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COOPERATIVE DAIRY DEVELOPMENT IN KARNATAKA, INDIA: AN ASSESSMENT

Harold Alderman

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FOREWORD

Commercialization of agriculture has great potential for increasing gains from trade in rural regions and for utilizing interregional and interhousehold differences in resources more fully. In recent years, many countries have attempted to expand the range of their agricultural exports into high-value products, such as meat, poultry, horticultural, and dairy products. Moreover, as incomes in developing countries rise, domestic markets for these products also expand.

Increased commercialization of semisubsistence agriculture is not, however, without its pitfalls. It exposes farmers to new risks as well as new opportunities—opportunities that may not be equally available to all sectors, with a consequent potential for worsening patterns of income distribution. Finally, increasing trade in agricultural commodities may lead to changes in rural price environments.

IFPRI has undertaken extensive research to examine these issues. Results published so far include *Income and Nutritional Effects of the Commercialization of Agriculture in Southwestern Kenya,* Research Report 63, and two working papers in a cash cropping series: *Commercialization of Subsistence Agriculture: Income and Nutritional Effects in Developing Countries,* Working Paper 1, and *Cooperatives and the Commercialization of Milk Production in India: A Literature Review,* Working Paper 2.

This study uses household level data to assess cooperative dairy promotion in Karnataka, India. The scale of India's programs to increase milk production and to market more milk in its cities is large and so is the controversy generated by it. By focusing on one region in India, the study provides a perspective that complements other studies on dairy development in particular and the research on commercialization of semisubsistence agriculture in general.

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Washington, D.C.
December 1987

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1

SUMMARY

The Karnataka Dairy Development Project was inaugurated in 1974 with the assistance of the World Bank. It is an example of an approach to agricultural development that emphasizes integrating rural households into a market economy by increasing the use of purchased inputs and increasing the marketed surplus. Such approaches have been controversial because it is alleged that the commercialization of agriculture that is a part of the approach worsens the distribution of income and the nutrition of the local population. The evidence available about such approaches is scant, even though the Karnataka project is modeled closely on the larger Operation Flood dairy development project, which has been at the center of these debates.

The study uses multivariate regression techniques to analyze data from five rounds of household surveys collected in two of the three ecological zones of Karnataka covered by the Karnataka Dairy Development Project. The households surveyed in each zone came from 21 villages with cooperatives and 10 villages without. The latter acted as a control group.

The data on milk production showed that the villages with cooperatives produced about twice as much milk as the villages in the control group. This difference can be attributed mostly to the larger number of crossbred cows and buffalo in the cooperative villages. But the presence of a cooperative seemed not to affect the yield of an animal (controlling for breed) per amount of feed or the probability that it would be lactating, both of which reflect management practices. And the differences in feeding rates were slight. It has often been assumed that the amount of labor used per animal increases if a cooperative is established, but no differences between the two sets of communities were found. Labor use, in fact, changed only with the size of the herd and its composition. But because those effects were offset by reductions in the use of labor per animal as herd size increased, the net differences in labor use were small.

Dairying seemed to have no influence on cropping patterns: in the entire sample, less than 4 hectares were used to produce fodder in any one round. Nor did the cooperatives seem to influence nondairy farm profits: they had no observable effect on input prices and increased the amount of household labor employed directly in food production only slightly.

The intent of the dairy development project was to raise producer prices without raising consumer prices. Producers in the villages with cooperatives did receive higher prices than producers in the control villages; the price of buffalo milk was 3 percent higher. This is a statistically significant difference. The price of cow milk was also higher, though by a less significant margin.

Tests designed to show the net effects of the commercialization of dairy production on food consumption showed that increases in the prices of rice and ragi reduced consumption of kilocalories and protein significantly. Whereas consumption of dairy products changed significantly with changes in milk prices, there was little impact on nutrient consumption due to substitution between calories. There appears to be less need for concern about the effects of local milk prices on nutrition than about the effects of local cereal prices on nutrient intake.

The presence of a cooperative tended to reduce the milk consumption of households (with differences in prices and income controlled for), whether they were members of a cooperative or not. But the nutrient consumption of nonproducers fell, while the nutrient consumption of producers increased because their income increased.

Cooperatives did appear to increase the incomes of the households in the cooperative villages. The incomes of larger landholders increased more than the incomes of smaller landholders, but relative, as opposed to absolute, income differences did not increase. No group lost absolutely. There was no net negative effect on the income distribution, though the positive relationship between dairy earnings and the size of landholding makes this conclusion worthy of further study.

Taken as a whole, the study shows that cooperatives are slowly transforming dairy production by replacing local breeds of cows with crossbred cows and buffalo. And farmers seem to prefer the latter. But cooperatives are not increasing the amount of inputs per animal type, nor are they changing fodder production. Consequently, the full potential of the crossbred cows, which require larger amounts of feed but produce more milk than local cows, is not being fulfilled. Both the changes in breeds and the lack of change in inputs show differences between the preferences of planners and farmers that should be taken under advisement in developing policy.

2

INTRODUCTION

Most approaches to agricultural development promote the integration of rural households with a market economy by increasing the use of purchased inputs and by increasing the marketed surplus. Such strategies frequently focus on high-value noncereal crops to earn or save foreign exchange or to meet rapidly growing demand for meat and produce in urban areas. While such cash-cropping strategies may create linkages between sectors of the economy,[1] they often have pitfalls that differ from problems associated with developing semisubsistence agriculture. They expose rural economies to the vagaries of interregional or international trade and the hazards of reliance on poorly developed internal transportation networks. In addition, an emphasis on commercialization of agriculture is alleged to have regressive effects on local income distribution and to worsen the nutrition of the local population. Available evidence on these problems is scant, however, even though crops are produced primarily for sale in many regions.[2]

An example of an agricultural development program that has promoted increased links between hitherto isolated producers of high-value agricultural commodities and an urban marketing grid is the Indian dairy development project known as Operation Flood. The scheme, begun in 1970, was intended to integrate 10 million milk producers into a network of small cooperatives, processors, and marketing unions by 1986. The program is presented as a model use of foreign aid and as an example of smallholder-oriented rural development by its supporters and as a public relations hoax by its more extreme critics.[3]

At times the debate on the merits of Operation Flood has been contentious, reflecting, at least in part, the amount of the resources involved. The first phase of Operation Flood required an investment of Rs 1,300 million.[4] The second phase is projected to cost nearly Rs 4,800 million. Much of the debate centers on which of Operation Flood's goals are worthwhile rather than on whether the goals have been met. But the debate has also focused on specific, measurable, microlevel questions. These include: Has dairy development led to increased production or only changed marketing patterns? Have there been any benefits and have they been equitably distributed? Has the promotion of milk as a cash crop contributed to a decline in rural nutrition? This study is intended to contribute to the quantitative evaluation of this cash-cropping approach in terms of its effects on the production and consumption of food in general and milk in particular, using the Karnataka Dairy Development Project for the study, which, although not formally under Operation Flood, is structured in the same way. In addition to being a case study, it is intended to contribute to the general question of the evaluation of the nutritional effects of commercialization on semisubsistence agriculture.

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[1] John W. Mellor, *The New Economics of Growth: A Strategy for India and the Developing World* (Ithaca, N.Y.: Cornell University Press, 1976).

[2] Joachim von Braun and Eileen Kennedy, *Commercialization of Subsistence Agriculture: Income and Nutritional Effects in Developing Countries,* Working Papers on Commercialization of Agriculture and Nutrition 1 (Washington, D.C.: International Food Policy Research Institute, 1986).

[3] A review of much of the literature on Operation Flood is presented in Harold Alderman, George Mergos, and Roger Slade, *Cooperative Dairy Development in India: Evolution, Debate, and Evidence,* Working Papers on Commercialization of Agriculture and Nutrition 2 (Washington, D.C.: International Food Policy Research Institute, 1987). See also Michael Lipton, "Indian Agricultural Development and African Food Strategies: A Role for the EEC," in *India and the European Community,* ed. W. Callewaert (Brussels: Center for European Policy Studies, 1985).

[4] A dollar was worth between Rs 7.3 and Rs 8.9 in the period 1970-79. It rose to Rs 12.45 by 1984.

3

THE CONTEXT OF THE STUDY

While the responsibility for agricultural development programs in India is shared by the states and the central government, the main program for dairy development in India is the federally sponsored project, Operation Flood. The project, initiated in 1970, has its antecedents in a private cooperative scheme first organized in Anand, in the Kaira district of Gujarat in 1946.[5] An essential feature of this approach is the establishment of thousands of producer cooperatives that regularly collect milk in the villages, ensure its quality, provide prompt payment to producers, encourage improved management techniques, and facilitate access to veterinary services and marketed inputs. These cooperatives are linked through unions in order to use chilling plants and factories that process fluid milk into storage products more effectively and, in so doing, to use flush season production more efficiently.

Operation Flood

Operation Flood has attracted international attention, in part because it is a major recipient of food aid.[6] Most of this aid comes as milk powder and butter oil, which are used in processing centers during slack seasons of domestic milk production. The reconstituted milk is then sold through the market grid, allowing the program to generate funds and maintain marketing channels. The amount of this aid raises the usual controversial questions of dependency and disincentives to domestic producers. However, this aid is also presented as an example of how to use commodity aid creatively to promote agricultural development.

The marketing goals of the program can be evaluated readily by monitoring the amount of milk delivered to the urban grid. This, however, may merely show a shift of marketing channels and not an increase in production.[7] Flood, however, does include a strategy for increasing dairy production. Given perceived grazing constraints and shortages of concentrates as well as the low productivity of indigenous breeds, it was not thought feasible either to increase the herd size or to increase the amount of inputs given to local animals.[8] While some attention has been given to increasing productivity through better husbandry, a major pillar of Operation Flood is the strategy of upgrading the quality of the national herd. This is to be achieved by increasing the number of crossbred cows while holding the size of the total national herd constant, or even reducing it.[9] While some studies have evaluated the production and consumption effects of the program on the household, they have generally been designed as quasi-

[5] Operation Flood is reviewed in Alderman, Mergos, and Slade, *Cooperative Dairy Development in India.* The history of the Anand scheme is presented by S. P. Singh and P. Kelley, *AMUL: An Experiment in Rural Economic Development* (New Delhi: Macmillan, 1981).

[6] Lipton, in "Indian Agricultural Development," records that between 1970 and 1981, Rs 1.5 billion in aid was provided for the program, 80 percent of which came through commodity aid from the World Food Programme and the European Economic Community.

[7] Piet Terhal and Martin Doornbos, "Operation Flood: Development and Commercialization," *Food Policy* 8 (August 1983): 235-239.

[8] National Dairy Development Board, *Breeding and Feeding for Milk Production in Operation Flood II* (Anand: NDDB, 1980).

[9] Ibid. This strategy is also discussed in Surendar Singh, "Operation Flood II: Some Constraints and Implications," *Economic and Political Weekly* (October 1979): 1765-1774; and K. Nair and M. Jackson, "Alternatives to Operation Flood II Strategy," *Economic and Political Weekly* (December 1981): 2129-2132.

experiments that match cooperative villages with similar nonprogram villages.[10] Such an approach, which often compares mean values between villages, is highly sensitive to the choice of villages and their comparability. This study, like a companion study in Madhya Pradesh,[11] attempts to improve on previous empirical household studies by employing multivariate regression techniques rather than by comparing village means.

Neither the Karnataka or Madhya Pradesh projects were administered under Operation Flood. This, however, is a distinction largely based on sources of funding; both states modeled their projects on the Anand scheme and included advisors from the National Dairy Development Board, which oversees Operation Flood.

The Setting in Karnataka

The Karnataka Dairy Development Project was inaugurated in 1974.[12] The project is based on a three-tier organization with the Karnataka Dairy Development Corporation (KDDC) at the apex and the village cooperative network being the base.[13] Four regional milk producer unions link the two. The KDDC was formed with a total capitalization of Rs 465 million, 247 million of which came from the World Bank and the remainder from the central and state governments.[14]

By September 1984 there were 1,875 functioning cooperatives, with a total membership of 313,000. Official figures indicate that 6.0 percent of these members came from families with landless laborers and 21.5 percent came from marginal farming families (less than 1 hectare holdings).[15]

These cooperatives serve as a catchment for the southern and hilly regions of the state—that is, three of the state's six ecological zones. The districts of Bangalore, Mysore, and Hassan, among others, are included in the catchment. Processing plant capacity reached 500,000 liters daily in 1981 and 650,000 by 1985.

The project proposed to increase production by improving animal nutrition and by crossbreeding. The former would be achieved by promoting cultivation of fodder and by supplying concentrates manufactured at local mills with a total capacity of 500 tons per day. This was revised downward to 200 tons per day. The breeding program would use frozen semen from Jersey and Friesian bulls and would be augmented by expanding veterinary and vaccination services through the cooperative societies.

Karnataka as a whole has had moderate rates of increase in agricultural production. Although less rapid and sustained than those in northern India, these rates have still been above the Indian average.[16] Milk production in the state increased 8.1 percent in the two-year period from 1977/78 to 1979/80, compared to 6.5 percent for India as a whole.

Detailed studies of dairy production are scarce. While the National Sample Survey provides some detailed information, the results for 1975/76 were not published until 1984.[17] That report indicates that the average daily production of milk in Karnataka was 0.83 a day from cows and 1.3 liters a day from buffalo. These were 79 and 59 percent of national averages for that year.

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[10] See Alderman, Mergos, and Slade, *Cooperative Dairy Development.*

[11] George Mergos and Roger Slade, *Dairy Development and Milk Cooperation: The Effects of a Dairy Project in India,* World Bank Discussion Paper 15 (Washington, D.C.: World Bank, July 1987).

[12] This section draws on the notes of Professor T. K. Lakshman, former director of research of the Centre for Rural Development Studies, University of Bangalore, who was a principal collaborator in this study. Lakshman was participating in this research at the time of his death.

[13] The KDDC is now the Karnataka Cooperative Milk Producer's Federation.

[14] Katar Singh, R. Srinivasan, and K. V. Raju, *Project Completion Report: Karnataka Dairy Development Project.* (Anand: Institute of Rural Management, 1985).

[15] Ibid.

[16] S. Sawart, "Investigation of the Hypothesis of Deceleration of Indian Agriculture," *Indian Journal of Agricultural Economics* 38 (1983): 475-491.

[17] *Sarvekshana* 8 (July 1984).

Like the rest of India, Karnataka has more cattle than buffalo—more than 9 million of the former and nearly 3 million of the latter. However, the role of cattle is primarily to supply draft power, as the low percentage of female cattle—49 percent—shows. Though the percentage of crossbred cattle in the total herd was low, promotion in the late 1960s and early 1970s resulted in Karnataka having more crossbred cattle than any other state in India.[18]

A study by the KDDC evaluated changes between a benchmark survey in 1977/78 and one in 1980/81.[19] The study documents a change in herd structure, with the number of local cows decreasing and crossbred cows increasing. Similarly, the total amount of feed used decreased, but use of concentrates increased. Average daily yields did not change, but the average number of days in lactation increased. Most significantly, the net return to farmers did not change. The study concentrates on growth in cooperative membership and does not measure changes in productivity. Nor does the study examine consumption or production and returns for farmers not in cooperatives.

Design of the Current Study

The current study was undertaken in two of the three ecological zones covered by the KDDC—the Maidan South and the Transitional South. Data from five rounds of surveys were collected. These included both stock and flow variables for 806 households. The sample included 21 villages from each of the two agroclimatic zones—42 villages with cooperatives. The principal crops in these villages are irrigated rice and ragi, with twice as much area devoted to the latter. Pulses, groundnuts, sugarcane, and mulberry trees for silk production are also grown in the area. Each zone was stratified into three brackets according to age of the cooperative. Seven villages were randomly chosen from each bracket. A census was taken in each village in order to stratify the sample according to landholding status. In each village, 13 households were randomly chosen—3 each from the landless, small farm, and large farm strata, and 4 from marginal farmers. The total from cooperative villages then is 546 (2 zones $\times$ 3 age brackets for cooperatives $\times$ 7 villages $\times$ 13 households). Twenty villages without cooperatives—10 from each zone—were chosen at random from a list of all villages excluding Dairy Cooperative Society (DCS) villages in each district. Again, a census was undertaken and 13 households were selected from each village according to landholding status.

The actual population weights—that is, the proportions of the population in each village belonging to the various landholding classes—are not available.[20] Averages for the villages or averages within the cooperatives cannot, then, be weighted to represent the average within the sampling universe. This, however, does not imply that the statistics for the subgroups are biased. For example, statistics for milk consumption among landless families should be representative of that subgroup. Moreover, the conclusions of this study are not based on comparisons of village means, but on multivariate regressions, which under standard assumptions are unbiased whether weighted or not.

Two types of potential sample selection bias must be considered. Often the villages included in a study are not truly representative of the set of villages from which they are chosen. A village representing dairy

[18] Singh, Srinivasan, and Raju, *Project Completion Report.*

[19] H. Sridhara, M. Munegowda, and K. Krishnamurthy, "Part II—Study on the Basic Resources and Potentials of the Dairy Farmer in KDDC Command Area—A Benchmark Survey," *Applied Forage Research and Demonstration in the KDDC Command Area of Karnataka* (Bangalore: University of Agricultural Science, 1983); and H. Sridhara, M. Munegowda, and K. Krishnamurthy, "Part III—Study on the Impact of KDDC Milk Supply Scheme on the Rural Economy in the KDDC Command Area," *Applied Forage Research and Demonstration in the KDDC Command Area of Karnataka* (Bangalore: University of Agricultural Science, 1984).

[20] Population weights have not been found among the papers of the late T. K. Lakshman.

cooperatives may have larger landholdings than the average cooperative or differ by some other characteristics that influence outcome variables. This type of bias is a particular problem for pairwise comparisons.[21] With a relatively large sample of randomly chosen villages and through the use of multivariate techniques, this study reduces such potential bias.

Another type of bias occurs when the set of villages in which cooperatives were established is inherently different from the control group. If, for example, cooperatives are established in the most productive villages, a comparison of randomly drawn villages with and without cooperatives will attribute such differences in production to the presence of the cooperatives when, in fact, they predated it. The absence of baseline data or longer time series in the villages, then, is a potential limitation of the current study. Published data indicate no significant differences in village sizes in the two subsets in the 1981 census, nor any difference in the average growth rates of population between 1971 and 1981. The latter may be a rough indicator of relative economic conditions as migration would presumably be greater out of the villages with fewer economic opportunities. The control and project subsample village population grew between 2.1 and 2.3 percent annually through the decade. While the control villages had a higher percentage of people in the scheduled castes (18.9 percent compared with 15.4), the project group also included one Tibetan refugee village that is probably closer to the scheduled castes in its social position than to more privileged groups.

A comparison of development indicators that predates the project does not support the view that these two sets differ in infrastructure. The percentage of control villages that had schools, electricity, paved roads, or post offices in 1971 is slightly higher than the corresponding percentage in villages that were to receive cooperatives in the subsequent decade.[22] While the average village in the control sample is slightly farther from the nearest town, the average distance is only 2 percent greater than the average for villages with cooperatives.

More precise indicators, such as the amount of milk produced before the project or the number of crossbred cattle at the time of entering the cooperative, are not available. Other comparisons using survey data show no statistically significant differences in the average prices of commodities other than milk or for wages between the two subsamples. General differences in infrastructure would presumably be reflected in such prices. Similarly, the average yields for the principal field crop, ragi, do not differ between the two subsamples.

Data were collected in five quarterly visits between January 1983 and April 1984. During each visit, data were collected on household incomes and total expenditures, incomes from the sale of milk and prices received, foodgrain yields and incomes from the sale of foodgrains and prices received, labor use in dairy production and other agricultural activities, labor input by each household member, use of modern inputs, and other variables. Daily production net of calf feeding was reported for each cow and by animal type. Production was reported for mornings and evenings separately. Cross checks on sales and production were available; the sum of production of individual cows was compared with total production data elsewhere in the survey, and sales plus home consumption was compared with production data.

Farmers reported the amounts of home-produced as well as purchased concentrates, green fodder, dry fodder, and other fodders fed to each animal. Only when a farmer did not know individual feeding rates were data collected by animal type.

Periodic data were also collected on at least two of the following three variables: the quantity of each food commodity consumed by the household, expenditures for

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[21] Alderman, Mergos, and Slade, *Cooperative Dairy Development.*

[22] Data are from India, Directorate of Census, *Census of India 1971, District Survey Tables,* various volumes (Bangalore: Directorate of Census, 1973).

each commodity, and the price paid for the commodity. While expenditure data provide a cross check for data entry errors, separately reported price data were the source for prices in the subsequent analysis. Expenditures on home-produced goods were evaluated using the average price in the village in that round. Such expenditures were included in total expenditures.

By returning to the same farmers in each round, the survey was able to capture specific seasonal and short-term price effects on production and consumption. This survey approach, referred to as panel data, is particularly useful for controlling for unobservable household-specific factors, such as differences in tastes, and is discussed further in Chapter 7.

In addition, stock or inventory data were collected during the first and last visit and included details of farm size. Data pertaining to other agricultural capital, household size, age and sex of household members, and anthropometric measures were also collected. Data on household size were not keypunched from the fourth or the fifth round for a subset of the sample. The size in the fourth round was used instead, where available. Otherwise, the third-round data were used.

4

CONCEPTUAL FRAMEWORK

A useful conceptual framework for viewing the effects of such projects on human nutrition has been devised by Per Pinstrup-Andersen.[23] A dairy scheme or any other agricultural project can influence nutrition through five pathways. Human nutrition can be affected by: changes in the food available locally; changes in a household's ability to obtain food; changes in a household's preference for foods, given availability and purchasing power; changes in the distribution of food within the household; and other changes in the environment that influence health.

These pathways are often complex, and are discussed in greater detail elsewhere. It is useful, however, to place these pathways in the context of the farm household model that implicitly underlies the data analysis already presented.[24]

Such models begin with the assumption that households maximize farm profits given input prices, output prices, capital assets, and human capital. The maximization is subject to the technology embodied in a production function. Such models may be modified to account for risk aversion as well. Households also maximize a utility function that includes food commodities, nonfood commodities, and leisure subject to exogenous income (including transfers and rents), net farm profits, and the value of time.

Note that the availability of a commodity does not enter the standard model directly, nor is the quantity a household produces generally an argument in the utility maximization or budget constraint from which demand equations are derived. Change in availability only enters into the conventional model insofar as it changes prices, that is, the relationship of demand to availability is important.

An agricultural project can affect household food consumption by introducing changes in technology that increase farm profits and, subsequently, food demand. In a general equilibrium framework, such a shift could lead to an increase of the supply of a commodity large enough to lower prices and profits, but such an issue is outside the discussion here. A project may also upgrade managerial skills, which can increase profits. In another vein, a project may have a significant effect on nutrition through asset transfers and, subsequently, profits. Neither Operation Flood nor the Karnataka project, however, transfers farm assets directly. Nevertheless, conditions created by such projects may encourage private investment, which might increase farm profits over time.

Under such a model, the first link between a project and its nutritional outcome is the change in profits the project induced. This comes from changes in productivity as well as changes in input and output prices. Ideally, total farm profits would be studied, because profits from one commodity may change following a reallocation of resources that affect profits from other commodities. In addition to changes in net profits, changes in labor earnings need to be included in the evaluation of the net effects of a project. The net effect on the demand for individual commodities or for nutrients can be calculated using such changes in earnings as well as changes in commodity prices. Furthermore, though nonseparability of consumption and production implies that a farm

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[23] Per Pinstrup-Andersen, "The Impact of Export Crop Production on Human Nutrition," in *Nutrition and Development*, ed. Margaret Biswas and Per Pinstrup-Andersen (Oxford: Oxford University Press, 1985).

[24] Details and variations of such models can be found in Inderjit Singh, Lyn Squire, and John Strauss, eds., *Agricultural Household Models: Extensions, Application, and Policy* (Baltimore, Md.: Johns Hopkins University Press, 1986).

household model should be estimated simultaneously rather than recursively, a picture of the net effect of a project on nutrition can include the effect of changes in production on the desire to purchase specific foods—that is, on preference ordering.

The goals of the research can be presented in terms of hypotheses about income, food prices, and demand preferences. These are presented below in terms of positive effects, although clearly one wants to test the negative effects as well. The components can then be linked together in order to give a picture of the net effect on nutrition. Furthermore, although demand for an individual food commodity is not an accurate indicator of nutrient demand—which itself is only a rough indicator of economic welfare—the net effect on milk consumption will be presented. In part, this is because a narrow concern with milk consumption, rather than nutrient consumption, still appears in a variety of professional and popular publications. For example, an attack on Operation Flood in the press, which apparently gave impetus to a governmental evaluation of the program, lamented that all the milk in the author's village had gone to towns, but expressed no acknowledgment of the rupees earned in what were presumably transactions freely entered into by farm households.[25] Similarly, a recent National Dairy Development Board report on the nutritional effects of Operation Flood acknowledged the importance of emphasizing nutrients rather than milk per se, then went on to present data documenting the relative decline of milk prices in urban centers and the change in the percentage of poor consumers who purchase milk from organized dairies, rather than in the informal sector, as if this data were evidence of nutritional improvements.[26] Furthermore, milk consumption per se is discussed here because of potential implications for pricing policy.

The hypotheses on the effects of the dairy project on income are as follows:

- The project has increased milk production by increasing production per cow or by increasing the size of the herd or by increasing the share of improved cattle types. The first has been achieved either by a shift of the production curve or a decrease in the size of a gap between the actual and optimal allocation of inputs. The second, the increase of the size of the herd, is not in line with the objective of keeping the national milk herd size constant but is a testable hypothesis that may explain any increase in production. The third can be considered a shift in technology embodied in capital.
- The project has either increased income from other farm activities or reduced such income less than any increase in dairy income.
- The project has increased wage earnings either by an increase in real wages or hours employed or both.

The hypotheses on the effects of the project on available food supplies and prices are as follows:

- The project has decreased or had no effect on the cost of food in project sites.
- In particular, the project has had no effect on the retail price of milk or milk products.
- The project has not created market disequilibria or forced sales. Observed sales of milk, then, reflect market mechanisms and not coercion. In the absence of such extra market effects, sales can be assumed to represent a farm household's optimization of consumer decisions given production possibilities.

The hypotheses on the effects on the desire to purchase nutrients are as follows:

- The project has had no effect on the propensity to purchase calories, controlling for income, or on the propensity to purchase protein, again, controlling for income.
- The project has had no effect on the propensity to consume milk.

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[25] C. Alvares, "Operation Flood: The White Lie," *Illustrated Weekly of India* (October 30, 1983), pp. 8-13.
[26] National Dairy Development Board, *Nutritional Impact of Operation Flood* (Anand: NDDB, 1983).

5

MILK PRODUCTION

Sometimes the reviewer of a book or a movie leaks the outcome of the story. With a good plot, however, knowledge of the final outcome need not detract from the enjoyment of the piece. Here Table 1 serves as such an indiscreet review. It reveals that households in villages organized into cooperatives produce appreciably more milk than their counterparts in the control villages. The rest of this chapter explores this difference and seeks to determine whether the outcome has policy implications or is merely an ironic twist of the basic story line.

The data in Table 2 illuminate this difference in production. They indicate that the composition of production by animal types differs markedly in the two groups of communities. Local cows actually produced more milk and buffalo only slightly less milk in the control villages than in the DCS villages. Households in the cooperative villages, however, reported that crossbred cows produced appreciably more milk. As can be seen, however, yields per lactating animal differ only slightly between the two communities. Much of the difference in production comes from differences in animal holdings and, to a lesser degree, in differences in length of lactation.

Conclusions from a comparison of group means may, of course, be misleading if the

Table 1—Daily household milk production, January 1983-April 1984

Round/Period	Cooperative Villages	Control Villages
	(liters/day)	
Round 1 (January-April 1983)	3.61 (0.20)	1.80 (0.18)
Round 2 (May-July 1983)	2.56 (0.17)	1.57 (0.16)
Round 3 (August-October 1983)	2.95 (0.19)	1.57 (0.17)
Round 4 (November 1983-January 1984)	3.07 (0.19)	1.93 (0.19)
Round 5 (March-April 1984)	2.91 (0.18)	1.77 (0.18)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.
Note: The numbers in parentheses are the standard errors of means.

Table 2—Milk yields per lactating animal and daily milk production, by animal type, January 1983-April 1984

Production or Yield/Animal Type	Cooperative Villages	Control Villages
	(liters/household/day)	
Production		
Local cows	0.48 (0.02)	0.54 (0.03)
Buffalo	1.08 (0.03)	0.88 (0.05)
Crossbred cows	1.46 (0.08)	0.31 (0.05)
	(liters/lactating animal/day)	
Yield		
Local cows	1.54 (0.05)	1.39 (0.04)
Buffalo	1.86 (0.03)	1.85 (0.06)
Crossbred cows	5.79 (0.15)	5.78 (0.49)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.
Note: The numbers in parentheses are the standard errors of means.

populations are not closely matched. By illustration, note that production per household differs by landownership class (Table 3). If landownership or other factors differ between the two communities, then the differences in production may be attributable to such factors rather than to the cooperative structure per se. Accordingly, the main part of this analysis will employ multivariate analysis to explore in detail the differences in production.

As a first step, the differences observed in Table 1 should be tested statistically, controlling for a number of relatively exogenous variables.[27] To do this, household milk production is regressed on characteristics of the household (the age of the head of the household, the education of the household head, household size, and the proportion of children under five in the household, who are, presumably, not available for herding) and of the farm (landholding categories and ownership of a well). In addition, a dummy variable for residence in the control villages (which have no dairy cooperatives) is included. The results, using a tobit regression to account for the special properties of the limit on negative values in the sample, are shown below:

$$\begin{aligned} \text{Total Milk Production} = & -3.37 + \underset{(0.00170)}{0.00133}\,\text{Agehead} \\ & + \underset{(0.083)}{0.405}\,\text{HHsize} - \underset{(2.18)}{6.01}\,\text{Cshare} \\ & + \underset{(0.460)}{1.73}\,\text{Literacy} + \underset{(0.864)}{0.029}\,\text{Matriculate} \\ & - \underset{(0.884)}{2.53}\,\text{Landless} - \underset{(0.787)}{1.07}\,\text{Marginal} \\ & + \underset{(0.873)}{1.789}\,\text{Large Farm} + \underset{(0.717)}{1.15}\,\text{Well} \\ & - \underset{(0.762)}{0.508}\,\text{Dry Season} - \underset{(0.650)}{2.56}\,\text{Control}, \end{aligned} \qquad (1)$$

where

Total Milk Production = the daily household milk production in each round,

Agehead = the age of the household head in months,

HHsize = the number of household members,

Cshare = the percentage of household members under age five,

Literacy = a dummy variable defined as one if the household head is literate,

Matriculate = a dummy variable defined as one if the household head has finished 10th grade,

Landless = a dummy variable defined as one if the household owns no land,

Marginal = a dummy variable defined as one if the household has a landholding less than 1 hectare,

Large Farm = a dummy variable defined as one if the household owns more than 2 hectares,

Well = a dummy variable defined as one if the household owns a well,

Dry Season = a dummy variable defined as one if the observation was taken between May and July 1983, and

Control = a dummy variable defined as one if the household resides in a control village (one with no dairy cooperative).

(The numbers in parentheses are standard errors.)

Table 3—Milk production by landholding category, January 1983-April 1984

Landholding Category	Size of Landholding	Production
	(hectares)	(liters/household/day)
Landless	0	1.47 (0.08)
Marginal farm households	0-1.01	1.86 (0.12)
Small farm households	1.01-2.02	2.77 (0.13)
Other farm households	More than 2.02	4.54 (0.18)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Note: The numbers in parentheses are the standard errors of means.

[27] The phrase "relatively exogenous" may appear contradictory, but inasmuch as variables that are frequently presumed to be exogenous—for example, family size, land ownership, and village residence—may reflect household decisions, the concept of exogeneity may admit relative positions.

Households that are larger or literate or have larger landholdings produce more milk. A higher education has no additional effect. Production is higher when the family owns a well, although this relationship may not be directly causal. The decline of production in the dry season is not significant.

The results show that the households of the control population produced significantly less milk than the residents of villages with cooperatives. Somewhat surprisingly, in another regression (not shown), the additional effect of membership in the cooperative, beyond the effect of the presence of the cooperative in the village, is lower rather than higher production. Only 7 percent of the sample households within villages organized into cooperatives, however, are not members. Since many of the benefits of the cooperatives, particularly the presumed advantage of a reliable market for milk, can be obtained without actual membership, a fair assessment of the effect of the cooperative should include the nonmembers residing in the cooperative villages as beneficiaries, directly or otherwise, of the system. The regression reported in equation (1) indicates that the average household in the cooperative villages produces nearly twice as much milk per day, controlling for other variables.[28] This difference is significant at a probability of error less than 0.001. In a separate regression, no significant difference was observed between older and more recently established cooperatives.

Although statistically significant, such differences in levels of production do not explain the structure of those differences or aid much in program design. Accordingly, it is useful to view the total production per household as a product of three components—the size of the herd, the probability that cows in the herd are lactating, and the yields of lactating cows. Furthermore, if each type of dairy animal is considered separately, total production is the sum of the production for each type of animal. In shorthand notation:

$$\text{Total Milk Production} = \Sigma_i\, [A_i(L_i/A_i)(Q_i/L_i)], \qquad (2)$$

where

A_i = the number of animals of type i that are maintained,

L_i = the number of lactating animals, and

Q_i = the quantity of milk produced per day.

Conceptually, the analysis of herd composition can be broken into the decision to maintain a herd and the subsequent herd stocking conditional on that decision. It does not appear warranted in this sample, however. Few households failed to maintain a herd at one time or another during the 15 months of the survey. But in a number of subsequent regressions, an appreciable proportion of the sample had values of zero for the dependent variable or the regressions were performed on truncated samples—for example, only cows in milk were used to estimate productivity.

Regressions using such samples must take account of these special properties.[29] In the analyses below both probit and tobit estimations are used to correct for biases that would be introduced if ordinary least squares (OLS) estimations were made. Familiarity with such econometric techniques, however, is not necessary for the reader to interpret the regression results presented.

Herd Size

The average household in the cooperative community had a herd of 5.5 cows and

[28] A variable obviously missing is the price of milk. Curiously, the variable had an unexpected negative and statistically significant sign even when deflated by a price index. Perhaps the variable should be lagged, although the data do not allow for a detailed investigation of long-run effects. The coefficient indicating the impact of the cooperative changed little with such an alternative model. Distance to the nearest town was not significant in earlier estimates. As this distance variable is missing for a few villages not reported in the district census, it is not used in the subsequent analysis.

[29] See George Maddala, *Limited Dependent and Qualitative Variables in Econometrics* (Cambridge: Cambridge University Press, 1983).

buffalo in September 1983, of which 28 percent were males or neutered. The milch herd was 36 percent local cows, 17 percent crossbred cows, and 47 percent buffalo. The control community had a somewhat smaller herd of 4.7 animals, 71 percent of which were milch animals. This milch herd was composed of 51 percent local cows, 5 percent crossbred cows, and 44 percent buffalo.

Regressions explaining herd size are shown in Table 4. Households in cooperative communities maintain significantly more crossbred cows and buffalo and fewer of the indigenous type of cows than the control group. The reduction of the number of the local stock is in keeping with the goal of Operation Flood to increase milk production by changing the composition of the national herd, but not its size. However, the net effect indicates that households in cooperatives have significantly larger herds. This is due mainly to a large increase in buffalo rather than in crossbred cattle as planned in the project. While literacy correlates with the number of buffalo maintained, higher education seems to be important only in the case of crossbred cows. Total herd size increases with the size of landholdings and households.

If the cooperative encourages or facilitates investing in cattle, such investment might be cumulative. Accordingly, regressions were run with dummy variables to test the differences between households in villages with newly established cooperatives, those where the DCS had operated between two and four years, and those where the cooperatives were older (Table 4). While the number of buffalo increases progressively with the age of the cooperative (with the newer cooperatives not being significantly different than the control community), a curious pattern is observed in the regressions explaining crossbred cattle. It appears that farms in the newer cooperatives enthusiastically adopt crossbred cattle, but progressively disinvest in these animals as the cooperative matures. (The first subpopulation is significantly different from the others at the 5 percent level. The second is different from the third at the 10 percent level.) This may reflect some drawbacks of owning crossbred cattle, which, if widespread, have serious implications for the dairy development strategy in the region. There are no significant differences between the cooperative subgroups in the regressions with total herd size as the dependent variable.

Although a cross between exotic and local breeds can outperform local stock, successive crosses present difficulties. More than half of second-generation calves that are 75 percent exotic do not live long enough to produce milk,[30] whereas cows that are 25 percent exotic have little if any advantage over local breeds. Early in their experience with crossbred cattle, then, farmers learn that they must either purchase calves or maintain local breeds for replenishing their herds. This, plus the possibility of low-value or high-risk progeny being born to crossbred cows, may discourage farmers.

Although bullocks are only of peripheral concern in this study, the regression concerning the number of bullocks is of some note. The relationship to landholding is, of course, expected. So is the relationship to household size. Since 86 percent of the bullock population were local bovines, it is noteworthy that there were no fewer bullocks in the cooperatives than in the control community, although there were significantly fewer local cows.[31]

Percent of Animals in Lactation

The probability that a cow or buffalo will be lactating at any given time reflects both the breeding success and the duration of lactation following a calving. The biological endowment of the animal, including breed and age, is important, of course. However, management is also important in order to maintain proper nutrition, recognize es-

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[30] R. E. McDowell, "Crossbreeding in Tropical Areas with Emphasis on Milk, Health, and Fitness," *Journal of Dairy Science* 9 (No. 68, 1984): 2418-2435.

[31] For this regression, any nonfemale animal was included as a bullock.

Table 4—Tobit regressions explaining the number of animals stocked, January 1983-April 1984

Independent Variables	Dependent Variables								
	Cows	Cross-breds	Buffalo	Milk-Herd Size	Cows	Cross-breds	Buffalo	Milk-Herd Size	Bullocks
Intercept	1.5397 (0.4335)	−4.0601 (0.4259)	0.8824 (0.4244)	1.0569 (0.2615)	2.0906 (0.4381)	−6.4278 (0.4690)	0.4708 (0.4307)	0.5225 (0.2531)	0.7778 (0.2942)
Agehead	−0.0057 (0.0005)	0.0014 (0.0005)	−0.0061 (0.0005)	0.0007 (0.0003)	−0.0025 (0.0005)	0.0011 (0.0005)	−0.0061 (0.0005)	0.0006 (0.0003)	−0.0055 (0.0004)
Household size	0.2306 (0.0272)	0.1272 (0.0239)	0.2711 (0.0265)	0.3462 (0.0107)	0.2331 (0.0273)	0.1318 (0.0237)	0.2675 (0.0265)	0.3455 (0.0158)	0.3028 (0.0213)
Cshare	−0.8439 (0.7169)	−0.2454 (0.6698)	−2.1678 (0.7049)	−2.6580 (0.4509)	−0.8265 (0.7167)	−0.3400 (0.6645)	−2.1255 (0.7039)	−2.8159 (0.4125)	−1.9959 (0.5639)
Literacy	−0.1531 (0.2102)	0.1920 (0.1967)	0.9611 (0.2058)	0.5861 (0.1318)	−0.1572 (0.2102)	0.1666 (0.1954)	0.9813 (0.2056)	0.5629 (0.1188)	0.5249 (0.1620)
Matriculate	−0.0743 (0.3018)	1.6096 (0.2542)	−0.1064 (0.2890)	0.1997 (0.1441)	−0.0824 (0.3018)	1.6953 (0.2521)	−0.1392 (0.2888)	0.2153 (0.1723)	−0.6126 (0.2349)
Landless	−1.4509 (0.2929)	−1.1603 (0.2736)	−0.2971 (0.2848)	−1.4897 (0.1860)	−1.4428 (0.2927)	−1.1717 (0.2716)	−0.3080 (0.2844)	−1.5080 (0.1645)	−1.4242 (0.2256)
Marginal	−0.7382 (0.2620)	−0.9255 (0.2397)	−0.5369 (0.2585)	−1.0245 (0.1737)	−0.7368 (0.2618)	−0.9507 (0.2381)	−0.5307 (0.2581)	−1.0360 (0.1475)	−0.9090 (0.2009)
Large farm	1.3520 (0.2811)	0.0974 (0.2439)	2.0405 (0.2735)	1.8866 (0.1425)	1.3472 (0.2808)	0.0671 (0.2420)	2.0488 (0.2731)	1.8745 (0.1601)	1.8142 (0.2154)
Well dummy	−0.6004 (0.2284)	0.2733 (0.1979)	0.6006 (0.2194)	0.1020 (0.1217)	−0.5856 (0.2282)	0.3291 (0.1964)	0.5916 (0.2189)	0.1022 (0.1284)	0.0805 (0.1753)
Control dummy	0.5363 (0.2053)	−2.7315 (0.2280)	−0.4416 (0.2031)	−0.6792 (0.1201)	. . .	. . .	. . .	. . .	. . .
Year coop dummy	. . .	. . .	. . .	. . .	−0.7967 (0.2619)	3.0159 (0.2575)	0.1011 (0.2569)	0.5187 (0.1485)	−0.3326 (0.2055)
2-4 year coop dummy	. . .	. . .	. . .	. . .	−0.4363 (0.2594)	2.4554 (0.2588)	0.5204 (0.2545)	0.7115 (0.1478)	0.3021 (0.2022)
Over 4-year coop dummy	. . .	. . .	. . .	. . .	−0.6860 (0.2636)	2.0793 (0.2613)	0.7898 (0.2564)	0.6004 (0.1496)	0.1872 (0.2048)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: Variable names are the same as in equation 1. The numbers in parentheses are standard errors.

trus, and provide a proper sire. The percentage of cows in lactation at any given time is also influenced by culling practices. In the model used to get the regression results reported in Table 5, management was proxied by the education of the herd owner and by the presence of a dairy cooperative. As current herd size may reflect culling practices, the size of the herd in the previous survey round was used to investigate scale effects. The unit of observation was the individual cow. Probit regressions were used rather than OLS.

As expected, the probability of lactation is strongly conditioned by the animal's age, with an apparent peak in probability of lactation, calculated from the quadratic terms, being between the ages of 96 and 108 months (Table 5). No other variable had a consistent effect; buffalo in the control group were somewhat more likely to be giving milk, but the opposite was observed with crossbred cows. Similar mixed results were observed for higher education and farm size, while no effects of herd size were apparent.

In a combined regression (not reported in Table 5), the coefficients of the dummy variables for crossbred cattle and for buffalo were both positive and highly significant, indicating that these animals are more likely to be in lactation than local cows. Moreover, the probability of lactation was also significantly higher for crossbred cows than for buffalo. This combined regression verifies differences between animal types, but the restrictions necessary for pooling the equations were rejected. In the combined regression, the net effect of the variable for the control community was not significant. As education was also not significant, it appears

Table 5—Probit results for probability of lactation, January 1983-April 1984

Independent Variable	Local Cows	Buffalo	Crossbred Cows
Intercept	−3.25	−3.35	−2.95
Cow age	0.056 (0.003)	0.068 (0.003)	0.081 (0.005)
Cow age^2	−0.00026 (0.00002)	−0.00032 (0.00002)	−0.00043 (0.00004)
Literacy	0.0045 (0.005)	−0.0087 (0.051)	0.106 (0.093)
Matriculate	0.251 (0.082)	−0.160 (0.076)	−0.087 (0.119)
Dry season	0.035 (0.051)	0.080 (0.047)	0.110 (0.087)
Landless	0.194 (0.080)	0.086 (0.072)	−0.126 (0.138)
Marginal	0.117 (0.067)	0.211 (0.066)	−0.082 (0.118)
Large farm	0.025 (0.061)	−0.021 (0.055)	0.108 (0.099)
Well ownership	−0.021 (0.052)	0.019 (0.044)	−0.079 (0.087)
Lagged herd size	0.0003 (0.004)	−0.0016 (0.004)	0.0027 (0.008)
Control dummy	0.062 (0.052)	0.083 (0.051)	−0.306 (0.130)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.
Note: The numbers in parentheses are standard errors.

that biological endowment was not appreciably augmented by education or management in the communities studied.

Milk Production Curves

It is of interest to observe whether the technical relationships transforming feed inputs into milk differ between cows in control and dairy cooperative households. It is plausible that management techniques differ so that output *at a given level of input* differs. A dummy variable for literacy is often included in production functions as a proxy for management. In the regressions reported in Table 6, a dummy variable for the control community was included to test the hypothesis that management, hence output per amount of inputs, differed in the two groups. Such regressions were made by animal type when the respondent was able to distinguish the feed given to the different breeds. Production was per lactating animal and inputs were per animal. A pooled regression (not reported) was also estimated, but the restrictions implied by such a pooling were rejected.

Only a few variables in the regressions had consistent and significant effects. Productivity was consistently lower in the dry season. The elasticity of purchased concentrates was statistically significant and positive and greatest for crossbred cows. It was also greater than the elasticities for home-produced concentrates, which were positive but not significant. While the coefficient of labor was positive and significant for cows, it was not significant in the other regressions. The coefficient of pasture hours was consistently negative and dry fodder was negative or not significant in each regression. These coefficients, then, were less than reliable for estimates of the marginal productivity of inputs, but the primary concern for their inclusion here was to prevent missing variable bias of the coefficient for the control community.[32]

There is no evidence in the sample to support the hypothesis that the dairy cooperatives increase productivity per lactating animal. Indeed, it appears that the productivity of crossbred cows was higher in the control population. Given that this appears to have been the case in each of the three subcategories of cooperatives grouped by age, containing 14 cooperatives each, this is unlikely to have been an artifact introduced by special conditions in some cooperative villages. Those few farmers in the control villages that adopted crossbred cattle represent the most progressive farmers in that community. They may have better management skills than the average farmer in the larger group of crossbred owners in the cooperative villages.

One other item of note in these regressions is that crossbred or local cows owned by the landless were significantly less productive than those owned by small farmers. The reverse is true for buffalo. The landless have larger herds of buffalo than small farmers, but smaller herds of two categories of cows. An econometric refinement, beyond the scope of this research, would analyze productivity and herd size as jointly determined.

Input Demand

It is possible that both communities are on the same production curve but use different amounts of inputs. This could lead to differences in production. Such differences might reflect differences in input prices or imperfections in markets not indicated by such prices. They may also reflect differences in attitudes toward risk or differences in allocative efficiency with risk aversion

[32] Regressions were also performed using data for those cows for which individual feed levels were known. These regressions included variables for the age of the animal and time since calving, as well as the reported value as a proxy for genetic stock. (This latter variable had virtually identical coefficients for each animal type.) A Heckman procedure, from James Heckman, "Sample Selection Bias as a Specification Error," *Econometrica* 47 (January 1979): 153-162, was used to account for any bias introduced by selection of lactating cows. The basic results do not differ from those reported in Table 7. In these regressions, however, dry fodder had small positive elasticities significant at the 10 percent level.

Table 6—Coefficients of production functions, January 1983-April 1984

Independent Variable	Dependent Variable: Model 1 — L Prod (Local Cows)	L Prod (Buffalo)	L Prod (Crossbred Cows)	Model 2 — L Prod (Local Cows)	L Prod (Buffalo)	L Prod (Crossbred Cows)
Intercept	−0.220	0.670	1.800	−0.240	−0.690	2.170
L fodder	0.114 (0.082)	−0.082 (0.056)	−0.318 (0.094)	0.122 (0.082)	−0.087 (0.057)	−0.311 (0.094)
L home-produced concentrate	0.014 (0.015)	0.010 (0.010)	0.034 (0.022)	0.014 (0.015)	0.010 (0.010)	0.031 (0.022)
L purchased concentrate	0.060 (0.017)	0.053 (0.012)	0.207 (0.027)	0.057 (0.017)	0.053 (0.012)	0.217 (0.028)
L pasture hours	−0.123 (0.041)	−0.016 (0.020)	−0.071 (0.020)	−0.133 (0.041)	−0.017 (0.020)	−0.068 (0.020)
L labor	0.169 (0.075)	0.002 (0.052)	−0.001 (0.072)	0.182 (0.075)	0.003 (0.052)	−0.004 (0.072)
Literacy	0.050 (0.075)	−0.040 (0.050)	−0.087 (0.093)	0.043 (0.067)	−0.039 (0.051)	−0.096 (0.094)
Dry season	−0.394 (0.083)	−0.373 (0.059)	−0.369 (0.114)	−0.395 (0.083)	−0.373 (0.059)	−0.361 (0.114)
Landless	−0.209 (0.102)	0.123 (0.071)	−0.351 (0.140)	−0.223 (0.103)	0.124 (0.072)	−0.376 (0.140)
Marginal farms	−0.195 (0.088)	0.126 (0.065)	−0.146 (0.127)	−0.203 (0.088)	0.125 (0.065)	−0.162 (0.128)
Large farms	−0.089 (0.100)	0.003 (0.071)	0.067 (0.120)	−0.096 (0.100)	0.001 (0.071)	0.068 (0.120)
L herd size	0.329 (0.132)	0.037 (0.095)	0.078 (0.137)	0.342 (0.182)	0.037 (0.095)	0.086 (0.137)
Well ownership	−0.136 (0.082)	0.069 (0.052)	−0.038 (0.096)	−0.120 (0.082)	0.068 (0.053)	−0.050 (0.099)
Control dummy	0.031 (0.066)	0.024 (0.045)	0.350 (0.150)	...	...	...
Under 2-year coop dummy	...	...	...	−0.168 (0.089)	−0.035 (0.067)	−0.403 (0.159)
2-4-year coop dummy	...	...	...	0.015 (0.094)	−0.016 (0.067)	−0.202 (0.166)
Over 4-year coop dummy	...	...	...	0.027 (0.087)	−0.021 (0.064)	−0.434 (0.169)
Degrees of freedom	477	795	265	475	793	263
R^2	0.15	0.10	0.35	0.15	0.10	0.36

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: L fodder, L home-produced concentrate, L purchased concentrate, L pasture hours, and L labor are the logs of the daily use of the respective inputs per animal. L Prod is production per lactating animal. L herd size is the log of the total number of milch animals owned. The other variables are defined in the text. The numbers in parentheses are standard errors.

held constant. A full analysis of such issues goes beyond the nature and quality of the data available, but a glance at Table 7 is enough to indicate that there were differences in the amounts of feed used that deserve investigation.

For example, there were major seasonal differences in input use, particularly for green fodder and dry fodder, although changes in the use of concentrates were also observed.[33] This may reflect the seasonality of the monsoon that began in July, though pasture hours, surprisingly, show no seasonal pattern. The pattern discernible in the use of other feeds is hard to explain. It is conceivable that the definition of home-produced concentrates was changed during the survey without any documentation being recorded.

Both communities reported a moderate amount of labor per animal—155 minutes daily in the cooperative villages and 164 in the other villages. This includes herding time, usually by children, as well as gathering fodder, milking, and marketing the milk. No differences in the reported ratio of hired to total labor were observed. In the control community, 15.3 percent of the labor was hired while 15.1 percent was hired where cooperatives were present. A regression of agricultural wages against time and a dummy variable for the control community indicated a significant rise in wages over the study period but no differences in the average wage in the two communities.

It should be recalled that herd composition in the two communities differs. This is a probable explanation for the differences in use of concentrate between the cooperative and control groups; an average of more than a kilogram of purchased concentrates was fed daily to crossbred cattle over the five survey rounds. Accordingly, the multivariate regressions to test for differences in input use reported in Table 8 were run by animal type. A test for pooling rejected the restrictions that such a pooling implies. However, inasmuch as labor is often collectively applied to the total herd, the regression for labor inputs is by herd rather than by animal type.[34] As no zero values were

Table 7—Daily feed inputs per animal, January 1983-April 1984

Period/Type of Village	Green Fodder	Dry Fodder	Purchased Concentrates	Home-Produced Concentrates	Other Feed	Pasture
			(kilograms/day)			(hours/day)
January-April 1983						
Cooperative villages	2.22	4.55	0.89	1.51	0.08	3.31
Control villages	0.96	5.20	0.57	1.64	0.14	4.36
May-July 1983						
Cooperative villages	2.20	4.02	0.19	0.65	0.34	3.40
Control villages	1.61	4.10	0.14	0.51	0.26	3.70
August-October 1983						
Cooperative villages	9.06	1.15	0.40	0.40	2.31	3.23
Control villages	8.30	1.09	0.19	0.04	2.39	4.14
November 1983-January 1984						
Cooperative villages	6.19	4.55	0.44	0.16	3.27	3.51
Control villages	5.30	4.71	0.18	0.15	3.04	4.12
March-April 1984						
Cooperative villages	1.34	7.19	0.40	0.26	3.36	3.46
Control villages	0.98	7.67	0.34	0.16	3.42	3.72

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

33 Green fodder and dry fodder were combined in the production function of Table 6 on the basis of dry matter equivalents.

34 Production functions similar to those presented in Table 6 were run with predicted rather than observed inputs. While production elasticities in these equations differ from the reported values, the coefficients of the control variables do not change.

Table 8—Coefficients from the feed demand equations, January 1983-April 1984

Independent Variable	Purchased Concentrates			Fodder[b]			Home-Produced Concentrates			L Labor Per Animal (Total Herd)	
	Cows[a]	Buffalo[a]	Cross-breds[a]	Cows	Buffalo	Cross-breds	Cows[a]	Buffalo[a]	Cross-breds[a]	Model 1	Model 2
Intercept	1.9784 (4.644)	7.6475 (2.948)	7.4758 (3.163)	−3.7510 (1.157)	−0.1663 (1.043)	−11.933 (2.294)	22.496 (4.422)	22.162 (4.065)	16.473 (8.812)	7.9319 (0.5369)	9.0865 (0.4885)
AgeHead	−0.0035 (0.0008)	−0.0029 (0.0005)	−0.00006 (0.0005)	−0.00001 (0.0002)	0.0002 (0.0002)	0.0002 (0.0004)	−0.0021 (0.0007)	−0.0031 (0.0006)	−0.0035 (0.0015)	−0.00001 (0.00008)	−0.00005 (0.00008)
Household size	0.0122 (0.0426)	−0.0012 (0.0300)	0.0514 (0.0235)	0.0007 (0.0110)	−0.0082 (0.0108)	−0.0270 (0.0171)	0.0569 (0.0388)	−0.0257 (0.0391)	−0.1112 (0.0650)	−0.0317 (0.0046)	−0.0151 (0.0042)
Cshare	1.9307 (1.067)	0.3048 (0.6604)	−0.6233 (0.5922)	−3.8891 (0.2835)	−0.2663 (0.2432)	−0.1711 (0.4304)	0.3435 (1.003)	0.5726 (0.8737)	−0.8889 (1.564)	0.1466 (0.1099)	0.8173 (0.09929)
Literacy	−0.0086 (0.3061)	−0.2535 (0.1863)	0.1139 (0.1854)	−0.0244 (0.0774)	0.0324 (0.0656)	0.1452 (0.1339)	−0.2070 (0.2785)	0.1529 (0.2452)	−0.1342 (0.4985)	−0.0756 (0.0306)	−0.0668 (0.0276)
Matriculate	−0.1385 (0.4708)	0.2053 (0.2826)	0.4972 (0.2271)	0.1676 (0.1210)	−0.0203 (0.1032)	−0.0736 (0.1653)	0.1047 (0.4295)	0.1266 (0.3707)	0.2326 (0.5973)	−0.0199 (0.0456)	0.0071 (0.0412)
Landless	0.8755 (0.4415)	0.1296 (0.2493)	0.5508 (0.2430)	0.0806 (0.1113)	0.1775 (0.0892)	−0.3224 (0.1761)	−0.2510 (0.4009)	−0.1171 (0.3352)	−0.6390 (0.6577)	0.2128 (0.0428)	0.1835 (0.0386)
Marginal	0.7018 (0.3839)	−0.1997 (0.2347)	0.7198 (0.2191)	−0.0828 (0.0951)	0.0013 (0.0832)	−0.2615 (0.1593)	−0.2225 (0.3420)	0.1931 (0.3100)	−0.2664 (0.5875)	0.1253 (0.0380)	0.0818 (0.0344)
Large farms	0.0946 (0.4318)	−0.2208 (0.2564)	−0.1973 (0.2181)	0.1326 (0.1061)	−0.1020 (0.0911)	−0.0618 (0.1568)	0.2108 (0.3772)	0.4313 (0.3348)	0.2388 (0.5704)	−0.2691 (0.0412)	−0.0996 (0.0383)
Well ownership	0.6543 (0.3469)	0.3831 (0.1910)	0.5159 (0.1747)	0.1009 (0.0888)	0.0846 (0.0697)	0.0967 (0.1267)	−0.2044 (0.3189)	−0.3471 (0.2515)	−0.1316 (0.4671)	−0.0233 (0.0322)	−0.0052 (0.0291)
Dry season	−0.8645 (0.4081)	−0.6276 (0.2370)	−1.1182 (0.2105)	−0.5499 (0.0981)	−0.7463 (0.0831)	−0.0053 (0.1489)	−0.3950 (0.3520)	0.2002 (0.2939)	−0.0330 (0.5384)	−0.1549 (0.0359)	−0.1532 (0.0323)
Percent lactating animals	0.6513 (0.5992)	1.1925 (0.3356)	1.2507 (0.3321)	1.0641 (0.1550)	0.8379 (0.1196)	0.9006 (0.2419)	0.5758 (0.5554)	0.1988 (0.4497)	0.7224 (0.8889)	0.7138 (0.6347)	−0.2182 (0.0756)
Log ragi price	−0.7889 (2.453)	4.4397 (1.758)	3.0448 (1.898)	2.1911 (0.6161)	−1.6525 (0.6089)	1.4654 (1.369)	6.7245 (2.321)	6.5650 (2.248)	−2.7879 (5.025)	0.3092 (0.2671)	0.1263 (0.2413)
Log milk price	−8.9269 (3.236)	−3.5822 (2.115)	−4.1602 (2.073)	4.3569 (0.7871)	5.6190 (0.7607)	1.7431 (1.496)	−8.0366 (2.842)	−8.4870 (2.7690)	2.6821 (5.423)	−1.2643 (0.3308)	−1.1764 (0.2986)

(continued)

Table 8—Continued

Log wage	3.4528 ...	−4.3065 (2.475)	−3.5429 (2.4450)	0.2034 (0.9734)	−1.8065 (0.8648)	6.7661 (1.760)	−11.561 (3.681)	−10.713 (3.303)	−8.7162 (6.620)	−1.5482 (0.4162)	−1.5945 (0.3757)
Percent buffalo	...	...	...	...	...	...	...	...	...	0.1893 (0.0319)	0.1716 (0.0288)
Log herd size	...	...	...	...	...	...	...	...	...	...	−0.5893 (0.0312)
Control	−0.7110 (0.3201)	−0.1468 (0.2169)	−0.2217 (0.2641)	0.1747 (0.0777)	0.0583 (0.0753)	−0.0238 (0.1896)	−0.4817 (0.2872)	−0.4869 (0.2873)	−0.0943 (0.7029)	−0.01674 (0.0331)	−0.0186 (0.0299)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.
Note: The numbers in parentheses are standard errors.
[a] These are Tobit regressions.
[b] Fodder is dry and green fodder combined on a dry matter basis.

valid for labor inputs, the logarithm of labor was used as the dependent variable. Such a transformation allows for direct estimation of wage and scale elasticities.

There are few regular results in Table 8. The control community differed in its input use in four cases; they used a smaller amount of concentrates for cows and of home-produced concentrates for cows and buffalo but more fodder for cows. In the other regressions, no significant differences between the communities were observed. There was likely, then, to be a small effect on total production due to differences in input use.

Literacy did not affect input use, although high school graduates used more concentrates on crossbreds and less labor (hired and household). Total labor inputs were also strongly related to farm size. There also is some evidence that landless and marginal farmers purchase more concentrates than other farmers. Most farmers also reduced inputs in the dry season.

Price effects were, frankly, too erratic to be plausible. This was particularly true for home-produced concentrates, but as mentioned, there is a time trend in the usage of such concentrates that correlates with the trend in prices. The trend in use of this input may, however, actually have reflected a change in the definition of the variable by the field staff. Finally, note that fodder inputs and concentrates increased when animals were lactating.

At this point it is useful to briefly summarize the results in this chapter. A significantly higher level of milk production is observed in the cooperative villages. This can be attributed to increases in the numbers of crossbred cows and of buffalo. There was no observable effect on production per animal or on lactation rates and only a slight effect on feeding rates attributable to the presence of a cooperative. Labor, the use of which is often presumed to increase with the presence of cooperatives, did not differ in the two communities in terms of labor per animal. The effect on total labor use, then, came only from the increase in herd size and the shift of composition. As there were apparently strong scale effects—with larger herds the labor per animal declined—the net effect on labor use was small.

This modest effect on labor is somewhat out of keeping with the conventional wisdom on dairying. However, the concern here is with the additional labor necessary to increase herd size and to maintain improved breeds, taking into account actual village practices rather than recommended levels of inputs. The project led to an increase of only 0.39 milch animals per farm household. Moreover, many activities, such as carrying milk to the collection center or taking animals to pasture, do not require more labor as herd size increases. These two factors account for the small increase in labor. This observation, however, does not belie the premise that the adoption of dairying as a household activity provides new and profitable activities for household members, particularly landless and marginal rural households. The data here were not conducive to a study of the effects of adoption of dairying as opposed to intensification.

Little land was devoted to fodder production—less than 4 hectares over the entire sample in any given round. Dairying, then, did not directly influence cropping patterns. Furthermore, with no observed effect of the project on wages or other input prices and only a small increase of household labor employed directly in milk production, there is no reason to anticipate changes in nondairy farm profits due to the introduction of the cooperatives. While other linkages are conceivable—for example, the effects if more manure were available or cash flow were to improve—the unavailability of adequate data to investigate total farm profits does not appear to be a serious obstacle to investigating the project's effect on household food consumption.

6

MILK MARKETING

Although Chapter 5 indicates that the cooperatives have helped increase production by encouraging the adoption of crossbred cows, a more visible role of dairy cooperatives, one perhaps more intrinsic to them, is in marketing. While the regressions presented in Chapter 5 were not able to measure a convincing producer response to milk prices, increases in production following increases in farmgate prices are plausible. Similarly, dairy development should affect consumer demand through prices; prices affect demand directly through commodity substitution and indirectly through the income of producers. Consequently, this chapter begins with an investigation of prices in the study area and then discusses the marketing patterns of milk producers.

Milk Prices in the Study Area

One of the most satisfying forms of market development would be a scheme that raised producer prices without raising consumer prices through reductions in marketing margins. Operation Flood and the Karnataka project have such intentions. While there is much rhetoric giving middlemen the responsibility for large price spreads, there is little evidence that milk marketing is not competitive. Nevertheless, there are economies of scale in marketing that are available to cooperatives. In general, such changes in marketing costs are more likely to lower consumer prices in the final urban markets than in rural markets. Indeed, since prices offered in rural areas are essentially the market clearing price in the major consuming region (usually urban) minus transport costs, lower marketing costs could raise prices in rural areas.

The regressions in Table 9 examine both producer and retail milk prices.[35] The control villages paid lower prices for both cow and buffalo milk, although only the latter was significantly lower at a 5 percent level of significance. The producers in the control community also received a lower price for their production. Furthermore, the difference in producer prices between the control villages and the cooperatives was nearly identical to the differences in retail prices. Local marketing margins, which were small, do not appear to have been affected on the average. The differences in prices, however, were small. The difference in producer prices between the two communities was approximately 3 percent.

A comparison of the intercepts in the two nominal retail regressions that represent first-round prices indicates that buffalo milk prices were higher than cow milk prices. This is consistent with the value placed on the higher fat content of buffalo milk. While the differences between the prices of the two commodities varied slightly during the subsequent rounds, the average price of buffalo milk remained greater than that of cow milk. A similar result is indicated by the variable for the share of buffalo milk in the equation for producer prices. Because this variable is the ratio in production, however, it is only a proxy for the percentage of buffalo milk in sales. For producers selling only buffalo milk, the farmgate price received in round 1 would have been Rs 2.33 per kilogram; this was virtually identical to the retail price of buffalo milk. The gap between producer and retail prices varied somewhat over the survey.

The gap was never large, however; it was in the neighborhood of 10 percent of the average price at its largest. It is likely

[35] The retail prices are average prices per kilogram in each village in each round, whereas the regressions on producer prices were run on the prices reported by individual farmers.

Table 9—Results of regressions explaining milk prices, January 1983-April 1984

Independent Variable	Nominal			Deflated by Cereal Price Index		
	Retail Price of Buffalo Milk	Retail Price of Cow Milk	Producer Price of Milk	Retail Price of Buffalo Milk	Retail Price of Cow Milk	Producer Price of Milk
			(Rs/kilogram)			
Intercept	2.313	2.103	2.169	2.624	2.386	2.470
Round 2	0.166 (0.032)	0.292 (0.038)	0.069 (0.019)	−0.016 (0.037)	0.132 (0.041)	−0.115 (0.021)
Round 3	0.211 (0.033)	0.345 (0.040)	0.038 (0.021)	−0.254 (0.038)	−0.089 (0.043)	−0.400 (0.023)
Round 4	0.334 (0.032)	0.398 (0.038)	0.130 (0.020)	−0.184 (0.037)	−0.083 (0.041)	−0.365 (0.022)
Round 5	0.267 (0.035)	0.414 (0.041)	0.228 (0.023)	−0.194 (0.040)	−0.017 (0.044)	−0.102 (0.025)
Share of buffalo milk in total production	. . .	. . .	0.151 (0.015)	. . .	. . .	0.150 (0.016)
Control dummy	−0.075 (0.023)	−0.041 (0.027)	−0.067 (0.016)	−0.076 (0.027)	−0.038 (0.029)	−0.074 (0.016)
R^2	0.318	0.352	0.141	0.218	0.118	0.263

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.
Notes: The numbers in parentheses are standard errors.

that many sales in the villages were directly between consumers and producers. This would have eliminated any marketing margin. The study, however, was not designed to document this detail of marketing.

A second set of regressions, which deflate the milk prices by an index of cereal prices, presents a similar picture.[36] The relative price of milk, either retail or farmgate, was lower in the later rounds than in the first. This similarity of the control variable in the two sets of regressions implies that cereal prices did not differ between the communities. This was confirmed by a test of the differences between mean cereal prices.

Marketing Patterns

Utilization of milk production is indicated in Table 10. To no one's surprise, the cooperative communities marketed a higher percentage of their production. This marketing was done almost entirely through the cooperative network. Most of the few sales to other vendors recorded from the cooperative villages occurred in two villages where the cooperatives did not function continuously during the five rounds. Although there is no documentation explaining the sporadic closures in these villages, it appears that a number of producers were able to make alternative marketing arrangements during such closures. Also, a moderate and increasing amount of sales to dairy cooperatives occurred in the control villages. It is possible that the cooperative network extended into some of the control villages between the times the survey was designed and completed.

The difference in the percentage of fluid milk retained for home consumption was

[36] The cereal price index is weighted by the average share of various grains in the entire sample and picks up both temporal and spatial variations. It is set to 1 at the mean.

Table 10—Use of milk production, January 1983-April 1984

Round/Type of Village	Sales of Fluid Milk: Total Sales	Sales of Fluid Milk: Percent Sold to Cooperative	Home Consumption of Fluid Milk	Milk Converted into: Ghee	Milk Converted into: Butter	Milk Converted into: Yogurt
			(percent of total production)			
Round 1						
Cooperative villages	67.5	67.2	22.4	0.9	1.5	7.6
Control villages	29.3	0.0	46.1	0.7	8.9	14.9
Round 2						
Cooperative villages	56.8	53.8	24.9	1.2	3.9	13.1
Control villages	39.9	0.9	38.6	1.1	6.2	14.2
Round 3						
Cooperative villages	52.7	49.9	27.3	1.0	2.4	16.6
Control villages	27.3	3.3	39.6	1.0	5.3	28.5
Round 4						
Cooperative villages	59.0	56.2	25.7	0.5	1.9	12.9
Control villages	33.1	4.1	37.2	1.4	5.5	22.7
Round 5						
Cooperative villages	58.1	54.9	24.3	0.3	1.3	15.9
Control villages	43.5	19.2	31.5	1.5	3.0	20.4

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

somewhat offset by higher production in the cooperatives. Nevertheless, average daily household consumption was higher in the control community (655 grams compared to 608). This difference is statistically significant (see the next chapter).

Ghee and butter production was less than 5 percent of total use in all rounds for the villages with cooperatives. The amount of butter and ghee produced was somewhat higher in the control villages, but it remained a small share of total use. Furthermore, data on the use of buttermilk collected during the final round—a low point in butter production—indicated that most buttermilk was consumed by the household or their animals. Both the low production of butter and the absence of a market or exchange channel for buttermilk is in contrast to the pattern of dairy use assumed for more remote regions. The value of butter and ghee sales in the control villages was about 1 percent of the total value of milk output. Similarly, although an appreciable portion of production was turned into yogurt, particularly in the control villages, only a few households reported selling a portion of this production.

A direct study of marketed surplus is largely redundant since marketed surplus is explained by production and consumption, which are discussed in the chapters preceding and following this one. Nevertheless, equation (4) gives the marketing ratio in the community. The regression was estimated using a logit functional form, which bounds the marketing ratios between 0 and 1. In this estimation, the marketing ratio is defined as the value of the sales of fluid milk, butter, or ghee over the total value of production evaluated at fluid milk prices. The logit form is

$$r = \text{ratio} = e^{\beta x}/(1 + e^{\beta x}). \quad (3)$$

It was estimated by regressing the logarithm of [ratio/(1 − ratio)] for producers only on the set of regressors.[37] The estimation was

[37] Strictly speaking, this linearizing transformation cannot be performed when any ratio is either 1 or 0. To simplify, any producer who sold his entire output was assumed to sell 99 percent of his output. Similarly, maximum consumption was set at 99 percent of output.

$$
\begin{aligned}
r = {} & 1.486 + \underset{(0.011)}{0.132}\,\text{Total Production} \\
& - \underset{(0.0004)}{0.0023}\,\text{Total Production}^2 - \underset{(0.007)}{0.051}\,\text{HHsize} \\
& + \underset{(0.167)}{0.313}\,\text{Cshare} + \underset{(0.066)}{0.266}\,\text{Landless} + \underset{(0.059)}{0.138}\,\text{Marginal} \\
& - \underset{(0.061)}{0.247}\,\text{Large Farm} - \underset{(0.051)}{0.030}\,\text{Dry Season} \\
& - \underset{(0.080)}{0.563}\,\text{Control} + \underset{(0.015)}{0.007}\,\text{Control} \times \text{Production} \\
& - \underset{(0.078)}{0.254}\,\text{Salespris}; \\
R^2 = {} & 0.228; \qquad (4)
\end{aligned}
$$

where $r = \text{Log}[\text{ratio}/(1 - \text{ratio})]$. Salespris is the producer price in the village. The coefficients of this equation are roughly four times the coefficients of a linear proportion model.[38]

The concern here, however, is more with the test of significance than with the actual value of the coefficients. The percentage of production marketed increased with total production, although at a decreasing rate. The marginal effect of total production became negative when daily output exceeded 28 kilograms. Only one household produced this much. This production effect accounts for only a small portion of the differences between communities. The negative coefficient of control indicates a significant average difference in the marketed ratio. This difference is approximately 14 percent, using a rule-of-thumb conversion to linear parameters. The lack of significance of the interaction term, Control × Production, implies that there is no evidence that the marginal response to output of control communities and cooperatives differed. Larger households market a smaller proportion. Holding household size constant, households with more children market more, indicating that household demand is lower than for a similarly sized household of adults only. Similarly, the higher ratio of sales for landless and marginal households can be explained by the lower demand of these presumably poorer households. Lower-income households have lower budget shares for luxury goods, but higher shares for grains. With milk production held constant, low-income households are more likely to market milk and purchase grain and other necessities than better-off households.

Finally, the negative effect of higher "salespris" should not be interpreted as the effect of increased profits leading to higher household demand. Although income responses were positive, the effect of a price rise on income was small relative to the coefficient of price in this equation. Here, as elsewhere in the study, the negative price coefficient remains a puzzle.

[38] T. Amemiya, "Qualitative Response Models: A Survey," *Journal of Economic Literature* 19 (December 1981): 1483-1536.

7

DIRECT MEASUREMENT OF THE EFFECT ON CONSUMPTION

This chapter gives estimates of demand curves for milk and other food commodities. Once the parameters of price and income changes are measured, it is fairly straightforward to estimate the effects of observed or anticipated price and income changes; the art of evaluation comes more in delimiting the changes to which the model should be applied. There is, however, a related issue addressed in this chapter. Whereas calculations of income or price effects made while holding demand parameters fixed can be viewed as moving along a demand curve, much of the debate on the effects of dairy cooperatives—and of other ways of intensifying cash cropping—carries implicit assertions that technological change leads to changes in preferences and, therefore, to shifts in demand curves. Evidence for this is presented in the discussion of the demand estimates. Before this discussion, however, it should prove useful to present a brief overview of the descriptive statistics related to food demand in the study area.

Budget Shares and Nutrient Intake in the Sample Sites

Whereas paired comparisons of group means are weak tests of differences between free-living (as opposed to laboratory) populations, the nature of the sample stratification in this study makes the cooperative and the control communities roughly comparable.[39] Table 11, then, gives an indication of the demand patterns to be investigated more formally in the next subsection. There were few apparent differences in the allocation and amount of expenditures between cooperatives and neighboring communities. Indeed, the only budget share for which there was an obvious and consistent difference is for meat. On closer inspection this reflects differences in the number of vegetarians in each group. There also seems to have been a somewhat greater budget share for dairy products in the control villages in all rounds except the second.[40]

There does, however, appear to have been a trend in both communities. While total expenditures apparently declined over the survey period, food expenditures increased. But, relative shares of expenditures on different food commodities did not change appreciably during the survey period.

Table 12 shows that reported calories and proteins consumed were high in all rounds, by Indian standards. But they are consistent with other data for rural Karnataka; the National Institute of Nutrition reports 2,992 calories per consumption unit for a sample in rural Karnataka in 1980.[41] Consumption rose through the survey period. Note, also, that consumption in the survey was stock drawdown plus purchases; physical intakes were not recorded. While calories were calculated using a standard percentage of edible portions for each commodity, wastage and spoilage—particularly from own stocks—were not reported.[42]

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[39] The sample, more or less, controls for landholding status.

[40] Nonfood expenditures were not recorded in round 1, hence budget shares cannot be calculated. Total food purchases, however, were investigated.

[41] National Institute of Nutrition, "Food and Nutrient Consumption Pattern in the Selected Districts of Different States," Indian Council of Medical Research, Hyderabad, 1981.

[42] The percentages of edible portions were taken from C. Gopalan, Brama Sastri, and S. Balasubramanian, *Nutritive Value of Indian Foods* (Hyderabad: National Institute of Nutrition, 1976).

Table 11—Budget shares allocated to food groups, January 1983-April 1984

Category	Round 2		Round 3		Round 4		Round 5	
	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages
	(percent of budget)							
Grains	35.85	35.49	39.25	40.27	46.84	49.56	48.12	48.18
Dairy	5.67	5.58	4.95	6.06	7.57	8.69	7.63	8.81
Pulses	6.16	6.79	6.18	5.91	6.57	6.83	6.76	6.79
Meat	4.57	3.27	4.60	3.41	4.49	3.35	5.19	3.53
Other foods	16.37	18.42	17.86	16.77	19.48	21.36	20.90	21.33
Total foods	68.62	69.55	72.84	72.42	84.95	89.79	88.60	88.64
Total expenditures per capita (rupees per week)	33.74	29.18	34.57	32.06	31.94	29.65	29.90	30.33
Food expenditures per capita (rupees per week)	23.15	20.29	25.18	23.22	27.13	26.62	26.49	26.88
Average household size	6.68	6.76	6.90	6.56	6.97	6.70	6.86	6.63

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Milk and meat, individually and jointly, contributed only a small share to the overall diet.

There was a pattern of increasing calorie consumption with land cultivated per capita, but it was not uniform (Table 13). On the other hand, average calorie intake per expenditure quartile rose regularly with expenditures within each round, with the overall average being 2,216 kilocalories per person per day for the poorest expenditure quartile and 3,237 kilocalories for the highest expenditure quartile. The daily intake was 2,493 for the second quartile and 2,827 for the third. The pattern in consumption according to landholding was weak, reflecting the coarseness of data on land size per

Table 12—Calorie and protein consumption, January 1983-April 1984

Source of Calories or Protein	Round 1		Round 2		Round 3		Round 4		Round 5	
	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages	Cooperative Villages	Control Villages
	(percent of total consumed)									
Calories										
Grains	77.0	77.0	76.0	75.0	78.0	77.0	79.0	79.0	78.0	78.0
Dairy	4.0	4.0	4.0	4.0	4.0	3.0	3.0	3.0	3.0	4.0
Pulses	5.0	4.0	7.0	8.0	7.0	6.0	5.0	6.0	6.0	6.0
Meat	0.7	0.5	0.7	0.4	0.7	0.4	0.6	0.4	0.7	0.4
Total calories	2,479	2,285	2,526	2,372	2,655	2,597	2,806	2,897	2,709	2,773
Protein										
Grains	72.0	75.0	69.0	69.0	70.0	72.0	72.0	73.0	71.0	72.0
Dairy	7.0	7.0	5.0	5.0	4.0	6.0	6.0	7.0	6.0	6.0
Pulses	14.0	12.0	19.0	19.0	16.0	16.0	15.0	14.0	15.0	15.0
Meat	5.0	3.0	4.0	3.0	4.0	3.0	3.0	2.0	4.0	2.0
Total protein (grams)	59	54	62	58	66	64	70	71	66	67

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Table 13—Per capita daily energy consumption by quartiles of land cultivated per capita, January 1983-April 1984

Quartile	Round 1	Round 2	Round 3	Round 4	Round 5
			(kilocalories/capita/day)		
1	2,369.76	2,430.01	2,644.04	2,680.81	2,672.25
2	2,330.68	2,388.96	2,483.71	2,817.91	2,735.56
3	2,436.73	2,511.87	2,716.30	2,962.41	2,827.96
4	2,566.24	2,673.71	2,836.07	3,132.67	2,963.85

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

household and even per capita—uncorrected for irrigation and soil quality—as indicators of access to resources.

However, another factor is at work here as well—consumption patterns and total expenditures varied greatly between rounds for many households. Such a phenomenon is commonly observed in repeated cross-sectional data.[43] In part, this reflects the fluidity of the household; members not only migrated but joined extended families and separated from them between interviews. The variation between periods also reflects, of course, errors of measurement, both random and systematic. Furthermore, the variation reflects obstacles that a household might face when attempting to plan its intertemporal consumption. There may be rationing in the labor and credit markets and an absence of suitable vehicles for saving.

Price movements were only moderate during the study period (Table 14). While the price of rice rose continuously during the year, the prices of maize and ragi remained fairly stable. Gram (chick pea) prices also rose, as did the price of vegetable oil, while meat prices stayed roughly constant in nominal terms. With the exception of the rise between the first and second rounds, retail milk prices also showed only moderate variation. There also appears to have been little difference in the commodity prices between communities. Intraperiod (spatial) price variation was generally below 10 percent of the mean value of each price. This is consistent with, but not proof of, the maintained hypothesis of integrated commodity markets.

Demand Model and Results

The basic model used for estimating the demand parameters is a modified version of the almost ideal demand system (AIDS).[44] The basic model is of the form

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log P_j + \beta_i \log(TX/\pi), \quad (5)$$

where w_i is the budget share to the i^{th} commodity, P_j denotes the price of the j^{th} good, TX is total expenditures, and π is a price index. The parameters to be estimated are α's, β's, and γ's. In the nonlinear version of AIDS, π is defined internally using the parameters of the system. However, Deaton and Muellbauer have tested the model using an approximation that allows the AIDS to be estimated as a linear model. They found the results not sensitive to this approximation. This analysis uses such an approximation: $\log = \sum w_k \log P_k$. Nonfood prices were not available from the survey questionnaire

[43] Christopher Scott, "Practical Problems in Conducting Surveys on Living Standards," in *Conducting Surveys in Developing Countries: Practical Problems and Experience in Brazil, Malaysia and the Philippines,* Living Standards Measurement Study Working Paper 3, ed. Christopher Scott, Paulo de Andre, and Ramesh Chambers (Washington, D.C.: World Bank, 1980).

[44] Angus Deaton and John Muellbauer, "An Almost Ideal Demand System," *American Economic Review* 70 (June 1980): 312-326.

Table 14—Retail prices, by round, January 1983-April 1984

Commodity	Round 1 Cooperative Villages	Round 1 Control Villages	Round 2 Cooperative Villages	Round 2 Control Villages	Round 3 Cooperative Villages	Round 3 Control Villages	Round 4 Cooperative Villages	Round 4 Control Villages	Round 5 Cooperative Villages	Round 5 Control Villages
	(Rs/kilogram/year)									
Rice	2.98	2.98	3.41	3.40	3.97	4.01	4.11	4.08	4.29	4.12
Maize	1.99	1.94	2.07	2.03	1.92	1.89	1.96	1.96	1.97	1.97
Ragi (eleusine coracora)	1.95	1.95	1.89	1.91	2.01	2.01	2.00	2.00	2.25	2.25
Vegetable oil	14.40	14.40	14.91	14.92	18.09	18.18	16.07	16.06	15.92	16.01
Buffalo milk	2.36	2.21	2.46	2.43	2.52	2.45	2.66	2.56	2.57	2.52
Cow milk	2.09	2.10	2.43	2.32	2.45	2.44	2.50	2.45	2.52	2.49
Goat meat	20.32	20.24	20.02	19.90	19.99	20.03	20.29	20.22	20.51	20.56
Gram	6.64	6.67	6.53	6.52	7.33	7.32	7.65	7.69	7.98	8.00

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

and were taken from a monthly index of nonfood prices for agricultural laborers in Karnataka.[45] The AIDS has been applied to a combination of time-series and cross-sectional data as it is here, but apparently not in its linearized form nor with household data.[46] Symmetry and homogeneity were imposed by restricting $\gamma_{ij} = \gamma_{ji}$ and $\sum_j \gamma_{ij} = 0$, respectively. While these restrictions were not formally tested, the robustness of policy conclusions based on these estimations was determined by ascertaining whether they hold using an unrestricted model as well.

Furthermore, in the interest of greater flexibility, a quadratic term for expenditure is included.[47] Also, the basic system is modified to include demographic variables such as family size, the proportion of children in the family, and an interaction of family size and total expenditures. The core model, to which later variations are applied in testing the effect of cooperatives, is as follows:

$$\begin{aligned} w_i = {} & \alpha_0 + \beta_{1i}\,\text{Lnexp} + \beta_{2i}(\text{Lnexp})^2 + \beta_{3i}\,\text{Nexp} \\ & + \beta_{4i}\,\text{HHsize} + \beta_{5i}\,\text{Cshare} + \beta_{6i}\,\text{Round dummy} \\ & + \beta_{7i}\,\text{Vegetarian dummy} + \gamma_{1i}\,\text{LnMilkPrice} \\ & + \gamma_{2i}\,\text{LnRicePrice} + \gamma_{3i}\,\text{LnRagiPrice} \\ & + \gamma_{4i}\,\text{LnGramPrice} + \gamma_{5i}\,\text{LnMeatPrice} \\ & + \gamma_{6i}\,\text{LnOtherFoodPrice} \\ & + \gamma_{7i}\,\text{LnNonfoodPrice}, \end{aligned} \tag{6}$$

where

- Lnexp = logarithm of total expenditures minus the logarithm of the price index,
- Nexp = household size × Lnexp,
- HHsize = household size,
- Cshare = number of children five years old or under divided by HHsize, and
- $\text{Ln}^{(j\text{th})}$price = logarithm of price for each principal commodity.

With the exception of the index on nonfood prices described above, all prices come from the survey data. Prices are consumer

[45] India, Ministry of Agriculture and Irrigation, *Bulletin of Agricultural Statistics,* various issues (New Delhi: Ministry of Agriculture and Irrigation, various years).

[46] Rajan Ray, "The Testing and Estimation of Complete Demand Systems with Household Budget Surveys: An Application of AIDS," *European Economic Review* 17 (1982): 319-369.

[47] Angus Deaton, "Issues in the Methodology of Multimarket Analysis of Agricultural Pricing Policies," Woodrow Wilson School of Development Studies Discussion Papers 116, Princeton University, Princeton, N.J., 1984.

prices reported by households, with averages for villages employed when the household did not report a price. The milk price is for fluid milk. When a household produced milk during the week of the interview the price paid to producers for the milk either by the cooperative when they were present or by local vendors was used. This reflects the opportunity cost to the household. Retail prices were used for nonproducers. As the difference between these prices was small, this refinement may be considered more important in principle than in practice. The sample included all observations for which commodity and total expenditures were reported. This excludes round 1.

In addition to a set of equations with commodity budget shares as regressors, estimations of equations with calories or protein per capita—for which no budget shares exist—were estimated using the same dependent variables as in equation (6). These are modifications of semilogarithm equations for nutrient demand. While such direct estimations of nutrient demand equations are standard, they have recently received renewed attention under the name of reduced-form nutrient demand equations.[48] They provide a point of comparison to the demand equations specified in terms of expenditures rather than quantities.

Table 15 reports results of the main demand equations while Table 16 presents the expenditure and price elasticities estimated from these results. Variations of this approach that test for institutional effects are discussed below. These variations allow for testing hypotheses of concern to this study and offer improvements over the basic model, but do not appreciably change the price and expenditure parameters from those in Table 16.

There is little need for an extensive discussion of these two tables. The income elasticities are plausible, both relatively and absolutely.[49] The total food expenditure elasticity obtained by weighting the individual commodity elasticities by the corresponding shares of total food expenditures was 0.76. The difference between such an expenditure elasticity and the calorie elasticity reflects the part of the increase in food expenditures that goes toward higher quality (more expensive) foods as income rises rather than toward increasing the quantity of food.[50] A similar observation has recently been reported for South India by Behrman and Deolalikar.[51] But their conclusion that calorie and protein expenditures or income elasticities are negligible is not generalizable; the results shown here indicate an appreciable income response.

The calorie and protein equations measure the net effect of price changes on nutrient consumption. They indicate that only increases in rice and ragi prices significantly reduced nutrient consumption. An increase in milk prices significantly *increases* calorie consumption. This type of substitution has been observed elsewhere as well.[52] From the standpoint of the net effects of changes in food consumption induced by the commercialization of dairying, there appears to be less need for concern over an increase of local milk prices than of local grain prices. The latter could work through reallocations

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[48] Mark Pitt and Mark Rosenzweig, "Health and Nutrient Consumption Across and Within Farm Households," *Review of Economics and Statistics* 67 (May 1985): 212-223.

[49] See K. Murty, "Consumption and Nutritional Patterns of ICRISAT Mandate Crops in India" (Hyderabad: International Crops Research Institute for the Semi-Arid Tropics, 1983), for other results from India using time-series and cross-sectional data.

[50] The average food and calorie elasticities from low-income strata calculated from various data sets estimated with a functional form similar to the one employed here were 0.82 and 0.48, respectively. See Harold Alderman, "Effects of Price and Income Increases on Food Consumption of Low-Income Consumers," International Food Policy Research Institute, Washington, D.C., 1986.

[51] Jere Behrman and Anil B. Deolalikar, "Will Developing Country Nutrition Improve with Income? A Case Study for Rural South India," *Journal of Political Economy* 95 (June 1987): 492-507.

[52] Mark Pitt, "Food Preferences and Nutrition in Rural Bangladesh," *Review of Economics and Statistics* 65 (February 1983): 105-114. Such a net impact is also discussed in Marcelo Selowsky, "Target Group-Oriented Food Programs: Cost-Effectiveness Comparisons," *American Journal of Agricultural Economics* 61 (1979): 988-994.

Table 15—Coefficients of demand equations, January 1983-April 1984

Independent Variable	Dependent Variable							
	Wmilk (Fluid)	Wrice	Wragi	Wgram	Wmeat	Wother-food	Calories Per Capita	Protein Per Capita
Intercept	−0.1177 (0.0338)	−0.5244 (0.0947)	1.2785 (0.1125)	0.0568 (0.0367)	−0.1101 (0.0441)	0.1665 (0.0720)	−18,426.5461 (3,869.7770)	−341.0153 (104.5223)
Lnexp	0.0921 (0.0160)	0.5086 (0.0495)	−0.3208 (0.0546)	0.0705 (0.0172)	0.0810 (0.0202)	0.0876 (0.0354)	4,001.3974 (312.8486)	95.3343 (8.4500)
$(\text{Lnexp})^2$	−0.0135 (0.0022)	−0.0700 (0.0069)	0.0263 (0.0076)	−0.0117 (0.0024)	−0.0104 (0.0028)	−0.0142 (0.0049)	−370.5518 (43.6578)	−8.4383 (1.1792)
Nexp	−0.0008 (0.0004)	−0.0078 (0.0013)	0.0012 (0.0015)	−0.0004 (0.0005)	−0.0010 (0.0005)	−0.0002 (0.0009)	−71.3469 (8.3407)	−1.8861 (0.2253)
Household size	0.0016 (0.0014)	0.0269 (0.0044)	−0.0062 (0.0049)	0.0001 (0.0015)	0.0033 (0.0018)	−0.0018 (0.0032)	195.0925 (27.9539)	5.1103 (0.7550)
Cshare	0.0033 (0.0047)	0.000004 (0.0147)	−0.0650 (0.0163)	0.0088 (0.0051)	0.0060 (0.0060)	−0.0187 (0.0105)	−476.1579 (92.9509)	−10.0353 (2.5106)
Lnmilk price	−0.0016 (0.0054)	−0.0087 (0.0052)	0.0068 (0.0085)	0.0054 (0.0048)	0.0228 (0.0062)	−0.0182 (0.0073)	157.2246 (106.8712)	3.5344 (2.8866)
Lnrice price	−0.0087 (0.0052)	0.1735 (0.0166)	0.0189 (0.0159)	−0.0038 (0.0059)	0.0105 (0.0069)	0.0150 (0.0112)	−198.3229 (117.8576)	−2.5381 (3.1833)
Lnragi price	0.0068 (0.0085)	0.0189 (0.0159)	0.1413 (0.0323)	0.0543 (0.0100)	−0.0298 (0.0120)	0.0659 (0.0175)	−364.1292 (220.9719)	−6.3116 (5.9684)
Lngram price	0.0054 (0.0048)	−0.0038 (0.0059)	0.0543 (0.0100)	−0.0074 (0.0093)	0.0042 (0.0090)	0.0173 (0.0088)	76.8863 (214.9159)	−1.5048 (5.8049)
Lnmeat price	0.0228 (0.0062)	0.0105 (0.0069)	−0.0208 (0.0120)	0.0042 (0.0090)	0.0384 (0.0188)	−0.0162 (0.0109)	99.3187 (307.2035)	−4.6959 (8.2975)
Lnotherfood price	−0.0182 (0.0073)	0.0150 (0.0112)	0.0659 (0.0175)	0.0173 (0.0088)	−0.0162 (0.0108)	0.0004 (0.0200)	656.5056 (280.9725)	28.0275 (7.5890)
Lnnonfood price	−0.0065 (0.0145)	−0.2055 (0.0213)	−0.2664 (0.0359)	−0.0700 (0.0180)	−0.0390 (0.0281)	−0.0643 (0.0295)	4,523.4367 (1,851.1870)	63.0275 (7.5890)
Vegetarian dummy	0.0098 (0.0013)	0.0085 (0.0039)	−0.0397 (0.0043)	0.0045 (0.0014)	−0.0558 (0.0016)	0.0294 (0.0028)	−7.9386 (24.7620)	−2.5396 (0.6688)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: The numbers in parentheses are standard errors. Lnexp is the log of total expenditures minus the log of the price index; Nexp is household size multiplied by Lnexp; Cshare is the number of children divided by household size; and the rest of the Ln variables are logs of prices for principal commodities. W indicates budget share.

Table 16—Income and price elasticities estimated from combined cross-sectional data, January 1983-April 1984

	Elasticity with Respect to							
Commodity	Milk Price	Rice Price	Ragi Price	Gram Price	Meat Price	Otherfood Price	Nonfood Price	Income
Fluid milk	−1.03	−0.17	0.14	0.10	0.46	−0.36	−0.13	0.89
Rice	−0.04	−0.17	0.09	−0.02	0.05	−0.07	−0.98	0.89
Ragi	0.04	0.10	−0.21	0.03	−0.12	0.36	−1.48	0.26
Gram	0.09	−0.06	0.86	−1.17	0.07	0.26	−1.11	0.81
Meat	0.53	0.24	−0.48	0.10	−0.12	−0.38	−0.91	1.08
Other foods	−0.08	0.06	0.29	0.07	−0.07	−1.00	−0.28	0.95
Calories consumed per capita	0.06	−0.08	−0.15	0.03	0.04	0.27	1.88	0.41
Protein consumed per capita	0.06	−0.04	−0.10	−0.02	−0.08	0.47	1.06	0.41

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: The data were evaluated using the following representative values:
Income was 30 Rs per capita per week; family size was 7.0. The following mean budget shares were used: milk budget share = 0.05, rice budget share = 0.21, ragi budget share = 0.18, pulse budget share = 0.06, meat budget share = 0.04, other food budget share = 0.23, total food budget share = 0.77. Calories per capita per day were 2,400, and protein per capita per day was 60 grams.

of feed or area. However, a reallocation of area to fodder has yet to occur; little land was devoted to fodder in the sample villages.

The results of the calorie and protein equations do differ somewhat from calculations of price elasticities taken from the commodity demand equations weighted by shares of total calories or protein. These price elasticities derived from the commodity demand equations indicate that total nutrients consumed decreased slightly following an increase in the price of milk.[53] The effect was small (the protein elasticity is −0.04) and may reflect the expression of the demand equations in terms of expenditures and not quantities. Given the range of values, however, the most plausible policy conclusion is that there is no indication that changes in milk prices had a significant effect—either positive or negative—on nutrient consumption through commodity substitution. This is discussed further in the concluding chapter.[54]

The negative or nonsignificant effects of household size on income elasticities do not necessarily represent economies of scale for food purchases. They may indicate instead that real incomes were higher at a given nominal income for larger households because of other economies of scale. The percentage of children showed no significant effect on the budget share equations, although families with more children consumed fewer calories and protein per capita than similarly sized families with fewer children. The equation for milk demand finds no evidence to support the view that milk is mainly used for infants in this community.

The dummy variable for vegetarians indicates higher milk and pulse consumption by these households. This group apparently consumes no fewer calories, although a significant difference in protein consumption was observed. Protein consumption among vegetarians was approximately 4 percent lower than among nonvegetarians.

[53] This result is contingent on imposing the restriction of homogeneity and symmetry. The unrestricted equations indicate an increase in calorie or protein consumption following an increase in milk prices. The restrictions on parameters also change the sign of the calorie elasticity with respect to nonfood prices.

[54] A further discussion of price and income response is also presented with the discussion of panel estimates below.

Does the Cooperative Change Consumer Response?

One of the central questions in this study is whether the tendency to consume milk is changed when dairy cooperatives are introduced. In order to test this, a number of variations of the basic fluid milk demand equations are presented in Table 17. Model 1 in that table introduces two new variables, which are individually and jointly significant—a dummy variable that is defined as 1 for milk producers and a dummy variable for the existence of a cooperative in the village (defined as 0 if there is a cooperative and 1 if the household is in a control village). Model 2 varies this by replacing the production dummy variable with a continuous variable defined as the value of current milk production as a share of total household expenditure (the price of milk × total production/total expenditures). The interpretation of the alternative production variables is discussed below. At this point, it is sufficient to note that the continuous variable termed milk value gives a better statistical fit and that both models have the same implication regarding the effect of the cooperatives on the consumption of milk.

The dummy variable for residence in the control village was significant ($p<0.005$) in both models. This implies that after controlling for incomes and prices, households in the villages with cooperatives consumed less milk. Using model 2, the dummy variable implies that the average budget share for milk was 9 percent higher in the control villages than in the cooperative villages, given equal incomes and production. Similarly, model 5 indicates that the consumption of butter and ghee was significantly higher in the control villages, with the coefficient of the control dummy variable being 38 percent of the average value of the share of the budget given to butter and ghee in the entire sample. In the same vein, the significant coefficient for control villages in model 6 implies that these villages devoted a greater share of their budgets to yogurt and buttermilk than cooperative villages did, after any price differences in fluid milk are accounted for. The average increase was more than 17 percent of the average budget share in the entire sample.

While a longitudinal study is better suited for a detailed analysis of the manner in which the presence of a cooperative led to a reduction in local milk consumption, some insight can be gained by treating the change as a function of the length of time the cooperative had been established. Intuition suggests that the effects of a cooperative on either tastes or marketing patterns would have been cumulative—that is, increasing with duration and reaching a plateau after some time. A time-series analysis might indicate a logistic or S-shaped curve with a slow initial impact and a subsequent maximum effect. With a cross-section, one would expect that villages that were in the cooperative only a short time would have had smaller shifts in consumption relative to the control than groups that were in the project a longer time. This is tested in model 4. The results do not indicate a clear pattern. Households in cooperatives that were less than two years old did not exhibit a statistically different consumption of fluid milk than households in the control villages, while cooperatives formed two or more years before the survey did show a difference in consumption patterns. The main inconsistency is that cooperatives more than four years old were intermediate between the other two groups of cooperatives rather than representing a trend.

The dummy variables for the presence or age of a cooperative shift the intercept of the demand curve but do not affect the slope. Model 3 presents a variant in which the income response is modified by an interaction between the control dummy variable and the logarithm of expenditures. The model implies that the income elasticity for milk was higher in the control villages by 0.03, or some 3.3 percent of the mean value. The amount is fairly small, although the statistical significance is high ($p<0.001$). Due to collinearity it was not possible to obtain significant results when both an intercept shift and a slope shift were included in the same model. There is no convenient criterion that gives preference for model 3 or model 2 on statistical grounds. However, as they both have the same implication for

Table 17—Variations of basic milk demand equations, January 1983-April 1984

	Dependent Variable							
	Wmilk (Fluid)				Wghee	Wother Dairy	Calories	Protein
Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	−0.08871	−0.1167	−0.1142	−0.1091	0.0151	0.0038	−18,491.5631	−342.5488
	(0.0361)	(0.0347)	(0.0348)	(0.0347)	(0.1585)	(0.0240)	(3,867.3302)	(104.478)
Lnexp	0.0828	0.0817	0.0803	0.0809	−0.0146	0.0499	4,016.7934	95.6974
	(0.0160)	(0.0157)	(0.0157)	(0.0156)	(0.0071)	(0.0108)	(312.7313)	(8.4486)
(Lnexp)^2	−0.0123	−0.0122	−0.0121	−0.0121	0.0031	−0.0060	−372.0396	−8.4734
	(0.0022)	(0.0022)	(0.0022)	(0.0022)	(0.0010)	(0.0015)	(43.6348)	(1.1788)
Nexp	−0.0008	−0.0006	−0.0006	−0.0006	0.00008	−0.0007	−71.1709	−1.8820
	(0.0014)	(0.0004)	(0.0004)	(0.0004)	(0.0002)	(0.0003)	(8.3356)	(0.2252)
Household size	0.0016	0.0011	0.0011	0.0010	0.0003	0.0028	194.6850	5.1007
	(0.0014)	(0.0014)	(0.0014)	(0.0014)	(0.0006)	(0.0009)	(27.9361)	(0.7547)
CShare	0.0038	0.0041	0.0041	0.0039	−0.0009	−0.0036	−467.1785	−9.8235
	(0.0047)	(0.0047)	(0.0047)	(0.0047)	(0.0021)	(0.0032)	(92.9933)	(2.5122)
Lnmilk price	0.0113	0.0056	0.0054	0.0055	0.0005	−0.0053	164.3094	3.7015
	(0.0058)	(0.0054)	(0.0054)	(0.0054)	(0.0024)	(0.0037)	(106.856)	(2.8868)
Lnrice price	−0.0128	−0.0057	−0.0058	−0.0058	−0.0038	0.0313	−175.024	−1.9885
	(0.0057)	(0.0056)	(0.0056)	(0.0056)	(0.0025)	(0.0038)	(118.332)	(3.1968)
Lnragi price	0.0133	−0.0086	−0.0087	−0.0078	0.0048	0.0195	−374.6438	−6.5596
	(0.0102)	(0.0098)	(0.0098)	(0.0098)	(0.0045)	(0.0068)	(220.8848)	(5.9673)
Lngram price	−0.0050	0.0039	0.0039	0.0045	−0.0043	0.0635	76.6289	−1.5108
	(0.0087)	(0.0085)	(0.0085)	(0.0085)	(0.0039)	(0.0059)	(214.7727)	(5.8022)
Lnmutton price	0.0300	0.0249	0.0249	0.0254	0.0015	−0.0493	119.1381	−4.2284
	(0.0151)	(0.0149)	(0.0149)	(0.0149)	(0.0068)	(0.0103)	(307.1526)	(8.2979)
Lnotherfood price	−0.0364	−0.0108	−0.0110	−0.0116	0.0097	−0.0888	697.9259	29.0045
	(0.0099)	(0.0092)	(0.0092)	(0.0092)	(0.0042)	(0.0163)	(281.5191)	(7.6054)
Lnnonfood price	−0.0004	−0.0093	−0.0088	−0.0102	−0.0084	0.0298	4,453.8673	62.2538
	(0.0236)	(0.0232)	(0.0232)	(0.0232)	(0.0106)	(0.0161)	(1,850.2682)	(49.9860)
Producer dummy	0.0106	...	...	...	...	...	...	...
	(0.0016)							

(continued)

Table 17—Continued

	Dependent Variable							
	Wmilk (Fluid)				Wghee	Wother Dairy	Calories	Protein
Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Control dummy	0.0038 (0.0013)	0.0051 (0.0013)	...	...	0.0017 (0.0006)	0.0027 (0.0009)	52.9250 (25.9533)	1.2483 (0.7011)
Control × Lnexp	...	...	0.0015 (0.0004)	...	...	...	...	...
Milk value	...	0.0227 (0.0020)	0.0227 (0.0020)	0.0228 (0.0020)	0.0071 (0.0009)	0.0197 (0.0014)	...	...
1-year coop dummy	...	...	...	−0.0025 (0.0016)	...	...	...	...
2-4-year coop dummy	...	...	...	−0.0071 (0.0016)	...	...	...	...
Over 4-year coop dummy	...	...	...	−0.0049 (0.0016)	...	...	...	...
Vegetarian dummy	0.0087 (0.0013)	0.0088 (0.0013)	0.0088 (0.0013)	0.0084 (0.0013)	0.0022 (0.0006)	0.0013 (0.0009)	−18.2038 (25.2524)	−2.7817 (0.6822)

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: The numbers in parentheses are standard errors. Lnexp is the log of total expenditures minus the log of the price index; Nexp is household size multiplied by Lnexp; Cshare is the number of children divided by household size; and the rest of the Ln variables are logs of prices for principal commodities. W indicates budget share.

evaluating the effect of cooperatives, this is not a major drawback.

The effect of the cooperatives on milk consumption was tested in terms of the presence or absence of a cooperative in the village rather than in terms of membership. A variant of model 2 that includes an additional dummy variable for membership was explored (but is not reported in Table 17) to test whether actual membership is important. This variable was not significant, although the village dummy variable did not change in size or significance compared to model 2. Although 93 percent of the sample from cooperative villages are members of the cooperatives, there was no indication of multicollinearity. There is some indication, then, that the presence of a cooperative rather than membership influenced the significant difference in milk consumption between the two communities.

This was also indicated by a variant of model 3 (not reported in Table 17) in which the dummy variable for control villages was replaced by two dummy variables—one for households within cooperative villages who produced milk at some time during the year and one for residents who never produced milk. The effect on nonproducers was twice that on producers, after accounting for the reported value of production.

These results lend support to the argument that the presence of a cooperative tends to reduce milk consumption, if income and prices are held constant, either through changes in tastes or through some changes in market structure yet to be specified. However, the net effects on welfare are not clear. Any decrease in the share of milk in the budget must increase the budget share of some other commodities. To measure the net effect on food consumption, dummy variables were included in the demand equations for calories and protein (models 7 and 8 in Table 17). Both models provide evidence that the presence of a cooperative had an effect on the demand for nutrients. Control villages had higher calorie consumption, controlling for income, but the effect is small, about 2 percent of the mean value of consumption. The difference in protein consumption is significant only at the 10 percent level. It also represents 2 percent of mean consumption. The importance of this reduction of nutrient consumption in the context of other price and income changes is discussed further below.

A short digression on substitution may be worthwhile. Although the nutritionist's concern about the effects of a project can be addressed by measuring food intake, other, more general welfare concerns cannot be measured by shifts in budget shares alone. Under the assumption that the prices and incomes of two groups are identical, differences in what they consume are merely indications of different preferences—even if the preferences are induced by a policy or project. However, if the change in budget shares is a consequence of price changes, the direction of the overall effect on welfare can be determined more easily.[55] However, observed prices, including adjustments for marketing margins, are already included in the regressions. These prices refer only to the rupee costs paid or to the rupee costs forgone at the time of a transaction.

It is possible that there is a difference in the other costs that was not seen, or that benefits forgone in the two communities were not observed directly. For example, if search costs or other time allocations necessary to obtain milk differed, then the total resource costs, which the market price underestimates, may also have differed. Furthermore, if these unobserved costs correlate with the presence or absence of a cooperative, then the dummy variable may measure the effect of the costs. Since own-price response is negative, the lower milk consumption in the villages with cooperatives is consistent with a hypothesis that search costs were higher in these villages. This could occur, for example, if there were fewer producers in these villages willing to sell to neighbors rather than selling to the cooperative. The actual market clearing

[55] Utility is nonincreasing (generally decreasing) in the face of a price increase.

price is the total of cash and noncash transaction costs. The latter were not measured.

Such an unobserved—and, therefore, untestable—effect is likely to affect nonproducers more than producers, as was observed in the data. However, producers within the cooperatives were also observed to have lower milk consumption than producers in the control villages. But here, too, there is the possibility that a price effect went unobserved—the bonus paid to members by cooperatives in proportion to sales. Such rebates would have raised the opportunity cost of milk to members and would be likely to have reduced consumption. As this analysis has used the farmgate price as the appropriate price for producers, the possibility that the price was underestimated must be considered.

To summarize, there is statistically significant evidence that households in villages with cooperatives consumed less milk than households with similar incomes in control villages, whether they were in the cooperative or not. This lower milk consumption, however, did not lead to lower nutrient intakes. The net welfare effect is not known, however, due to the inability to test the hypothesis that the effect was due to changes in tastes rather than differences in the amount of resources required to purchase milk.[56]

The Effect on Production

In the previous subsection, differences in milk consumption were observed between communities, holding production constant. As differences in production were also indicated in Chapter 5, the indirect effects on consumption that may be attributable to changes in production should also be considered. Income effects are one obvious influence on consumption; so are price effects. The net effects of these will be discussed below. In this chapter, however, various shifts in consumption are analyzed separately. There is an interest in testing whether the source of earnings affects consumption patterns.[57] Model 1 in Table 17 includes a dummy variable for milk producers that indicates that producers of milk consume more fluid milk than nonproducers with the same expenditures and facing the same price level. Similarly, models 2-4 indicate that as milk production increases by one unit, consumption increases by 0.023 units.[58] While such an increase may appear intuitive, it should be recalled that the estimating equations already attempted to distinguish between farmgate prices and retail prices, which would control for differences in opportunity costs. Furthermore, any income effect of increased production should already have been recorded as an increase in total expenditures, included as an independent variable in the model. Finally, this effect was observed after controlling for the presence of cooperatives.

Nevertheless, the effect is apparently statistically significant. Although theory usually postulates that production and consumption are optimized separately, this result seems to indicate a link.[59] Furthermore, although the effect is small, it is of the same order of magnitude as the effect on the *budget share* of milk indicated by the

[56] George Stigler and Gary Becker, "De Gustibus Non Est Disputandum," *American Economic Review* 67 (March 1977): 76-90, argue that economic factors should be sought before explanations in terms of taste. That is a useful guideline but not, of course, a proof.

[57] Susan Horton, "The Determinants of Nutrient Intakes," *Journal of Development Economics* 19 (September/October 1985): 147-162, and Benton Massell, "Consistent Estimation of Expenditure Elasticities from Cross-Section Data on Households Producing Partly for Subsistence," *Review of Economics and Statistics* 51 (May 1969): 136-142, report such effects but do not explore the issue in depth.

[58] The term "milk value" is calculated as the value of production over total expenditure. The coefficient of this term in the budget equation is the change in quantity consumed over the change in quantity produced, holding total expenditure and prices constant. The complete effects of a production increase, of course, must also include the income effect.

[59] This does not imply that one does not affect the other, but that the production possibility curve and the optimal point on an indifference curve are linked through a plane of prices (including wages). Most household production models are recursive, with consumption being determined by income from the production process as well as by exogenous prices.

dummy variable for control villages. Therefore, the production effect contributes to the net effect of the cooperatives. It is important, then, to investigate whether it is an artifact of the measurement process.

Suppose that the coefficient of milk value does not measure how milk consumption is affected by a change of production per se, but by a missing variable. Often higher consumption of agricultural products by producers is attributed to differences in farmgate and market prices, and by costs in time allocated to marketing. For example, suppose that there exists a proportional markup (or discount) over the prices recorded in the data that is attributable to marketing costs. The model employed here, then, is a variant of

$$w_h = \alpha + \beta \ln(P_h \lambda_h), \qquad (7)$$

where λ_h is the proportional price adjustment. The subscript h indicates that the markup or discount differs between households. For a nonproducer, the markup or discount could be 1—that is, no specific adjustment. The approach is general and, as indicated below, the actual value of λ does not affect the results. Equation (7) then can be formulated as

$$w_h = (\bar{\alpha} + \beta \ln \lambda_h) + \beta \ln P_h$$

or

$$w_h = \alpha_h + \beta \ln P_h, \qquad (8)$$

while the estimates in Table 17 use an average intercept term; they are of the form $w_h = \bar{\alpha} + \beta \ln P_h$. A dummy variable for producers will, of course, allow the intercept term to vary according to the category of production. It will not, however, distinguish whether the effect is from unaccounted marketing costs or is a real effect of production. Suppose, however, that a separate intercept can be employed for each household. In such a case, any household-specific value of λ will be recorded in the intercept and will not be proxied by a production variable. The panel nature of the data allows such an approach.[60]

For each household, the average value of all variables for all rounds was calculated and regressions were estimated using the households' deviation in period t from its average. The estimation was performed on the model

$$(w_{ht} - \bar{w}_h) = \beta(X_{ht} - \bar{X}_h), \qquad (9)$$

where X stands for the regressors in equation (6). For the logarithmic variables, the average of the logarithm—not the logarithm of the average—is used. Note that no intercept term is included; the model, in effect, already has an implicit intercept for each household. Variables that do not change over the panel period, such as the dummy variable for the presence of a cooperative, net out in such an approach; that is: $(\text{fixed variable})_{ht} - \overline{(\text{fixed variable})}_h = 0$. Therefore, their effect cannot be studied.

Denoting the variables in this within-sample model as Dwmilk, DLexp, and so forth, the results of such a model are[61]

$$\begin{aligned} \text{Dwmilk} = & -\underset{(0.0018)}{0.0201}\text{DLexp} - \underset{(0.0004)}{0.0013}\text{DHHsize} \\ & + \underset{(0.0052)}{0.0064}\text{DLmilkp} - \underset{(0.0056)}{0.0100}\text{DLricep} \\ & - \underset{(0.0086)}{0.0068}\text{DLragip} + \underset{(0.0090)}{0.0072}\text{DLgramp} \\ & + \underset{(0.0147)}{0.0247}\text{DLmeatp} - \underset{(0.0080)}{0.0064}\text{DLotherfood} \\ & - \underset{(0.0433)}{0.0247}\text{DLnonfood} + \underset{(0.0035)}{0.0469}\text{Dmvalue}; \\ R^2 = & \ 0.116. \end{aligned} \qquad (10)$$

Such within-sample models frequently have less variation than cross-sectional mod-

[60] Orly Ashenfelter, Angus Deaton, and Gary Solon, "Does It Make Sense to Collect Panel Data for Developing Countries?" Woodrow Wilson School Development Studies Paper 119 (Princeton University, Princeton, N.J., May 1985), discuss the uses and pitfalls of such data. Zvi Griliches and Jerry Hausman, "Errors in Variables in Panel Data," National Bureau of Economic Research Technical Working Paper 39, Cambridge, Mass., May 1984, discuss the econometric properties of a subset of such models.

[61] The reader should not confuse such notation with a first difference variant of panel models. While they are used in similar circumstances, the econometric properties differ (see Griliches and Hausman, "Errors in Variables in Panel Data").

els. For example, the change in household expenditures over a short period is generally far less than differences in expenditures observed among a population. For this reason, panel models risk having a low signal to noise ratio. Nevertheless, this particular regression is instructive. The estimated price elasticity is −0.87 and the income elasticity is 0.60; both are slightly lower in absolute value than the parameters in Table 16. However, given the nature of panel data, the differences are not disturbing. The rice and meat cross-price elasticities in this regression are −0.20 and 0.49, respectively. These are nearly identical to the corresponding terms in the combined cross-section and time-series approach.

Before continuing the discussion of the effect of milk production, observe Table 18, which presents demand parameters derived from panel data in a format similar to Table 16.[62] While such a fixed effects approach does not fulfill all the goals of the demand estimates in this section—the effects of the cooperatives cannot be studied—it provides some perspective on the earlier estimates. For example, while it is occasionally argued that high calorie and protein elasticities are more likely artifacts of differences in household effects such as schooling, these effects are controlled in the panel approach with no appreciable differences in elasticities.[63] Not only do the individual commodity expenditure elasticities change only slightly with the panel approach, but so do the calorie and protein elasticities. This is in contrast to Behrman and Deolalikar's results for other villages in South India. At the very least the contrast implies that Behrman and Deolalikar's results are not generalizable. The main difference probably stems from the instrumental variable approach to expenditures that Behrman and Deolalikar use with instruments that vary little in the panel approach and, hence, carry little information. This study uses expenditures as directly observed.

The price parameters from the panel approach can also be interpreted as short-run responses to price changes, whereas the combined cross-sectional data may be considered a more long-term response.[64] The results in Tables 16 and 18 do not differ appreciably, indicating that the price parameters are robust with respect to the handling of fixed household effects.

The particular motivation for this approach, however, is to estimate the coefficient of the deviation of milk production from the household average. This term is close to the value of the corresponding terms in Table 17 and is clearly statistically significant.

One may vary the assumption of a proportional price markup and assume, instead, a fixed marketing markup. The true price would be $\bar{P}_t + \lambda_h$, and a variant of equation (8) that is linear in prices would be more appropriate. The corresponding estimated equation is

$$\begin{aligned} \text{Dwmilk} = {} & \underset{(0.00004)}{0.0005\text{Dexpcapita}} - \underset{(0.0004)}{0.0011\text{DHHsize}} \\ & + \underset{(0.0025)}{0.0088\text{Dmilkp}} - \underset{(0.0013)}{0.0021\text{Dricep}} \\ & - \underset{(0.0040)}{0.0013\text{Dragip}} - \underset{(0.0013)}{0.0007\text{Dgramp}} \\ & + \underset{(0.0007)}{0.0010\text{Dmeatp}} - \underset{(0.0008)}{0.0006\text{Dotherfoodp}} \\ & - \underset{(0.0040)}{0.0019\text{Dnonfoodp}} + \underset{(0.0035)}{0.0464\text{Dmvalue}}; \\ R^2 = {} & 0.131. \end{aligned} \tag{11}$$

As expected, this variant has results comparable to the previous model. As both approaches give similar coefficients for

[62] These equations do not use the variable Dmvalue. Also, the complete system imposes both symmetry and homogeneity. Only the latter can be imposed in the single equation estimation of equation (10). Hence, some differences in the milk demand parameters are observed.

[63] Jere Behrman and Barbara Wolfe, "More Evidence on Nutritional Demand-Income Seems Overrated and Women's Schooling Underplayed," *Journal of Development Economics* 14 (1984): 105-128; and Behrman and Deolalikar, "Will Developing Country Nutrition Improve with Income?"

[64] C. Peter Timmer and Harold Alderman, "Estimating Consumption Parameters for Food Policy Analysis," *American Journal of Agricultural Economics* 61 (December 1979): 982-987.

Table 18—Income and price elasticities estimated from panel estimates, January 1983-April 1984

	Elasticity with Respect to							
Commodity	Milk Price	Rice Price	Ragi Price	Gram Price	Meat Price	Otherfood Price	Nonfood Price	Income
Fluid milk	−0.99	−0.21	0.09	0.08	0.52	−0.19	−0.30	0.53
Rice	−0.05	−0.19	0.17	−0.06	0.02	0.09	−0.98	0.69
Ragi	0.03	0.19	−0.49	0.10	−0.23	−0.01	−0.57	0.30
Gram	0.07	−0.22	0.29	−0.85	0.42	0.52	−1.23	0.84
Meat	0.65	0.12	−1.05	0.63	−0.09	0.39	−0.86	0.80
Other foods	−0.04	0.08	−0.01	0.14	0.07	−0.83	−0.27	0.73
Calories per capita	0.01	0.07	−0.35	0.19	0.16	−0.20	3.99	0.44
Protein per capita	−0.05	0.08	−0.36	0.18	0.18	−0.07	3.91	0.44

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: The data were evaluated using the following representative values:
Income was 30 Rs per capita per week; family size was 7.0. The following mean budget shares were used: milk budget share = 0.05, rice budget share = 0.21, ragi budget share = 0.18, pulse budget share = 0.06, meat budget share = 0.04, other food budget share = 0.23, total food budget share = 0.77. Calories per capita per day were 2,400, and protein per capita per day was 60 grams.

changes in the production of milk despite somewhat different assumptions about the measurement of prices, it is difficult to dismiss this statistically significant result as an artifact of unspecified price or marketing costs.[65]

Cross-sectional regressions that include dummy variables for production frequently show a relationship between production and consumption. In the cross-sectional analysis of this data set, separate dummy variables for producers of ragi and rice indicate that consumption of these grains is higher when the household produces them. The coefficient of the dummy variable for ragi producers is more than 20 percent of the mean value of the household budget share and significant at $p<0.0001$, while the rice producer dummy variable is 6 percent of the mean budget share and is significant at $p<0.005$. While a drawdown of household stocks—which is not a factor with perishable milk—makes an analysis similar to equation (9) difficult, the link between production and consumption may be similar. In Chapter 9 an attempt will be made to put these links together in order to evaluate the net effects of the dairy cooperatives.

[65] The variable is virtually unchanged when the model is run on a subset of farmers who always produce some quantity of milk. The effect then is apparently not a corner effect observed upon entry into production.

8

CHANGES IN EXPENDITURE AND INCOME DISTRIBUTION

Changes in dairy production and milk marketing are primary goals of dairy development projects and of Operation Flood in particular. But as cooperative dairying has developed in India it has tended to present itself, and hence has been evaluated, as a way to increase the incomes of the poorer segments of rural India. Comparisons of household incomes, then, should be an important component of any study of the effects of dairy development on households. Incomes, however, are hard to measure in rural communities both because measuring the costs of inputs as well as output is complex and because the variability of short-term earnings masks long-run productive potential. Total expenditures are generally presumed to reflect a household's perception of its long-run earnings. They have the further advantage of being easier to measure than income.

To test whether there were differences in the total household expenditures of the two communities in this study, a regression was run that explains expenditures as a function of household assets and demography:

$$\begin{aligned} \text{L Totexp} = {} & \underset{}{4.46} + \underset{(0.00005)}{0.0002\,\text{Agehead}} + \underset{(0.002)}{0.095\text{HHsize}} \\ & - \underset{(0.059)}{0.430\,\text{Cshare}} + \underset{(0.016)}{0.122\,\text{Literacy}} \\ & + \underset{(0.024)}{0.089\,\text{Matriculate}} - \underset{(0.027)}{0.232\,\text{Landless}} \\ & - \underset{(0.024)}{0.122\,\text{Marginal}} + \underset{(0.026)}{0.166\,\text{Largefarm}} \\ & + \underset{(0.017)}{0.060\,\text{Well}} - \underset{(0.016)}{0.007\,\text{Dryseason}} \\ & - \underset{(0.034)}{0.071\,(\text{Control} \times \text{Landless})} \\ & - \underset{(0.028)}{0.032\,(\text{Control} \times \text{Marginal})} \\ & - \underset{(0.033)}{0.158\,(\text{Control} \times \text{Mediumfarm})} \\ & - \underset{(0.035)}{0.115\,(\text{Control} \times \text{Largefarm})}; \end{aligned}$$

$$R^2 = 0.59. \qquad (12)$$

The regression with the logarithm of daily household expenditures as the dependent variable contains no particular surprises. Households with an older head had higher expenditures than other households with similar assets. Literacy increased household expenditures, with higher education having an additional impact. Larger households had higher total expenditures, controlling for the proportion of children. A separate regression (not shown) indicates that expenditures per capita, however, decreased with household size. Total expenditures increased over landholding groups in correlation with ownership of that asset. Ownership of a well also enhanced household expenditures.

The particular concern here is for the four interaction variables that are the products of the control dummy variable and the landholding class dummy variables. The coefficients measure the proportional difference between the expenditures of a household in one of the various land ownership groups within the control community and a household in the corresponding group in the villages with cooperatives. The signs of all four coefficients are negative, indicating that the control groups had lower expenditures than their neighbors. Presumably they had lower earnings, as there is no indication that savings differed. This, of course, implies that households in cooperative villages had higher expenditures. Marginal farmers appear to have benefited least of the farm groups. The expenditures of the control and project groups in the marginal farm category are not significantly different. Landless farmers in project villages did spend more than those in control villages, but this difference is smaller than the differences seen among medium and large farmers.

Before discussing this further, it is worthwhile to consider the relationship of dairy and nondairy earnings. Earlier it was argued that the project did not affect other crops or labor allocation. If so, although the villages differed in dairy earnings, they should not differ in other earnings. As the data did not directly record farm or off-farm income, an indirect approach would be to subtract dairy earnings—including the value of production consumed at home—from total expenditures and presume that the remainder indicates other earnings.

It should be noted that nondairy earnings far exceeded dairy earnings even within the sample taken from villages with cooperatives. Table 19 indicates that dairy earnings were sufficient to pay for 10-25 percent of total expenditures observed.

A regression for the logarithm of other earnings similar to equation (12) is as follows:

$$
\begin{aligned}
\text{Lotherearnings} = {} & 4.14 + \underset{(0.00007)}{0.0002}\,\text{Agehead} \\
& + \underset{(0.003)}{0.102}\,\text{HHsize} - \underset{(0.082)}{0.392}\,\text{Cshare} \\
& + \underset{(0.023)}{0.101}\,\text{Literacy} + \underset{(0.034)}{0.049}\,\text{Matriculate} \\
& - \underset{(0.037)}{0.151}\,\text{Landless} - \underset{(0.016)}{0.016}\,\text{Marginal} \\
& + \underset{(0.037)}{0.178}\,\text{Largefarm} + \underset{(0.025)}{0.021}\,\text{Well} \\
& + \underset{(0.022)}{0.003}\,\text{Dryseason} \\
& + \underset{(0.048)}{0.009}\,(\text{Control} \times \text{Landless}) \\
& + \underset{(0.040)}{0.020}\,(\text{Control} \times \text{Marginal}) \\
& - \underset{(0.047)}{0.029}\,(\text{Control} \times \text{Mediumfarm}) \\
& - \underset{(0.049)}{0.077}\,(\text{Control} \times \text{Largefarm}); \\
R^2 = {} & 0.40. \qquad (13)
\end{aligned}
$$

Table 19—Ratio of the value of milk production to total expenditures, by landholding class, January 1983-April 1984

Landholding Class	Cooperative Villages	Control Villages
Landless	0.164	0.107
Marginal farm households	0.160	0.120
Small farm households	0.218	0.125
Other farm households	0.228	0.191

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

The major difference between equations (12) and (13) is that the interaction variables do not indicate differences between the control and project communities; none of the coefficients is significant. A second observation is that the relationship of other earnings to landholding size was only moderate. The average value of the dependent variable is 4.96, while the landless group differed from the medium-sized farm class by −0.15 and from the largest landholders by −0.33.

Another way to look at this latter point is to look at the Gini coefficients of expenditures—a measure of distribution in which 1 indicates total concentration of resources and 0 indicates equitable distribution. Gini coefficients for total expenditures per capita are 0.1921 for the project villages and 0.1951 for the control community.[66] While these appear low, it should be recalled that such coefficients are generally lower in a fairly homogeneous rural community than in a larger community with greater divergence in ecological conditions or a higher degree of urbanization. These coefficients are also lower than those for assets—for example, the Gini coefficient for land cultivated was

[66] The values are 0.2143 and 0.2050, respectively, if dairy earnings are excluded.

0.5876 in this sample. Although the statistical significance of this measure cannot be ascertained, in both communities dairy earnings lowered the Gini coefficient. A greater drop was observed in the subsector with larger dairy earnings.

Within both the control and project communities, expenditures increased with landholding. This pattern, of course, existed before the project. The project, however, apparently widened this gap since the project appears to have increased dairy earnings more for the larger landholdings than it did for the smaller landholding groups. In no case, however, is there evidence that any particular group of farmers lost absolutely following the introduction of the cooperatives.

9

CONCLUSIONS

A framework for investigating the linkages between agricultural projects and nutrition was presented in Chapter 4. This chapter returns to those hypotheses in order to summarize the results of the study.

Effects on Production

The first hypothesis, that *the project increased milk production,* may be accepted.[67] Average production was twice as high in villages with dairy cooperatives. However, the hypothesis that the project leads to an *increase in production per cow through a shift in production curves* has to be rejected because the increase was achieved primarily through a shift in herd composition. The hypothesis that the increase came about through *a change in input use* may be partially accepted, though the effect of this change is small.

Using the production elasticities from Table 6 and the effects of the cooperative on input use from Table 7, one can calculate that milk production of local cows was 4 percent higher and that of buffalo, 1 percent higher in the villages with cooperatives. No statistically significant differences for input use with crossbred cows were observed.

The project did increase the size of the average herd. This hypothesis may be accepted because the households within cooperatives had 0.39 more milch animals. That it also *resulted in greater investment in improved cattle* may also be accepted. There was an increase of 0.45 crossbred cows and 0.21 buffalo per household in project villages and a decrease of 0.26 local cows.

The hypothesis that *the project did not result in a reduction of income from other activities* is supported by the evidence presented. No significant effects on other income, either positive or negative, were observed to be related to the presence of a cooperative. As virtually no additional fodder was planted in any of the villages, reallocation of land to forage crops is not an issue in this region. Cropping patterns do not appear to have been directly affected; nor were differences in input or output prices observed. However, considering that no measurable effect was discerned, this hypothesis can only be supported, not accepted.

The study also found no negative effects on income distribution, although the positive relationship between dairy earnings and farm holdings makes this finding worth further investigation.

The hypotheses that *the project increased labor earnings through a change in wages or through changes in labor patterns* may both be rejected. No significant differences in reported wages were observed. This also provides support for the hypothesis that the project did not result in a reduction of income from other activities because wages are a major input in agricultural production. Nor were major changes in the amount of labor hired for dairy activity observed. Changes in farm labor could be deduced from the increase in herd size, although this was mitigated by scale economies, as indicated in Table 6. No differences in labor per animal were observed. The net effect, including the effect of herd size and composition, was a 6 percent increase in

[67] For convenience, the hypotheses from Chapter 4 are indicated by italics. When a hypothesis is presented in terms of a measurable effect, "acceptance" implies a difference significant at the 5 percent level. When a hypothesis is worded in terms of the absence of an effect, the failure to measure an effect is indicated by the word "supported." This distinction is meant to distinguish those cases in which a level of significance for acceptance can be stated from those cases in which the conventional tests of significance can reject a hypothesis but not formally accept the alternative of no response.

labor applied to dairy activities. This is a negligible effect on total household labor.

Effects on Availability of Food Supplies

The study supports the hypothesis that *the project decreased or did not influence the cost of grains.* No statistically significant differences in cereal prices—the main component of food budgets—were reported between project and nonproject sites.

But the hypothesis that *the project had no impact on the retail price of milk* is rejected. Buffalo milk was 3 percent higher in the cooperative villages—a statistically significant amount. A smaller, less significant, difference was also observed for cow milk.

The hypothesis that *no market coercion was observed* was not tested. Households appeared free to change the amount they sold absolutely or relative to production, but no tests of extramarket coercion or obstacles to sales were devised.

Effects on the Desire to Purchase Nutrients

In regard to this last set of hypotheses, the premises that *the project did not influence average propensities to consume either calories or protein* have to be rejected. Small but significant differences in average levels of protein or calorie consumption at a given income level were observed. These were measured as a neutral shift of calorie or protein demand rather than as an increase in the marginal propensity to consume.

Similarly, the hypothesis that *the project had no influence on the average propensity to consume milk* may also be rejected. That is, with income and price held constant, people in the project areas consumed less milk. This could be either a neutral reduction over all income levels or a less steep relationship of income and milk consumption than in other areas.

To determine what portion of the total effect of change in nutrient demand may be attributed to the introduction of dairy cooperatives, it is necessary to add the effects of changes in income, prices, production, and the presence of cooperatives. Inasmuch as the data do not show that wages, employment, or the prices or allocation of land to cereal crops changed, differences in total expenditures between the two communities may be attributed to the dairy project. As stated earlier, the limited increase in the number of animals may account for the lack of increase in herd labor.

When calculated in a manner similar to equation (12), the average difference in expenditures was 8 percent. Similarly, equation (3) from Table 9 indicates that milk prices differed by 3 percent. These changes, along with the appropriate elasticities from Table 18, give the effects reported in Table 20. Similarly, the effect that can be attributed to the cooperative was calculated using the coefficients of the control dummy variable from models 2, 7, and 8 in Table 17, converted to percentage terms. The producer effect was calculated using the coefficient of milk value from equation (10), assuming a 5 percent increase in the appropriate ratio of the value of milk production to total expenditures. The producer effect used to calculate changes in calories or proteins came from estimates not included in the text. These terms were not significant and are included mainly for comparison with the calculations for milk.

Nonproducers in the villages with cooperatives had a net decrease in their milk and nutrient consumption. Since these effects were calculated using short-run changes in expenditures or milk production, this presumably also pertained to producers when their cows were not lactating. Milk producers had a net decrease in milk consumption, but a net increase in nutrient consumption. This was due to the positive income effect that overrode the negative effect of the cooperatives on consumption. This is important. The potential of the project to improve nutrition had nothing to do with changes in milk consumption per se, nor with changes in milk prices, but with the potential for

Table 20—Changes in milk, calorie, and protein consumption attributed to dairy cooperatives in Karnataka, January 1983-April 1984

Type of Consumption/ Source of Change	Producers	Nonproducers
	(percent)	
Fluid milk consumption		
Due to price change	−3.0	−3.0
Due to increased income	3.5	. . .
Producer effect	7.0	. . .
Cooperative effect	−9.0	−9.0
Net change	−1.5	−12.1
Energy consumption		
Due to price change	0.0	0.0
Due to income change	3.8	. . .
Producer effect	0.0	−2.1
Cooperative effect	−2.1	−2.1
Net change	1.7	−2.1
Consumption		
Due to price change	−0.1	−0.1
Due to income change	3.8	. . .
Producer effect	0.3	. . .
Cooperative effect	−1.9	−1.9
Net change	2.1	−2.0

Source: Data from the household survey conducted in Karnataka by the International Food Policy Research Institute and the Centre for Rural Development Studies, University of Bangalore, January 1983-April 1984.

Notes: The producer effect is the impact of milk production on demand, and the cooperative effect is the impact of the presence of a cooperative on demand, with income and price held constant in both instances.

increasing income. Policies that attempt to increase milk consumption may moderate increases in income and so are counterproductive to reaching nutritional goals. In this calculation, the cooperative affected producers and nonproducers equally. No further negative effects are likely if production in the villages is increased.

Note also that the price effects shown here were calculated using the panel approach. If the combined time-series and cross-sectional data are used, the effect of an increase in milk prices on nutrient consumption is a small increase. The net result is that there is no measurable decline in nutrient consumption even for nonproducers. Since the decline ranges between negligible and small, there seems to be little rationale for designing dairy policy in this region around its possible effect on the nutrition of consumers.

10

POLICY IMPLICATIONS

The current study is one of the most extensive empirical investigations of dairy development in India. While no single study can provide insight relevant to all the diverse conditions of India, the evidence presented can provide some guidelines for future policy and for future research.

The dairy cooperatives appear to be slowly transforming the nature of dairy production in the project sites. The indigenous cow is being replaced by both crossbred cows and by buffalo. However, the adoption of crossbred cows has not accelerated with the length of membership in the cooperative. This poses a challenge to planners. More than half the crossbred cattle in the sample were obtained by purchases rather than through farm breeding, even in the older cooperatives. Although this study does not have enough data on private or public investment to undertake a benefit-cost analysis, it should be clear that the social returns to a project will be far lower if investment in capital comes from disinvestment elsewhere than if the project encourages a net increase in breeding of crossbred cattle.

Given that many farmers obtain their crossbred cattle from purchases, thereby avoiding both the risk of getting an unwanted crossbred male and the difficulty of breeding and feeding a crossbred calf with the volume of milk produced by a local variety cow, the possibility that the dairy development corporation might provide calves bred centrally rather than by artificial insemination in the villages might be explored. Similarly, the conclusion that farmers in Karnataka, like those in other regions in India, still maintain more buffalo than cows for milk implies an obvious orientation for animal breeders. Perhaps improvement of buffalo can take precedence over or at least equal priority with the strategy of promoting crossbred cattle. Given that the proportion of buffalo to other animals is higher among the landless, upgrading buffalo may further the equity goals of the project. While the National Dairy Development Board has taken some steps along these lines, it is not clear that such a promotion should be accomplished through the cooperatives rather than through other agricultural programs.

The difference in crossbred stocking rates raises another issue for further consideration. If crossbred cattle are more profitable than other animals, what prevents farmers in the control villages from adopting the technology? Considering the role of education in the adoption of crossbred cattle, it is possible that the cooperative provides a similar effect as a conduit for information necessary for successful adoption. If the cooperative reduces risk or raises profitability, why is this not reflected strongly in other aspects of dairy investment and production? On the other hand, if the difference reflects a subsidy to cooperatives or rationing of scarce capital made possible by a near monopoly on exotic breeding stock, then the production benefits apparent in the cooperatives have little to do with the cooperative structure per se.

While many forms of agricultural insurance are not viable due to difficulties in monitoring damage, guaranteeing incentives to maintain property or apply inputs, and the high covariance of risk over a small area,[68] smoothly functioning cooperatives could reduce these obstacles and provide insurance themselves for owners of crossbred cattle

[68] Peter B. R. Hazell, Carlos Pomareda, and Alberto Valdés, *Crop Insurance for Agricultural Development: Issues and Experience* (Baltimore, Md.: Johns Hopkins University Press, 1986). See also, Hans Binswanger and Mark Rosenzweig, "Behavioral and Material Determinants for Production Relations in Agriculture," *Journal of Development Studies* 22 (April 1986): 503-539.

and improved buffalo. Village cooperatives would be better able to estimate their level of effort and risk than more distant insurers. At the same time, cooperatives could pool with a larger union to share risks. The temptation to subsidize such a scheme is great, however, and were that to occur, there would be the additional risk that the insurance would be provided only to the wealthier, more powerful farmers. The usefulness of such an approach in encouraging adoption of new breeds of cows and buffalos, then, depends on the degree to which the cooperatives are truly cooperative in structure.

If, as the data from the sample surveyed here imply, there were no major differences in inputs per animal type or of changes in fodder production, the project must be considered a failure in this respect. The effect on local practices is more gradual than dramatic. According to these data, too little concentrate and green fodder have been supplied to maintain weight during lactation and still yield milk near an animal's genetic potential under field conditions. This has been observed elsewhere in Karnataka as well.[69] Until the use of concentrates increases, the full potential of crossbred cattle is unlikely to be fulfilled. Here, as with investment in crossbred animals, the difference between farmers' choices and those of the planners must be taken as a signal. Technological packages are often adopted piecemeal; that must be understood when investments and projections are made. Moreover, when a portion of a package is not universally adopted, one must consider whether what is being offered is unsuited to local economic or physical conditions or both.

The current study was unable to ascertain either how profitable dairying was in the region, or the optimal amount of feed inputs. Nevertheless, a few remarks about pricing are warranted. First, the price advantage enjoyed by producers in cooperatives was small relative to other local villages; the measured difference in milk prices averaged 3 percent, controlling for animal type. While it may be that the presence of cooperatives kept private vendors from taking larger profits, the converse is also possible. In any case, no evidence warranting elimination or increased regulation of these traders was found in the study.

During the period of the survey, milk prices fell relative to grain prices. Dairy prices are largely determined by the prices in the urban market, plus marketing costs. If urban prices are rigid, particularly if they are depressed by local regulations, there is an obvious potential for thwarting development goals for the dairy sector.

According to the results of this survey, there is no nutritional justification for controlling the price of milk. Although the own-price elasticities of dairy goods are large, so are the cross-price elasticities. The net effect on nutrient consumption of an increase in dairy prices was virtually zero, except with regard to the effect on producer incomes. Nonproducers of milk may decrease their dairy consumption following such a price increase, but such a decrease is from a small base. Furthermore, because only a small share of nonproducers' budgets is given to milk, the effect of a price increase on their real income is still small. A greater concern from the standpoint of nutrition is the relationship of ragi prices to nutrient consumption. Caution must be taken to ensure that the demand for feed does not put upward pressure on the prices of coarse grains in the region.

Furthermore, marketing patterns—production minus demand—differ in the cooperative villages, leading to less consumption of milk by milk producers at a given amount produced, compared with milk producers in the control villages. Nevertheless, the effects of increased production work through both income and preferences to offset some of this. In general, the value of dairy development in this region is neither augmented nor reduced by nutritional linkages: instead benefits come through increased income and its distribution. To the degree that such income streams justify the investment, the project is warranted.

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[69] Sridhara, Munegowda, and Krishnamurthy, *Applied Forage Research.*

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