=1}^{N} Q_j \qquad \qquad \text{(Supply is the sum of milk shed supplies)}$$

Milk Shed Marginal Expenditure Functions:

$$(4.4.22) \qquad Q_j = \frac{\left(P - b_{csj} \right)}{\left[\left(1 + {}_s \, L_j \right) S_{csj} \right]} \qquad \qquad \text{(Quantity of cheese produced by shed)}$$

Milk shed Lerner index:

$$(4.4.23) \qquad L_j = a + b \; \frac{1}{N_j} \qquad \qquad \text{(The effective Lerner index by shed)}$$

Relationship between milk shed size and number of firms:

$$(4.4.24) \qquad N_j = c + d \, Q_j \qquad \qquad \text{(The number of firms by shed)}$$

In the system, N is the total number of milk sheds which is equal to nine, the number of DDC cheese factories operating in 1991. The endogenous variables are L_j, N_j, Q, q_j, and P. The system consists of 29 equations. The endogenous variable for number of factories per milk shed (N_j) must be treated as an integer variable when solving the system. The system yields cheese price, cheese quantity, cheese quantity per cheese shed, Lerner index by shed, and factory number by shed. The market performance criteria can then be calculated from a partial equilibrium model calibrated with the predicted private solution.

It should be noted that the effective cheese supply equation is directly determined from the shed milk supply firm and the Lerner index. This relationship ensures that each milk shed is in equilibrium. Milk price by shed can be calculated from the defined milk supply functions.

Two additional private market partial equilibria are calculated with modifications to the equation system (equations 4.4.20 to 4.4.24). A market equilibrium for private firms that maintain competitive conjectures is calculated by setting the Lerner index to zero (e.g., a = b = 0) in the equation system. The system is solved as before.

The impact of institutional constraints on market performance that result from private firms producing sub-optimal quality cheese is examined. To do so the equation system incorporates modified private firm cost structure (See sections 2.3 and 2.4 for a discussion of institutional constraints). The private firm cost structure is modified based on expert opinion and information gathered from participatory appraisals with private producers and cheese experts. The changes in cost structure are introduced into the equation system through changes in private firm processing cost, private cheese price, and the percentage of cheese lost in production (See section 5.6).

4.5 Theory for Econometric Estimation of Private Firm Market Power Behavior

The validity of the method for predicting private firm equilibrium in section 4.4 depends on correct characterization of private market power behavior. Specifically, it must be shown that the relationship between the Lerner index and the number of firms is theoretically justified. It must also be shown that the relationship between the number of firms in a milk shed and milk shed size is theoretically justified.[47] In this section these relationships are specified and an econometric method to account for the endogeneity of the relationships is presented.

Econometric estimation is used for three reasons: (1) there is an endogenous relationship between the Lerner index and the number of firms in a milk shed, (2) it permits statistical validation of relationships, and (3) it allows for separation of effects between the number of

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[47] Milk shed size is measured by production level of milk/cheese.

firms and the existence of a DDC factory in the milk shed on the Lerner index. The statistical results from estimation are presented in section 5.3. The system specified in this section depends on the validity of the method developed to compute the Lerner index from observed private behavior. This method for estimating the Lerner index is presented in section 4.5.2.

4.5.1 System Estimation of Private Firm Market Power Behavior

The parameters a, b, c, and d used in the equations 4.4.23 and 4.4.23 come from estimation of the system defined by equations 4.5.1 and 4.5.2:

(4.5.1) $\qquad L_j = a + b \dfrac{1}{N_j} + \gamma_2 DDC_j + \epsilon_{1j}$

(4.5.2) $\qquad Q_j = \beta_0 + \beta_1 L_j + \beta_2 Low_j + \beta_3 high_j + \epsilon_{2j}$

(4.5.3) $\qquad N_j = c + d\, Q_j + \epsilon_{3j}$

Endogenous variables are the Lerner index (L_j) calculated for each private milk shed observation using the method in section (4.5.2), the number of private factories in milk shed j (N_j), and the amount of cheese produced in private milk shed j (Q_j). Instrumental variables used are DDC, high, Low and District. DDC is a dummy variable for the presence of a DDC factory in proximity to the private milk shed, low and high are dummy variables for factory elevation and district is a dummy variable for district location. Yak cheese factories are located in four districts. A dummy variable is specified for the adjacent districts (district). The coefficients a, b, c, and d are used as the parameters in equations (4.4.23) and (4.4.24). The system is estimated from data for private producer behavior by milk shed in the years 1994 and 1996 (see below and section 5.3 for a detailed description of the data).

The relationship between the Lerner index for the milk shed and the number of firms estimated in equation 4.5.1 results directly from the theoretical relationship in equation 4.2.14. This relationship, in turn, is derived from the profit maximization problem of a private firm with potential monopsony power (see section 4.2):

(4.2.14) $\qquad L_j = \dfrac{1}{N_j \epsilon_s} \left(1 + \dfrac{Q_j^*}{Q_j} \right).$

Equation 4.2.14 shows a direct and indirect reciprocal relationship between the Lerner index and the number of firms. The indirect reciprocal relationship between Lerner index and the number of firms stems from empirical evidence about the nature of the conjectural variation term

$\dfrac{Q_j^*}{q_{ij}}$. There is strong empirical evidence to expect a decrease in the value of the conjectural

variation term as the number of firms in a milk shed increases Scherer and Ross (1990) (see discussion in section 3.3). A decrease in the value of the conjectural variations term results in a decrease in the Lerner index of market power. The elasticity of milk supply ($_s$) is not included in the equation system because econometric estimation of individual milk sheds elasticities was not possible.

The dummy variable for a DDC factory is included because the presence a DDC factory has an

influence on the conjectural variations $\dfrac{Q_j^*}{q_{ij}}$ of private firms operating in proximity to a DDC

factory. DDC factories near private factories set a floor price that private factories must exceed to obtain milk. Private firms must offer a premium above DDC price because the DDC is considered more reliable in fulfilling contract terms. In fact, in all private milk sheds near a DDC factory, private milk price is observed to be higher than DDC milk price. The use of a dummy variable for DDC presence controls for the effect of the DDC price floor on private producers.

The relationship between shed size (Q_j) and Lerner index (L_j) in equation 4.5.2 is based on the fact that a higher Lerner index will decrease the amount of an input purchased (*ceteris paribus*). Dummy variables for elevation are included based on the observed relationship between altitude and factory production levels. Cheese factories at higher elevations process less milk due to the lower productivity of pastures at higher altitudes. The dummy variable for the DDC is not in equation 4.5.2 because the DDC presence is reflected by the value of the shed Lerner index.

Firm number (N_j) is related to milk shed size (Q_j) in equation 4.5.3 on the basis of a minimum efficient firm size argument. The argument is that firms below a threshold level of production cannot produce at a competitive cost. Since observed markets are small, currently supporting 1, 2, or 3 firms, collusive and non-collusive Cournot type conjectures result in economic profits. There is a potential inconsistency with the MES argument that the number of firms is limited by milk shed size. This inconsistency stems from a technical aspect of cheese production.

Cheese production capacity depends on the size of the copper milk pot used to make cheese. All factories use a standard 300 liter capacity copper pot. Even in markets with multiple factories, cheese factories are observed not to be using their 300 liter copper pots at capacity. This under-utilization indicates that firms have not achieved MES in a technical sense.

The MES argument can also be made on the basis of institutional constraints. Such constraints can raise private production costs dramatically at higher levels of production. Employers in

Nepal need to monitor employees closely due to pervasive shirking. They must also monitor employees to prevent corruption. Private cheese production requires owner supervision during frequent marketing trips to Kathmandu to ensure that employees do not under-report cheese revenue and protect cheese properly during transportation. Additionally, owners must closely supervise cheese storage in villages located at some distance from their factories to ensure proper salt treatment and protection of cheese from a harsh environment. Private cheese producers can partially rely on family members for supervision. However, this resource is limited and not a perfect substitute for the owner's supervision.

Given the above institutional constraint, equation 4.5.3 can be thought of as defining firm size in an MES framework. An alternative explanation of why firms are not producing at capacity would be that the observed market behavior represents lags in adjustment. If firms are in an adjustment phase and eventually will increase in size to take advantage technical efficiencies, average firm size should be increasing over time. However, average firm size has decreased marginally from 1994 to 1996, indicating that if anything firms are now even less efficient in a pure technical sense.

The district dummy variable is used across equations as an instrument. This variable reflects differences in ethnicity for factory owners and milk producers.   Equations 4.5.1 to 4.5.3 have to be estimated as a system due to the two-way nature of the relationships between Lerner index, firm number and firm size. The econometric results are obtained using the full information maximum likelihood estimator from the iterative three-stage least squares method. Results are presented in section 5.3. Estimates will provide a reliable short-term means of predicting private market equilibrium and performance measures. There is strong potential that the method represents longer-term results given that average private firm size is not increasing.

4.5.2 Estimation Method for Private Firm Lerner Index

To estimate the equation system for private producer monopsony behavior (equations 4.5.1 to 4.5.3), a Lerner index is calculated each for milk shed. The Lerner index is calculated for 14 observations of private firm behavior in 1994 and 1996. Each observation represents the observed milk price and quantity in milk sheds with private producers. The method draws heavily on relationships derived in section 4.4.

The reciprocal of the Lerner index is a measure of the elasticity of the perceived input supply curve. A firm with pure monopsony power makes its production decisions based on the marginal expenditure ME (or marginal outlay MO) function (equation 4.4.11 shown below) which is an increasing function of the quantity of the input purchased (see section 4.4):

$$(4.4.11) \qquad ME_{Q_m} = \frac{\partial(P_m \, Q_m)}{\partial Q_m} = P_m + Q_m \, \frac{\partial P_m}{\partial Q_m} \, .$$

The variables in equation 4.4.11 are as defined as in section 4.4. A linear approximation of the cheese marginal expenditure function is derived from the estimated milk supply functions (equation 4.4.16 shown below, see section 4.4.2 for the derivation).

$$(4.4.16) \qquad P = P_j = (1 + {}_sL_j) \, S_{csj} \, Q_j + b_{csj}$$

Where L_j is the Lerner index of monopsony power in milk shed j, $S_{csj} = S_{msj}$, and $b_{csj} = b_{msj} + M_{private} + PL_{pr}$ for milk shed j. Under the observed market structure, firm Lerner indexes and shed Lerner indexes are equal (i.e., $L_{ij} = L_j$). Note that when L_j reaches its maximum value (i.e., $L_j = 1/{}_s$) the expression $(1 + {}_sL_j) = 2$. Solving for cheese quantity in equation (4.4.16) yields:

$$(4.5.4) \qquad L_j = \frac{P^*_{cheese} - S_{msj} \, Q^*_{cheesej} - b_{msj} - M}{{}_s \, S_{msj} \, Q^*_{cheesej}} \, .$$

P^*_{cheese} is the market price of private cheese that does not vary across milk sheds, and Q^*_{cheese}, is the quantity of cheese produced by private producers in the milk shed j. All other terms are as defined in section 4.4.2. Equation 4.5.4 is used to calculate the Lerner index for private producer behavior in milk sheds. The Lerner indexes are then used to estimate behavior for the private firms as described in section 4.5.1. The price and quantity of cheese produced by private firms are obtained from the participatory appraisals with private cheese producers conducted in 1994 and 1996. The milk supply elasticity is econometrically estimated. Due to reliance on an economic-engineering model the method is not ideal but necessary due to data constraints. Appendix B presents an alternative method to determine market power.

4.6 Methods to Determine Baseline DDC Market Behavior

Baseline competitive and pure market power behavior of the DDC are determined as a solution to an equation system imposing market conditions and the predicted firm behaviors. Cheese demand, shed milk supply and shed cheese supply functions used for determination of baseline models are.

$$(4.6.1) \qquad P = S_d \, Q - b_d \qquad\qquad \text{(Market cheese demand function)}$$

$$(4.6.2) \qquad P_m = P_{mj} = S_{msj} \, Q_{mj} + b_{msj} \qquad\qquad \text{(Shed milk supply functions)}$$

(4.6.3) $P = S_{cj} Q_j + b_{msj} + M_{DDC}$ (Shed cheese supply functions)

P_m is the price of milk (in cheese units) that the DDC holds constant across milk sheds; Q_{mj} is the quantity of milk (in cheese units) produced in milk shed j; S_{msj} is the shed milk supply function slope; b_{msj} is the shed milk supply function intercept; M_{DDC} is the processing cost of cheese exclusive of milk cost that does not vary across milk sheds; S_{cj} is the shed cheese supply function slope (note $S_{cj} = S_{msj}$); S_d is the demand slope; and, b_d is the demand intercept. The methods used to calculate these terms are presented in section 4.4.

4.6.1 The Competitive Market Equilibrium

The equilibrium under an assumption of competitive behavior is obtained by solving for the intersection of the cheese demand and cheese supply functions. The cheese supply function is an aggregate of shed cheese supply functions. The cheese supply functions are simply the estimated milk supply functions with processing cost (M_{DDC}) added (defined above). Equations 4.6.4 to 4.6.5 define the system of equations used to solve for competitive DDC behavior.

(4.6.4) $P = S_d Q - b_d$ (Cheese demand function)

(4.6.5) $P = S_{cj} Q_j + b_{msj} + M_{DDC}$ (Shed cheese supply function)

The index term (j) equals 1 to N, where N is the number of milk sheds. Note that
$Q = \sum_{j=1}^{N} Q_j$ which forces aggregate supply to equal demand. Solution of equations 4.6.4 to 4.6.5 yields the cheese price-quantity equilibrium under competitive DDC behavior. Milk price and quantity can be estimated with the shed milk supply functions evaluated at the equilibrium price of cheese. A partial equilibrium model can be used to estimate market performance criteria.

4.6.2 The Market Power Equilibrium

The equilibrium under an assumption that the DDC takes full advantage of its monopoly and monopsony market power is also examined. Pure market power behavior by the DDC is imposed by solving for the intersection of the marginal revenue function for cheese demand and the marginal expenditure function for cheese supply.

The marginal revenue function for the DDC is defined in equation (4.6.6):

(4.6.6) $MR_{DDC} = \dfrac{\partial(P \cdot Q)}{\partial Q} = P + Q \dfrac{\partial P}{\partial Q}$

Applying the above definition of the MR function for the DDC to the linear demand function specified in equation 4.6.4 yields equation 4.6.7:

(4.6.7) $MR_{DDC} = P + Q\ S_d.$

Substituting the definition of P yields:

(4.6.8) $MR_{DDC} = S_d\ Q + b_d + Q\ S_d.$

Simplifying equation 4.6.8 yields the MR function of the DDC in terms of cheese price:

(4.6.9) $P = 2\ S_d\ Q + b_d.$

The marginal expenditure function is similarly derived (see section 4.4.2). The DDC marginal expenditure function for cheese by cheese shed is defined in equation 4.4.10:

(4.4.10) $P = 2\ S_{cj}\ Q_j + b_{cj}.$

Equations 4.6.10 and 4.6.11 define the system of equations used to solve for market power DDC behavior.

(4.6.10) $P = 2\ S_d\ Q - b_d$ (Cheese MR function)

(4.6.11) $P = 2\ S_{cj}\ Q_j + b_{cj} + M_{DDC}$ (Cheese MR expenditure functions by shed)

where the terms are as defined previously. Solution of equations 4.6.10 and 4.6.11 yields the cheese price-quantity equilibrium assuming the DDC uses its market power. Milk price can be computed with the shed milk supply functions evaluated at the equilibrium price of cheese. A partial equilibrium model can be used to estimate market performance criteria.

4.6.3 Dairy Development Corporation Output Market Behavior

Information is obtained on how the DDC actually behaves in the output market by using the Lerner index of DDC monopsony power. This index is estimated nonparametrically (see sections 4.3 and 5.4). The DDC Lerner index is used to calculate the perceived marginal expenditure function for cheese of the DDC. The function is termed perceived because the DDC is not exercising its full potential market power. The DDC can be viewed to be acting as a pure monopsonist/monopolist that perceives milk supply and cheese demand own price elasticities to be higher than they actually are. The perceived marginal revenue function of the DDC can then

be determined by the intersection of the marginal expenditure function with the observed price-quantity DDC market equilibrium.

In order to estimate the DDC perceived marginal expenditure function from the estimated monopsony Lerner index the perceived DDC cheese supply function must be determined. Equation 4.6.12 defines the aggregate perceived cheese supply function.

(4.6.12) $$P = S_{cper} Q + b_{cper}$$

The slope and intercept terms of the perceived cheese supply function are given by equations 4.6.13 and 4.6.14:

(4.6.13) $$S_{cper} = \frac{P^*}{Q^*} \quad \frac{1}{L} \, ,$$

(4.6.14) $$b_{cper} = P^* - S_{scper} Q^*,$$

where: P^* is the observed DDC price which is the same in all milk sheds and Q^* is the observed total quantity of cheese produced by the DDC (note the star symbolizes a specific value). L is the Lerner index estimated for the DDC using the method described in section 4.3 and estimated in section 5.4. The geometrical relationships used to derived equations 4.6.13 and 4.6.14 are described in section 4.4. The aggregate functions can be used because two conditions are met: (1) milk supply elasticity across milk sheds is the same implying that the aggregate milk supply elasticity is equal to the shed level elasticities and (2) the DDC pays the same price for milk in all milk sheds.

The DDC's perceived aggregate marginal expenditure function (equation 4.5.15) for cheese is derived as before (see section 4.4.2):

(4.5.15) $$P = 2 S_{cper} Q + b_{cper}.$$

The DDC's perceived marginal revenue function is now derived based on its intersection with the perceived marginal expenditure function at the observed DDC price and cheese quantity equilibrium. Equation 4.6.16 defines the perceived marginal revenue function.

(4.6.16) $$P = S_{mrper} Q + b_d$$

where: b_d is the previously defined demand intercept and S_{mrper} is calculated as in equation (4.6.17):

$$(4.6.17) \qquad S_{mrper} = \frac{b_d - ME_p}{Q^*} \ .$$

In equation 4.6.17, ME_p is the price obtained from evaluation of the perceived marginal expenditure function at the observed quantity of cheese produced (Q^*). From the perceived marginal revenue function (4.6.16) the perceived cheese demand function can be obtained as defined in equation (4.6.18).

$$(4.6.18) \qquad D_{cper}(Q) = \int_0^{D_{xint}} MR_{per}(\overline{X})dq \ \frac{1}{Q}$$

where: D_{cper} is the perceived demand function and (D_{xint}) is the x-axis intercept of the perceived demand function. For the linear functional form specified the perceived demand function is defined in equation (4.6.19).

$$(4.6.19) \qquad P = (.5) \, S_{mrper} \, Q + b_d$$

The perceived demand elasticity can be calculated as defined in equation (4.6.20)

$$(4.6.20) \qquad _{dper} = \frac{P^*}{Q^*} \ \frac{1}{(.5) \ S_{mrper}}$$

The effective DDC Lerner index is $1/ \, _{dper}$.

4.7 Chapter Summary

Chapter four establishes the method for evaluating the performance of the yak cheese industry under different market structures. The chapter also presents the development of a method to predict private market equilibrium post DDC privatization. The method developed represents the primary original contribution of the dissertation. The nonparametric test of DDC monopsony power, the method to predict DDC market equilibrium for different DDC market objectives, and the method used to compute the output market DDC Lerner index are also presented (see sections 4.3 and 4.6).

Economic surplus measures, calculated from a partial equilibrium model of the yak cheese and milk markets, are the primary evaluation criteria of market performance. A partial equilibrium approach as opposed to the alternative of using a CGE model is justified because the yak cheese

industry is relatively small and has limited linkages with the larger economy (see section 4.1.1). The use of consumer surplus, as opposed to alternative measures of welfare is justified because consumers spend a small proportion of their budget on cheese, limiting income distortions (see section 4.1.2). Similarly yak cheese producers and yak milk producers consume little of the products they produce, limiting income effects associated with the producer surplus measure. No explicit weighting scheme for surplus measures is adopted. However, among the economic surplus measures, milk producer surplus is the most important criterion because the industry was established to assist herders and they are the poorest group of industry participants. Two additional market performance measures are also calculated: (1) foreign exchange generated, and (2) total industry output.

Section 4.2 presents a theoretical model of private firm behavior given potential monopsony power. The model is fundamental to the development of the nonparametric test of DDC yak milk market behavior (see section 4.3). Section 4.2 also establishes the relationship among the number of firms' in a milk shed, firms conjectures about rivals and the Lerner index of monopsony power (see section 4.2 for a detailed explanation of equation 4.2.10). Equation 4.2.10 establishes the theoretical basis for asserting that market power decreases as the number of firms increases.

$$(4.2.10) \qquad L_{ij} = \frac{\left(MVP_{mij} - P_{mj}\right)}{P_{mj}} = \frac{s_{ij}}{s} \left(1 + \frac{Q_j^*}{q_{ij}}\right).$$

Section 4.4 is the main original contribution of the dissertation. In this section, a system of equations is developed to predict private market equilibrium post DDC privatization. The system ensures market equilibrium in both the yak cheese and milk markets. It also allows for the exercise of market power by firms to vary in the milk sheds based on the number of firms operating in the milk shed. The number of firms in a milk shed is also established endogenously in the system. Yak cheese demand and yak milk supply used in the model are based on elasticities that are econometrically estimated (see sections 5.1 and 5.2). Table 4.2 summarizes the types of equations in the system (see section 4.4 for a detailed presentation and for definitions of the variables in table 4.2).

Table 4.2 Equations used to predict private market equilibria.

Equation Type	Description of the Equation Type
1. $P = S_d Q + b_d$	The wholesale demand for yak cheese in Kathmandu (price dependent).
2. $Q = \sum_{j=1}^{N} Q_j,$	Aggregate supply of yak cheese sold in Katmandu. N is the number of milk sheds (9).
3. $Q_j = \dfrac{\left(P - b_{csj}\right)}{\left[\left(1 + {}_s L_j\right) S_{csj}\right]}$	The effective cheese supply functions for each milk shed. When the Lerner index is at its maximum this formula is the marginal expenditure function. When the Lerner index is zero, this formula is the cheese supply function.
4. $L_j = a + b \dfrac{1}{N_j}$	Defines the relationship between market power (the Lerner index) and the number of firms in a milk shed.
5. $N_j = c + d Q_j,$	Defines the relationship between the number of firms in a milk shed and the quantity of cheese produced in the milk shed.

The parameters for the relationship between the Lerner index and the number of firms (equation four in Table 4.2) and for the relationship between the number of firms and the quantity of cheese produced (equation five in Table 4.2) are obtained econometrically. To account for two-way, effects the parameters are estimated using an equation system utilizing the three-stage-least-squares estimation method (equations 4.5.1 to 4.53, see section 4.5 for details).   The estimation uses data collected in 1994 and 1996 on the behavior of private cheese producers, both in markets with and without DDC yak cheese factories. The method for computing the private producer monopsony Lerner index is presented in section 4.5.2.

(4.5.1) $L_j = a + b \dfrac{1}{N_j} + {}_2 DDC_j + {}_{1j}$

(4.5.2) $Q_j = {}_0 + {}_1 L_j + {}_2 Low_j + {}_3 high_j + {}_{2j}$

(4.5.3) $N_j = c + d Q_j + {}_{3j}$

Chapter five presents both the intermediate estimations required for construction of the models and the model results.

Chapter 5. Estimation

Chapter five presents the estimations required to construct models to evaluate yak cheese industry performance under different market structures. Sections 5.1 and 5.2 present the econometric estimation of the yak cheese demand and yak milk supply elasticities. These elasticities are required for the model to predict private market equilibrium and the partial equilibrium model used to calculate performance criteria. Section 5.3 presents the econometric estimation of private firm monopsony power behavior parameters based on the theoretical presentation in section 4.5. The result of the nonparametric test of DDC market power behavior is presented in section 5.4.

The economic-engineering models of DDC and private cheese production used to obtain the processing costs of converting yak milk to yak cheese are presented in section 5.5. Section 5.5 also shows the impact of institutional constraints on the cost of processing milk to cheese.

Section 5.6 shows the private producer equilibrium predicted from the model developed in section 4.4. Section 5.6 also shows the DDC equilibrium predicted from the model developed in section 4.6. Market performance criteria calculated from the partial equilibrium model described in section 4.1 are presented in section 5.7.

5.1 Econometric Estimation of Yak Cheese Demand

The demand for yak cheese is estimated using the Almost Ideal Demand System (AIDS) developed by Deaton and Muellbauer (1980). The AIDS model allows for the imposition of theoretical constraints that improve estimation results. Specifically the conditions of adding up, homogeneity of degree zero in prices and income, and Slutsky symmetry can be imposed. The AIDS model gives a first-order approximation to any demand system and satisfies the axioms of choice exactly including perfect aggregation over consumers (Deaton and Muellbaur 1980). Results can be interpreted as that of a representative consumer's demand functions. The AIDS model is defined as follows:

$$(5.1.1) \qquad w_i = {}_i + \sum_j {}_{kj} \mathrm{Log}(p_j) + {}_i \mathrm{Log}\{x/P\}$$

where i and j are equal to the number of products in the demand system, p_j is the price of the jth product, x is total expenditure, w_i is the budget share of the ith product, and P is a price index defined as follows:

$$\text{(5.1.2)} \qquad \text{Log(P)} = \beta_1 + \sum_k \alpha_k \text{Log}(p_k) + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \text{Log}(p_k)\text{Log}(p_j)$$

Theoretical restrictions are imposed in the AIDS model through restrictions on the parameters in equation 5.11 that are defined in equations 5.1.3 to 5.1.5.

$$\text{(5.1.3)} \qquad \sum_{i=1}^{n} \alpha_i = 1 \qquad \sum_{i=1}^{n} \gamma_{ij} = 0 \qquad \sum_{i=1}^{n} \beta_i = 1$$

$$\text{(5.1.4)} \qquad \sum_{j=1}^{n} \gamma_{ij} = 0$$

$$\text{(5.1.5)} \qquad \gamma_{ij} = \gamma_{ji}$$

Given that equations 5.1.3 to 5.1.5 hold, the AIDS model imposes the restrictions that total demand system expenditure adds up ($\sum w_i = 1$), homogeneity of degree zero in prices and income, and Slutsky symmetry.

The demand system includes all fresh cheeses marketed in Nepal. This specification stems from an assumption about the nature of consumers' behavior. Weak separability of the direct consumer utility function is assumed (equation 5.1.6)

$$\text{(5.1.6)} \qquad u = v(q_1, q_2, q_3, q_4, q_5, q_6) = f[v_1(q_1, q_2), v_2(q_3, q_4), v_3(q_5, q_6)]$$

In equation 4.1.6 consumer utility (u) is a function of the quantities of goods consumed (q_i, $i = 1$ to 6). Weak separability implies that the utility function v( ) can be expressed as an increasing function (f) which consists of sub-utility functions (v_i, $i = 1$ to 3) that have groupings of the goods as their arguments (Deaton and Muellbauer 1980). The sub-utility functions (v_i) may have only a single good as an argument and weak separability can be extended to include the possibility of further embedding in sub-groupings.

Weak separability is a necessary and sufficient condition to allow for two-stage budgeting where consumers allocate expenditures to broad commodity groups (first-stage) and then allocate expenditure to specific commodities in groups. Figure (5.1) depicts two-stage budgeting for the fresh cheese demand system. Consumers allocate expenditure between food and all other groups and then allocate expenditure within the fresh cheese group consisting of yak, cow and buffalo cheese.
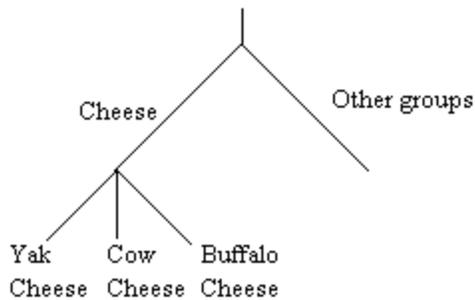
Figure 5.1 Commodity groups and separability.

Weak separability and the implied two-stage budgeting process allow for the estimation of conditional (second stage) demand systems such as the one defined by equation 5.1.1 (Deaton and Muellbauer 1980). The justification for a demand system consisting of fresh cheeses rests on the distinct nature of fresh cheese as compared to other goods available in Nepal.

5.1.1 The Data

The demand system is estimated using monthly data obtained from the DDC on the price and quantity of yak, cow, and buffalo cheese marketed by the DDC (1988-1993). Western tourists purchase almost all the cheese produced in Nepal. However, the DDC markets cheese at a wholesale level to firms that then retail it to consumers. The demand function we estimate is for wholesale yak cheese demand. The DDC was the sole significant producer of cheese from 1988 to 1993. The retail market for cheese is highly competitive with numerous establishments marketing cheese.

The utilized price variables are deflated using the Nepalese CPI for food obtained from the Nepalese Central Bureau of Statistic (CBS 1995). The number of tourists is used in the model as a proxy demographic variable. Colavito (1994) found that cheese demand for lower-income tourists is higher than that of wealthy tourists. The percentage of lower income tourists increases with absolute tourist numbers (Rastriya Bank 1989). The number of tourists by month was obtained from published statistics by the Nepalese ministry of Tourism (1994). Table 5.1 presents summary statistics for the variables.

Twenty-six observations were deleted from the data set due to irrational DDC cheese pricing policy. Cheese production follows a seasonal pattern with production starting with the monsoon in late June and ceasing by mid-November. Rather than raise prices on a seasonal basis, the

DDC rations cheese between the months of February and July (Colavito 1994).[48] The DDC data for the rationed months could not be considered representative. However, for the remaining months of the year, retailers reported being able to buy cheese from the DDC on demand (Colavito 1994).   Retailers are unable to store cheese for extended periods of time due to harsh a harsh environment and a lack of refrigeration capacity.

Table 5.1. Summary statistics of variables used for demand estimation.[a]

Variable	Name	Mean	Std Dev.	Min	Max
Yak cheese sold by the DDC (kg/month)[b]		6129.15	1926.10	3614	10128
Buffalo cheese sold by the DDC (kg/month)[b]		714.97	992.57	70	5065
Cow cheese sold by the DDC (kg/month)[b]		3065.76	1681.92	585	7144
Yak cheese price (Rs./kg)	P_1	154.75	18.31	116	183
Cow cheese price (Rs./kg)	P_2	122.52	15.15	96	147
Buffalo cheese price (Rs./kg)	P_3	108.83	14.60	83	132
Yak cheese expenditure share	w_1	0.68	0.15	0.37	0.9
Cow cheese expenditure share	w_2	0.27	0.14	0.05	0.49
Buffalo cheese expenditure share		0.05	0.06	0.02	0.27
Number of tourists	d	18393.88	5244.93	8509	29239
Number of Observations		34			

[a] Prices are deflated.
[b] These variables enter the model through the expenditure shares.

5.1.2 The Empirical Model

All theoretical restrictions are imposed during estimation. Equations 5.1.7 and 5.1.8 define the AIDS:

$$(5.1.7) \quad \begin{aligned} w_1 &= {}_1 + {}_{11}(\ln P_1 - \ln P_3) + {}_{12}(\ln P_2 - \ln P_3) + {}_1(\ln X - ({}_1(\ln P_1 - \ln P_3) \\ &+ {}_2(\ln P_2 - \ln P_3) + \ln P_3 + {}_{11}Z_1 + {}_{12}Z_2 + {}_{22}Z_3)) + {}_1 d + {}_1 \end{aligned}$$

$$(5.1.8) \quad \begin{aligned} w_2 &= {}_2 + {}_{12}(\ln P_1 - \ln P_3) + {}_{22}(\ln P_2 - \ln P_3) + {}_2(\ln X - ({}_1(\ln P_1 - \ln P_3) \\ &+ {}_2(\ln P_2 - \ln P_3) + \ln P_3 + {}_{11}Z_1 + {}_{12}Z_2 + {}_{22}Z_3)) + {}_2 d + {}_2 \end{aligned}$$

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[48] See section 6.2 for the implications of this behavior for determining DDC objectives.

Where X is total expenditure on cheeses and the variables Z_1, Z_2 and Z_3 are defined in equations 5.1.9 to 5.1.11. The remaining variables are defined in table 5.1.

$$(5.1.9) \qquad Z_1 = \frac{\ln P_1^2}{2} - \ln P_1 \ \ln P_3 + \frac{\ln P_3^2}{2}$$

$$(5.1.10) \qquad Z_2 = \ln P_1 \ \ln P_2 - \ln P_1 \ \ln P_3 - \ln P_2 \ \ln P_3 + \ln P_3^2$$

$$(5.1.11) \qquad Z_3 = \frac{\ln P_2^2}{2} - \ln P_2 \ \ln P_3 + \frac{\ln P_3^2}{2}$$

The AIDS model is estimated using Zellner's non-linear iterative seemingly unrelated regression technique in the SAS package. Estimation is non-linear due to the non-linear restrictions on parameters implied by the AIDS model.

5.1.3 The Results

Model results are presented in Table 5.2. The three parameters needed to compute demand elasticity are tested for significance using a multiple hypothesis test. The Bonferoni procedure for adjusting the nominal probability value is used for the multiple hypothesis test of the three parameters. The overall level of significance selected is .2 resulting in a nominal probability value of .067 for each hypothesis test.[49] At this significance level, the coefficients for the price index of expenditures ($_1$) and the yak cheese price ($_{11}$) are significantly different from zero.

All parameters have their expected signs. The proxy demographic variable, number of tourists visiting Nepal for the yak cheese share equation has a positive coefficient ($_1$). This coefficient for the cow cheese share equation ($_{12}$) is negative. These differing signs for by share equation reflect that with increased tourism, greater numbers of low-expenditure tourists are present and these tourists consume more yak cheese. Conversely, cow cheese (sold more to restaurants) experiences decreased demand as more lower-income tourists are present. These tourists are less likely to frequent restaurants than higher-income tourists.

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[49] The nominal probability value (w) is calculated as follows: w = .2/(no. of tests).

Table 5.2 Demand system results.

Parameter	Estimate	Standard Error
$_1$[a]	0.705575	0.65458
$_2$	0.677908	0.63764
$_1$[b, c]	-0.256188	0.05236
$_2$[c]	0.231139	0.05133
$_{11}$[b, c]	-0.716149	0.36041
$_{12}$	0.342475	0.36847
$_{22}$	-0.025109	0.54035
$_1$[c]	0.257447	0.06877
$_2$[c]	-0.268984	0.06757

Equation	R-Squared
w_1	.55
w_2	.51

Yak Cheese Demand Elasticity[d]	-2.3

No. of Observations	34

[a] This parameter is not found to be significant in the multiple hypothesis test (see text).

[b] These parameters are significant in the multiple hypothesis test (see text).

[c] These parameters are individually significantly different from zero at a significance level of (.05).

[d] The elasticity of yak cheese demand is computed at mean prices and budget shares from (Green and Alston 1990):

$$_{ij} = _{ij} + \frac{_{ij} - _i(_j + _k _{kj}\ln P_k)}{w_i} \quad \text{where: } _{ij} = -1 \text{ when } i = j, \text{ and } _{ij} = 0 \text{ when } i \neq j:$$

The elasticity of demand is found to be highly elastic with a value of -2.3 for yak cheese.

5.1.4 Misspecification Testing

Model misspecification can result in biased and inconsistent estimators Goldberger (1991). The use of biased and inconsistent estimators for policy determination may result in erroneous policy recommendations. For a statistical model to be considered adequate its assumptions must be valid. McGuirk, Driscoll, Alwang and Huang (1995) recommend that econometric model assumptions for single equation models and systems be verified by subjecting the model to a battery of misspecification tests. These misspecification tests should include tests for normality, linearity (functional form), heteroskedasticity, independence, and structural change. The battery of misspecification tests should include joint misspecification tests because isolated individual tests can be misleading. Table 5.3 presents the results of a full-system misspecification test battery applied to the cheese demand system. The battery of tests was applied to the Linear Almost Ideal Demand System (LAIDS) version of the AIDS model specified in equations 5.17

and 5.18 to facilitate test implementation.[50] The tests were implemented using a GAUSS program developed by Dr. Anya McGuirk.

Table 5.3 Full-system misspecification tests for the cheese demand system.[a]

Assumption Tested	Test Type	P-value
Normality	Small test	0.787347
Normality	Multivariate Jarque-Bera	0.068569
Linearity	RESET LR F-test (Rao approx.)	0.944838
Linearity	KG2 Polynomial LR F-test (Rao approx.)	0.556456
Heteroskedasticity	RESET LR F-test (Rao approx.)	0.210820
Independence	Autocorrelation LR F-test (Rao approx.)	0.103774
Structural change	Split-sample LR F-test (Rao approx.)	0.304486
Joint Multivariate conditional mean tests		
Joint conditional mean	Approx. F-test	0.418897
Trend	F-test	0.141554
Linearity	F-test	0.974788
Independence	Autocorrelation F-test	0.392216
Joint Multivariate conditional variance tests		
Joint conditional var.	Approx. F-test	0.254864
Trend	F-test	0.140209
Static HC	Reset F-test	0.119514
Dynamic HC	ARCH F-test	0.317237

[a] The tests are applied to the linear version of the AIDS model specified in equations 5.17 and 5.18.

The battery of misspecification tests is evaluated by the p-values. Informally model misspecification is indicated by p-values less than .02 (personal communication with A. McGuirk 1997). The lowest p-value is .07 for the Jarque-Bera normality test. The alternative small normality test yields a much higher p-value of .8. All p-values for the joint tests are above .11. The full system misspecification p-values reveal that the demand system used to estimated yak cheese demand elasticity can be considered statistically adequate.

5.2 Econometric Estimation of Yak Milk Supply

Yak milk supply for cheese production is estimated for the period 1983 - 1993 when the DDC was the only producer of yak cheese. Since the DDC was the only producer of cheese the amounts of milk processed at its factories represent industry totals. Supply response is estimated using a single equation model. Data needed for estimation with a production function or profit

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[50] The misspecification tests could not be applied directly to the AIDS model due to the non-linearity of AIDS model parameters.

function systems approach are not available. A profit function systems approach includes the joint estimation of input demands and output supplies (Sadoulet and de Janvry, 1995). Estimation using a production function or profit function systems approach allows for the imposition of theoretical constraints that improve efficiency in estimation. Estimation with these approaches requires quantity data on the inputs used in production. Such data are not available for either milk production or DDC cheese production.[51]

Yak milk supply for cheese production is estimated with a single equation Nerlovian-type model. The prices of outputs and inputs are included in Nerlovian models. The inclusion of these prices in the Nerlovian supply function is based on the theoretical properties of supply functions as derived from a producers' profit maximization problem. The derivation for a supply function presented below follows closely Beattie and Taylor (1985). The indirect profit function for an agricultural producer with two possible outputs and two inputs is:

$$
\begin{aligned}
\tilde{} = &\; p_1 \; y_1^*(p_1, p_2, r_1, r_2) + p_2 \; y_2^*(p_1, p_2, r_1, r_2) \\
&- r_1 \; x_1^*(p_1, p_2, r_1, r_2) - r_2 \; x_2^*(p_1, p_2, r_1, r_2)
\end{aligned}
$$

(5.2.1)

Where: p_1 and p_2 are prices of agricultural outputs, r_1 and r_2 are the prices of inputs, $y_1^*()$ and $y_2^*()$ are supply functions and, $x_1^*()$ and $x_2^*()$ are factor demand functions. The indirect utility function (equation 5.21) can be written as:

(5.2.2) $\qquad \tilde{} = \tilde{}(p_1, p_2, r_1, r_2).$

The supply functions for agricultural producers can be obtained from the indirect profit function by using a result of the envelope theorem known as Hotelling's lemma. To obtain the supply functions, the indirect profit function (5.2.2) is differentiated with respect to output prices:

(5.2.3) $\qquad \dfrac{\tilde{}}{p_1} = y_1^*(p_1, p_2, r_1, r_2),$

(5.2.4) $\qquad \dfrac{\tilde{}}{p_2} = y_2^*(p_1, p_2, r_1, r_2).$

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[51] There are 12 years of DDC data with selected input quantities. However, these data are aggregated across factories and not sufficient to estimate a supply response function for milk. The data is used for the nonparametric estimation of DDC market power behavior which requires only limited numbers of observations (see sections 4.3 and 5.4).

The prices of inputs and outputs should be included in the supply function. The basic Nerlovian model incorporating partial adjustment and price expectations is:

$$(5.2.5) \qquad q_t^d = \quad_1 + \quad_2 p_t^e + \quad_3 z_t + u_t,$$

where q_t^d is the desired level of production in period t, p_t^e is a vector of expected prices and z_t is a vector of exogenous shifters. The desired production level (q_t^d) may differ from the actual production level because full adjustment from past production may not be possible in a single period. The vector of prices (p_t^e) includes the price of the commodity itself, prices of competing commodities (potential outputs) and prices of production inputs. Expected prices may differ from observed prices due to the lag between production decisions and sale of the commodity. Exogenous factors (z_t) in equation 5.2.6 could include private and public fixed factors and variables describing weather that affect the productivity of inputs.

5.2.1 The Data

The empirical model includes milk quantity (kg), DDC milk price (Rs./kg), ghee price[52] (Rs./kg), wage rate (Rs./per day), and maize flour price (Rs./kg). Summary statistics for these variables are presented in table 5.4.

The model is estimated using panel data. Observations are yearly for the period 1983 -1993 for each factory site of the DDC. The quantity of milk used for yak cheese production and the price paid to herders for their milk by factory site were obtained from DDC records. The prices for ghee and maize flour used are national average prices for the hills obtained from statistical publications of the Nepalese ministry of agriculture (DFAMS 1994).[53] An average national urban wage rate was obtained from published data of the Nepalese central bank (Rastriya Bank 1995). Data on rainfall were obtained from published material from the Nepalese Central Bureau of Statistics (CBS 1995). The rainfall data are for the Kathmandu valley which is centrally located south of the factory sites. Prices were deflated by Nepalese CPI indexes published by the Nepalese Central Bank (Rastriya Bank 1995).

Data observations for the year 1990 were not used due to the impact of the Nepalese Movement to Restore Democracy on the production patterns of herders. Many herders refused to supply milk to the DDC during the movement. Observations from two factory sites that experienced partial milk strikes were also not used. Data for eight factory sites was used. Data for two factory sites was not used due to reported milk strikes.

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[52] Clarified butter
[53] Data by factory site are not available.

Table 5.4. Summary statistics of variables used for supply estimation.[a]

Variable	Mean	Std. Dev.	Minimum	Maximum
Milk quantity (kg)	74131	53149.33	2350	188697
Milk price (Rs./kg)	3.78	0.49	2.22	4.90
Wage rate (Rs./per day)	20.23	3.09	15.97	26.54
Ghee price (Rs./kg)	45.93	2.12	42.19	48.17
Maize flour price (Rs./kg)	2.87	0.25	2.53	3.44
Amount of Rain (mm)	1787	210.08	1383	2086
Number of Observations	74			

[a] Prices are deflated.

5.2.2 The Empirical Model

The yak milk supply model is based on the Nerlovian model defined above. A number of assumptions are made on the basis of information specific to Nepalese yak milk production. The empirical model is:

$$(5.2.6) \quad Log(Q_t) = \beta_0 + \beta_1 Log(P_{mt}) + \beta_2 Log(P_{gt}) + \beta_3 Log(W_t) + \beta_4 Log(Ma_t)$$
$$+ \beta_5 Log(R_t) + \beta_6 D_{1t} + \beta_7 D_{2t} + \beta_8 D_{3t} + \beta_9 D_{4t} + \beta_{10} D_{5t}$$
$$+ \beta_{11} D_{6t} + \beta_{11} D_{7t} + \beta_{12} T_t + \epsilon_t$$

where: Q = milk quantity, P_m = milk price, P_g = ghee price (lagged), W = wage rate (lagged), Ma = maize price (lagged), R = amount of rain, T = a time trend and D_i (i = 1 to 8) are dummy variables for factory location.

There is an implicit assumption that expected yak milk price is equal to the observed milk price. This assumption can be made because the DDC sets yak milk price before the production season begins which allows herders to make their production decisions with perfect knowledge of the price.

The price of ghee (clarified butter) is included in the supply model because ghee is a commodity that competes with yak cheese for herders' milk. Herders have the ability to produce ghee themselves at the time of milking. The implicit price of milk given by observed ghee price is lower than the DDC price for yak milk. However, production of ghee frees herders from remaining in proximity to DDC factories and reduces the labor needed for carrying milk to DDC factories. Herders require minimal amounts of variable inputs and capital to produce ghee. Ghee production requires firewood which is free to herders and plentiful in most areas of yak herding. The price of ghee is introduced as a variable lagged by one period because herders at

the time of production decisions do not have perfect expectations with respect to the price of ghee. Herders must decide upon their herding route before the season begins and take their ghee to markets at the end of the production season. Herders isolated in the hills also lack current information on ghee market prices.

The daily urban wage rate is included in the model due to reference in the literature that yak herders are increasingly sending their children to urban areas to seek wage employment (HMG/DANIDA 1991). A reduction in family members involved in herding decreases herder ability to produce and transport milk to DDC factory sites. Wage rate is introduced in the supply model as a lagged variable because herders at the time of production decisions do not have perfect knowledge of casual wage rates that would prevail during the production season. Family decisions on the allocation of labor are made before the start of yak milk production season.

The price of maize flour is included in the model because herders use maize as a feed concentrate during the late winter and early spring months. Maize flour price is introduced in the model as a variable lagged by one year because farmers make the decision to plant and save their own maize for feed use based on the prices available at the time of harvest in the previous year. Farmers do not report purchasing maize for feed concentrate at the time of use. It should be noted that storage of maize results in high losses because of pervasive pest problems and that at the time they use maize concentrate they are not able to transport saved maize to markets. Their effective choice for maize to feed their yaks is made at harvest time.

The amount of rain is used because of its potential to affect the productivity of grazing land which is the primary feed input for the production of yak milk. Dummy variables for factory location are included in the model to account for fixed effects by location. A separate dummy variable is included for each milk shed (i.e., d_i=1 for observations from the specified factory otherwise d_i=0 where i = 1 to 7)).

There is an implicit assumption in the supply model that herders are able to adjust their production levels to desired levels (q_t^d) within a single period. This assumption rests on two observed facts. Given that herders will produce milk, the essential decision they face is whether to produce ghee or to sell to the DDC. This decision is made on a yearly basis by their route choice. Absolute numbers of dairy animals and their productivity in the cheese producing region are reported not to have changed substantially during the period of estimation (Miller 1994). This indicates that herders' choice of animal numbers and hence decision to produce milk is stable. Variables in the model are expressed logarithmically so that the coefficient ($_1$) of milk price can be interpreted as the elasticity of milk supply.

5.2.3 The Results

The results are presented in Table 5.5. The four parameters for milk price (β_1), ghee price(β_2), wage rate (β_3), and maize flour price (β_4) are tested for significance using a multiple hypothesis test. These parameters can be interpreted directly as elasticities. The Bonferoni procedure for adjusting the nominal probability value is used for the multiple hypothesis test of the four parameters. The overall significance level selected is .2 resulting in a nominal probability value of .05 for each hypothesis test.[54]   At this significance level, the coefficients for yak milk price (β_1) and ghee price (β_2) are significantly different from zero.

Table 5.5 Milk Supply estimation results.

Variable	Parm.	Estimate	Error
Intercept[c]	β_0	25.711815	7.98583627
Yak milk price[b,c]	β_1	2.126262	1.00035410
Ghee price[b,c]	β_2	-1.969408	0.97819933
Wage rate[a]	β_3	-3.003296	2.13043901
Maize price[a]	β_4	0.686634	1.10777989
Rain amount	β_5	-0.118626	0.50526276
D_1	β_6	0.379945	0.20188511
D_2[c]	β_7	-0.557244	0.21446290
D_3[c]	β_8	-0.985151	0.20282358
D_4[c]	β_9	-1.751843	0.22844059
D_5[c]	β_{10}	-1.628421	0.22507467
D_6[c]	β_{11}	-0.694460	0.20374547
D_7	β_{12}	-0.201316	0.20303543
Time trend[c]	β_{13}	0.106402	0.04344160
R-Squared		.76	
F-value		15.00	Prob> (.0001)
No. of Observations		74	

[a] This parameter is not found to be significant in the multiple hypothesis test (see text).
[b] These parameters are significant in the multiple hypothesis test (see text).
[c] These parameters are individually significantly different for a significance level of .05.

The elasticity estimate for yak milk supply for cheese production is 2.13. The high estimated elasticity is not consistent with expectations. Yak cheese production technology is highly

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[54] The nominal probability value (w) is calculated as follows: w = .2/(no. of tests).

traditional. Production methods show little variation in input levels and productivity either across time or location (Miller 1994). A partial explanation of the high elasticity lies in the relationship between yak milk supplied and the price of ghee. The high -1.97 and significant cross elasticity of ghee indicates that yak milk producers exercise their option to produce ghee rather than supply milk to the DDC.

The high and significant cross-price elasticity for ghee is consistent with the exercise of monopsony power by the DDC. This assertion can be made because of the evidence that the DDC is earning economic profits because of monopsony power (see section 5.4 for the nonparametric estimation of DDC monopsony power). If yak milk producers were receiving a competitive price from the DDC they should produce little ghee because ghee has a much lower value than yak cheese.

5.2.4 Misspecification Testing

Table 5.6 presents the results of a battery of misspecification tests applied to the yak milk supply model (equation 5.2.6). See section 5.1.4 for a discussion concerning misspecification testing.

Table 5.6 Yak milk supply equation misspecification tests.

Assumption Tested	Test Type	P-value
Normality	SAS Univariate	.050
Conditional Variance		
Static Homoskedastic	Reset Test	.116
Dyn. Homoskedastic	Reset Test	.826
Joint Test	Reset Test	.831
Condition Mean		
Functional Form	Reset	.052
Parameter Stability	Trend	.060
Joint	Reset	.112

The battery of misspecification tests is evaluated by the p-values. Informally model misspecification is indicated by p-values less than .02 (personal communication with A. McGuirk 1997). The lowest p-value is .05 for the normality test. All p-values for the joint tests are above .11. The misspecification p-values reveal that the equation used to estimated yak cheese supply elasticity can be considered statistically adequate.

5.3 Econometric Estimation of Private Firm Monopsony Behavior

In this section, private firm monopsony behavior is examined using estimates from an equation system. Monopsony power is estimated in terms of a relationship between the Lerner index and the number of firms in a milk shed. In the system, the number of firms per milk shed is related to characteristics of the milk shed. Theoretical justification for the model is presented in section 4.5.

5.3.1 The Data

The milk shed Lerner index, milk shed size, firm number and dummy variables for location, elevation and the presence of a DDC factory are used for estimation of monopsony behavior. Table 5.7 presents summary statistics of the variables used in the specified equation system.

The Lerner index is computed for each milk shed using equation 4.5.4 (see section 4.5.2 for the derivation and variable definitions). Equation 4.5.4 utilizes the estimated milk supply elasticity and the processing cost of cheese determined from an economic engineering model (described in section 5.5).

$$(4.5.4) \qquad L_j = \frac{P^*_{cheese} - S_{msj} \ Q^*_{cheesej} - b_{msj} - M}{_s S_{msj} \ Q^*_{cheesej}}$$

Milk shed size, as measured in marketable kg's of cheese, and shed firm numbers were obtained from participatory appraisals conducting in 1994 and 1996 with private yak cheese producers and industry experts.[55] Panel data is used for estimation with six observations from 1994 and eight observations from 1996.

The dummy variable for the presence of a DDC factory equals one when there is a DDC factory in proximity to a milk shed and zero otherwise.[56] The dummy variable for location groups adjacent districts. There are five districts with cheese factories. There are two dummy variables for factory elevation, high and low.[57]

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[55] Firm size was reported to be equal in milk sheds with multiple private firms.
[56] Proximity refers to the ability of private producers to sell their milk to the DDC factory.
[57] The base category for the elevation dummies is average elevation.

Table 5.7. Summary statistics of variables used for estimating monopsony power.

Variable	Mean	Std. Dev.	Minimum	Maximum
Shed Lerner index	0.31	0.10	0.15	0.45
Shed Total Size (Cheese kg)	6107.14	42	2000	13000
Number of Firms per Milk Shed	1.50	0.76	1	3
Number of Observations	14			

5.3.2 The Empirical Model

The equation system as follows:

(5.3.1) $\qquad L_j = a + b\,\dfrac{1}{N_j} + \_2\,DDC_j + \_{1j}$ $\qquad\qquad$ (Lerner Index)

(5.3.2) $\qquad Q_j = \_0 + \_1\,L_j + \_2\,Low_j + \_3\,High_j + \_{2j}$ (Milk Shed Size)

(5.3.3) $\qquad N_j = c + d\,Q_j + \_{3j}$ $\qquad\qquad\qquad$ (No. of firms in a milk shed)

where L_j is the Lerner index in milk shed j, N_j is the number of firms in j, Q_j is the size of the (measured in cheese kg's), DDC_j is the dummy variable for the presence of a DDC factory, and $High_j$ and Low_j are the elevation dummies.

L, N, and Q are endogenous variables. DDC, Low, high and district are instrumental variables.[58] The equation system is estimated using the full information maximum likelihood estimator from the iterative three-stage least square's technique.

5.3.3 The Results

Model results are presented in Table 5.8. The four coefficients that are used as parameters in the simultaneous equation system used to solve for private market equilibrium are jointly tested for significance. These parameters include the intercept coefficients (a) and (c), the coefficient on firm numbers (b), and on milk shed size (d). The Bonferoni procedure for adjusting the nominal probability value is used for the hypothesis tests of the four parameters. The overall level of significance selected for the test is .2 yielding a nominal probability value of .05 for each

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[58] District is used as an instrumental variable for all endogenous variables (see section 3.5).

hypothesis test.[59]   At this significance level, all four of the parameters (a, b, c, and d) are significantly different from zero.

The R-squared for the Lerner index and number of firms in a milk shed equations which have the four tested parameters are .76 and .68. R-squared for the milk quantity equation is .3. It should be noted that the system has nine parameters which are estimated from 14 observations. Though more observations would improve the estimation, the fact that the needed parameters are significant using just 14 observations indicates that relationships are strong.

Table 5.8 Private monopsony power system estimation results.

Parameter	Estimate	Std. Error
$a^{a,b}$	0.265856	0.05050
$b^{a,b}$	0.136230	0.05988
$_2{}^{b}$	-0.120755	0.02068
$_0$	-1974.14	6771.1
$_1$	17353.26	20712.3
$_2{}^{b}$	9222.42	2760.1
$_3$	-17.580127	1988.3
$c^{a,b}$	0.693131	0.22629
$d^{a,b}$	0.00013212	0.00003196
Equation	**R-squared**	
Lerner index	0.76	
Milk shed size	0.30	
No. of firms in a milk shed	0.68	
Number of Obs.	14	

[a] These parameters are significant in the joint (see text).
[b] These parameters are individually significantly different from zero at a significance level of .05.

Parameters have the expected signs. A strong reciprocal relationship between number of firms and the Lerner index is revealed in equation 5.3.1 by the significance of the coefficient on firm number (b). The significance and negative value of the coefficient on DDC ($_2$) is a strong indication of the validity of the assertion that the presence of a DDC factory acts to induce private conjectures closer to a competitive level (see section 3.6 for a discussion). The number of firms in a milk shed is shown to be strongly dependent on milk shed size by the significance of the coefficient on milk shed size (d) in equation 5.3.3. The finding that the relationship between firm number and milk shed size is significant validates the argument that firms must achieve a minimum efficient size to operate effectively (see section 4.5 for a discussion).

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[59] The nominal probability value (w) is calculated as follows: w = .2/(no. of tests).

5.3.4 Misspecification Testing

This section presents misspecification tests on the econometric model used to estimate private firm behavior and the relationship between market size and the number of firms. For a general discussion of the need for misspecification tests see section 5.1.4. Due to the small sample size (14 observations) system misspecification tests are not used. Instead equations 5.3.1 and 5.3.3 from which model parameters are estimated are tested individually. Table 5.9 presents misspecification test results for the equations used to estimate private firm behavior (equation 5.3.1) and the relationship between market size and the number of firms (equation 5.3.3).

Table 5.9 . Misspecification tests for the private behavior model[a]

Assumption Tested	Test Type	P-value (1)	P-value (2)
Normality	Multivariate Jarque-Bera	0.176391	0.613480
Linearity	RESET test of order 2 F-test	0.226975	0.120474
Linearity	Second-order KG polynomial F-test	0.547383	0.120474
Heteroskedasticity	RESET order 2 F-test	0.821983	0.125792
Heteroskedasticity	Polynomial F-test	0.180185	0.125792
Independence	Modified-LM residual F-test of order: 1	0.396849	0.705740

[a] The p-values in column one refer to tests on equation 5.3.1 and in column two refer equation 5.3.3

The misspecification tests are evaluated by the test p-values. Informally model misspecification is indicated by p-values less than .02. The lowest p-value in table 5.9 is .12 for the linearity tests of functional form. Overall the misspecification p-values reveal that the equations used to estimate private behavior can be considered statistically adequate.

5.4 Nonparametric Test of DDC Milk Market Monopsony Power.

This section presents the nonparametric test of DDC monopsony power. The test provides an estimate of the Lerner index of DDC monopsony power. The theoretical basis for the test (as developed by Love and Shumway (1994)) is presented in section 4.3.

5.4.1 The Data

The Linear programming model defined in section 4.3 is constructed using DDC data. Annual data are available for the years 1982 to 1993. Variables used include quantity and price for yak cheese, yak milk, labor, wood, and salt (see table 5.10). Prices are deflated by Nepalese CPI indexes published by the Nepalese central bank (Rastriya Bank 1995).

The DDC maintains only aggregate data over the entire observation period. Aggregation is across the DDC factories and DDC center costs. The center costs included in the model are labor costs of administration and marketing.

Labor quantity is measured by the number of employees. Employee salaries vary by classification and seniority. Average salary is the total DDC labor cost for yak cheese production divided by the number of employees. The remaining variables were directly reported by the DDC. It should be noted that inputs used include only a partial list of the inputs needed to produce cheese. DDC does not record quantity information for a number of cheese production cost categories. The linear programming model requires input quantity (equation 5.4.1). The variables for which quantity data are unavailable include fuel, maintenance items, chemicals, electricity (for the store room in Kathmandu) and miscellaneous categories. The implication of using a subset of inputs is discussed in section 5.3.3.

Four observations were deleted from the data used to estimate the LP model. The deleted observations failed the required sign test (e.g., $P_m^t - P_m^s$ ^{s} $q_i^t - q_i^s$ where ^{s} means different signed observations must be deleted) described in section 4.3.

Table 5.10. Summary statistics of variables for the nonparametric monopsony test.

Variable Definition	Name in the Model	Mean	Std. Dev.	Min	Max
Cheese quantity (kg)	c	69,959	11,685.31	55,977	86,306
Cheese price (Rs./kg)	cp	66	7.89	56.34	78.527
Milk quantity (kg)	m	733,454	99,585.39	603,579	882,386
Milk price (Rs./kg)	mp	4.62	0.29	4.24	4.97
Labor (No. of workers)	l	127	35.53	90	187
Average Salary (Rs.)	lp	820	65.27	735	922
Wood (kg)	w	11,828	2,080.18	9,277	13,959
Wood (Rs./kg)	wp	1.36	0.054	1.28	1.45
Salt (kg)	s	917	133.78	724	1,079
Salt (Rs./kg)	sp	2.25	0.07	2.12	2.31

5.4.3 The Empirical Model

The LP model to test DDC monopsony power is shown in equation 5.4.1. The subscript for firm (i) is no longer needed because the DDC is the sole producer. Firm milk shed subscript (j) is not needed because DDC data are aggregated across milk sheds.[60]

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[60] Aggregation implies that the test is for overall average DDC conduct in milk markets.

(5.4.1) Objective $= \min(a^{t+}, a^{t-}, m^{ts}) \sum\limits_{t=1}^{T} a^{t+} + a^{t-} + \sum\limits_{s} \sum\limits_{t=1}^{T} m^{ts}$

Subject to constraints (i) to (iv):

(i) $cp^{t}[(c^{t} - a^{t-} + a^{t+}) - (c^{s} - a^{s+} + a^{s-})] - \{[(wp^{t}(w^{t} - w^{s})] + [sp^{t}(s^{t} - s^{s})]$
       $+ [lp^{t}(l^{t} - l^{s})] + [mp^{t}(m^{t} - m^{s})]\} - m^{ts}(m^{t} - m^{s}) \geq 0$

(ii) $a^{t+} \geq 0 \quad \forall t$

(iii) $a^{t-} \geq 0 \quad \forall t$

(iv) $m^{ts} \geq 0 \quad \forall t \; s$

The variables in equation 5.4.1 are defined in table 5.7. The parameters in equation 5.4.1 are defined in section 4.3. Following Love and Shumway (1994) the weight terms b^{t+}, b^{t-} and c^{ts} that are specified in the original model (see equation 4.3.5) drop out because they are assigned a value of one. The value of one is assigned because a priori information on their value is not available. The parameters b^{t+} and b^{t-} are weights on the technical change parameters and c^{ts} is a weight on the monopsony power parameter. The LP model is solved using all observations where $s \neq t$ except when $P_m^t - P_m^s \geq {}^s q_i^t - q_i^s$. Eight observations are used to solve the model (see section 5.4.1). There are 128 constraints in the model distributed as follows: type i 56, type ii 56, type iii 8, and type iv (8). There are ten variables in the LP model.

5.4.4 The Results

The linear programming model is solved using the linear programming package in the Excel program. The model yields 56 monopsony power parameters (m^{ts}). To obtain the Lerner index values from the monopsony power parameters (m^{ts}) the following equation is used (see section 4.3):

$$(5.4.2) \qquad L^{ts} = \frac{m^{ts}}{P_m^t} .$$

The average Lerner index for DDC monopsony power in the milk market calculated by averaging the L^{ts} yielded from equation 5.4.2. The average DDC Lerner index of monopsony power is .33. This value implies a perceived input supply elasticity of 3.03 (e.g., $\varepsilon_s = 1/L$) The actual estimated supply elasticity is 2.13 (see section 5.2) which implies a maximum possible Lerner index of .47. The test reveals that for the years 1982 to 1993 the DDC exercised 70% percent of its potential milk market power. This is a direct contradiction of the DDC's mandate which is to provide a "fair" price to milk producers.

The average value of the Hicks-neutral technical change terms are a^{t+} =130 and a^{t-} = 744. This indicates that both positive and negative Hicks-neutral technical change has occurred. Overall technical change as measured by the difference between a^{t+} and a^{t-} is a negative 614. The units of the technical change terms are cheese kgs. Average observed output (Y^t) is 69,959 (see table 5.7). On the basis of the average level of output technical change over the period was is negative .9%. This indicates that technical change and that provision of unproductive jobs is negligible.

The linear programming model does not include all inputs used to produce yak cheese (see section 5.4.1). For the results to be valid it must be shown that failure to include all inputs does not bias the results (for a list of these variables see section 5.4.1). The assumption that results are not biased is maintained for three reasons: (1) the major variable cost of yak cheese production is from milk and labor costs which minimizes the impact of other inputs, (2) the inputs not included in the model are of a type that do not have major changes in prices, and (3) the variables not entered into the model are not of a type associated with changes in technical efficiency.

5.5 Economic-Engineering Models

Detailed economic-engineering models of public and private yak cheese production were developed for a USAID dairy support project (Colavito 1994). These economic-engineering models are used to calculate the processing cost of converting yak milk into cheese. The processing cost is used to derive cheese supply functions from estimated milk supply functions. The cheese supply functions are then used to predict in the markets with private producers. The supply functions are also used to construct the partial equilibrium models. The estimated processing cost is also needed to calculate the private producer monopsony Lerner index by milk shed.

The impacts of institutional constraints are incorporated into the economic-engineering models. The private processing cost is recalculated based on the modified cost structure and used to predict private market equilibrium.

Typically economists do not like to rely on economic-engineering models to calculate processing cost. Problems with economic-engineering models include the use of accounting data which may not reflect true depreciation and may not be representative of the production process over time. However, economic-engineering models used for this report were reviewed by a number of experts including: USAID project officers, a project dairy technologist, DDC staff and the Dairy Enterprise Support Project director. The models indicate the presence of economic profits. This conclusion is supported by the nonparametric test of DDC monopsony power which indicates that the DDC is earning economic profits.

5.5.1 Data Collection

Data used to construct the economic-engineering models came from a variety of sources. Information was gathered directly from cheese producers in remote production areas during two treks conducted in 1994. A participatory appraisal approach was used to collect the information. Participatory appraisal (PA) is a means of learning from, and with, farmers, traders, processors, community members, policy markers and others in order to gather needed information and investigate and evaluate constraints and opportunities. PA is broader than participatory rural appraisal (PRA). The broader scope of the PA process includes:

- Comprehensiveness. All stakeholders are involved in the participatory process.
- Multi-Disciplinary Core PA Team. To ensure triangulation, or the balancing of divergent points of view, a multi-disciplinary data collection team is formed.
- Use of Secondary Information and Lessons Learned. To ensure the PA benefits from all previous work and lessons learned, all available secondary information for the immediate area of interest is reviewed prior to going into the field.
- Field Analysis. Data is reviewed and interpreted on a daily basis.
- Flexibility. The PA team has broad authority to make decisions concerning future PA directions.
- Active Bias Avoidance. The PA team actively searches out under-represented and disadvantaged stakeholders such as women and specific ethnic groups.
- Community Participation and Feedback. The PA team defines the relevant community universe at each stage of the process, regarding communities as separate PA and program units.
- Rapidity. The PA team will normally spend only 2-3 days in each village/step along the geographic and marketing watershed.

A sample of PA methods for acquiring information include:

- Direct Observation. Direct observation involves developing a checklist of indicators and then systematically observing objects, people, events and characteristics to cross-check responses obtained from using other methods.
- Semi-structured interviews. Semi-structured interviews start with a written checklist of questions, with follow-up questions added as new or unexpected information is revealed.
- Group Discussion for Analysis. This is used for analyzing information previously collected in order to validate it.
- Seasonal Calendar. It is important to conceptualize marketing and production activities by constructing seasonal calendars.

- Ranking. Rankings provide relative rather than absolute measurements and indicate the degree of importance a respondent places on a range of issues.
- Flow diagrams. These are used to summarize key relationships and indicate cause and effect.
- Historical Profiles. These profiles show a timeline of important events and trends useful for developing project activities.

For this effort the PA team consisted (at various points in time) of: the researcher, a sociologist, dairy technology experts, DDC staff, HMG veterinarian office staff, HMG Ministry of Agriculture staff, a veterinarian, herders interested in assisting, range management experts, sellers of yak cheese (who surveyed their customers for the research) and rural development specialists.

Factory records were inspected for both the DDC and private firms. Information gathered from the treks was cross-checked through interviews with cheese production experts in Kathmandu, inspection of DDC center records, and through interviews with suppliers of cheese production inputs. Appendix A presents the details of the economic-engineering models including assumptions concerning interest rates and depreciation that are critical to assessing actual annual costs. The depreciation rates are specific to the items based on the participatory appraisal information gathering process.

5.5.2 Processing Cost

Table 5.11 presents the DDC and private processing costs. Processing cost is the cost of producing cheese less the cost of purchasing milk.

Table 5.11. Processing cost of converting milk to cheese for average firm sizes.[a]

Item	DDC	Private
Annual Capital Cost (Rs.)	465,045	36,457
Annual Milk Cost (Rs)	966,466	522,910
Annual Variable Cost (excluding milk) (Rs.)	496,841	282,828
Annual Total Cost (Rs.)	1,928,352	842,195
Value of ghee/butter Produced (Rs.)	369,656	132,064
Total Processing Cost of yak cheese (Rs.)[b]	592,229	185,411
Quantity of Cheese Marketed (kg)	9,587	4,275
Processing Margin (Rs./kg)	62	44

[a] 1994 prices are used..
[b] The processing cost is total cost less the cost of milk and the value of butter.

The value of ghee/butter produced is subtracted from the processing cost. Ghee is a by product of private production and butter is a by production of yak cheese production. The yak cheese industry does not significantly affect the quantity of ghee/butter produced in Nepal. These products are produced from milk in lower elevations in quantities vastly surpassing the amounts from the yak cheese industry.

5.5.3 Impacts of Institutional Constraints

There are three impacts represented in this section stemming from institutional constraints that private producers face (see section 2.4 for details):

1. the price of private yak cheese is lower than DDC cheese because wholesalers cannot determine storage properties of cheese at the time of purchase resulting in incentives to produce low quality cheese (note it would be optimal to increase quality if all private producers did so),

2. private producers under invest in equipment, inputs and infrastructure because they receive a low price for their cheese, and

3. private producers have higher marketing costs because wholesalers will purchase only small quantities of their cheese at a time because cheese storage properties are unknown.

Based on the participatory appraisals and consultation with cheese experts, the processing cost is calculated for a reduced level of institutional constraints.[61] The cheese production experts and industry participants were asked how much expense they would need to incur to increase the quality of their private cheese to something approximating DDC quality. The changes are presented in table 5.11.

The changes in the structure of private production cost include changes in the amount of capital employed, the marketing cost, the price of the cheese and the percentage of cheese lost. Annualized capital costs change from Rs. 36,457 to Rs 128,647. The increase in capital represents expenditure on improved equipment, factory infrastructure and improved storage facilities. Improved equipment such as cheese hoops, thermometers, cheese harps, aluminum milk cans is needed to improve quality. Improved factory infrastructure for the comfort of workers is needed to attract more educated and qualified cheese makers. Improved racks are needed in storage facilities to prevent cheese from being crushed in stacks. The private storage facilities must also be improved to decrease pest losses.

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[61] Tek B. Thapa was the main expert relied upon for this change in cost structure. He is a cheese and dairy expert formerly with the DDC and during the authors field work was employed by the same USAID dairy project.

The marketing costs for private producers with improved cheese quality are predicted to decrease from Rs 72,032 to Rs 29,400. This is reflected in table 5.12 as a change in the variable cost of production. The decrease reflects the fact that with higher quality cheese, the private producers will be able to bring their cheese to market in larger amounts, decreasing trips and costs. The decreased costs include less time in Kathmandu which is expensive for cheese producers and the need to buy fewer bus tickets. These reductions in marketing costs are assumed to be similar across factories. The loss rate of private cheese producers is predicted to decline from 20% to 10%. The price of yak cheese is predicted to rise from Rs. 180 to Rs. 190 (DDC price for 1994 was 200). The experts were asked to estimate the increased costs private firms would have to incur to produce DDC quality cheese. To be conservative it is assumed that private firms (with the increased costs to improve cheese quality) are able to increase the price they receive by one-half the difference between the current private and DDC price.

Table 5.12. Modified private processing cost for average firm size.[a,b]

Item	Private (Modified)	Private (Actual)
Annual Capital Cost (Rs.)	128,647	36,457
Annual Milk Cost (Rs.)	522,910	522,910
Annual Variable Cost (excluding milk) (Rs.)	240,196	282,828
Annual Total Cost (Rs.)	891,753	842,195
Value of Butter Produced (Rs.)[c]	132,064	132,064
Total Processing Cost of yak cheese (Rs.)[d]	236,778	185,411
Quantity of Cheese Marketed (kg)	4809	4,275
Processing Margin (Rs./kg)	49	44

[a] Modified refers to changes in cost structure from partial relaxation of institutional constraints
[b] 1994 prices are used..
[c] The DDC produces butter while private firms produce ghee
[d] The processing cost is total cost less the cost of milk and the value of butter.

With the changes in cost structure, private firm profitability rises (Table 5.13). Under the observed cost structure, profit is Rs 59,370 for an average firm. Private firm profit rises to Rs. 154,093 following the modifications to cost structure. The rise in firm profits indicated from this analysis indicates that the severe institutional constraints present in Nepal (and other LDCs) have a substantial direct economic cost to processing firms.

Table 5.13. Private profit for production with reduced institutional constraints.[a]

Private Firm	Marketed Yak Cheese (kg)	Yak Cheese Price (Rs)	Total Cost (Rs)	Profit (Rs.)[b]
Observed	4,275	180	842,195	59,370
Modified	4,809	190	891,753	154,093

This approach does not permit definitive conclusions about the presence of institutional constraints in the yak cheese industry. It is an attempt at a conservative partial assessment of the impacts of institutional constraints. It is conservative because not all institutional constraints facing private firms are modeled. It is also conservative because it is assumed that private firms are able to raise their cheese price by only one-half the difference between the current private and DDC price. The prediction of private equilibria based on this modified cost structure yields an insight into the welfare implications of institutional constraints for the yak cheese industry.

5.6 Market Equilibrium

The market equilibria solved for five market structures are presented in this section. Three market equilibria are predicted for private producers:

1. using estimated private monopsony behavior,
2. imposing competitive behavior on private producers, and
3. using estimated private monopsony behavior and a private firm cost structure reflecting reduced institutional constraint impacts,

Two market equilibria are predicted for the DDC:

1. imposing competitive behavior on the DDC, and
2. imposing monopoly and monopsony conduct on the DDC.

These equilibria are used to estimate market performance criteria. The market performance criteria are presented in section 5.7. The primary comparison is between predicted private and actual DDC market equilibrium (for 1991).

The method for solving market equilibria was derived in section 4.4. The equilibria are solved using simultaneous equation systems that impose the determined market power behavior. It should be noted that the equations are linear. Linearity of the system implies that the accuracy of prediction decreases for solutions "far" from the observed DDC price-quantity equilibrium of 1991 from which the models are calibrated.

5.6.1 Private Producer Equilibria

The system of equations used to solve for predicted private market equilibria are presented below (Equations 4.4.20 to 4.4.24). The equations are derived in section 4.4.

(4.4.20) $P = S_d Q - b_d$ (Wholesale demand in Kathmandu)

(4.4.21) $Q = \sum_{j=1}^{N} Q_j$ (Supply is the sum of milk shed supplies)

Milk Shed Marginal Expenditure Functions:

(4.4.22) $Q_j = \dfrac{\left(P - b_{csj}\right)}{\left[\left(1 + _s L_j\right) S_{csj}\right]}$ (Quantity of cheese produced by shed)

Milk shed Lerner index:

(4.4.23) $L_j = a + b \dfrac{1}{N_j}$ (The effective Lerner index by shed)

Relationship between milk shed size and number of firms:

(4.4.24) $N_j = c + d\, Q_j$ (The number of firms by shed)

Where P is the price of yak cheese (in Kathmandu), Q is the total quantity of marketable yak cheese, Q_j is the quantity of marketable yak cheese produced in milk shed j, L_j is the Lerner index of monopsony power in milk shed j, N_j is the number of firms in milk shed j and N is the total number of milk sheds (nine in 1991). The demand slope (S_d), demand intercept (b_d), supply slope(S_{csj}), and supply intercept (S_{csj}) are calculated as shown in section 4.4. The elasticity of supply ($_s$) is estimated econometrically. The parameters a, b, c, and d in equations 4.4.23 and 4.4.25 are also estimated econometrically (see section 5.3).

Equations 4.4.23 and 4.4.24 are used to impose estimated monopsony market power in the equation system. The theory behind the relationship between the Lerner index and the number of firms in a milk shed, and the number of firms number in a milk and the size of a milk shed is presented in section 4.5 Equation 4.4.22 represents milk shed cheese supply which under conditions of partial monopsony power is the perceived marginal expenditure function (see section 4.4.2 for the derivation). The demand (4.4.20) and aggregate supply functions (4.4.21) ensure global equilibrium in the system.

The endogenous variables are: L_j, N_j, Q, Q_j, and P. The system consists of 29 equations. The endogenous variable for number of factories per milk shed (N_j) is treated as an integer variable when solving the system.

Solution to the system yields cheese price, cheese quantity, cheese quantity per cheese shed, Lerner index by shed, and number of factories by shed. The condition that milk supply and demand balance at the milk shed level is embedded in equation 4.4.22. In the equation, the price of cheese (P) and the effective Lerner index define the quantity of cheese produced (Q_j), which defines the quantity of milk produced. Since the cheese supply function is simply the milk supply function with the processing cost added milk price is in balance and can be calculated from the shed milk supply functions. The market performance criteria can then be computed (section 5.7).

Two additional private market equilibria are calculated with modifications to the equation system. A private market equilibrium for firms that maintain competitive conjectures is calculated by setting the Lerner index to zero (e.g., a = b = 0). When the Lerner index is zero, the marginal expenditure functions (equation 4.4.22) correspond to the milk shed cheese supply functions. The impact of institutional constraints on private market equilibrium that result in a lower cheese price, under investment and higher marketing costs are also examined (see sections 5.5 and 2.4). To do so the equation system is recalculated using the modified private firm cost structure (see above). The changes in cost structure are introduced into the system as changes in private firm processing margin, private cheese price relative to DDC cheese, and the percentage of cheese lost in production (see sections 4.4 and 5.5).

Two effects are introduced in the models as shifts in demand and supply. Private produced cheese is lower in quality than DDC cheese and private producers lose more cheese in the production process. The lower quality of privately produced cheese is handled in the models as a downward shift of demand. The demand shift represents the wholesale price gap between privately produced and DDC cheese. This approach is detailed in section 4.4.1. The higher production loss is similarly handled as an upward shift in the supply function. This approach is detailed in section 4.4.2. The effects of these adjustments are noted when comparing DDC and private equilibria.

The solutions to the three predicted private equilibria and the observed DDC equilibrium in 1991 are presented in table 5.14. The equation systems are solved using the Mathcad program. The program reported that solutions were unique and the solutions were further tested for uniqueness by changing the initial values for the endogenous variables. The starting values for the endogenous variables were varied beyond the feasible range and solutions remained constant. The program is presented in Appendix c.

Market performance between the structures is compared using economic surplus and alternative measures. This comparison is presented in section 5.7. Direct comparison of the solutions reveals that private firms will produce more cheese than the DDC and at a lower market price.

The total amount of cheese produced rises 7.4% and cheese price declines from Rs 213 to Rs 185 (see scenario 1 and 4, Table 5.14). However, production falls in the two smaller milk sheds (see rows 8 and 9, Table 5.14).

Table 5.14 Private Producer Equilibria[a,b]

	Market Structure Scenarios									
Milk Shed Location	(1) Private predicted from estimated behavior			(2) Private with competitive behavior imposed			(2) Private with low Impct of Inst. Constraints			(4) DCC Actual
	Quantity	N	L	Quantity	N	L	Quantity	N	L	Quantity
1. Langtang	6,417	2	.34	7,999	2	0	6,803	2	.34	6,039
2. Gosaikunda	17,221	3	.32	20,845	3	0	18,254	3	.32	15,738
3. Kangsing	8,251	2	.34	10,407	2	0	9,276	2	.34	8,235
4. Chordung	18,021	3	.32	21,815	4	0	19,103	3	.32	16,470
5. Thodung	14,517	3	.32	17,573	3	0	15,389	3	.32	13,268
6. Kyama	10,696	2	.34	13,331	2	0	11,338	2	.34	10,065
7. Chankhu	11,668	2	.34	14,543	3	0	12,368	2	.34	10,980
8. Pike	3,580	1	.41	4,848	1	0	3,795	1	.41	3,660
9. Taksindu	1,790	1	.41	2,424	1	0	1,897	1	.41	1,830
Total Quantity	92,661			114,285			98,223			86,285
Cheese Price	185			162			190			213

[a] Quantity = the amount of cheese marketed (kgs), N = the number of firms in the shed and L = the Lerner index of monopsony power in the milk shed.

[b] The models are calibrated with DDC price and quantity data from 1991. The prices are inflated to 1994 levels, the year for which processing costs are calculated from the economic engineering models.

Monopsony behavior of private firms at the milk shed level is shown to range from more severe to less severe than the DDC's monopsony behavior. The nonparametric test of market power for the DDC has an effective average Lerner index of .33 (see sections 4.3 and 5.4). The computed private Lerner index is .32 in milk sheds with three firms, .34 in milk sheds with two firms and .41 in milk sheds with a single firm. The meaningfulness of these Lerner index differences depends on the accuracy of the elasticity estimates used to construct the model, private firm behavior parameters and the processing cost determined from the economic-engineering models of cheese production. The decline in production in the smaller sheds is a reflection of increased exercise of monopsony power by private firms with no competitors to limit their market power. It should be noted that even though the Lerner index for milk sheds with two firms is higher than the DDC level (.34 vs. 33), cheese production in these milk sheds is higher under private production. This higher production level is because private producers have lower production costs resulting in a higher demand for yak milk.

When competitive behavior is imposed on private firms, the quantity of cheese produced shows a substantial increase over DDC and private levels. The model shows that the amount of cheese produced by competitive private firms is 34% more than the DDC and cheese price falls from

Rs. 185 to Rs. 162 (see scenario 2 and 4, table 5.14). When market equilibrium is predicted based on the modified private cost structure reflecting reduced institutional constraints (see discussion above), private firms produce more cheese. Production of cheese rises 6% over the level produced by private producers assuming the same private monopsony behavior (see scenario 3 and 4, table 5.14). Cheese price also rises substantially from Rs 185 to Rs 190. This rise in price is due to improved cheese quality assumed in the adjustment made to model the reduced impact of institutional constraints.

5.6.2 DDC Equilibria

Two market equilibria are predicted with changes in DDC behavior:

1. under competitive behavior on the DDC, and

2. under simultaneous monopoly and monopsony conduct.

Competitive behavior on the part of the DDC is imposed by determining equilibrium price and quantity at the intersection of the cheese demand and the aggregate cheese supply functions. The aggregate cheese supply function is simply the sum of shed cheese supply functions. The shed cheese supply functions are the estimated milk supply functions with processing cost added (see section 4.6 for details). Equations 4.6.4 to 4.6.5 define the system of equations used to solve for competitive DDC behavior.

(4.6.4) $\quad\quad P = S_d \, Q - b_d$ $\quad\quad\quad\quad$ (Cheese demand function)

(4.6.5) $\quad\quad P = S_c \, Q_j + b_{ms} + M_{DDC}$ $\quad$ (Shed cheese supply function)

Where P is the price of yak cheese in Kathmandu, Q is the total quantity of yak cheese, Qj is the quantity of yak cheese produced in milk shed j and M_{DDC} is the processing cost exclusive of milk cost. M_{DDC} is calculated from an economic-engineering model of yak cheese production (see section 5.5). Note that $Q = \sum_{j=1}^{N} Q_j$ which forces aggregate supply to equal demand. In 1991, nine milk sheds had cheese production. The demand slope (S_d), demand intercept (b_d), supply slope (S_c) and supply intercept (b_{ms}) are calculated as shown in section 4.6. Simultaneous solution of the equation system (equations 4.6.4 and 4.6.5) yields the cheese price-quantity equilibrium for DDC competitive behavior.

The market power equilibrium contains the assumption that the DDC takes full advantage of its monopoly and monopsony market power. Pure market power behavior on the part of the DDC is imposed by solving for the intersection of the marginal revenue function derived from cheese

demand and the marginal expenditure function derived from cheese supply. Equations 4.6.10 and 4.6.11 define the equations used to solve for market power behavior of the DDC behavior:

(4.6.10) $P = 2\, S_d\, Q - b_d$ (Cheese MR function)

(4.6.11) $P = 2\, S_c\, Q_j + b_{ms} + M_{DDC}$ (Cheese ME expenditure function)

The terms are as defined previously. Simultaneous solution of the equation system (equations 4.6.10 and 4.6.11) yields the cheese price-quantity equilibrium under DDC market power behavior. The equation systems are solved using the Mathcad program.

Solutions to the two predicted DDC equilibria are shown in table 5.15. The solutions were unique and the solutions were further tested for uniqueness by changing the initial guesses for the endogenous variables. The starting values for the endogenous variables were varied beyond the feasible range, and solutions remained constant. The program used is presented in Appendix C.

Table 5.15 DDC Equilibria[a,b]

	Market Structure Scenarios					
Milk Shed Location	(1) DDC production with competitive behavior imposed	(2) DDC production with pure market power imposed	(3) Private predicted from estimated behavior			(4) DCC Actual
	Quantity	Quantity	Quantity	N	L	Quantity
1. Langtang	8,381	4,190	6,417	2	.34	6,039
2. Gosaikunda	21,840	10,920	17,221	3	.32	15,738
3. Kangsing	11,428	5,714	8,251	2	.34	8,235
4. Chordung	22,856	11,428	18,021	3	.32	16,470
5. Thodung	18,412	9,206	14,517	3	.32	13,268
6. Kyama	13,968	6,984	10,696	2	.34	10,065
7. Chankhu	15,237	7,619	11,668	2	.34	10,980
8. Pike	5,079	2,540	3,580	1	.41	36,60
9. Taksindu	2,540	2,070	1,790	1	.41	1,830
Total Quantity	119,741	59,870	92,661			86,285
Cheese Price	177	241	185			213

[a] Quantity = the amount of cheese marketed (kgs), N = the number of firms in the shed and L = the Lerner index of monopsony power in the milk shed.

[b] The models are calibrated with DDC price and quantity data from 1991. The prices are inflated to 1994 levels, the year for which processing costs are calculated from the economic engineering models.

Comparison of the solutions reveals that if the DDC behaved competitively it would produce the highest quantities at the lowest price. behavior produces the most cheese at the lowest market

price. The total amount of cheese under competitive DDC behavior rises 39.8% above actual DDC production and 29% above the levels that are predicted to occur under fully privatized production (see table 5.15). Under competitive DDC behavior, the price of cheese is Rs. 177 compared to the actual price of Rs 213 and the predicted private price of Rs 185. It is interesting to note that the competitive production level exceeds the private level with competitive behavior by 4.5%. This difference is due to the lower percentage of cheese lost by the DDC and the higher value of DDC cheese due to its quality. Private producers have lower processing costs which result in more demand by them for milk than the DDC at a given cheese price. However, this effect is overwhelmed by the higher percentage of cheese that they lose and the lower demand for their lower quality cheese (see above and section 4.4).

Under the assumption that the DDC will employ pure market power, the least amount of cheese is produced at the highest market price. The total amount of cheese with pure market power by the DDC declines 30.6% declines below actual DDC production levels and 35% below predicted private production levels. The price of cheese is Rs 241 compared to the actual price of 213 and the predicted private price of 185.

The cheese output Lerner index for observed DDC behavior is also calculated. The Lerner index is calculated from the perceived marginal revenue curve. The perceived marginal revenue curve of the DDC is determined by the intersection of the estimated marginal expenditure curve and with the observed price quantity equilibrium of 1991. The method is detailed in section 4.7. The output market Lerner index is estimated to be .26. This is substantially below the level of input market power being exercised (see section 5.4). The importance of this finding is discussed in chapter 6.

5.7 Market Performance Evaluation Criteria

This section presents the comparison of market performance across potential market structures using a partial equilibrium framework. Market performance is compared using herder surplus, processor surplus, consumer surplus, total surplus, foreign exchange generated and total quantity of cheese produced. Section 4.1 presents the theoretical basis for using these partial equilibrium model measures to evaluate market performance. The partial equilibrium models include both the yak cheese and milk markets. The models used are described in section 4.1.

The primary comparison is between the observed performance of the DDC and the predicted performance under private production. These two structures represent obtainable outcomes. DDC performance is measured using a partial equilibrium model with 1991 DDC data (called observed DDC in the tables). Predicted private performance is based on a partial equilibrium model calibrated with 1991 DDC data and imposing forcasted private monopsony behavior and cost structure (called "predicted private" in the tables). Prediction of private performance is

described in section 4.4 and solved in section 5.4. Market structures representing pure
competitive behavior and pure market power behavior by the DDC are also evaluated to allow
for broader comparisons (see sections 4.6 and 5.4).[62] Market performance of private producers
with competitive behavior is also presented (called "competitive private" in the tables).

Herder producer surplus is the most important market performance criterion. An explicit
weighting scheme is not adopted, but herder welfare should be given priority because herders
represent the poorest group of industry participants. The industry was established to improve
their welfare.

Table 5.16 presents the comparison of herder producer surplus by milk shed. At an industry
level, privatization of the DDC results in increased herder welfare. Producer surplus goes from
Rs 1,972,129 under DDC production to Rs 2,276,975 under predicted private production. This
represents a 15.4% increase in the measure of welfare of yak herders. The highest level of yak
herder welfare is achieved under the market structure where the DDC acts in a competitive
manner. This result is due to the higher level of wholesale demand for DDC cheese and their
lower rate of cheese loss in production. At a milk shed level, private performance exceeds the
DDC's in seven of nine milk sheds (compare column 1 with column 5 in table 5.13). The two
milk sheds where DDC performance is better are small milk sheds that support only one
processor (see section 5.6). These two sheds represent only a small fraction of cheese production
and herder welfare. Overall, the analysis of producer welfare indicates that the DDC should be
privatized.

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[62] Pure market power refers to the joint exercise of monopoly and monopsony power.

Table 5.16 Yak herder producer surplus by milk shed (Rs).[a]

Locations	Market Scenarios[a]				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	Predicted Private	Competitive Private	Competitive DDC	Market Power DDC	Observed DDC
1. Langtang	155,868	242,149	265,819	66,455	138,028
2. Gosaikun	430,672	631,056	692,739	173,185	359,709
3. Kangsing	212,547	330,203	362,480	90,619	188,220
4. Chordung	450,704	660,407	724,959	181,239	376,440
5. Thodung	363,067	531,995	583,995	145,999	303,243
6. Kyama	259,780	403,582	443,031	110,758	230,047
7. Chankhu	283,397	440,272	483,306	120,827	250,960
8. Pike	80,027	146,757	161,102	40,276	83,653
9. Taksindu	40,013	73,379	80,551	20,138	41,827
Total	2,276,075	3,459,801	3,797,984	949,496	1,972,129

[a] The market scenarios are defined as follows:
Predicted private- based on estimated private firm monopsony behavior
Competitive private- competitive behavior imposed on private firms
Competitive DDC- competitive behavior imposed on the DDC
Market power DDC- joint monopoly and monopsony behavior imposed on the DDC
Observed DDC - the actual DDC behavior in 1991.

Figure 5.3 presents a supply and demand diagram comparing the DDC and predicted private outcome. The impact of the lower demand for private cheese and the higher processing cost for DDC cheese is represented in figure 5.3. In figure 5.3, private demand is shifted downward by the amount of the observed price gap. The lower processing cost for private firms' results in the lower private cheese supply curve depicted in figure 5.3. The figure indicates that the gain in producer surplus from privatization stems from a decreased exercise of monopsony power and decreased processing cost.
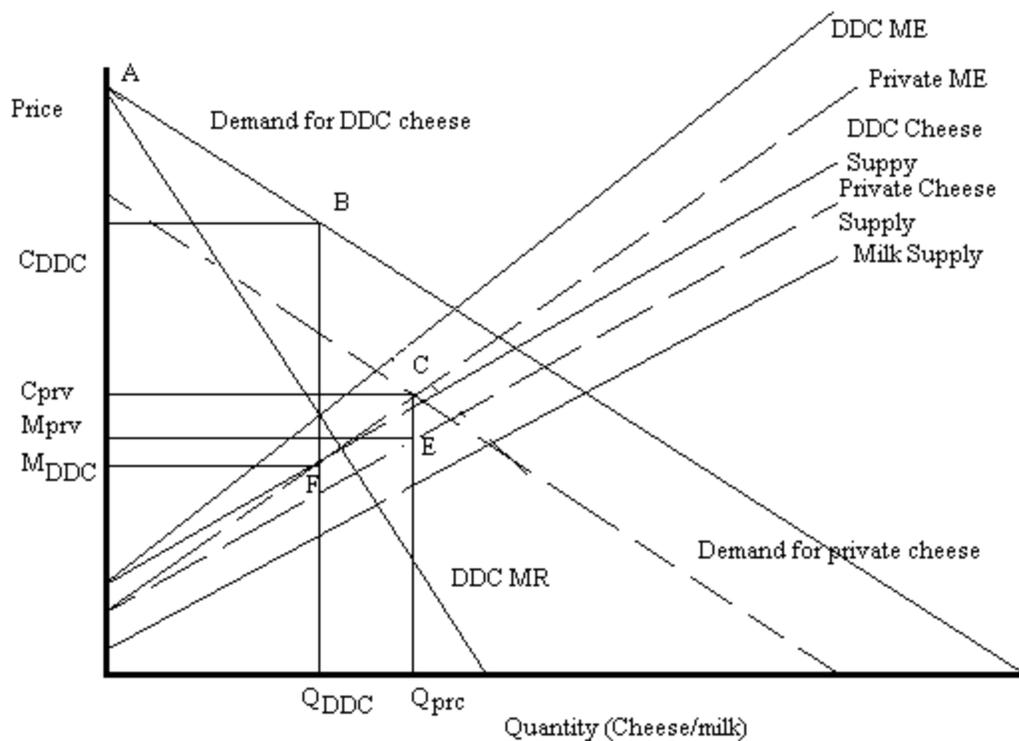
Figure 5.2 Comparison of DDC and predicted private market equilibrium.[a]

Variable	Definition
C_{DDC}	Price of DDC cheese
C_{prv}	Price of private cheese
M_{prv}	Price paid by private producers for milk
M_{DDC}	Price paid by the DDC for milk
Q_{DDC}	Quantity of cheese produced by the DDC
Q_{prv}	Quantity of cheese produced by the DDC

Note: Private functions are depicted with dashed lines

At an industry level, privatization of the DDC results in decreased processor welfare (Table 5.17). Processor surplus declines 16.8% with DDC privatization (compare column 1 with column 5 in table 5.14). It should be noted that the processors differ by the market structure. If private producers were restricted from operating (i.e., sole DDC production) their producer surplus would fall to zero. The decline in processor welfare is consistent across all milk sheds. It should also be noted that the DDC processor welfare is actually very close to its potential maximum. Processor welfare is higher under DDC production due to the higher wholesale demand for DDC cheese. The implications of higher processor welfare under DDC production are limited. The DDC distributes benefits to groups wealthier than the herders (urban consumers and milk producers near roads). As stated before, herder welfare is the primary criterion to evaluate industry performance.

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Table 5.17 Yak Cheese processor producer surplus by milk shed (Rs).[a]

Locations	Market Scenarios[a]				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	Predicted Private	Competitive Private	Competitive DDC	Market Power DDC	Observed DDC
1. Langtang	381,628	242,149	265,819	468,626	461,917
2. Gosaikun	1,011,649	631,056	692,739	1,221,261	1,203,784
3. Kangsing	520,401	330,203	362,480	639,035	629,887
4. Chordung	1,058,703	660,407	724,959	1,278,609	1,259,774
5. Thodung	852,843	531,995	583,995	1,029,556	1,014,818
6. Kyama	636,046	403,582	443,031	781,043	769,862
7. Chankhu	693,868	440,272	483,306	852,046	839,849
8. Pike	219,800	146,757	161,102	284,015	279,950
9. Taksindu	109,900	73,379	80,551	142,007	139,975
Total	5,484,839	3,459,801	3,797,984	6,695,665	6,599,816

[a] The market scenarios are defined in table 5.13.

DDC privatization results in a 7% increase in foreign exchange generated by the industry (Table 5.18). Increased production and the fact that final consumer demand for yak cheese is unaffected by quality account for the higher foreign exchange earnings. Final consumers are unaware of differences in cheese quality between the DDC and private firms. Final consumers pay the same price for both cheeses.[63] Wholesaler surplus (consumer surplus) is highest under private production (compare column 1 with column 5 in table 5.15). This result is due to increased production by private firms and the low wholesale price of yak cheese in this scenario. Total surplus is slightly higher under observed DDC production (compare column 1 with column 5 in table 5.15). However, total industry production under predicted private behavior rises by 7% above observed DDC levels. Secondary impacts, such as employment generated by the industry, will rise with the increased levels of private production.

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[63] However, there is preliminary evidence that in the longer run cheese demand may be reduced by low quality private cheese as consumers of bad quality cheese will no longer purchase cheese.

Table 5.18 Industry level market performance criteria.[a]

Locations	Market Scenarios[a]				
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Performance Criteria	Predicted Private	Competitive Private	Competitive DDC	Market Power DDC	Observed DDC
Foreign Exchange($)	462,008	569,827	597,027	298,513	430,215
Consumer Surplus (Rs.)	4,607,703	7,009,229	7,694,355	1,923,589	3,995,348
Producer Surplus (Rs.)	5,484,839	3,459,801	3,797,984	6,695,665	6,599,816
Quantity (kg)	92,661	114,285	119,741	59,870	86,285
Total Surplus (Rs)	10,092,543	10,469,030	11,492,339	8,619,254	10,595,164

[a] The market scenarios are defined in table 5.13.

The potential impacts of reducing institutional constraints present in private markets are also evaluated using the market performance criteria. The private producer equilibrium is predicted using a modified cost structure. Section 5.5.2 presents the modifications to private firm cost structure and characteristics. The performance criteria for private production with reduced institutional constraint impact are presented in table 5.19. As expected, private market performance with reduced institutional constraints improves for all the performance indicators. Private performance with the reduced institutional constraints also exceeds DDC performance for all criteria except processor surplus (compare column 1 with column 2 in table 5.16). Herder producer surplus rises 12% above the predicted private outcome and 28% above DDC levels.

Table 5.19 Performance criteria with reduced institutional constraint impact.[a]

Locations	Market Scenarios			
	(1)	**(2)**	**(3)**	**(4)**
Market Performance Criteria	Reduced Inst. Const.	Predicted Private	Competitive Private	Observed DDC
Processor Producer Surplus (Rs)	6,162,979	5,484,839	3,459,801	6,599,816
Herder Producer Surplus (Rs)	2,529,606	2,251,263	3,459,801	1,972,129
Consumer Surplus (Rs)	5,230,850	4,607,703	9,409,222	3,995,348
Foreign Exchange($)	489,737	462,008	569,827	430,215
Quantity (kg)	98,223	92,661	114,285	86,285
TS	11,457,462	10,092,543	12,869,023	10,595,164

[a]   Reduced inst. constraint refers to performance criteria calculated from private
behavior predicted with a modified cost structure reflecting reduced institutional
constraints. The other market scenarios are defined in table 5.13.

The policy implications of the market performance criteria presented in this section are discussed in chapter six.

Chapter 6. Conclusions

6.1 Overview of the Study

In recent years the international development community has emphasized free markets, privatization of public enterprises, and elimination of parastatal purchasing boards in least-developed countries (LDCs). However, public enterprises serve important functions in LDCs including the mitigation of market failures.

The major objective of this research is to measure the economic impacts of privatizing the Nepalese yak cheese industry. To achieve the research objective, the market power behavior of the DDC and private firms is also determined. Quantification of economic impacts can improve yak industry privatization policy and has broader implications for the privatization of agro-industries in developing countries. Economic impacts of privatization stem from changes in market structure that may change the monopsony behavior of cheese processors and institutional constraints that differ between the public and private sectors (see section 1.2.2 for a definition of institutional constraint). Additionally, changes in market performance are evaluated assuming pure competition, pure profit-maximization and using a private firm cost structure representing a reduction in private sector institutional constraints.

The public enterprise Dairy Development Corporation (DDC) of Nepal has produced yak cheese since 1969 along with a variety of other dairy products. Yak cheese is produced in factories located in remote high hill areas. The DDC's mandate is to charge a "fair" price to consumers and pay a "fair" price to milk producers. However, herders that supply milk are highly traditional and poorly organized to bargain for price leading to conditions conducive to monopsony power (see chapter two).

The international donor community has put considerable pressure on Nepal to restructure the DDC and privatize the yak cheese industry. Successive Nepalese governments have resisted this international pressure for privatization of the industry. However, private producers of cheese have emerged in recent years. Currently factory milk sheds have a variety of market structures including: single DDC factories, single private factories, multiple private factories, and mixed public and private production.

Market performance is evaluated using partial equilibrium models which include the yak cheese and milk markets (see section 4.1). The models are constructed based on econometric estimates of cheese demand and milk supply elasticity (see sections 5.1 and 5.2). The models also use processing cost obtained from economic-engineering models of cheese production (see section 5.5). The market performance criteria used for evaluation include, consumer surplus, cheese

processor surplus, total surplus of the cheese market, herder producer surplus, foreign exchange generated and total industry output (see section 4.1). The most important performance criterion is herder producer surplus because herders are the poorest industry beneficiaries and the industry was established to improve their welfare.

The impact of DDC privatization is determined from a comparison of the performance criteria between the observed DDC market equilibrium and a predicted private market equilibrium. Private equilibrium is predicted using a system of equations developed for this research (see section 4.4 for theory, and sections 5.6 and 5.7 for results). The equations ensure that demand and supply at the aggregate level and in the individual milk sheds are in balance. Private monopsony behavior is incorporated in the system of equations through relationships between the Lerner index and number of firms in a milk shed and between the number of firms in a milk shed and the milk shed size. The parameters for private monopsony behavior are estimated econometrically (see sections 4.5 for theory, and section 5.3 for estimation). A private equilibrium is also predicted using the equation system with a modified firm cost structure reflecting reduced impacts of institutional constraints. Private behavior is also predicted under an assumption of competitive behavior. Similarly, market equilibria imposing competitive and pure profit maximizing behavior on the DDC are predicted (see section 4.6 for theory, and sections 5.6 and 5.7 for results).

6.2 Findings

This section presents the important empirical findings of the dissertation research. The policy implications of these findings are presented in section 6.3. The important research findings include:

- Comparison of herder welfare as measured by producer surplus shows that a shift from DDC to private production will improve the aggregate welfare of milk producers. Herder producer surplus will rise 15.4%. This finding is based on a calculation of herder surplus for the observed DDC equilibrium in 1991 and for the private market equilibrium predicted from the developed equation system. Since herder welfare was the principal reason for establishing the industry, this is a key finding. Private production will also increase the amount of foreign exchange generated by the yak cheese industry by 7%. However, DDC privatization marginally decreases the total economic surplus of the cheese market. The decline in total surplus is because private firms produce low quality cheese. Producer welfare also falls following privatization because of the lower quality cheese.

- At a milk shed level, milk producer welfare will be decreased by DDC privatization in the two smallest milk sheds. This decline is due to monopsony power that the model to predict

private equilibria shows to prevail in these markets. The model shows that production levels are so small that only one cheese producer can exist in these markets.

- Findings are strongly consistent with the conclusion that private firms are exercising monopsony power. This finding depends on results from the private firm economic-engineering model of cheese production and on the econometric estimation of private firm behavior. Though economic-engineering models cannot provide definitive proof of market power, the comprehensive model of private cheese production shows high economic profits. Econometric estimation shows a strong and statistically significant reciprocal relationship between the Lerner index (and by implication milk price) with the number of firms in a milk shed. This result is consistent with the theoretical relationship between the Lerner index of monopsony power (and milk price) with the number of processing firms in a milk shed.

- Milk shed size is the key determinant of the number of private firms operating in the milk shed. Econometric estimation reveals a strong and statistically significant positive relationship between milk shed size and the number of firms in a milk shed. This is consistent with the assertion that private firms must reach a minimum efficient size (MES) to achieve economies of scale. However, firm size above MES results in increased production costs (i.e., private firms have a u-shaped long-run average cost curve). Private firms may be below MES only in markets with a single firm. This would occur if the market size is below MES. Firms may also be operating above MES. This would occur in milk sheds where milk sheds size permits the additional entry of only a fractional firm.

- The DDC is found to exercise monopsony power. This result comes from the nonparametric test of their monopsony power behavior. The result is also supported by the higher price paid by private firms in milks sheds with multiple private firms. The nonparametric test indicates that the DDC is using 72% of its potential monopsony power. To a lesser extent, the DDC also exercises monopoly power (60% of its potential monopoly power).

- DDC behavior is not rational. It is found to exercise "more" monopsony power than monopoly power. The exercise of market power is inconsistent with their objective to provide "fair" prices to producers and consumers. The differential exercise of market power between the input and output markets if not the result of pricing errors is potentially inconsistent with plausible objectives. The potential objectives discussed for DDC management of the yak cheese industry include profit-maximization and maximization of labor employed. Pure profit-maximization would imply that the DDC takes full advantage of its market power. Taking less advantage of monopoly power may indicate constraints on DDC behavior in the cheese market. However, this is clearly sub-optimal because cheese consumer welfare is not a consideration because these groups are a much wealthier than the herders. The maximization of labor used would imply that the DDC would not take

advantage of market power. However, the reason the DDC does not take full advantage of its market power may be a desire to provide employment opportunities.

- Failure in the market for information about the quality of cheese has a substantial impact on market performance. When the models are solved under conditions that cheese quality is known, they indicate improvements in milk producer welfare, industry surplus and foreign exchange generation. The increase in production levels resulting from partial removal of the cheese quality information problems did not lead to a change in the number of factories in any milk sheds. The improvements in market performance are caused by reduced processing costs. The impact on market performance would be more dramatic if production level rose to a point where more firms could be supported. An increase in the number of firms would decrease monopsony power and would further increase herder producer surplus.

6.3 Policy Implications

In this section the policy implications stemming from and related to the empirical findings of the research are presented. The policy recommendations include:

- DDC privatization can be advocated on the basis that it will improve the welfare of milk producers. Total surplus measured as wholesaler consumer surplus plus processor producer surplus falls only slightly with DDC privatization. This fall is caused by the lower quality of private cheese. However, more weight should be given to milk producer welfare given that consumers are wealthy in comparison and the DDC benefits wealthier groups than the yak herders.

6.3.1 Policy Implication if the DDC is privatized

In this section, policy recommendations are made assuming that the DDC is privatized. The policy recommendations include:

- Efforts are needed to mitigate the negative effects of privatization on herder welfare in the two smaller markets. These efforts could include: assistance to herders to organize into cooperatives to bargain for higher milk price. Alternatively, these herder groups could produce cheese. In these small markets there would be a higher chance of success in organizing herders. This high chance stems from two reasons:(1) the costs of organizing would be lower because there are fewer herders in the smaller markets and (2) because these herders face the greatest monopsony power they would perceive the greatest gains from organizing to reduce monopsony power. A second alternative to mitigate negative impacts in smaller markets from monopsony power would be to regulate the behavior of private firms in these markets. A potential strategy would be to allow private firms to bid for the right to

produce in these markets based on the price of milk they pay herders. Private firms could also be required to pay the average observed milk price in markets with multiple firms.

- Improvement in the quality of private yak cheese would result in large increases in all performance criteria. Strategies to improve quality would have to provide financial incentives to firms to improve quality. Such strategies could include efforts to differentiate the consumer price of cheese by quality and provide incentives to producers to establish reputations. Potential development actions to accomplish these goals include:

  1. A yak cheese stamp could be developed to differentiate high and low quality cheese. The stamp should be provided following: laboratory examination of cheese samples and assessment of private production practices from site inspections. The incentive to produce the higher quality cheese could be an advertising campaign or provision of training to participants. The advertising campaign would create a price difference between low and high quality cheese. The campaign could be paid for by funds already targeted by USAID or from taxes assessed on yak cheese.

  2. Assisting private producers to form an association to monitor cheese quality and build awareness of higher quality cheese produced by its members would contribute to building reputations. Essentially a production region could establish a reputation (this is a common system in Europe).

  3. Quality could directly be improved with training. Such training would include teaching private producers to handle important inputs with proper care, stress the importance of proper pasteurization, stress cleanliness and stress the importance of proper storage conditions.

- Strategies to decrease the processing cost of private cheese production would improve welfare, especially the welfare of milk producers by increasing demand for milk by processors. Strategies to improve the productivity of cheese processors though training would be more cost effective than training herders to improve milk productivity. The lower cost of training cheese producers is because there are fewer cheese producers than milk producers. Strategies to decrease processing cost would include:

  1. Improved access for private firms to import inputs needed from outside the country by making it less difficult for private producers to have access to hard currency. The most important of these inputs are rennant and cheese culture obtained from Denmark.

  2. Training to improve efficiency using inputs and equipment would reduce costs.

3. Reduce or eliminated forestry department charges for wood used by the factories. These factories are located in areas with no shortage and use little wood relative to abundance. If the forestry department no longer had the power to tax producers it would also eliminate their power to extort bribes.

4. Private production costs would be reduced if they were permitted access to official sources of credit. Currently the development banks in Nepal do not recognize yak cheese firms for loan purposes.

5. Elimination of the octroi tax on yak cheese collected on the road between Kathmandu and the factories. This adds cost, the delays in transportation hurt quality and opportunities for officials to demand bribes are created.

- The welfare of yak herders and their community could be improved by taxing cheese in the location of production. The tax should be in the form of a lump sum license fee for operation. Since private producers are earning economic profits such a tax would not change the milk price and quantity purchased. It would reduce their profits. The tax revenue could be used for development activities in the local community and efforts to improve the productivity of cheese producers and yak herders.

6.3.2 Policy Implications if DDC privatization is delayed

Due to political-economic factors, DDC privatization may be delayed for a period of time. The following policy recommendations are for the operation of the DDC:

- The DDC pricing system needs to be reformed to decrease the level of monopsony power being exercised. The DDC should raise milk price to a level closer to the competitive price.

- The DDC needs to rationalize its output prices to fit seasonal changes. The DDC needs to raise price in the winter season and lower price in the spring. Storage costs for DDC are essentially constant throughout the year, independent of the amount of cheese stored. Rational pricing would increase their profits which are used for development efforts. The welfare of consumers and wholesalers are not an important consideration.

6.4 Caveats and Future Research

This research effort represents a first attempt to provide a tractable model specifically for the yak cheese industry and with particular data constraints. Improvements and extensions of the model for broader application and increased reliability would include:

1) Introducing a statistically estimated cost function that captures changes in processing cost with changes in quantities processed. A major weakness of the models is their reliance on economic-engineering models for processing cost and the associated assumption that processing cost does not vary by quantity produced. Estimation of the private firm cost function using cross-sectional data would improve the models. The collection of such data would require extensive field work to obtain needed observations. Determination of processing cost would also allow more precision in assessing license fees on private producers with monopsony power. Ideally the licensee fee would approximate economic profits.

2) Introducing nonlinear supply and demand functions in the model. The model developed relies on the relationship between the Lerner index and the marginal expenditure function of a linear supply curve. Improved estimation of milk supplies though a production function or profit function system that incorporates theoretical constraints and can better approximate functional form would improve the reliability of the model. Cross-sectional data collected across the factory locations could be used in such an approach.

3) An improved approach to estimating the relationship between monopsony power (the Lerner index) and the number of firms in a particular production region would increase the reliability of model results. An improved approach would include determining the relationship in way closer to theory.

6.4.1 Future Research

This section presents future research required to improve yak cheese industry development policy. The future research topics include:

- The impacts of institutional constraints causing the cheese quality information problem need to be tested by a method that can provide a statistical test for their presence. The method employed to detect institutional constraint impact for this effort is only indicative of the potential impacts that institutional constraints have on the welfare of market participants.

- Only a fraction of yak milk produced in the high hills is currently being used for yak cheese production. These areas are located in the western and far western areas of the country which are considerably distant from Kathmandu. The DDC has had no activity in these areas and there are no private producers there. Longer term models to predict outcomes would need to include potential production from these areas.

- If the DDC is not privatized there is a need to define measurable objectives and base pricing policies on those objectives.

6.4.2 Potential Model Applications

The approach used to model DDC privatization can be directly applied for analysis of other agro-industry privitizations. Agro-industry privatization is an important issue across developing countries. The simultaneous equation system developed to predict the private market equilibrium after DDC privatization has the potential to be extended to solve a broader range of research problems. The equation system can be adapted to applications where there are multiple production regions and monopsony behavior varies by region. Such situations would include:

- The evaluation of development activities to improve the productivity of raw agricultural input production. Improved productivity may increase the number of processors and decrease the effects of monopsony market power. Changes in monopsony power in particular production regions will change the overall market equilibrium. To solve for the new market equilibrium in this situation the equation system developed can be utilized.

- Evaluating development activities to improve the productivity of processing raw agricultural inputs or decreasing institutional constraints. Improved productivity may increase the number of processors and decrease the presence of market power. Changes in market power behavior in individual regions will change the market equilibrium. Similarly this new market equilibrium can be predicted by the equation system developed.

- Evaluating policies to bring the behavior of processors closer to competitive outcomes. Such policies could include efforts to assist raw product producers to bargain for higher price or to form cooperatives.

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Appendix A. Economic Engineering Models of Cheese Production

This appendix presents the economic-engineering models used to estimate processing costs for private firms and the DDC (sections 1.A and 2.A). These processing costs represent the cost of converting milk to marketable cheese. It does not include the cost of milk. In the research, processing cost helps determine the milk shed cheese supply functions (see section 4.4). Processing cost is added to the milk supply functions to derive the cheese supply functions . Processing cost is also used to compute the Lerner index for each private milk shed (see section 4.6.3).

Firm economic profits are also estimated from the economic-engineering models. Economists do not generally consider economic-engineering models to be capable of providing proof of market power. However, since data constraints prevent the implementation of more rigorous methods the profit, results are presented to indicate that market power may be present.

The economic-engineering model prices and parameters were collected during field work conducted for a USAID dairy support project. The methods used for data collection are described in section 5.5. The data were collected in 1994 and prices are in 1994 rupees. The exchange rate was $1= Rs 49 in 1994.

Institutional constraint impacts are also introduced in the analysis through modifications to the private firm economic-engineering model parameters. The modifications were determined through consultation with Nepalese cheese experts and producers (see section 5.5).

A.1 Economic-Engineering Model of Private Cheese Production

Table A.1 presents the physical parameters used to estimate private processing cost. The costs are estimated for an average sized private firm which produces 5,344 kgs of cheese annually. There is variability in private firm size. The standard deviation of private firm size is 1,928 kgs of cheese. Though not ideal the modeling process used for this effort does not incorporate changes in processing cost with changes in firm size. There are also no industry level statistics to calculate model parameters. The parameters are based on interviews with selected private producers and experts (see section 5.5). The technology and management practices are similar across firms leading to the expectation that these parameters are representative of the industry. A key parameter of private production that differs from DDC production is the loss rate of cheese (20% vs. 8.5%). Private producers reported high losses both during the production process and marketing process across production regions. Cheese loss occurred during production from mistakes in the cheese recipe and due to poor storage facilities in the hills. Unlike DDC facilities, private stores are not rodent proof. During marketing, private producers lost cheese

due to rough treatment in transportation (crushing) and poor temporary storage conditions in Kathmandu. Once reaching Kathmandu private producers are unable to give the cheese its daily salt treatment.

Table A.1. Private firm physical parameters.

PARAMETERS:	Values
Average Percentage of Milk Fat	6.5%
Cheese Yield (per kg of milk)	0.11
Butter Yield (per kg milk)	0.038
Milk Collected Yearly (kg)	48,580
Total Annual Cheese Production (kg)	5,344
Total Annual Butter Production (kg)	1,846
Production Loss Rate for Cheese	10.00%
Marketing Loss Rate for Cheese	10.00%
Loss Rate for Butter	2.00%
Rennet Rate (kg/per kg of milk)	0.00003
Culture Packs (per year)	4
Salt Rate (kg/per kg Cheese)	0.01
Number of Months Cheese is Cured	2
Fire wood (CBF/kg Cheese)	0.25
Number of Branches	1
Number of Workers at the Factory Branch	3

Source: Colavito (1994)

Table A.2 presents the financial parameters used to estimate private processing cost. Key parameters in the table include the interest rate, marketing cost and the cost of the cash advance. The interest rate represents the opportunity cost of money. Interest rates vary greatly in rural Nepal. In the cheese production region, unofficial rates faced by processors ranged from 10% to 30%. These rates vary depending on the processors' relationship to the loan giver and the standing of the processor in the community. An average rate for private firms as determined from the Participatory Appraisal was used (20%). It should be noted that less powerful members of society cannot receive these high interest rates from investment of their money. Borrowers would simply abscond with their money.[64]

The marketing cost includes bus fare, the cost of living in Kathmandu, and time cost while marketing the cheese. The transportation cost includes the vehicle transportation change and a

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[64] If herders could receive these high rates of interest they would actually be better off selling their herds and living off investment income.

portering charge. The vehicle transportation cost is constant across factories the portering charge represents and average cost across factories. The advance cost is the interest cost to the processor of providing the 50% advance to herders based on the previous year's milk sales. The owners' salary is included because the model is designed to estimate economic profit. The salary reflects the owners' opportunity cost of earnings forgone from alternative employment. The owners are engaged in managing their cheese factories full time.

Table A.2. Private firm financial parameters.

PARAMETERS:	Value
Average Monthly Worker Salary (Rs)	1,700
Owner Monthly Salary (Rs)	2,000
Total Monthly Salary Cost (Rs)	11,100
Amount of Cheese Transported per Trip (kg)	500
Cost per Marketing Trip exclusive of transportation (Rs)	900
Price Paid per Fat unit per kg (Rs)[a]	1.60
Price Paid for Milk (Rs/kg)	10.40
Price of Rennet (Rs/kg)	9,000
Price per Culture Pack (Rs)	1,400
Cost of Storage per Month (Rs)	700
Advance Percentage (last based on last season milk cost)	50.00%
No. of Advance Outstanding Months	6
Salt Cost (Rs/kg)	7
Market Price of Cheese (Rs/kg)	180
Market Price of Ghee (Rs/ kg)	73
Transportation to Kathmandu (Rs/kg)	4.00
Relevant Annual Interest Rate	20%
Fire Wood Rate (Rs/500 Cubic Board Feet)	2,000
Total Firewood Cost (Rs)	5,344

Source: Colavito (1994)
[a] Milk price per liter is based on fat content: Price = (No. of Fat Units) × (Fat Unit Price)

Table A.3 presents both the total and annual cost of capital items. The inventory of capital items needed to produce cheese and their average life was determined from interviews with producers, interviews with cheese experts and visual inspection of cheese factories. To determine item costs, interviews with producers, cheese experts and equipment dealers were used. The Excel program payment function was used to determine the annual cost of the capital items. This function yields the payments for a loan to purchase the item given the loan amount, the number of payments (here the item lifetime) and the interest.

Table A.3. Annual costs of capital items for a branch factory.

Item	New Cost (Rs)	Interest Rate	Life in Years	No. of items	Annual Cost (Rs)	Total Cost (Rs)
Separator 300L./Hr.	20,000	20%	7	1	5,548	20,000
Cheese Kettle (300L)	12,000	20%	20	1	2,464	12,000
Cheese Rack	10,000	20%	10	1	2,385	10,000
Separator 160L./Hr.	12,000	20%	7	1	3,329	12,000
Churn	9,000	20%	8	1	2,345	9,000
Factory Shed	4,000	20%	5	1	1,338	4,000
Cheese Tank	1,500	20%	15	1	321	1,500
Tools	1,500	20%	5	1	502	1,500
Thermometer	200	20%	1	3	720	600
Lamp (Petromax)	1,000	20%	5	1	334	1,000
Glassware	1,000	20%	2	1	655	1,000
Centrifuge	1,100	20%	5	1	368	1,100
Blower	800	20%	2	2	1,047	1,600
Cheese Scoop	710	20%	5	2	475	1,420
Drum	300	20%	5	1	100	300
Milk Cans	1,800	20%	5	9	5,417	16,200
Cheese Hoops	500	20%	5	4	669	2,000
Cheese Harp	500	20%	5	2	334	1,000
Culture Equipment	500	20%	5	1	167	500
Cheese Knife	400	20%	5	2	268	800
Scale	350	20%	5	2	234	700
Iron Bucket	300	20%	2	4	785	1,200
Cheese Cloth (Indian)	400	20%	1	8	3,840	3,200
PVC Pipe	13	20%	2	50	425	650
Misc.	10,000	20%	10	1	2,385	10,000
Total					36,457	113,270

Table A.4 presents annual variable costs. It includes costs for storage, supplies, labor, milk, marketing, and miscellaneous items. The costs use the physical and financial parameters specified in tables A.1 and A.2.

Table A.4. Variable annual costs for a private factory.

Category	Cost Item	Cost (Rs.)
Storage	Rental of Storage Space	8,400
Supplies	Rennet Cost	10,930
	Culture Cost	5,600
	Salt Cost	374
	Firewood Costs	5,344
	Chemicals	2,500
	Sub-total	24,748
Labor	Annual Labor Costs	133,200
Milk Purchase	Total Milk Purchase Cost	505,227
	Total Advance Payment	252,614
	Advance Payment Interest Cost	17,683
	Sub-Total	522,910
Cheese Marketing	Owner Cost Items:	
	Kathmandu Storage Cost	24,000
	Kathmandu Salary Cost	16,000
	Owner Trip Costs	8,657
	Transportation to Kathmandu	21,375
	Misc.	2,000
	Sub-Total	72,032
Miscellaneous	Interest Cost of Cheese Storage	13,073
	Miscellaneous	10,000
	Sub-Total	40,756

Table A.5 presents the calculation of private processing cost and economic profit (see 5.5 for a discussion). Processing cost is used as a margin in the equation system to solve for market equilibria and in the partial equilibrium models to calculate market performance criteria. The value of ghee produced is subtracted from the total processing cost to obtain the processing cost of yak cheese. Table A.5 also presents the economic profit for an average private firm in 1994 rupees using the observed price of private cheese. The profits are economic because they include the opportunity cost of capital and the owners' time. The result is a profit of Rs 59,370.

Table A.5. Processing cost and economic profit for an average private firm.[a]

Item	Value
Cheese Price (Rs/kg)	180
Cheese Quantity Marketed (kg)	4,275
Annual Capital Cost (Rs.)	36,457
Milk Cost (Rs)	522,910
Processing Cost (excluding milk) (Rs.)	319,284
Total Cost (Rs.)	842,195
Value of ghee Produced (Rs.)	132,064
Total Processing Cost of yak cheese (Rs.)	185,411
Processing Cost (Rs./kg)	44
Total Revenue (Rs)[a]	901,565
Total Cost (Rs)	842,195
Economic Profit (Rs)	59,370

[a] Total revenue includes the value of yak cheese and ghee.

Table A.6 presents the cost structure of a private firm reflecting a reduction in institutional constraints (see section 2.4 for a description of the constraint specifics and section 5.5 for a description of how these constraints are incorporated in the economic-engineering models). The modifications to cost structure are based on the opinions of private cheese producers and cheese experts (see section 5.5 for a discussion). The capital cost rises from Rs 36,457, to 128,647. This rise reflects increased capital cost to construct a small factory center to store cheese and house employees and to improve equipment. The fall in marketing cost from Rs 72,032 to Rs 29,400 reflects a reduction in the number of marketing trips. The increased expenditure on capital is expected to increase cheese quality, allowing wholesalers in Kathmandu to purchase larger quantities of cheese. The quantity of cheese produced rises because of a speculated decrease in the private loss rate from 20% to 10%. The price of cheese rises for the modified cost structure due to the improvements in cheese quality. The analysis shows a 160% rise in the firms economic profits.

Table A.6. Modified private firm cost structure reflected reduced inst. constraints.

Category (Rs)	Observed	Modified	Change
Cheese Quantity (kg)[a]	4,275	4,809	534
Wholesale Price (Rs/kg)	180	190	+ 10
Annual Capital Cost(Rs)	36,457	128,647	+ 92,190
Marketing Cost (Rs)	72,032	29,400	- 42,632
Total Revenue (Rs)[b]	901,565	1,045,846	144,281
Total Cost (Rs)	842,195	891,753	+ 49,558
Processing Cost (Rs/kg)	44	49	+ 5
Profit	59,370	154,093	94,723

[a] The quantity of cheese marketed rises due to a decrease in the loss rate from 20% to 10%
[b] The total revenue includes the value of cheese and butter.

A.2 Economic-Engineering Model of DDC Cheese Production

This section presents the economic-engineering model for an average sized DDC factory. A number of general issues concerning the cheese production economic-engineering models are discussed in section A.1. These issues are not repeated in this section. The economic-engineering model of DDC production differs substantially from that of private firms due to differences in firm structure and performance (see section 2.3 for details). The DDC model is for a factory with three mobile satellite factories and a permanent factory center. DDC factories are considerably larger than their private counterparts. The DDC operation also includes an integrated marketing and production system.

Table A.7 presents the physical parameters used to estimate DDC processing cost. There are a number of important differences between the DDC and private firms in the physical parameters of production. DDC losses are substantially less than private losses for both cheese and butter. It should be noted that private firms produce ghee using an indigenous churn while the DDC uses a conventional butter churn to produce butter. The DDC also employs substantially more labor than the private firm (even on a per kg basis).

Table A.7. DDC factory physical parameters.

PARAMETERS:	Values
Average Percentage of Milk Fat	6.5%
Cheese Yield (per kg of milk)[a]	0.11
Butter Yield (per kg milk)	0.038
Milk Collected Yearly (kg)	95,253
Total Cheese Production (kg)	10,478
Total Butter Production (kg)	3,620
Production Loss Rate for Cheese	6.00%
Marketing Loss Rate for Cheese	2.50%
Loss Rate for Butter	1.00%
Rennet Rate (kg/per kg of milk)	0.00003
Culture Packs (per year)	6
Salt Rate (kg/per kg Cheese)	0.012
Number of Months Cheese is Cured	4
Number of Branches	3
Number of Workers	15

[a]This is a physical parameter that does not differ between public and private production, loss rates differ between public and private production.

Table A.8 presents the financial parameters used to estimate DDC processing cost. An important model parameter used is the interest rate. The DDC receives funds below cost from the Nepalese government and foreign donors. However, this represents a subsidy and reduces the cost of risk. For the economic-engineering model of DDC production, the same interest rate that private producers faced was used (20%). This is done to facilitate direct comparison of profitability and processing cost. A number of costs are different for the DDC. The cost of rennet and culture are lower for the DDC because they have official access to hard currency needed to import these items from Denmark. The lower cost of hard currency to the DDC is not expunged from the analysis because there are provisions for private firms to obtain hard currency at the same rates. Due to a lack of connections private firms at the time of the research were not been able to obtain this subsidy. The DDC also receives a higher price for butter than the private producers receive for ghee because of higher DDC quality. The system for charging the DDC for fuel wood is different from that for private producers. The DDC fuel wood charge is computed based on the amount of cheese (i.e., there is a per cheese kg wood charge). Private producers are assessed a charge based on a direct "estimate" of wood used and in practice this is much higher than the DDC charge.

Table A.8. DDC factory financial parameters.

PARAMETERS	Value
Average Salary (Rs/month)	1,800
Price Paid per Fat unit per kg (Rs)	1.50
Price of Rennet (Rs/kg)	6,369
Price per Culture Pack (Rs)	1,265
Advance Percentage	40.00%
No. of Months the Advance is Outstanding	6
Salt Cost (Rs/ kg)	7
Market Price of Cheese (Rs/kg)	200
Market Price of Butter (Rs/kg)	117
Transportation Charge to K'du (Rs/kg)	3.50
Relevant Interest Rate	20.00%
Fire Wood Rate (Rs/kg)	1
Total Firewood Cost	10,478

Table A.9 presents both the total and annual cost of capital items used in the mobile branch factories. Table A.10 presents both the total and annual cost of capital items used at the factory center. See section A.1 for a discussion of how theses costs and the items effective lifetimes were determined. The capital cost for the center is based on engineering estimates of the cost to build a typical DDC factory center (NZFHRC 1994). NZFHRC 1994 also estimated the value of land for a typical DDC factory compound.

Table A.9. Annual costs of capital items for a DDC branch unit.

Item	New Cost (Rs)	Total Cost (Rs)	Interest rate	Life in years	No. of items	Annual Cost
Separator 300L./Hr.	20,000	20,000	20%	10	1	4,770
Cheese Kettle 300L	12,000	12,000	20%	20	1	2,464
Cheese Kettle 160L	7,000	7,000	20%	20	1	1,437
Factory Shed	4,500	4,500	20%	4	1	1,738
Cheese Harp	5,012	5,012	20%	12	1	1,129
Cheese Knife	3,251	3,251	20%	15	1	695
Tools	2,000	2,000	20%	5	1	669
Milk Cans	1,800	27,000	20%	15	15	5,775
Cheese Stirrer	1,519	1,519	20%	15	1	325
Cheese Thermometer	1,115	1,115	20%	2	1	730
Milk Thermometer	1,115	1,115	20%	2	1	730
Centrifuge	1,100	1,100	20%	5	1	368
Lamp	1,000	1,000	20%	5	1	334
Glassware	1,000	1,000	20%	3	1	475
Blower	800	800	20%	3	1	380
Cheese Cloth	700	5,600	20%	2	8	3,665
Cheese Hoops	641	5,128	20%	5	8	1,715
Cheese Press (Local)	500	500	20%	5	1	167
Culture Equipment	500	500	20%	5	1	167
Bucket	500	1,500	20%	5	3	502
Cheese Scoop	383	383	20%	3	1	182
Scale	350	350	20%	5	1	117
PVC Pipe 1m	13	650	20%	2	50	425
Misc.	6,500	6,500	20%	5	1	2,173
Total		109,523				31,134

Table A.10. Annual costs of capital items for a DDC factory center.

Item	New Cost (Rs)	Total Cost (Rs)	Interest rate	Life in years	No. of items	Annual Cost
Item	Cost	Cost	Rate	Years	Items	Cost
Buildings	700,000	700,000	20%	35	1	140,237
Land	83,500	283,500	20%	NA	NA	16,700
Cheese Racks	10,000	10,000	20%	15	1	2,139
Butter Churn	10,000	20,000	20%	7	2	5,548
Tools	2,000	2,000	20%	5	1	669
Milk Cans	1,800	7,200	20%	15	4	1,540
Lamp	1,000	4,000	20%	5	4	1,338
Glassware	1,000	1,000	20%	3	1	475
Culture Equipment	1,000	1,000	20%	5	1	334
Furniture	1,000	15,000	20%	8	15	3,909
Blower	800	1,600	20%	3	2	760
PVC Pipe	13	650	20%	4	50	251
Misc.	15,000	15,000	20%	15	1	3,208
Sub-Total		1,060,950				177,108
Items In Storage						
Scale	2,000	4,000	20%	5	2	1,338
Milk Cans	1,693	6,772	20%	15	4	1,448
Cheese stirrer	1,519	3,039	20%	15	2	650
Cheese Thermometer	1,115	4,460	20%	2	4	2,919
Milk Thermometer	1,115	4,460	20%	2	4	2,919
Glassware	1,000	1,000	20%	3	1	475
Centrifuge	1,200	2,400	20%	5	2	803
Cheese Cloth	732	7,320	20%	2	10	4,791
Cheese Hoops	641	3,205	20%	5	5	1,072
Blower	619	1,238	20%	3	2	588
Bucket	300	1,200	20%	5	4	401
Cheese Scoop	383	766	20%	3	2	364
Misc.	5,000	5,000	20%	10	1	1,193
Sub-Total		44,860				18,960
Total		1,105,810				196,068

Table A.11 presents annual variable costs. It includes costs for storage, supplies, labor, milk, marketing and miscellaneous items. The costs use the physical and financial parameters specified in tables A.7 and A.8. The DDC cost includes an additional cost for its marketing cost in Kathmandu. The DDC maintains a permanent marketing operation in Kathmandu unlike the private firms.

Table A.11. Variable annual costs for a DDC factory.

Category	Cost Item	Cost (Rs.)
Supplies	Rennet Cost	15,167
	Culture Cost	7,590
	Salt Cost	880
	Firewood Costs	10,478
	Other Chemicals	20,243
	Other	20,000
	Annual Costs	74,358
Labor	Annual Labor Costs	324,000
Milk Cost	Total Milk Purchase Cost	928,717
Marketing	DDC computed cost of Marketing (per kg)	24.09
	Interest Cost of Center Storage (per kg)	2.95
	Total Cost (per kg)	27.04
	Total Cost	226,766
Miscellaneous	Advance Payment Cost Calculation:	
	Total Advance Payment	371,487
	Interest Cost	26,004
	Cheese Transportation	32,472
	Butter Transportation	127
	Interest Cost of Cheese Storage	63,648
	Miscellaneous	30,000
	Total	152,251

Table A.12 presents the calculation of DDC processing cost and economic profit (see 5.5 for a discussion). The value of butter produced is subtracted from the total processing cost to obtain the processing cost of yak cheese. The profit reported in table A.13 is economic profit because the opportunity cost of capital and the owners' time are included.

Table A.12. Processing cost and economic profit for an average DDC factory.[a]

Item	Value
Cheese Price (Rs/kg)	180
Cheese Quantity Marketed (kg)	9,587
Annual Capital Cost (Rs.)	289,469
Milk Cost (Rs)	954,721
Processing Cost (excluding milk) (Rs.)	1,020,840
Annual Total Cost (Rs.)	1,975,561
Value of Butter Produced (Rs.)	419,260
Total Processing Cost of yak cheese (Rs.)	601,580
Processing Cost (Rs./kg)	62
Total Revenue (Rs)[a]	2,336,703
Total Cost (Rs)	1,975,561
Economic Profit (Rs)	361,142

[a] Total revenue includes the value of yak cheese and butter.

Appendix B. Estimation of Market Power behavior

The method to compute the Lerner index for milk sheds with private firms uses an economic-engineering model to determine processing cost. This approach is not ideal but was necessary due to a lack of data needed to implement more advanced techniques. Appendix B presents the conjectural variations approach to estimating market power parameters. Given certain conditions, the approach allows for determination of a Lerner index as required for implementation of the method to predict private producer equilibrium.

Conjectural variation methods of measuring the degree of apparent collusion between firms involve parameterizing the marginal revenue (and/or marginal expenditure) function of firm j in industry i and measuring the difference between observed price and marginal revenue at observed outputs. Conjectural variation methods assume that industry prices and outputs are the result of profit-maximizing behavior. The models determine the level of collusion consistent with the observed equilibrium. An important assumption of conjectural variation models is that firms are assumed to simultaneously and independently choose output based on expectations of rival firm behavior (Geroski 1988).

A conjectural variation model developed by Azzam and Pagoulatos (1988) is presented because it allows for parameterization of market power in both the input and output markets. The presentation below directly follows Azzam and Pagoulatos (1988). Their model is described to provide researchers with quick access to a more accepted method of determining market power for implementation of the dissertation model.

The Azzam and Pagoulatos (1988) theoretical model considers an agro-industry with N firms and a firm production function defined as:

(A.1) $\qquad q_j = f(x_{1j}, x_{2j}, ..., x_{mj})$,

where q_j is output (over which firms have monopoly power), is an agricultural input (over which firms have monopsony power), and x_{kj} (where $k = 2, ..., m$) are non-agricultural inputs. Industry output demand is given by equation A.2 and the supply function for the agricultural input is given by equation A.3.

(A.2) $\qquad P = g(Q)$,

(A.3) $\qquad w_1 = h(X_1)$

where P is the price of output, Q is total output, w_1 is the price of the agricultural input and X_1 is the total amount of the agricultural input supplied. The maximization problem for each j firm is given by:

$$(A.4) \qquad \pi_j = Pq_j - \sum_{k=1}^{m} w_k x_{kj} \qquad \text{for } j = 1,2,...,N$$

The first order conditions are given by equations A.5 and A.6:

$$(A.5) \qquad \frac{\partial \pi_j}{\partial x_{1j}} = P\left(1 - \frac{\theta^j}{\varepsilon}\right)f_{x1j} - w_1\left(1 + \frac{\mu^j}{\eta}\right) = 0$$

$$(A.6) \qquad \frac{\partial \pi_j}{\partial x_{kj}} = P\left(1 - \frac{\theta^j}{\varepsilon}\right)f_{xkj} - w_k = 0$$

where j = 1,..,N, K=2,...,M, ε is the price elasticity of output demand, η it the price elasticity of agricultural input supply, θ is the conjectural variation elasticity in the output market (equation A.7), μ is the conjectural variation elasticity for the agricultural input market (equation A.8), and f_{xkj} is the marginal product of the kth input for firm j (equation A.9).

$$(A.7) \qquad \theta_j = \frac{\partial Q}{\partial q_j}\frac{q_j}{Q}$$

$$(A.8) \qquad \mu_j = \frac{\partial X}{\partial x_j}\frac{x_{1j}}{X_1}$$

$$(A.9) \qquad f_{xkj} = \frac{\partial q_j}{\partial x_{kj}}$$

Econometric estimation of equations A.4 to A.6 requires that a functional form be selected. Azzam and Pagoulatos (1988) suggest a translog production function (equation A.10) to limit a priori constraints in modeling equation A.4. For exposition purposes it is assumed that there are three inputs other than the agricultural input and that the conjectural variation term does not vary by firm which allows the firm subscript j to be dropped.

$$(\text{A.10}) \qquad \text{Ln}\,(Q) = b_0 + \sum_{k=1}^{4} b_k \text{Ln}(X_k) + 1/2 \sum_{k=1}^{4}\sum_{j=1}^{4} b_{kj}\text{Ln}(X_k)\text{Ln}(X_j)$$

The marginal product for the kth input given the translog production function defined in equation A.10 is:

$$(\text{A.11}) \qquad fx_k = \left[b_k + \sum_{j=1}^{4} b_{kj}\text{Ln}(X_j) \right] \frac{Q}{X_k}$$

A system of equations (equations A.12 to A.16) that can be estimated econometrically is obtained by substituting equation A.11 into equations A.5 and A.6.

$$(\text{A.12}) \qquad \text{Ln}\,(Q) = b_0 + \sum_{k=1}^{4} b_k \text{Ln}(X_k) + 1/2 \sum_{k=1}^{4}\sum_{j=1}^{4} b_{kj}\text{Ln}(X_k)\text{Ln}(X_j)$$

$$(\text{A.13}) \qquad S_1 = \frac{1 - (\quad/\quad)}{1 + (\quad/\quad)} \left[b_1 + \sum_{j=1}^{4} b_{1j}\text{Ln}(X_j) \right]$$

$$(\text{A.14}) \qquad S_2 = \left\{ 1 - (\quad/\quad) \right\} \left[b_2 + \sum_{j=1}^{4} b_{2j}\text{Ln}(X_j) \right]$$

$$(\text{A.15}) \qquad S_3 = \left\{ 1 - (\quad/\quad) \right\} \left[b_3 + \sum_{j=1}^{4} b_{3j}\text{Ln}(X_j) \right]$$

$$(\text{A.16}) \qquad S_4 = \left\{ 1 - (\quad/\quad) \right\} \left[b_4 + \sum_{j=1}^{4} b_{4j}\text{Ln}(X_j) \right]$$

where $S_i = \dfrac{w_i X_i}{PQ}$ (for i=1,2,3, and 4) are input share equations. Azzam and Pagoulatos (1988)

use the iterative three-stage least squares procedure to estimate the system. It should be noted that because all the variables in the system are endogenous, instrumental variables must be selected to allow for estimation. The conjectural variation elasticities can be recovered if the price elasticities   and   are known.

Given adequate data and observations, the Azzam and Pagoulatos (1988) model could be used to estimate the monopsony power behavior of private producers for each of the milk sheds. The

Lerner index can be determined from the conjectural variation elasticity given that average firm market share and the elasticity of supply for shed j are known (equation A.17).

$$(A.17) \qquad L_j = \frac{s_j}{s} \left(1 + \frac{Q_j}{q_j} \right).$$

There are theoretical problems with the use of conjectural variation models. The selection of a functional form introduces the possibility of misspecification errors. Also models such as the one presented do not incorporate dynamic firm market power behavior (Geroski 1988).

Appendix C. Mathcad Programs used to Predict Market Equilibria

C.1 Mathcad worksheet to predict private market equilibria

Parameters for Estimation of Model Equilibrium:

Yak Milk Supply Elasticity: $\quad s := 2.13$

Yak Cheese Demand Elasticity: $\quad d := -2.3$

Conversion Milk to Cheese: $\quad C := \dfrac{1}{.11}$

Cheese Loss (DDC): $\quad \text{Loss }_D := .085$

Cheese Loss (Private): $\quad \text{Loss }_P := .2$

Milk price per kg (DDC) $\quad P_{mu} := 9.8$

Milk cost per cheese Kg (DDC): $\quad \text{Milk91}_{DDC} := (P_{mu} \cdot C) \cdot \dfrac{1}{1 - \text{Loss }_D} \quad \text{Milk91}_{DDC} = 97.3671$

Yak Cheese Price (DDC): $\quad P_{cheese} := 213$

Private Processing Market Margin: $\quad M := 44$

Private Cheese Price: $\quad P_{privatec} := 192$

Cheese Supply by Shed (DDC 1991):

Factory Locations:	Cheese Produced:	Marketable Cheese:

1. Langtang:
2. Gosaikunda:
3. Kangsing:
4. Chordung:
5. Thodung:
6. Kyama:
7. Chanku:
8. Pike:
9. Taksindu

$$\text{DDCR} := \begin{bmatrix} 6600 \\ 17200 \\ 9000 \\ 18000 \\ 14500 \\ 11000 \\ 12000 \\ 4000 \\ 2000 \end{bmatrix} \qquad \text{DDC} := \begin{bmatrix} \text{DDCR}_0 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_1 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_2 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_3 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_4 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_5 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_6 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_7 \cdot (1 - \text{Loss }_D) \\ \text{DDCR}_8 \cdot (1 - \text{Loss }_D) \end{bmatrix}$$

DemandFunction (1991 Data)

DDC Cheese Marketed: $\qquad$ Demand Function Slope:

$$Q_{cheese} := \sum_{i=0}^{8} \text{DDC}_i \qquad\qquad MC := \dfrac{d}{\left(\dfrac{P_{cheese}}{Q_{cheese}}\right)} \qquad S_d := \dfrac{1}{MC}$$

Demand Intercepts:

Y-Intercept: $H_d := \left| S_d Q_{cheese} \right| \qquad b_d := P_{cheese} + H_d \qquad b_d = 305.6087$

X-Intercept: $\text{Length}_d := \left| \dfrac{P_{cheese}}{S_d} \right| \qquad \text{Int}_x := Q_{cheese} + \text{Length}_d \qquad \text{Int}_x = 284738.85$

Cheese Demand Function: $D_c(q) := S_d q + b_d \qquad\qquad D_c(Q_{cheese}) = 213$

Milk Supply Functions by Location (1991 Data):

1. Langtang

$$MS91_1 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_0}\right)} \qquad S_1 := \dfrac{1}{MS91_1} \qquad H_1 := \left(S_1 \cdot DDC_0\right) - \left(Milk91_{DDC}\right) \qquad S_1 = 0.0076$$

$$b_1 := -H_1 \qquad SM_1(q) := S_1 \cdot q + b_1$$

2. Gosaikunda

$$MS91_2 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_1}\right)} \qquad S_2 := \dfrac{1}{MS91_2} \qquad H_2 := \left(S_2 \cdot DDC_1\right) - \left(Milk91_{DDC}\right) \qquad S_2 = 0.0029$$

$$b_2 := -H_2 \qquad SM_2(q) := S_2 \cdot q + b_2$$

3. Kangsing

$$MS91_3 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_2}\right)} \qquad S_3 := \dfrac{1}{MS91_3} \qquad H_3 := \left(S_3 \cdot DDC_2\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_3 := -H_3 \qquad SM_3(q) := S_3 \cdot q + b_3$$

4. Chordung

$$MS91_4 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_3}\right)} \qquad S_4 := \dfrac{1}{MS91_4} \qquad H_4 := \left(S_4 \cdot DDC_3\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_4 := -H_4 \qquad SM_4(q) := S_4 \cdot q + b_4$$

5. Thodung

$$MS91_5 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_4}\right)} \qquad S_5 := \dfrac{1}{MS91_5} \qquad H_5 := \left(S_5 \cdot DDC_4\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_5 := -H_5 \qquad SM_5(q) := S_5 \cdot q + b_5$$

6. Kyama

$$MS91_6 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_5}\right)} \qquad S_6 := \dfrac{1}{MS91_6} \qquad H_6 := \left(S_6 \cdot DDC_5\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_6 := -H_6 \qquad SM_6(q) := S_6 \cdot q + b_6$$

7. Chanku

$$MS91_7 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_6}\right)} \qquad S_7 := \dfrac{1}{MS91_7} \qquad H_7 := \left(S_7 \cdot DDC_6\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_7 := -H_7 \qquad SM_7(q) := S_7 \cdot q + b_7$$

8. Pike

$$MS91_8 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_7}\right)} \qquad S_8 := \dfrac{1}{MS91_8} \qquad H_8 := \left(S_8 \cdot DDC_7\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_8 := -H_8 \qquad SM_8(q) := S_8 \cdot q + b_8$$

9. Taksindu

$$MS91_9 := \dfrac{s}{\left(\dfrac{Milk91_{DDC}}{DDC_8}\right)} \qquad S_9 := \dfrac{1}{MS91_9} \qquad H_9 := \left(S_9 \cdot DDC_8\right) - \left(Milk91_{DDC}\right) \qquad S_3 = 0.0056$$

$$b_9 := -H_9 \qquad SM_9(q) := S_9 \cdot q + b_9$$

Predicted Private Market Partial Equilibrium Model Solution:
Parameters:
Supply Function Slopes and Intercepts:

   1. Langtang: $\quad S_L := S_1 \qquad Int_L := (b_1 + M) + S_L \cdot (DDC_0 - DDCR_0 \cdot (1 - Loss_p))$

   2. Gosaikunda: $\quad S_G := S_2 \qquad Int_G := (b_2 + M) + S_G \cdot (DDC_1 - DDCR_1 \cdot (1 - Loss_p))$

   3. Kangsing: $\quad S_K := S_3 \qquad Int_K := (b_3 + M) + S_K \cdot (DDC_2 - DDCR_2 \cdot (1 - Loss_p))$

   4. Chordung: $\quad S_{Cd} := S_4 \qquad Int_{Cd} := (b_4 + M) + S_{Cd} \cdot (DDC_3 - DDCR_3 \cdot (1 - Loss_p))$

   5. Thodung: $\quad S_{Th} := S_5 \qquad Int_{Th} := (b_5 + M) + S_{Th} \cdot (DDC_4 - DDCR_4 \cdot (1 - Loss_p))$

   6. Kyama: $\quad S_{Ky} := S_6 \qquad Int_{Ky} := (b_6 + M) + S_{Ky} \cdot (DDC_5 - DDCR_5 \cdot (1 - Loss_p))$

   7. Chanku: $\quad S_C := S_7 \qquad Int_C := (b_7 + M) + S_C \cdot (DDC_6 - DDCR_6 \cdot (1 - Loss_p))$

   8. Pike: $\quad S_P := S_8 \qquad Int_P := (b_8 + M) + S_P \cdot (DDC_7 - DDCR_7 \cdot (1 - Loss_p))$

   9. Taksindu $\quad S_T := S_9 \qquad Int_T := (b_9 + M) + S_T \cdot (DDC_8 - DDCR_8 \cdot (1 - Loss_p))$

Yak Cheese Demand (Based on DDC 1991 Behavior):

Demand Slope(abs): $\qquad d := \cdot S_d \qquad\qquad\qquad\qquad d = 0.0011$

Demand Y-Intercept: $\qquad Int_d := b_d - (P_{cheese} - P_{privatec}) \qquad Int_d = 284.6087$

Lerner Function Slope and Intercept: **Firm Number Slope and Intercept:**

$a := .27 \qquad b := .14 \qquad\qquad\qquad e := .69 \qquad\qquad f := .00013$

Integer Function Defined (Integer(n) returns an integer value): $Integer(x) := if(x - floor(x) < .5, floor(x), ceil(x))$

Guess Values for Model Variables:

Quantity Demanded: $\quad Q_d := 10000 \qquad$ Quantity Supplied: $\quad Q_s := 100000$

Price of Cheese: $\qquad P := 100$

Location:	Cheese Quantities	Lerner Index	
1. Langtang:	$Q_L := 5000$	$L_L := 0$	$N_L := 1$
2. Gosaikunda:	$Q_G := 5000$	$L_G := 0$	$N_G := 1$
3. Kangsing:	$Q_K := 5000$	$L_K := 0$	$N_K := 1$
4. Chordung:	$Q_{Cd} := 5000$	$L_{Cd} := 0$	$N_{Cd} := 1$
5. Thodung:	$Q_{Th} := 5000$	$L_{Th} := 0$	$N_{Th} := 1$
6. Kyama:	$Q_{Ky} := 5000$	$L_{Ky} := 0$	$N_{Ky} := 1$
7. Chanku:	$Q_C := 5000$	$L_C := 0$	$N_C := 1$
8. Pike:	$Q_P := 5000$	$L_P := 0$	$N_P := 1$
9. Taksindu	$Q_T := 5000$	$L_T := 0$	$N_T := 1$

Equations System for Determination of the Predicted Private Market Equilibrium

Given

Demand Equilibrium Equations:

$$Q_d = Q_s \qquad P = -d \cdot Q_d + Int_d$$

$$Q_s = Q_L + Q_G + Q_K + Q_{Cd} + Q_{Th} + Q_{Ky} + Q_C + Q_P + Q_T$$

Milk Shed Equilibrium Equations:

1. Langtang:

$$Q_L = \frac{P - Int_L}{\left(1 + {}_s \cdot L_L\right) \cdot S_L} \qquad L_L = a + b \cdot \left(\frac{1}{N_L}\right) \qquad N_L = Integer\left(e + f \cdot Q_L \right.$$

2. Gosaikunda:

$$Q_G = \frac{P - Int_G}{\left(1 + {}_s \cdot L_G\right) \cdot S_G} \qquad L_G = a + b \cdot \left(\frac{1}{N_G}\right) \qquad N_G = Integer\left(e + f \cdot Q_G \right.$$

3. Kangsing:

$$Q_K = \frac{P - Int_K}{\left(1 + {}_s \cdot L_K\right) \cdot S_K} \qquad L_K = a + b \cdot \left(\frac{1}{N_K}\right) \qquad N_K = Integer\left(e + f \cdot Q_K \right.$$

4. Chordung:

$$Q_{Cd} = \frac{P - Int_{Cd}}{\left(1 + {}_s \cdot L_{Cd}\right) \cdot S_{Cd}} \qquad L_{Cd} = a + b \cdot \left(\frac{1}{N_{Cd}}\right) \qquad N_{Cd} = Integer\left(e + f \cdot Q \right.$$

5. Thodung:

$$Q_{Th} = \frac{P - Int_{Th}}{\left(1 + {}_s \cdot L_{Th}\right) \cdot S_{Th}} \qquad L_{Th} = a + b \cdot \left(\frac{1}{N_{Th}}\right) \qquad N_{Th} = Integer\left(e + f \cdot Q \right.$$

6. Kyama:

$$Q_{Ky} = \frac{P - Int_{Ky}}{\left(1 + {}_s \cdot L_{Ky}\right) \cdot S_{Ky}} \qquad L_{Ky} = a + b \cdot \left(\frac{1}{N_{Ky}}\right) \qquad N_{Ky} = Integer\left(e + f \cdot Q \right.$$

7. Chanku:

$$Q_C = \frac{P - Int_C}{\left(1 + {}_s \cdot L_C\right) \cdot S_C} \qquad L_C = a + b \cdot \left(\frac{1}{N_C}\right) \qquad N_C = Integer\left(e + f \cdot Q_C \right.$$

8. Pike:

$$Q_P = \frac{P - Int_P}{\left(1 + {}_s \cdot L_P\right) \cdot S_P} \qquad L_P = a + b \cdot \left(\frac{1}{N_P}\right) \qquad N_P = Integer\left(e + f \cdot Q_P \right.$$

9. Taksindu

$$Q_T = \frac{P - Int_P}{\left(1 + {}_s \cdot L_T\right) \cdot S_T} \qquad L_T = a + b \cdot \left(\frac{1}{N_T}\right) \qquad N_T = Integer\left(e + f \cdot Q_T \right.$$

$F := \text{Find}(Q_s, Q_d, Q_L, Q_G, Q_K, Q_{Cd}, Q_{Th}, Q_{Ky}, Q_G, Q_P, Q_T, N_L, N_G, N_K, N_{Cd}, N_{Th}, N_{Ky}, N_G, N_P, N_T, L_L, L_G, L_K, L_{Cd}, L_{Th}, L_{Ky}, L_G, L_P, L_T, P)$

$$
F = \begin{bmatrix}
92661.16166 \\
92661.16166 \\
6417.41106 \\
17220.54369 \\
8751.01509 \\
18021.49921 \\
14517.31881 \\
10695.68511 \\
11668.02012 \\
3579.77905 \\
1789.88953 \\
2 \\
3 \\
2 \\
3 \\
3 \\
2 \\
2 \\
1 \\
1 \\
0.34 \\
0.31667 \\
0.34 \\
0.31667 \\
0.31667 \\
0.34 \\
0.34 \\
0.41 \\
0.41 \\
185.15596
\end{bmatrix}
$$

The predicted market outcome imposing competitive behavior is determined by setting the Lerner equation parameters a and b to zero. The market outcome reflecting reduced institutional constraints is determined by solving the model with a processing cost of Rs. 48 and a private yak cheese price of Rs. 203.

C.2 Mathcad Worksheet to Predict DDC Market Equilibria

Equilibrium Condition Observed Variable Values

Yak Cheese Price: $P_{cheese} := 213$

Cheese to Milk Conversion Factor: $C := \dfrac{1}{.11}$

Percentage of Cheese Lost (DDC): $Loss := .085$

Unit Milk Price (kg): $P_{mu} := 9.8$

Milk Cost per Cheese (kg): $P_{milk} := \left(P_{mu} \cdot C\right) \cdot \dfrac{1}{1 - Loss}$ $P_{milk} = 97.3671$

Exchange Rate: $Ex := 50$

Retail Price Yak Cheese: $Retail := 277$

Quantity of Cheese Marketed: $Q_{cheese} := 94300(1 - Loss)$ $Q_{cheese} = 86284.5$

Estimated Variable Values

Yak Cheese Demand Elasticity: $d := -2.3$
(Econometric Estimation)

Yak Milk Supply Elasticity: $s := 2.13$
(Econometric Estimation)

Processing Cost: $M := 62$
(Economic Engineering Model)

Lerner Index (monopsony): $Lerner := .33$
(Nonparametic Estimation):

Fraction of cheese sold for \$: $E := .9$
(Survey Estimate)

Demand Related

Demand Function Slope:

$$CDemand_{der} := \dfrac{d}{\left(\dfrac{P_{cheese}}{Q_{cheese}}\right)} \qquad CSlope_{demand} := \dfrac{1}{CDemand_{der}}$$

Demand Intercepts:

Y-Int: $H_{cdemand} := \left| CSlope_{demand} \cdot Q_{cheese} \right|$ $b_{cdemand} := P_{cheese} + H_{cdemand}$

X-Int: $Length_{cdemand} := \left| \dfrac{P_{cheese}}{CSlope_{demand}} \right|$ $Demand_{xint} := Q_{cheese} + Length_{cdemand}$

Cheese Demand Function: $D_c(q) := CSlope_{demand} \cdot q + b_{cdemand}$ $D_c\left(Q_{cheese}\right) = 213$

Marginal Revenue Function Derived:

$$MR(q) := D_c(q) + q \cdot \dfrac{d}{dq} D_c(q)$$

Aggregate Milk/Cheese Supply based on Econometric Estimates

Milk Supply Slope:

$$MSupply_{der} := \frac{s}{\left(\dfrac{P_{milk}}{Q_{cheese}}\right)} \qquad MSlope_{supply} := \frac{1}{MSupply_{der}}$$

Y-Int: $H_{msupply} := \left(MSlope_{supply} \cdot Q_{cheese}\right) - \left(P_{milk}\right) \qquad b_{msupply} := -H_{msupply}$

Milk Supply Function: $\qquad S_m(q) := MSlope_{supply} \cdot q + b_{msupply}$

Cheese Supply Function $\quad S_c(q) := S_m(q) + M$

Derivation of the Marginal Outlay or Expenditure Function

Milk Input Marginal Expenditure: $\quad ME_m(q) := S_m(q) + q \cdot \dfrac{d}{dq} S_m(q)$

Cheese Marginal Expenditure: $\quad ME_c(q) := \left(ME_m(q) + M\right)$

Perceived Milk/Cheese Supply Based on Nonparametric estimation

Milk Supply Slope: $\quad MSlope_{per} := \dfrac{Lerner}{\left(\dfrac{Q_{cheese}}{P_{milk}}\right)}$

Y-Intercept $\quad H_{per} := \left(MSlope_{per} \cdot Q_{cheese}\right) - \left(P_{milk}\right) \qquad b_{per} := -H_{per}$

Perceived Milk Supply Function: $\quad S_{mper}(q) := MSlope_{per} \cdot q + b_{per}$

Perceived Cheese Supply Function $\quad S_{cper}(q) := S_{mper}(q) + M$

Elasticity of Perceived Milk Supply:

$$Elastic_{ms}(q) := \left(\frac{P_{milk}}{Q_{cheese}}\right) \cdot \frac{1}{\dfrac{d}{dq}\left(S_{mper}(q)\right)} \qquad Elastic_{ms}\left(Q_{cheese}\right) = 3.0303$$

Derivation of the Perceived Marginal Outlay or Expenditure Function

Milk Input Marginal Expenditure: $\quad ME_{mper}(q) := S_{mper}(q) + q \cdot \dfrac{d}{dq} S_{mper}(q)$

Cheese Marginal Expenditure: $\quad ME_{cper}(q) := \left(ME_{mper}(q) + M\right)$

Calculation of Model Equilibriums

Competitive Equilibrium

$Eq_{com}(q) := D_c(q) - S_c(q)$ $q := 100$ $q_{com} := root(Eq_{com}(q), q)$ $q_{com} = 119740.651$

$p_{com} := D_c(q_{com})$ $pm_{com} := S_m(q_{com})$

$p_{com} = 177.0917$

Pure Monopoly and Monopsony Market Power Equilibrium

$Eq_{power}(q) := MR(q) - ME_c(q)$ $q := 21000$ $q_{power} := root(Eq_{power}(q), q)$ $q_{power} = 59870.3255$

$p_{power} := D_c(q_{power})$ $pm_{power} := S_m(q_{power})$

$p_{power} = 241.3502$

Monopsony Model Equilibrium:

$Eq_{msony}(q) := D_c(q) - ME_c(q)$ $q := 100$ $q_{msony} := root(Eq_{msony}(q), q)$

$p_{msony} := D_c(q_{msony})$ $pm_{msony} := S_m(q_{msony})$

Separating the impacts of DDC Output and Input Market Behavior

Pure Monopsony Lerner Index: Estimated DDC Monopsony Lerner Index:

$\dfrac{1}{s} = 0.4695$ $Lerner = 0.33$

DDC Equilibrium Assuming no monopoly power based on estimated Lerner Index:

$Eq_{am}(q) := D_c(q) - ME_{cper}(q)$ $q := 100$ $q_{cper} := root(Eq_{am}(q), q)$

$p_{cper} := D_c(q_{cper})$ $p_{mper} := S_m(q_{cper})$

Estimation of DDC Output Market Behavior

Perceived Marginal Revenue Curve:

$PME := ME_{cper}(Q_{cheese})$ $Slope_{PerMR} := -\left(\dfrac{b_{cdemand} - PME}{Q_{cheese}}\right)$ $Slope_{PerMR} = -0.0013$

Perceived MR Curve $PerMR(q) := Slope_{PerMR} \cdot q + b_{cdemand}$

Perceived Demand Curve $PerDemand(q) := (.5 \cdot Slope_{PerMR}) \cdot q + b_{cdemand}$

Elasticity of Perceived Demand at Actual Equilibrium:

$dper := \left(\dfrac{P_{cheese}}{Q_{cheese}}\right) \cdot \left(\dfrac{1}{\dfrac{d}{dq} PerDemand(q)}\right)$ $dper = -3.7332$

Lerner Index for Cheese Output Market

Actual: Perceived:

$Lerner_{output} := \dfrac{-1}{d}$ $Lerner_{output} = 0.4348$ $Lerner_{poutput} := \left(\dfrac{-1}{dper}\right)$ $Lerner_{poutput} = 0.2679$

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Vita

Luke A. Colavito was born June 13, 1963. He is the son of Mr. Luke J. Colavito and Mrs. Greta M. Colavito. Mr. Colavito received a Bachelor of Science degree in economics from SUNY-Binghamton in 1987. While attending SUNY-Binghamton, he completed an internship with the county planning bureau and worked as a field assistant and manger at the Boyce Thompson Institute for Plant research located in Ithaca, New York during holidays and summers.

Mr. Colavito served in the Peace Corps from February 1987 to May 1990 in Nepal. He served under the National Agricultural Research Council where he worked on studies of modern variety adoption and training office staff. Just after Peace Corps service Mr. Colavito married Bimala Rai in Nepal. Mr. Colavito then worked on a potato variety evaluation study for the Swiss Development Corporation in Nepal.

Mr. Colavito entered the graduate program in the department of agricultural and resource economies at the University of Maine in the spring of 1990 and received a Master of Science degree in 1993. At the University of Maine, Mr. Colavito worked as a graduate assistant on an IPM project to reduce the use of herbicides on potatoes. Upon completion of his masters program Mr. Colavito entered the Doctor of Philosophy program in agricultural and applied economics at Virginia Polytechnic Institute and State University in the fall of 1993. At Virginia Tech Mr. Colavito received funding while pursuing his Ph.D. from 1993 to 1997 as a graduate assistant working on a variety of assignments. These assignments including TA work for classes in environmental law and microeconomics and research assignments on a Zambian structural adjustment program and a USDA funded study on the feasibility of establishing a horticultural shipping-point market in Southwest Virginia. Mr. Colavito received additional support to do Ph.D. field work on the Nepalese yak cheese industry though a USAID dairy development project. He is currently working as a research associate at Virginia Tech developing a Fiscal Impact Model for Virginia counties.