

THESIS



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A Commodity Subsector Approach to the Design
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Duncan Harvey Boughton

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**A COMMODITY SUBSECTOR APPROACH TO THE DESIGN OF AGRICULTURAL
RESEARCH: THE CASE OF MAIZE IN MALI**

By

Duncan Harvey Boughton

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ABSTRACT

A COMMODITY SUBSECTOR APPROACH TO THE DESIGN OF AGRICULTURAL RESEARCH: THE CASE OF MAIZE IN MALI

By

Duncan Harvey Boughton

This study examines the potential contribution of a commodity subsector approach to the design of agricultural research programs through a case study of agricultural production, processing, and demand for maize in Mali. The framework stresses how conditions at one level of a subsector influence constraints and opportunities for technical and institutional innovations at other levels.

The study examines the historical impact of maize technology development and diffusion in Mali. Farm-level adoption of intensive maize was rapid, given guaranteed prices and a vertically integrated technology delivery and output marketing system provided by Mali's cotton parastatal. Subsequent cereal market liberalization and increased aggregate cereal production resulting from improved rains caused maize prices to fall. Farmers adopted more extensive cultivation techniques in response.

A rapid interdisciplinary appraisal of the maize subsector confirmed that expansion was hindered by "thin market" characteristics. Only a small proportion of maize is traded through the market, and quantity and quality are unpredictable. The rapidly growing urban population is a potential source of increased demand for maize to broaden the market. Processing difficulties and unfamiliarity with maize were identified as the main constraints for urban consumers.

Opportunities to expand urban demand for processed maize products are explored in detail. A one-year study of cereal procurement and consumption was undertaken in the capital city, Bamako. The potential demand for maize flour was estimated with a Tobit model using contingent valuation data obtained through household consumption tests of different quality flours (dehulled and whole grain). Demand for maize flour appears adequate to support financially viable processing units, but is unlikely to significantly increase aggregate urban demand for maize because of low household processing costs, which reflect the low opportunity cost of women's time. Increased maize processing costs following the January 1994 devaluation of the CFA franc will further dampen short-run demand. Whole grain flour is significantly cheaper than dehulled flour, which suits the need of poor urban consumers.

Given the significant increase in fertilizer prices following devaluation, opportunities for technological innovations to improve farm-level productivity are also studied.

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In memory of fellow students David W. Makanda and F. Kapola Sipula

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ABBREVIATIONS

ae	adult equivalent
CFA F	CFA Franc, currency unit used by member countries of the West African Monetary Union of which Mali is a member, convertible with the French Franc at 1 FF = 100 CFA F since January 12th 1994
CFDT	Compagnie Française pour le Développement des Fibres Textiles
CIMMYT	International Wheat and Maize Improvement Centre
CMDT	Compagnie Malienne pour le Développement des Textiles
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CSE	Commodity Subsector Economics program (IER)
CV	contingent valuation
DNSI	Direction Nationale de la Statistique et de l'Informatique
DPAER	Département Planification Agricole et Economie Rurale (IER)
DRSPR	Département de Recherche sur les Systèmes de Production (IER)
ENSUP	Ecole Nationale Supérieure
FCU	food consumption unit (household survey unit of observation)
FTE	full time equivalent
FVS	frequent-visit survey
GIE	groupement d'intérêt économique
GMM	Grands Moulins du Mali
GRM	Gouvernement du République du Mali
IER	Institut d'Economie Rurale
IITA	International Institute for Tropical Agriculture
IRAT	Institut de Recherches Agronomiques Tropicales et Cultures Vivrières
IRCT	Institut de Recherches du Coton et des Textiles Exotiques
INSAH	Institut du Sahel
IRR	Internal Rate of Return
INRSP	Institut Nationale de Recherche sur la Santé Publique
ISNAR	International Service for National Agricultural Research
MSU	Michigan State University
NARS	National Agricultural Research System
OHV	Opération Haute Vallée
OLS	Ordinary Least Squares (regression)
OPAM	Office des Produits Agricoles du Mali
PRISAS	Programme Régional de Renforcement Institutionnel en Matière de Recherches sur la Sécurité Alimentaire au Sahel
PRMC	Programme de Restructuration du Marché Céréaliier
SE	section d'énumération (sampling unit)
SVS	single-visit survey
RD	Recommendation Domain
SIM	Système d'Information du Marché
USAID	United States Agency for International Development
VAT	Value Added Tax
VCR	value cost ratio

CHAPTER ONE

INTRODUCTION

This chapter sets out the objectives of the dissertation in relation to current agricultural research policy concerns and the context of the Malian national agricultural program within which the dissertation research was undertaken.

1.1 The challenge: increasing the payoff to investment in agricultural research in Africa

Adequate funding for African national agricultural research systems (NARS) is at risk despite the relatively early stage of their development. This situation has arisen due to increased competition for aid funds and donor perceptions of the historical performance of investments in African NARS.

Increased competition for donor funds reflects supply and demand-side factors. The economic recession in North America and Western Europe that began in the late 1980s severely aggravated the budget deficits of donor countries. This makes it politically very difficult to defend and maintain foreign aid budgets in real terms. At the same time there has been a rapid growth in the demand for aid funds. The reunification of Germany, and market reform programs in Eastern Europe and Russia, have generated huge demands for both capital investment and structural adjustment funds.

Increased competition for aid funds is forcing donor administrations to become more critical in their evaluation and use of aid funds. At the same time, donor resources for monitoring and evaluation are also being cut back. Consequently, countries and/or sectors of the economy that show positive

economic impacts will have a competitive advantage in securing aid flows. Thus it is important for African NARS to demonstrate that donor investments in agricultural research are productive.

In contrast to the need for clear signals to donors that agricultural research is an effective use of funds, investment in African NARS since independence is widely perceived as unproductive. These perceptions appear to have been generated more by the problems encountered in implementing agricultural research projects than by empirical results. A review by Daniels et al. (1992) found only 4 empirical studies of returns to investment in African agricultural research, compared to 66 in Latin America and 25 in Asia. Yet donors are very aware of the difficulties encountered by agricultural research projects. These include a shortage of and inability to retain qualified national staff, inadequate level and timely availability of recurrent local funds, and poor linkages with agricultural extension services (Eicher, 1991).

Recent empirical evidence indicates that agricultural research investments in specific commodities in Africa can be profitable. A set of agricultural research impact studies funded by USAID found a wide range in rates of return (from negative to 135%), but comparable in several cases to those obtained in Asia and Latin America (Oehmke and Crawford, 1993). However, evidence that investment in specific commodity research programs has been profitable does not necessarily imply that investment in African agricultural research systems has generated a satisfactory overall return.¹ Furthermore, the profitability of investments in a

¹ A research system can be viewed as a portfolio of investments. High returns to some research projects are necessary to compensate for low or negative returns on others. The overall return to investments in a research system over time is therefore a more valid measure of whether good use has been made of public funds.

particular commodity in the past is not a reliable guide to the profitability of future investments (Maredia, 1993).

While considerable efforts have been made to strengthen NARS, through the establishment of organizations such as the International Service for National Agricultural Research (ISNAR), little consideration has yet been given to the role of systemic studies of factors upstream and downstream from farm-level production that affect returns to investment in agricultural research (Fox, 1987; Henry de Frahan, 1990; USAID, 1992).

1.2 The opportunity: incorporating marketing considerations into agricultural research planning

Historically, agricultural research has tended to focus on a single stage (often farm-level production) for a single commodity (Staatz and Bernstein, 1992). Interactions with other stages in the commodity subsector, or other commodities at the same stage, were frequently overlooked. Since the mid-1970s, farming systems researchers have stressed the need for a holistic approach to the design of farm-level technology in order to take account of the range of constraints and interactions confronting the farmer (Collinson, 1982). This concern has not been limited solely to the farm-level production stage. Other stages with which the farmer as client is concerned (e.g. own consumption taste preferences, on-farm processing technology) have also been taken into account. But is this enough?

Agricultural development beyond semi-subsistence requires specialization, and this inevitably draws the farmer into a greater degree of exchange with other stages in the food system (Staatz, 1994). An increasing proportion of inputs (tools,

fertilizers, labor, technical information) is obtained off-farm, and an increasing proportion of farm-level products and services is sold or exchanged. Farmers may even choose to purchase food in the market place rather than produce it themselves in order to devote their limited time to other agricultural or non-agricultural activities (Staatz and Bernstein, 1992). The adoption of technology at farm-level will increasingly depend on the extent to which it enables farmers to respond to evolving off-farm client preferences for different product characteristics (e.g. quality, seasonal availability, lot size) as expressed by market prices.

Agricultural product and input markets have an increasingly important influence on the incentives for adoption of farm-level production technology as agricultural specialization and development occurs.² The rate of adoption of farm-level production technology in turn is an important contributory factor affecting the level of returns to investment in research (Henry de Frahan, 1990). Furthermore, innovation in product and input markets can directly generate benefits for farmers and consumers as well as having a positive impact on farm-level incentives.

But if the linkages between markets, technology adoption and returns to investment in agricultural research are so important, why have they not been considered explicitly in agricultural research planning by African NARS? First, from before independence until to the recent past, agricultural product and input prices have been officially set by the state in most African countries. Second, pricing policy for agricultural products and inputs is often formulated in a different ministry from that responsible for agricultural research, and possibly with different objectives

² The conceptual relations between markets and farm-level incentives for technology adoption will be examined more closely in the next chapter.

that may or may not encourage farm-level technology adoption. Third, agricultural economists trained in market analysis procedures are rarely found in African NARS.

Although institutional and human resource constraints remain, the market and macroeconomic policy environment of NARS has changed dramatically over the last decade. For most African countries it is no longer true that the state retains control over agricultural product and input prices. Market liberalization and structural adjustment policies have radically altered incentives for technology adoption, and the mechanism that generates those incentives. There is a real need to consider not only how changes in the market and macroeconomic policy environment have affected the impact of agricultural research, but how agricultural research design can anticipate and adjust to policy changes to improve its impact. The potential contribution of systemic analysis of market considerations in the planning of agricultural research programs is the central issue of this dissertation.

1.3 The context: Mali's national agricultural research program and the role of the maize subsector study

The Malian Agricultural Research service was established in 1961 with responsibility for ensuring coordination among organizations undertaking agricultural research in Mali. Prior to this date, most agricultural research had been carried out under the auspices of the Centre Fédéral de Recherches Agronomiques de Bambey (in Senegal) and the Office du Niger.³ During the first decade or so after independence, agronomic research continued to be implemented primarily by the

³ The two exceptions to this generalization are cotton research, conducted at M'Pessoba by IRCT from 1925 onwards, and livestock research, begun in 1927 with the establishment of a livestock farm at Sotuba, which subsequently grew into a major livestock research station for the Sahel by 1950 (Shetty et al., 1991).

French Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (IRAT), under a technical assistance agreement with the Malian government (GRM) which ran through 1974. As more and more nationals were trained, the research program was increasingly designed and managed by national staff. Today, livestock, crop and social science research are all managed by a national agricultural research institute, the Institut d'Economie Rurale (IER).

Since 1989, IER has implemented three major initiatives to improve its productivity. First, it has developed (with ISNAR) a twelve-year strategic plan that provides the technical programming framework for agricultural research activities. Second, it is in the process of implementing a structural re-organization that decentralizes research planning and financial management on a regional basis. Research user committees will also be established to help ensure the relevance of the research program for its intended beneficiaries. Finally, the legal status of IER has changed from a service in the Ministry of Rural Development to a parastatal institution with financial and personnel management autonomy. IER has received financial commitments from USAID and the World Bank in order to implement the organizational restructuring and the first six-year phase of its strategic research plan.

Commodity subsector studies were included in the strategic plan, but their role, content and relationship to technical research programs were not defined. The inclusion of subsector studies was motivated by a growing realization among research program managers that agricultural research was only useful if it resulted in technologies that were adopted, and that farmers would only adopt technology if it was profitable. Recent changes in cereal marketing policy, in particular the

removal of guaranteed prices, have given rise to fears concerning the profitability of existing crop production technologies (Staatz, 1989).⁴

Maize is a case in point. In the course of an historical assessment of the impact of maize research and extension carried out in collaboration with IER, Boughton and Henry de Frahan (1994) found the prevailing view among research and extension program managers to be that the area and production of intensive maize expanded very rapidly when a guaranteed price was in effect; a boom that evaporated after cereal markets were liberalized in 1986.⁵ In order to address these concerns, the study was expanded to consider opportunities and constraints for development of the maize subsector as a whole.

From IER's perspective, the primary role of the maize subsector study was to provide a learning experience to define more clearly the role of subsector studies within the overall research program, and identify and develop the necessary organizational linkages and methods for implementing them. Maize is very appropriate as a "pilot" study for three reasons. First, as stated above, changes in the organization of cereal marketing over the last decade have had an important impact on the incentives to adopt farm-level maize production technology. Second, lessons from the maize study can be expected to have important implications for other cereals in regard to both utilization and farm-level production. Finally, the limited geographical scope of maize production reduces the logistical complexity of implementing a study.

⁴ Staatz challenged the view that changes in marketing policy were responsible for the lack of profitability of farm-level technology, and urged researchers to examine options for reducing unit costs of farm-level production.

⁵ This prevailing view turned out to be an oversimplification, as will be shown in chapter 3.

The maize subsector study was implemented in two phases. An initial interdisciplinary appraisal of the whole subsector was carried out between February and April 1992 in order to identify constraints and opportunities for innovation. On the basis of this appraisal, funding proposals for an in-depth study of opportunities for increased urban utilization of maize were prepared and defended. The in-depth study was implemented over an 18-month period July 1992 through December 1993. The initial appraisal was funded by the Programme Régional de Renforcement Institutionnel en Matière de Recherches sur la Sécurité Alimentaire au Sahel (PRISAS) of the Institut du Sahel (INSAH) and the Agricultural Technology Impact Assessment add-on to the USAID-MSU Food Security in Africa Cooperative Agreement. For the in-depth studies, local costs were funded by the Programme de Restructuration du Marché Céréaliier (PRMC), and MSU participation by USAID/Mali and the Agricultural Technology Impact Assessment add-ons to the USAID-MSU Food Security II Cooperative Agreement.

1.4 Objectives of the dissertation

The goal of the dissertation is to demonstrate the potential contribution of a commodity subsector or marketing systems approach to the design of agricultural research programs through a case study of maize in Mali. The study uses this systemic approach to understanding constraints and opportunities for technological, policy and institutional innovation in the maize subsector. Opportunities to expand urban demand for maize through the supply of processed products with attributes that match consumer preferences are explored in detail. In light of the significant increase in fertilizer prices following devaluation in January 1994, opportunities for

complementary technological innovations to improve productivity at farm-level are also studied.

The specific objectives of the dissertation are:

- 1) to apply a commodity subsector approach to the analysis of constraints to and opportunities for technological, institutional and policy innovation in the Malian maize subsector;
- 2) to examine the economic impact of, and interaction between, maize technology development and diffusion in Southern Mali and institutional and policy change over the period 1969 - 1990;
- 3) to analyze the role of maize in cereal consumption in the capital city, Bamako, a potentially important source of demand growth to overcome the "thin market" impediment to further development of the maize subsector;
- 4) to quantify potential demand for pre-processed maize flour, and estimate the magnitude of demand at retail prices that reflect the costs of existing processing technology;
- 5) to evaluate the impact of fertilizer price increases on the profitability of maize cultivation, and identify opportunities for increased farm-level productivity.

1.5 Outline of the dissertation

The dissertation is organized as follows. The next chapter develops a conceptual and methodological framework for the application of a commodity subsector perspective to the design of agricultural research.

The third chapter illustrates the relevance of a commodity subsector perspective to the design of agricultural research by an examination of factors that

affected the historical payoff to farm-level maize technology development and diffusion in Mali. The results of the initial subsector appraisal are presented in chapter 4 in the form of an overview of the maize subsector, together with the rationale for the choice of in-depth studies.

The next three chapters are concerned with urban demand for cereals and the potential to expand demand for maize through the supply of processed maize to urban consumers. Chapter 5 describes the survey instruments, sampling method and characteristics of sample households in Bamako. Chapter 6 provides an empirical description of cereal procurement and utilization, including an analysis of the cost of meals prepared from different cereals and processing methods. Chapter 7 examines a key opportunity for expansion of urban demand for maize (of relevance to millet and sorghum as well) by a quantitative analysis of the potential market for maize flour of different qualities.

Increases in the price of imported fertilizers following devaluation in 1994, motivate a search for opportunities to increase farm-level productivity. Chapter 8 evaluates the impact of fertilizer prices on profitability of the maize enterprise, and identifies geographical and technical foci for future agronomic research.

The final chapter draws out the implications of the study for maize technology development and diffusion in Mali, and reflects on the methodological lessons for use of a subsector approach to inform research design in African NARS.

CHAPTER TWO

CONCEPTUAL AND METHODOLOGICAL FRAMEWORK

The previous chapter noted that despite the importance of the rate of farm-level technology adoption for the rate of return to research investments, factors affecting incentives to adopt farm-level production technology other than the technical parameters of the innovation itself are usually considered as exogenous in the design of agricultural research. A better understanding of constraints and opportunities upstream and downstream from farms could contribute to more effective farm-level technology development by a better match between farm-level technology and market conditions, or through the identification of interventions that make those conditions more conducive to technology adoption.

This chapter examines the potential contribution of the commodity subsector approach as a means to understand how conditions upstream and downstream affect farm-level technology adoption incentives, and to assess whether they can be modified to encourage innovation and increase productivity. The first section briefly reviews factors that affect incentives for farmers to adopt technology. Section two presents a conceptual framework for examining the relationship between incentives to adopt technology at farm level, innovation at other stages of the food system involved in the production of goods and services, and the payoff to research investments as measured by benefits to farmers and consumers. Section three discusses the problem of demand articulation (the communication of consumer preferences for products and services) in the early stages of agricultural transformation, often characterized by high transactions costs. The final section outlines the approach and methods used for the maize subsector case study.

2.1 The relationship between markets and incentives for technology adoption

The incentives for farmers to adopt technology are determined in large part by the expected profitability of an innovation. There are certainly other factors that enter into the adoption decision, such as how adoption would be perceived by peers or family members, but profitability remains important (Coulibaly, 1987).¹

Profitability can be defined as the difference between the value of additional output (or outputs) and the cost of the additional input (or inputs) required to generate it.²

In a market economy, financial profitability can be measured by multiplying outputs and inputs by their respective prices and calculating the difference. The greater the difference between the sum of additional costs and additional benefits resulting from adoption, the greater the incentive to do so, ceteris paribus.

In addition to the expected or average amount of profit, the degree of risk has an important effect on the incentives to adopt farm-level technology. Risk refers to uncertainty concerning outcomes. Of particular concern in regard to farm-level technology adoption is uncertainty concerning revenues (i.e., output levels and/or prices) and costs (i.e., input quantities and/or prices). Because of diminishing marginal utility of income, farmers prefer lower to higher variability for any given average level of income (Robison and Barry, 1987). Variability in product and input prices affects the variability in the profits to be derived from farm-level technology adoption. Thus, variability in input and product prices, and the way in

¹ During the 1950s and 1960s, a considerable amount of attention was devoted to non-profit related factors such as the characteristics associated early or late adopters (summarized by Rogers and Shoemaker, 1971).

² Proponents of social capital theory (e.g., Robison and Schmid, 1994) would argue that factors such as peer group approval enter directly into the calculation of profitability along with input and output prices. We focus on the financial dimension of profitability for simplicity.

which they interact with each other and with physical input and output levels, have important effects on incentives.³

Price levels and price variability for farm products and inputs reflect constraints and opportunities in the off-farm economy, as communicated through agricultural input and output markets. These constraints and opportunities change in response to policy, institutional and (off-farm) technological innovation (e.g., the development of additional uses for a farm product, or processing technologies that permit greater substitution between products). Since institutional, policy and technical changes in product and input markets can have important repercussions on farm-level technology adoption incentives, they should not be ignored at the design stage. The only exception to this would be a static, purely subsistence agrarian economy. Market considerations are irrelevant to such an economy since all inputs and products are supplied and consumed by the household. In most cases, however, markets have an important role to play in facilitating agricultural development in general, and the adoption of improved technology in particular. The next section sets out a conceptual framework for including these considerations.

2.2 The food systems matrix as an integrative framework for agricultural research and development questions

The purpose of this section is to describe a conceptual framework that relates farm households to relevant components of the rest of the economy. This is

³ Product price variability does not necessarily have a negative effect on incentives for technology adoption. If product prices are negatively correlated with production levels, price variability can have a stabilizing effect on net returns. The important principle is to identify what the effect of variability is in a given context, and to ask whether or not there exist ways to enhance the positive and/or mitigate the negative effects of variability.

a first step toward the identification of constraints and opportunities off-farm that do, or could, have an impact on incentives for farm-level technology adoption.

The relationships between farming and marketing systems can best be understood in relation to the food system as a whole. The food system has been defined as "the entire set of actors and institutions involved in input supply, farming, and the processing and distribution of agricultural products (including their links with international trade)" (Staatz and Bernstein, 1992, p. 4). Both farming and marketing systems are components (or subsystems) of the food system.

A simple but effective tool for organizing analysis of a food system is a matrix of agricultural products and functions (Figure 2.1). Originally conceptualized by Shaffer (1970), and further developed by Holtzman (1986), each column of the matrix represents a commodity subsector (i.e., the entire range of productive processes and services associated with a specific commodity or group of closely related commodities).⁴ The rows of the matrix represent individual stages or functions in the production and transformation of commodities.

Interdependencies, or system interactions, are common to both vertical and horizontal dimensions. At the farm-level production stage (horizontal dimension), different crop enterprises compete for limited household resources of land, labor and capital, while livestock enterprises enhance crop productivity through increased soil fertility. Similarly, in the vertical dimension, transport costs to urban centers play a

⁴ Although some authors (e.g. Holtzman 1986) have advocated that the term "commodity subsystem" is more appropriate than "commodity subsector" in view of the interdependencies between different stages, we use commodity subsector in order to avoid confusion with the frequent use of the terms crop or livestock subsystems in reference to components of farming systems. Fundamental to the concept of a commodity subsector is the recognition that productive activity occurs not only at the farm level, but at every stage as inputs are supplied and value added to a product as it moves from field to cooking pot.

key role in determining which horticultural products can be cultivated profitably, while investment in cooperative processing facilities may provide a means to overcome high transport and storage costs associated with bulky and/or perishable commodities. Interdependencies can also occur between different stages of different commodity subsectors. For example, administered prices for cotton seed, a by-product of cotton ginning, are a major component of the cost of feed supplements fed to draft animals in Mali. Interdependencies between stages in a subsector, or across subsectors, can either help or hinder technical innovation and need to be taken into account from the outset.

Figure 2.1. Food Systems Matrix

PRODUCTION/DISTRIBUTION FUNCTIONS	COMMODITY SUBSECTORS						
	Millet	Sorghum	Maize	Rice	Cotton	Livestock...	Off-farm
Input Distribution	▲ S						
Extension	u						
Farm-level production	b	◀ ----- Farming Systems Approach ----- ▶					
Processing	s						
Storage	e						
Transport	c						
Exchange, transactions	t						
Finance	o						
	r						
Coordination functions							
- Prices	A						
- Quality control	p						
- Regulations	p						
- Property rights	r						
- Contracts	o						
- Risk management	a						
	c						
Consumption	▼ h						

Source: adapted from Ndoye and Newman (1984).

In the context of increasing specialization and exchange that characterizes agricultural development, a commodity subsector perspective broadens the scope for productivity gains. Instead of limiting the search for possibilities to drive down unit costs of production to the farm level, researchers can examine possibilities at several or all stages in the commodity subsector. As Staatz and Bernstein (1992) observe, if marketing costs represent 50% of the final product value (as is commonly the case in developing countries) then a 10% reduction in marketing costs has the same effect on the overall productivity of the subsector as a costless 10% increase in crop yield. For farmers, a reduction in marketing costs would be preferable to a yield increase since it requires no additional inputs or risk and would have an upward rather than a downward effect if any on farm gate prices.⁵ In the case of export crops such as cotton and groundnut, driving down unit costs at multiple stages may be the only way to maintain real incomes in the face of declining real world market prices.

A commodity subsector perspective provides researchers with additional options in the search for innovations. Increasing specialization and exchange in the food system requires coordination between economic agents at different stages in the subsector. Technological innovation by itself may fail to achieve all potential productivity gains within a given commodity subsector because of inadequate coordination. Institutional and policy innovations can complement technological innovation by reducing barriers to the effective communication of consumer

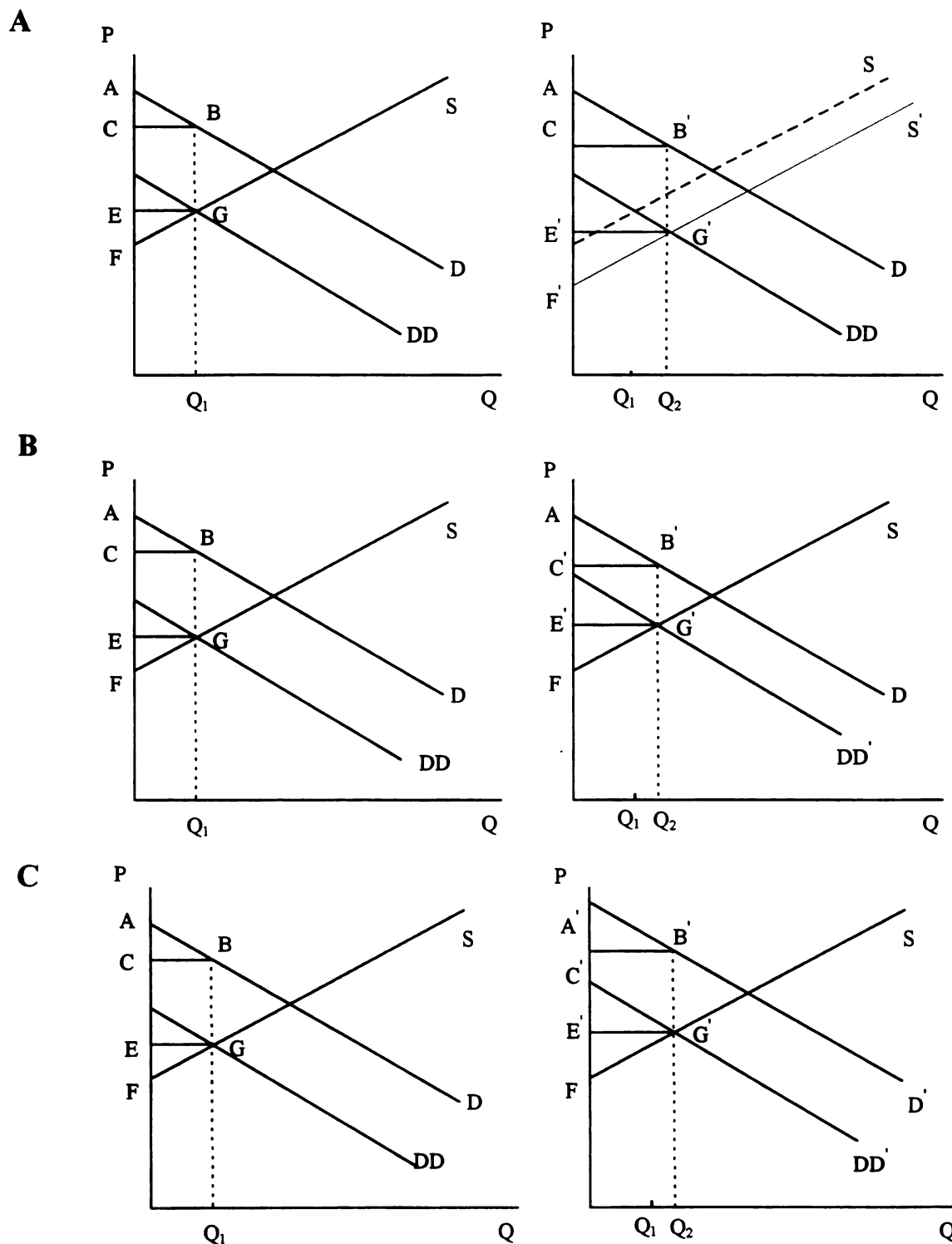
⁵ A reduction in marketing costs would result in a shift in the farm gate demand curve to the right, and hence an increase in farm-gate price unless supply were perfectly elastic, in which case the farm gate price would remain constant. An increase in yield would result in a shift in the farm gate supply curve to the right, and hence a decrease in farm gate price unless demand were perfectly elastic, in which case the farm gate price would again remain constant.

preferences and market opportunities to farmers, and by increasing the ability of private sector participants at all stages of a commodity subsector to respond to those opportunities.

The potential payoff to research that integrates commodity subsector and farming systems perspectives to identify innovations at multiple stages can be illustrated by a frequently used analytical framework that measures the effects on consumers' and producers' welfare of changes in technology (Norton and Davis, 1981).⁶ Figure 2.2 depicts three scenarios: 1) a farm-level production innovation with a fixed marketing margin per unit of output (e.g., a higher yielding variety or breed of livestock); 2) an innovation that reduces marketing costs (e.g. a reduction in processing losses); and 3) an innovation that improves the quality of the product for the consumer without increasing marketing costs (e.g., by a better match between the attributes of the product and those sought by consumers). Consumers' welfare, or 'consumer surplus', is represented by the area below the demand curve and above consumer price.⁷ Producers' welfare, or 'producer surplus' is represented by the area above the supply curve and below farm-gate price (where the derived demand curve DD or DD' intersects the supply curve). Within the limitations of a partial equilibrium framework (i.e., effects on welfare from changes in the production and consumption of other goods and services in the

⁶ This approach assumes that the conditions for Pareto optimality are met. While they never are in the real world, due to violations such as the presence of transactions costs, this does not pose a serious problem for the present purpose of illustration.

⁷ The downward sloping demand curves imply a non-marginal increase in supply. This need not be the case for a small-country exporter, or if a farm-level innovation is relevant to only a small proportion of producers, or if the product has many possible substitutes.

FIGURE 2.2: Effect of Food System Innovations on Consumer and Producer Surplus**Notes:**

P = price per unit; Q = quantity per time period; S = supply curve
 D = demand curve; DD = farm-gate derived demand; ' = shift

economy as a result of innovation in the commodity subsector of interest are ignored), welfare gains can be illustrated by changes in producer and consumer surplus.

In Figure 2.2 A, a farm-level production innovation results in a rightward shift of the supply function (i.e., the marginal cost of production is lower for any given level of output). At market-clearing prices, the price paid by consumers remains higher than that received by producers by an amount equal to the marketing margin (C-E) or 'wedge'. Consumer surplus increases from triangle ABC to triangle AB'C'. Producer surplus changes from triangle EDF to triangle E'D'F'.⁸ The gross benefit (i.e., ignoring the costs of innovation development and diffusion) is equivalent to the sum of the differences between the two pairs of triangles. Consumers unambiguously gain. Whether producers gain or not depends on the relative elasticities of the supply and demand curves.

In Figure 2.2 B, an innovation reduces marketing costs (represented by a smaller wedge C'-E' as opposed to C-E). Both consumers and producers are unambiguously better off as a result of the increase in quantity produced and consumed from Q_1 to Q_2 in response to lower marketing costs.⁹

Finally, consider the payoff to an innovation that improves the quality of the consumer product without increasing per unit marketing costs, illustrated in Figure 2.2 C. As a result of the quality improvement, demand shifts to the right and more is purchased at every price than before. Producer surplus increases unambiguously

⁸ In the diagrams, the presence of an apostrophe after a letter indicates that the corresponding location has changed as a result of the innovation.

⁹ Exceptions occur if either the demand curve or the supply curve is perfectly elastic. In this case the entire surplus accrues to the group with less than perfectly elastic price response.

from triangle EDF to triangle E'D'F. Consumer surplus also increases unambiguously from triangle ABC to A'B'C', the size of the consumer gain depending on the elasticity of farm-level supply.¹⁰

An important consideration is that, in general, the benefits from the three types of innovation are additive. With development, an increasing share of total costs is incurred, and an increasing share of value added is created, off farm. In order to avoid diminishing returns to research effort, it may be necessary to devote research resources to opportunities to reduce off-farm unit costs of producing complementary goods and services as well as reducing farm-level costs of production. This raises the issue of the respective roles of the private and public sectors in funding agricultural research, addressed in the following section.

2.3 The role of demand articulation in food system innovation

In order to shift the farm-gate demand curve for a given commodity, other than through relative prices, or population or income growth, there has to be an increase in the value of the product to the consumer. This can be accomplished through the incorporation of additional services such as processing, improvements in product quality, or by changing consumers' knowledge or desire for the product (e.g., through extension programs or advertising). For existing goods and services, prices act as signals of value. For potential products that are not currently available, additional means for eliciting and communicating consumer preferences are needed. Demand articulation is the process whereby consumer preferences are

¹⁰ An unambiguous consumer gain is dependent on the per unit marketing margin remaining constant as quantity demanded increases, implying a perfectly elastic supply of marketing services.

communicated to potential suppliers at different stages in a commodity subsector. We first relate the concept of demand articulation to existing consumer theory, and then consider the implications of demand articulation for private and publicly-funded research to promote food system innovation.

2.3.1 Demand articulation and consumer theory

Senauer et al. (1991) observe that "The traditional economic theory of the consumer is virtually worthless for analyzing the potential demand for a new product, since it has not previously entered consumers' preferences (utility functions)" (p 160). Lancaster (1991) extended the standard neoclassical treatment of consumer theory by conceptualizing consumer demands for attributes, with different products containing different combinations of attributes. Since most "new" food products are in fact new combinations of basic attributes about which consumers already have well-formed preferences, consumer theory as extended by Lancaster can accommodate the demand for new products (Senauer et al., 1991).

In the case of alternative cereals, or cereals with different degrees of processing, attributes are present in fixed proportions. Consumers vary their consumption of those attributes through the choice of meals they consume. In the present context, the demand for a meal is defined as the demand for a particular dish at a particular mealtime (breakfast, lunch, dinner or lunch/dinner combined). In a modified neoclassical framework, households would be expected to equate:

$$\frac{MU_{mi}}{p_i} = \frac{MU_{mj}}{p_j}$$

where MU_{mi} is the marginal utility of a given meal and p_i is the marginal cost of providing it (including the cost of grain, processing services, fuel and

complementary sauce ingredients).¹¹ The invention of a new dish, or a change in the marginal utility of a particular dish arising from a better match between the product and attributes sought by consumers, would result in a shift in the derived demand for the cereal and/or form from which it can be prepared.¹² Similarly, a reduction in the cost of complementary processing services necessary to transform the cereal into the dish would also result in a shift in the derived demand for the cereal and form concerned. The hypothesis, maintained but not tested in this dissertation, that demands for cereals and for processing services are jointly derived from the household demand for meals is consistent with neoclassical theory as extended by Lancaster. Whether some or all of a set of processing services required to prepare a given dish are already embedded in the cereal (i.e., as processed cereal), or whether they are supplied by the household, will depend on the relative costs of supplying the services.

¹¹ The purpose here is not to claim that the theory as discussed is an adequate representation of reality, but that conceptually it can be extended to the demand for new products. The notion that a household equates utility at the margin is obviously a gross simplification given the complexity of household decision-making institutions in urban Mali. Responsibility for the provision of grain and responsibility for processing cereals is divided among family members on the basis of gender and seniority. A household head seeking to provide family cereal requirements at minimum cost has an objective that conflicts with a food preparer seeking to prepare meals with minimum labor input. The extent to which these conflicting objectives are reconciled through interdependence of individual utility functions (e.g. the extent to which household heads derive benefit from a reduction in their wives' workload) could have an important effect on the choice of cereal and processing technology. In practice, the potential complexity of the decisions relating to food consumption appears to be overcome through the use of standard operating procedures. This implies that non-marginal changes in prices of raw materials or alternative processing technologies may be necessary to provoke a shift in the quantity or form in which cereals are purchased.

¹² For example, the marginal utility of a particular dish could vary due to consumer preferences for light versus heavy meals at different times of day.

2.3.2 The role of public and private sector research in facilitating demand articulation

The transition from an agricultural sector that supplies only unprocessed products, with all subsequent value added by consuming households, to one that supplies products with at least some of the subsequent services already incorporated, is fundamental to the process of agricultural transformation. In order to make correct decisions as to whether and/or when it is profitable to provide these services and/or quality improvements, private sector participants need information concerning:

- 1) consumer preferences in regard to processing and quality (i.e., in what form consumers want to purchase the product, including packaging, and what attributes enhance or degrade quality in the eyes of the consumer);
- 3) how much consumers are willing to pay for different quantities of product with the desired attributes;
- 2) appropriate technology (type of equipment and scale) and the costs of providing products with desired attributes.

In developed countries, much of the research necessary to generate the information required by economic agents engaged in agricultural transformation activities is generated by the private sector. Virtually all food processing companies have a product development section, which in turn may contract out parts of the product development process to specialized firms (e.g., package design and test marketing). Similarly, many farmer cooperatives such as Ocean Spray in the USA, or the Milk Marketing Board (MMB) in the UK, seek to increase demand for raw agricultural products through the development of new products with a high

proportion of value added off-farm (e.g., cranberry juice in the case of Ocean Spray, imitation French cheeses in the case of the UK MMB).

The higher the level of average consumer incomes the greater the opportunity for marketing products with processing services and quality attributes incorporated. This is partly because incomes are correlated with the opportunity cost of consumers' time, and hence with their willingness to pay for products that save time by incorporating processing services (Hull et al., 1983), and partly because consumers enjoy variety in the food products they consume.

The lower consumer income levels, the more restricted will be the set of products with value added that consumers are willing to buy, and the more limited the quantities. The smaller the set of products for which effective demand exists, the greater the risk of new product failure. For entrepreneurs, the riskiest point in the agricultural transformation process is right at the beginning when incomes are lowest and the existing and potential product space is smallest. One way to reduce risk is through the provision of information that increases the probability of making a correct decision about what product specifications consumers are willing to pay for in quantities sufficient to be profitable to supply. But is this an appropriate task for publicly funded research?¹³

The justifications for providing information partly or wholly through publicly funded research are the public good character of, and externalities generated by, such information. Information on consumer preferences for product attributes is a public good because once a product has been successfully launched the information

¹³ This argument could be formulated in terms of the need to reduce transactions costs facing potential entrepreneurs in order to stimulate agricultural transformation (Staatz et al., 1994).

concerning the attributes consumers are willing to pay for is literally on the shelf. Unless there is an enforceable system of patent rights to protect manufacturers of new products, effectively granting a monopoly to the patent-owning firm, firms will underinvest in seeking the required information. Even if legislation exists, it may be difficult to enforce in the food industry because of the wide variety of potential products (hence the tendency to product proliferation in developed country food industries). Second, the invention of a new product or process frequently generates positive externalities. The acceptance of a new consumer product expands the opportunity set for similar products or processes.

Publicly funded agricultural research aimed at promoting agricultural transformation will not necessarily be limited to the consumer-processor interface. The specific attributes required by consumers, and the technology employed to provide them, may in turn require certain attributes in the raw material. Wheat for bread-making, for example, must attain certain minimum protein levels in order for the dough to be sufficiently elastic to be processed industrially. The same characteristic is irrelevant for wheat used as livestock feed. How is the raw material with the necessary qualities to be identified? Do the varieties currently available to farmers have the required characteristics? Do these varieties require different husbandry and/or storage practices to enhance or preserve those attributes? Will farmers require contracts in order to manage the risk arising from higher cash outlays? How can farmers identify seed with the necessary attributes? Is the demand for raw product with these characteristics likely to be sufficiently great to justify breeding for a specific characteristic? The successful articulation of consumer demand for a particular product may have implications for the technology,

institutions and policies conditioning productive activity at multiple stages in a commodity subsector. Failure at any one stage will drive up costs at all subsequent stages, possibly to the point of choking off demand for the final product.

The next section outlines methods used to identify constraints and opportunities to technological and related innovation in the maize subsector in Mali.

2.4 Outline of methods used

The previous sections described the potential contribution of a commodity subsector approach to the identification of constraints and opportunities for development of the food system, and the role of demand articulation in the process of technological innovation in food systems that use markets to coordinate production and consumption activities. This section provides an outline of the methods used to accomplish the objectives set out in chapter 1. More detailed explanations are reserved for the chapters dealing with specific research questions.

A combination of methods was used to measure the impact of, and assess the contribution of institutional and policy changes to, the development and diffusion of maize technology at farm level over the period 1974 - 1990. Following Traxler and Byerlee (1991), a careful historical review was undertaken to trace the link between research and extension activities and farm-level of adoption of new technology over time, using annual reports from the organizations involved supplemented by numerous interviews with researchers, extension managers and farmers. Financial impacts were measured using partial budgets, and economic impacts by benefit-cost analysis.

The study of constraints and opportunities upstream and downstream from farms was motivated by significantly reduced incentives for intensive maize cultivation after the removal of guaranteed prices in 1986. A rapid subsector appraisal (Holtzman, 1986) was carried out by an interdisciplinary team using informal interviews with economic agents at different stages of the subsector, including researchers, extension workers, farmers, rural and urban wholesalers and retailers, transporters, processors, poultry rearers, as well as rural and urban consumers. These interviews were supplemented by literature review and descriptive analysis of marketing margins. Descriptive information, constraints and research questions for different stages of the maize subsector was organized using a Research Planning Matrix (Tefft et al., 1990). The large and rapidly growing urban population of Bamako was identified as an important source of potential demand growth, and the difficulty of processing maize as a constraint to increased urban consumption.

The main focus of subsequent research was to determine the potential demand for processed maize and whether, given the costs of existing processing technology, supplying that demand could be a means to overcome the "thin market" dilemma (Tomek and Robinson, 1990). Short of large-scale market tests, there are two possible approaches to the issue. One is to infer potential demand from existing household consumption patterns. The other is to ask household decision-makers about hypothetical purchasing intentions. The approaches are obviously complementary, and both were employed.

To determine existing cereal utilization patterns in the capital city, a year-long survey of cereal procurement by a sample of Bamako households was

undertaken. Given the maintained hypothesis that the demands for cereals and processing services are jointly derived from the demand for meals, careful attention was given to the dishes prepared, and the processing techniques employed.

Modified Engels curves were estimated by regression to determine the effects of income and demographic factors, including proxy variables for the opportunity cost of women's time, on the demand for processed and unprocessed cereals. To complete the picture of existing household utilization of cereals, the cost of meals prepared from rice and coarse grains was calculated on the basis of detailed observations of processing and meal preparation activities in a subset of sample households.

To estimate the potential demand for maize flour, a contingent valuation experiment was designed in conjunction with consumer tests of two qualities of maize flour prepared by a local processing firm. A demand equation was estimated using a standard censored tobit model. The results were used to derive, for six population subgroups, expected demands, and price and income elasticities for each flour quality before and after devaluation.¹⁴ Estimated retail prices for each type of flour were calculated on the basis of the pre- and post-devaluation costs of processing with existing technologies. Aggregate demand for the population of Bamako was also estimated at retail prices, and compared to existing levels of maize consumption.

Devaluation also affects maize growers. Partial budget analysis is used to assess the effect of fertilizer price increases following devaluation on incentives to cultivate intensive maize. Opportunities for improved productivity are identified by

¹⁴ At midnight on January 12th, 1994, the government announced a 50% devaluation of the CFA franc.

comparing the cost of existing fertilizers to alternative sources, and examining the level of adoption of improved varieties. Since varietal performance and fertilizer response is environment-specific, logistic curves are fitted to historic adoption data to predict the geographic locus of future maize area expansion.

The results from consumption and farm-level production analyses are used to identify a combination of technology, policy and institutional innovations needed for accelerated development of the maize subsector.

2.5 Summary

This chapter has argued that a commodity subsector approach offers possibilities to improve the design of agricultural research through a better understanding of factors upstream and downstream from farms that structure farm-level technology adoption incentives. The argument was developed within a food systems framework, emphasizing the need for attention to demand-side constraints and opportunities for innovation. A roadmap of methods used was also presented. The next chapter explores how conditions upstream and downstream from farms, including the organization of agricultural research and extension activities and their interaction with cereal pricing policy over time, have affected farm-level maize technology adoption in southern Mali in the past.

CHAPTER THREE
HISTORICAL DEVELOPMENT PATH AND IMPACT OF FARM-LEVEL
MAIZE TECHNOLOGY¹

The central thesis of this dissertation is that the use of a commodity subsector perspective to incorporate market considerations into the design of agricultural research programs can improve the payoff to investment in African NARS. This can be illustrated by an historical analysis of the development path and impact of farm-level maize technology in Southern Mali over the period 1969 - 1990. Careful attention is given to the role of institutional and policy factors, and their effect on farm-level technology adoption incentives. The first section describes specific objectives and methods used for this component of the study. Section 2 traces the history of maize research, and section 3 the diffusion of maize technology in Southern Mali. Section 4 examines the financial and economic impacts of investment in maize technology development and diffusion. The final section looks at implications for future maize research and technology development.

The choice of maize for a case study of agricultural research impact in Mali was motivated by four considerations. First, maize is the only rainfed cereal with potential for intensification. Second, a number of improved maize varieties had been made available to farmers by extension services. Third, maize is grown in a well-defined geographical area, reducing the logistical complexity and cost of the study. Finally, there was considerable concern among Malian researchers and

¹ This chapter is based primarily on Boughton and Henry de Frahan (1994), one of seven agricultural research impact studies undertaken in Africa for USAID (AFR/ARTS/FARA) under the Food Security in Africa Cooperative Agreement.

extension workers concerning the negative effects of cereal market reform during the 1980s on technology adoption at the farm level (Staatz, 1989).

The prevailing view among Malian research and extension staff was that the cultivation of intensive maize experienced a boom during the early 1980s when there was a guaranteed market, that subsequently collapsed when the cereal market was liberalized. Since this was an experience that might occur in the future for other commodities, given the commitment to market reform in Mali, the historical assessment of the financial and economic impact of maize research and technology diffusion was broadened to include an assessment of constraints and opportunities for further development of the subsector. This would not only enable the team to understand better the historical constraints to the impact of maize research and extension in southern Mali, but also to identify the kinds of technological, institutional and policy-related innovations that could enhance the future contribution of the maize subsector to agricultural and economic development in Mali.

The impact assessment study was initiated in July 1991 in collaboration with IER's Farming Systems Department (DRSPR). The study benefitted from strong collaboration with the two regional development organizations in the study area, the Compagnie Malienne pour le Développement des Textiles (CMDT) and the Opération Haute Vallée (OHV).

3.1 Objectives and methods

In collaboration with DRSPR researchers, the study objectives were formulated as a logical sequence of questions:

- 1) What technologies have been developed and diffused for maize over the last ten to fifteen years?
- 2) What technologies have been accepted, rejected or modified by farmers, and why?
- 3) What has been the impact of maize technology adoption at the farm household level?
- 4) What factors have encouraged and what factors have constrained the adoption of maize technology at the farm household level?
- 5) What is the profitability, or rate of return, to investment in maize research and diffusion at the national level?
- 6) What factors have encouraged and what factors have constrained the rate of return to investment in maize research and diffusion?

With only slight modifications (such as the historical time span of maize technology development) these six questions provided a valuable guide throughout the duration of the study.

The first question involved documenting maize research and extension activities since the late 1970s through literature review (annual reports of research and extension agencies in particular), and in-depth interviews with the researchers and extension workers involved.

Questions two through four focus on the farm-level impact of maize technology, and were addressed using secondary data from extension agencies, complemented by informal surveys with farmer groups and detailed interviews with extension workers. Topics discussed included:

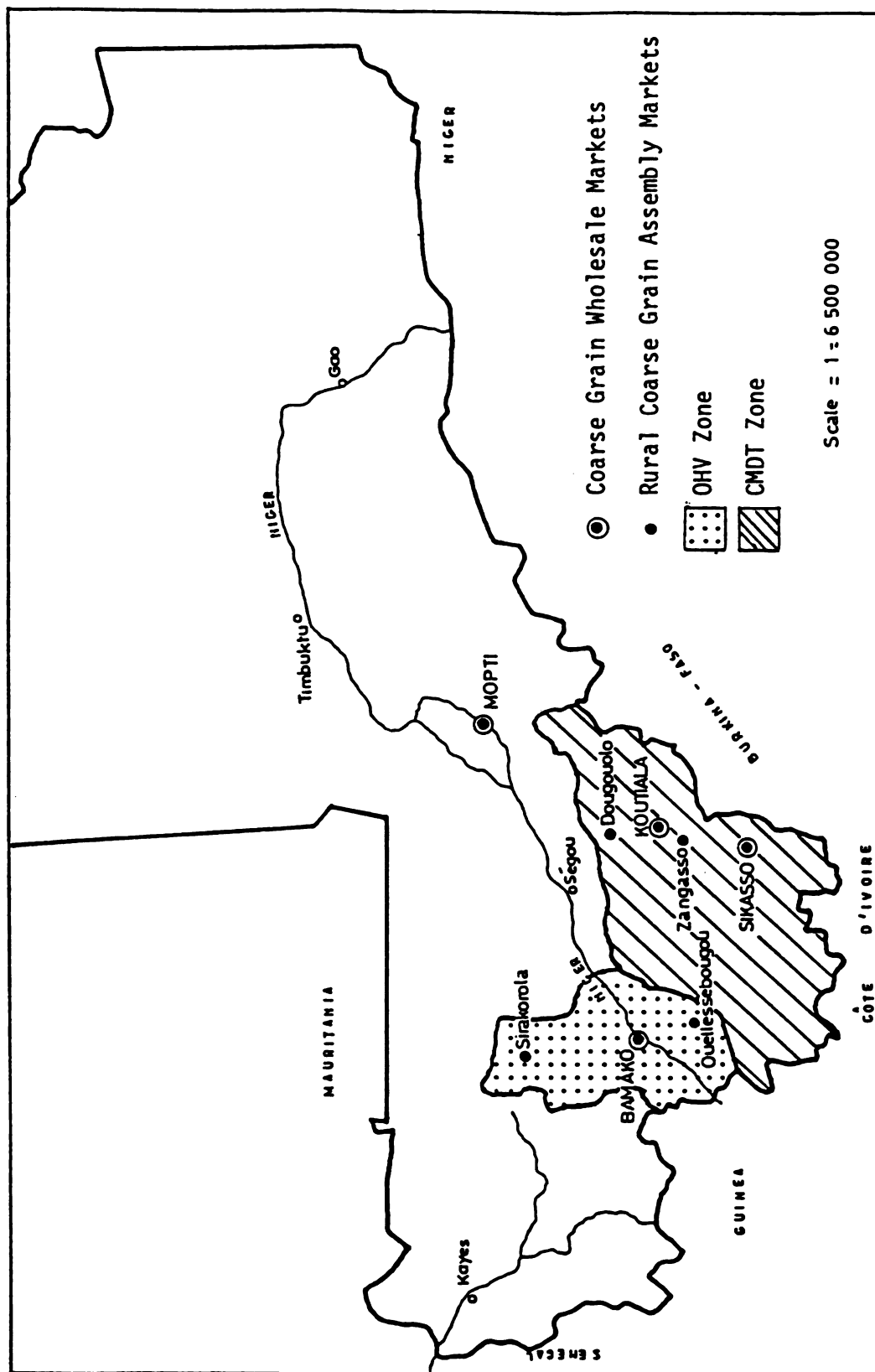
- existing varieties and cultural practices for maize, changes that have occurred over time and source of the changes, advantages and disadvantages of new varieties/practices, modifications to recommended practices that farmers have made and reasons for those changes;
- changes in area cultivated and cropping pattern, availability and mix of food grains, changes in cash income, changes in food preferences, effects on soil fertility;
- how has adoption of technology been affected by climatic changes, availability of animal traction, availability of seed and other inputs, price supports, access to markets, storage and processing facilities.

Subsequently, financial crop budgets for different recommendation domains were developed using secondary data on the adoption of husbandry practices in the CMDT and OHV zones (see map, Figure 3.1).²

Once the farm-level impacts had been determined, questions five and six on the economic impact of maize technology development and extension could be addressed. A benefit/cost analysis was undertaken, whereby economic prices were applied to the different crop enterprise budgets and then net benefits were aggregated over the area of improved maize cultivated in each recommendation domain over time. Costs were estimated by examining the historical expenditures of relevant institutions (IER, OHV, CMDT), and the proportion of expenditures that could be attributed to maize.

² A recommendation domain refers to a group of farmers utilizing similar husbandry practices for maize under similar agro-climatic conditions.

Figure 3.1: The CMDT and OHV Zones of Southern Mali



3.2 History of maize research in Mali

A careful examination of the historical development path of maize technology is instructive for three reasons. First, the evolution from a single discipline applied to a single crop, to multiple disciplines working on a single crop, to multiple disciplines working on cropping systems (intercropping), and finally to farming systems research, increases the complexity of the research organization task. Mali's experience with maize shows that when organizational development (both within research and between research and other organizations such as extension) lags behind the complexity of research activity, the consequence is wasted resources as a result of duplication and/or technical error.³ Since the addition of a commodity subsector perspective increases the complexity of research still further, this experience underlines the need to consider how to minimize the organizational "transactions costs" for NARS. Second, the study reveals that research program decisions often involve implicit judgments about subsector conditions upstream and downstream even when those conditions have not been explicitly verified. Finally, the examination reveals the importance of accurately tracing the technology development and diffusion process to identify research impacts correctly.

3.2.1 Initial establishment of a rainfed cereal crop varietal improvement program (1964-1980)

In 1962, a technical assistance agreement was concluded between GRM and the Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières

³ Bonnen (1990) refers to the development of organizational capacity as institutional capital. He argues that increases in human, physical, and institutional capital must accompany technological development for sustained economic growth.

(IRAT), a French tropical research institute created in 1960. IRAT was to take responsibility for soil science, rice and wheat varietal improvement, and research on industrial crops and sugar cane. In 1964, this agreement was amended to include the creation of a varietal improvement program for millet, sorghum and maize.⁴ The human and financial resources devoted to IRAT's program in Mali appear to have been small relative to other West African countries (in particular Senegal and Burkina Faso). Maize was allocated only a small part of these resources in view of the limited area cultivated relative to other rainfed cereals (IRAT, 1974).

Research on maize was largely confined to varietal testing, with a limited amount of work on fertilizer use in the context of a broader study of the fertilization of rainfed cereals.⁵ Interest in anything more than a token effort to develop maize production first became apparent at the annual meeting of the National Agronomic Research Committee in April 1969. At that time, maize cultivation was limited to small plots around the farm household, and a limited area of flood recession cultivation in the Senegal river valley, with yields estimated to be in the range 600 - 1000 kg/ha. The committee's interest appears to have been stimulated in part by a project proposal from the Direction des Industries to consider a range of possible

⁴ Prior to the inception of the rainfed cereal improvement program that remained under IRAT management until 1974, maize varietal work had been limited to the application of mass selection procedures to local ecotypes (Le Conte, 1965). This activity had resulted in the standardization of a local, early, yellow-grained variety called Zanguereni (85 days).

⁵ Analysis of the fertilizer trials indicated that, given prevailing prices of cereals and fertilizer, moderate doses of nitrogen and phosphate had every chance of being profitable on maize, marginally profitable on sorghum, and not profitable on millet. For maize, a binary formulation of nitrogen and phosphate was recommended (Pieri, 1973). In the view of IER's fertilizer agronomist this approach remains valid today despite the fact that the CMDT uses a complete formula (A. Traoré, personal communication).

industrial uses of maize. The project was considered premature because of uncertainty surrounding the feasibility of large-scale intensive maize cultivation. Nevertheless, given the value of maize as a food crop, its agronomic potential, and the lack of progress made in regard to the intensification of millet and sorghum, the committee considered that greater effort should be devoted to maize research than had been the case hitherto (IRAT, 1974). The main thrust of the research effort throughout the 1970s continued to be varietal improvement.⁶

The varietal selection criteria in use at the time reveal researchers' judgments about product demand and input supply. The criteria stated in annual reports of the period are (i) flint or semi-flint, yellow or white maize; (ii) duration 80 - 120 days; (iii) high yielding open pollination; (iv) resistant to lodging or shattering; (v) average height of 2 - 2.5 meters. Since virtually any maize cultivar will satisfy criteria (i) and (ii), researchers were effectively implying that consumers had no preference in regard to color, processing characteristics or time of maturity. The dominant criterion is (iii), since (iv) and (v) are simply instrumental in achieving high yields. The insistence on open-pollinated varieties resulted from researchers' perceptions that hybrid seed multiplication was too costly to establish, despite the absence of any formal economic analysis. The primary goal of intensification through open-pollinated varieties remains in place to this day despite the widespread adoption of hybrids by smallholders in Eastern and Southern Africa.

The strategy of focusing most of the maize research effort during the 1970s on varietal improvement failed to result in any significant breakthrough. By the end

⁶ Details of IRAT's strategy, which involved exploiting the genetic potential of West African ecotypes to the maximum extent possible (Le Conte, 1965), are given in Boughton and Henry de Frahan (1994).

of the decade, the need for a broader approach to the development of maize production potential had been recognized:

It is all too frequently assumed that development problems can be solved by the diffusion of a new variety, and therefore breeding is the prescription. But the variety is just one element, and not always the most important, in a set of factors of production that need to be improved: hence the desire on the part of the Institute's maize research [program] to become multidisciplinary, integrated in a "farming systems" perspective. (IER, 1982, p. 17)

The lack of resources devoted to maize research in Mali was offset to a considerable extent by the opportunity to benefit from research carried out by IRAT in other West African nations, including Benin, Côte-d'Ivoire, Burkina Faso, Senegal, Togo and Cameroon. Indeed, very little of the research on which the first extension bulletins for maize were based was carried out in Mali.⁷ For improved husbandry practices, Table 3.1 shows the principal countries where research was undertaken.

Table 3.1: IRAT Maize Research in West Africa (1962-1979)

RESEARCH THEME	COUNTRY
Soil preparation techniques	Bénin, Côte d'Ivoire, Burkina Faso, Sénégal, Togo
Seedbed preparation	Sénégal, Côte d'Ivoire
Date of planting	Bénin, Cameroun, Sénégal
Planting density	Bénin, Cameroun, Côte d'Ivoire, Burkina Faso, Sénégal, Togo
Crop rotation	Bénin, Burkina Faso, Sénégal, Côte d'Ivoire

Source: Nicou (1981)

⁷ M. Fok, personal communication, October 1991.

In sum, while the 1970s did not produce the varietal breakthroughs hoped for, the availability of research findings from other parts of the region, combined with the high potential of local varieties (particularly Tiémantié), meant that the elements of a technical package were nevertheless in place by the end of the decade.

3.2.2 Towards an integrated approach to maize research (1980-present)

While varietal improvement remained a key component of maize research, the 1980s saw a substantial increase in the scope of maize research activities, the number of disciplines involved, and linkages with national and international organizations. Research into improved maize-based intercropping systems was initiated on-station by a team of ICRISAT and local scientists, and packages were subsequently tested on-farm by the SAFGRAD project and farming systems teams. A serious outbreak of maize streak virus in southern Mali in 1983 prompted an intense collaborative effort between researchers from varietal development and crop protection departments of IER, and staff of the CMDT's Cellule Recherche d'Accompagnement.

The increase in complexity of the research agenda was the result of both demand and supply-side factors. On the demand-side, researchers became more aware of (what they perceived to be) farmers' needs for improved maize technology, rather than crop yield performance as an end in itself. On the supply-side, there was a considerable increase in the number of trained national scientists

and external donor support.⁸ This increase in complexity involved a corresponding increase in organizational demands, primarily for communication among researchers and between researchers and extension. Whereas personnel and financial resources were the binding constraints on research output during the 1970s, organizational capacity (or organizational capital) became the major constraint on the effectiveness of maize research during the 1980s.

a) Varietal development

During the 1980s, emphasis was increasingly placed on disease resistance and early maturity as varietal selection criteria. Disease resistance became prominent as a criterion following a dramatic outbreak of maize streak virus in the southern part of the CMDT zone in 1983. The emphasis on early maturity was a response to the needs of farmers in the central and western parts of the country where rainfall is lower, and non-mechanized farmers for whom early harvested maize remains a key part of their hungry season food security strategy. The importance of early maturity was also emphasized in feedback from the first on-farm tests of promising varieties, initiated by the Semi-Arid Food Grains Research and

⁸ USAID became a major donor to the Malian NARS during the 1980s, funding the ICRISAT and SAFGRAD projects, as well as part of the farming systems program. This support has continued into the 1990s, with a shift in emphasis from FSR to supporting research on key commodities and IER's restructuring program. Other major donors during the 1980s were the Dutch government (farming systems research), the French aid program (mainly in the form of resident scientific personnel), and the Ciba-Geigy Foundation (for the establishment and operation of a rainfed cereal research station at Cinzana).

Development (SAFGRAD) project in collaboration with regional development agencies.⁹

In contrast to effective communication between the SAFGRAD and maize varietal improvement programs of IER, the CMDT's maize promotion project (Projet Maïs) undertook on-station and on-farm varietal evaluation independently of IER. This project began in 1980 with funding and technical assistance from the French cooperation program.¹⁰ The project management saw researchers as academic, citing as an example fertilizer recommendations made without regard to the formulations actually available to farmers.¹¹ IER researchers were unaware of the project's varietal selection activities until they accidentally discovered them in the course of a tour of the project's seed farm!¹²

The project's autonomy in regard to research was abruptly terminated by the 1983 maize streak virus outbreak. IER responded rapidly to the crisis and a cooperative program of plant pathology studies, together with screening for varietal resistance, was mounted by IER and the CMDT's Research and Development Liaison Unit at Sikasso (the unit which evolved out of the Projet Maïs). Within four years, the pathology of the virus was understood and early planting was identified

⁹ The fact that the head of the maize varietal improvement program participated in the SAFGRAD project during his early career, and received MS training under SAFGRAD project funds, probably contributed to the effectiveness of the feedback between the two programs.

¹⁰ The role of this project will be discussed more fully in the next section.

¹¹ M. Fok, personal communication, October 1991.

¹² O. Niangado, personal communication, November 1991.

as a cultural practice liable to reduce incidence of the disease. More importantly, since early planting of maize aggravates the labor bottleneck and increases the risk of drought at flowering time, an early-maturing streak-resistant variety of white maize had been identified, multiplied and made available to farmers. The success of this collaboration had an important impact on the relationship between IER and the CMDT, which has continued to contribute financially to the IER maize research program ever since.

The adjustment of varietal selection criteria to reflect farmers' needs better was accompanied by a diversification of the sources of maize germplasm that began at the end of the 1970s with the arrival of CIMMYT material. Compared to the previous decade, an impressive list of ten varieties was nominally available to the farming community by the end of the 1980s. However, of these, three were extended directly by the CMDT (Tuxpeno 1, Molobala 2, E211) without IER involvement, and two (Across 7844 and Golden Crystal) have yet to be disseminated in the OHV zone because registered seed is not available from the national seed multiplication service. Furthermore, all external introductions (except Golden Crystal, which is not available) are white, whereas the preference of urban consumers and poultry rearers is for yellow.

Despite these weaknesses, progress made in varietal development during the 1980s was dramatic compared to that made during the 1970s. In particular, the identification and release of the streak resistant, early-maturing TZESR-W in less than four years was an astounding achievement, and the result of intense collaboration between both disciplines and structures (CMDT and IER). Informal

discussions with farmers reveal that while TZESR-W was primarily selected for streak resistance, it is particularly appreciated for its early duration and ability to perform relatively well with only moderate doses of fertilizer. The robust performance of TZESR-W went unrecognized by the formal research system until 1993, however, when the first farmer-managed maize varietal tests were conducted by the Sikasso farming systems team (DRSPR, 1994). Lack of effective collaboration between on-station and on-farm research is also evident in the case of maize-based intercropping research.

b) Maize-based intercropping research

Maize-based intercropping systems have long been a part of the farming systems indigenous to southern Mali (Dolo, 1987). Efforts to improve maize/millet intercropping were initiated on-station by ICRISAT during the early 1980s, and subsequently tested on-farm by the SAFGRAD project. Further on-farm testing was undertaken by the Farming Systems Research programs based at Sikasso and Bougouni for the CMDT zone, and at Sotuba for the OHV zone. The CMDT's Cellule Recherche d'Accompagnement also conducted demonstrations of improved maize-late millet packages.¹³ Contrary to the prevailing wisdom that the rapid expansion of intercropped maize in Southern Mali in recent years is a consequence

¹³ Initially the CMDT's maize project was against intercropping, promoting only a sole maize package. After the dramatic outbreak of maize streak virus in 1983, and the drought spells of 1983 and 1984, CMDT staff realized that intercropped maize was more resistant to drought and disease problems than sole maize. In the case of streak virus, intercropped maize was less severely attacked than sole maize (which often suffered a complete wipeout). In the case of drought, the intercropped late millet yields would compensate for the loss of maize yield to some extent.

of this research¹⁴, and despite the significant personnel and financial resources devoted to the improvement of this traditional practice, no concrete evidence of farm-level impact has been established. It is important to understand the reasons for this lack of impact in order to identify ways of improving the effectiveness of future research endeavors.

The ICRISAT research on maize/millet intercropping was initiated in 1982 after staff observed that farmers' traditional intercropping practices suffered lower yield reductions than sole maize in the event of drought or disease attack (Shetty et al., 1991).¹⁵ The goal was to intensify the system (increase total yield per unit area) while preserving its robustness. The agronomic research led to a spacing recommendation of two rows of maize (equivalent to a full sole maize stand) to one of millet, the latter sown when the maize plants reach the 3-4 leaf stage. This recommendation implies an increase in the population of millet from 10,000 plants/ha (farmers' practice) to 30,000 plants/ha.¹⁶ The varietal and fertilization research confirmed that the existing recommendations for sole maize were (agronomically) appropriate for the intensified system.

The improved maize-millet intercropping system was tested on-farm for four consecutive years from 1984 to 1987, first by the SAFGRAD project and

¹⁴ D. Attwood, personal communication, November 1991.

¹⁵ Maize and millet are a good combination from an agronomic perspective because the two cereals have complementary growth cycles which reduce competition for soil moisture, spread drought risk, and make full use of the longer rainy season experienced in southern Mali.

¹⁶ S. Shetty, personal communication, October 1991.

subsequently by its successor unit, the Cellule des Essais Multilocaux et Prévulgarisation (CEMP). After three years of on-farm tests, SAFGRAD researchers concluded that the maize/millet intercropping system was higher yielding and more stable than either sole maize or millet, and that the improved method of planting in alternate rows was higher yielding than the traditional practice of mixing the crops in the row. They noted that the system of planting in alternate rows was more difficult to weed mechanically and recommended that additional research be undertaken to facilitate mechanical weeding of the alternate row system (Traoré et al. 1987).¹⁷ The CMDT's Cellule Recherche d'Accompagnement encountered the same difficulty of mechanical weeding in their program of on-farm demonstrations (Dolo, 1987).

As a result of the difficulties encountered in mechanical weeding, the "improved" system was never extended by the CMDT.¹⁸ Two key questions remain unanswered: first, why was the mechanical weeding problem caused by the narrow between-row spacing never corrected, and second, why has the improved system not yet been extended to non-mechanized farmers in the CMDT zone?

A considerable amount of effort was also devoted to maize/millet intercropping by all three farming systems research units in operation at the time. The team based at Bougouni undertook on-farm trials between 1981 and 1985, and

¹⁷ The establishment of a research program to address issues relating to the mechanization of intercropping systems in general was a recommendation an intercropping workshop held in Mali in 1987 (A. Diarra, personal communication).

¹⁸ As one CMDT extension worker expressed it, with more than a little irony, "Having taken so many years to reach the stage of mechanized farming, are we supposed to go and tell the farmer to pick up the hand hoe again?"

pre-extension tests during 1986 and 1987 following a workshop on maize-millet intercropping held in Sikasso in 1985. This research focussed on the two planting methods as well as different levels and types (mineral versus organic) of fertilizer application. In many cases the team found it difficult to draw definitive conclusions from the on-farm trials and tests because of operational difficulties. In general, fertilizer doses lower than those recommended by the CMDT were most profitable given farmers' practices. The team based at Sikasso began work on maize-millet intercropping somewhat later than the Bougouni team, but focussed on similar technical themes (fertilization in particular). A synthesis of this work is currently being prepared. The farming systems team at Sotuba was not established until 1986, and hence was in a position to benefit from the work previously undertaken.

The farming systems team at Sotuba, anxious to avoid duplication of effort and reduce the time taken to deliver technology to the farmer, chose to go straight into pre-extension of a maize-millet intercropping package. They did so on the basis there was already a proven package available. This was clearly a false premise given the fact that the Sikasso farming systems team had not yet completed a definitive analysis of their on-farm research, the on-farm testing undertaken by SAFGRAD and the CMDT had identified difficulties in mechanical weeding, and the CMDT was not actively extending any package for maize-millet intercropping. In the course of three years of on-farm tests the team ran into a number of setbacks which left them bemused and discouraged:

Maize/millet intercropping, which performs well in the Southern Mali [CMDT] zone, has not lived up to expectations in the OHV zone. The intercrop was introduced because of the similarity between the two zones. The lack of positive results shows that a direct transfer of

technology does not always work. A diagnostic study of the reasons for the failure of this intercrop in the OHV zone is necessary to understand the principal constraints and provide feedback to commodity researchers. (IER, 1992, p. 55)

The fact that one farming systems team could proceed with a pre-extension campaign on the basis that a proven package was available when other researchers had already encountered difficulties and/or had not yet completed a definitive analysis illustrates the organizational constraints encountered as the scope and complexity of the research agenda increased.

Two important conclusions can be drawn from this review. First, while the on-station and on-farm research conducted to date has confirmed the strengths of the traditional practice of intercropping maize with late millet in southern Mali, there is no evidence of any farm-level adoption of an improved maize-millet intercropping system. The only distinctive element of the "improved" maize-millet intercropping system is the plant density/spatial arrangement, which has not been promoted by the CMDT because it cannot be weeded using animal traction. Rather than being attributable to any improved technology package, the rapid expansion of intercropped maize area in southern Mali in recent years reflects the traditional system's suitability to uncertain climatic and market conditions.¹⁹ Such improvements in husbandry practices that have taken place at farm level appear to be primarily a spillover from earlier extension efforts to promote improved sole maize (e.g., plowing, fertilizer use, mechanical sowing).

¹⁹ Following the liberalization of cereal markets in 1986, maize prices fell both absolutely and relative to millet and sorghum. Since 1986, millet prices have been consistently higher than maize prices in southern Mali, in part due to the export demand for millet from Côte-d'Ivoire.

The second conclusion that can be drawn is that there has been a considerable amount of duplication of research effort at the on-farm testing and "pre-extension" stages due to overlapping functions between different sections, and a lack of timely and effective communication of results. The CEMP, the CMDT's Cellule Recherche d'Accompagnement, and the three farming systems teams operating in southern Mali all have mandates for on-farm research.²⁰ The difficulties in effective communication of results between units is in part a reflection of the former program review process that was organized according to program boundaries and emphasized disciplinary critique. These weaknesses are currently being addressed by the restructuring of IER, which seeks to decentralize the planning and review process and emphasize development-oriented review criteria.

The addition of a commodity subsector perspective will increase the complexity of the research agenda still further, at least in terms of the number of variables to be taken into consideration. It will therefore be important to identify organizational linkages that will avoid duplication or communication failure. Further, this review suggests that a careful assessment of the current state of technology development and diffusion would be a useful component of the initial subsector appraisal phase.

3.3 The diffusion of maize technology in Southern Mali

The development of new technologies is not by itself sufficient for investments in research and extension to generate benefits for society. Farmers

²⁰ This duplication has been noted by other observers. See Dembélé (1990).

must adopt the technologies that flow from these investments. This requirement in turn implies that technological innovation must both enable farmers to further their objectives (e.g., income generation and/or enhanced food security), and be technically feasible and financially viable to implement. The high potential yields and early maturity of maize compared to sorghum or millet might lead one to consider the attraction of intensive maize production to be self-evident.

Maize offers no "free lunch", however. The husbandry requirements of a successful maize crop are demanding. The preparation of an adequate seedbed requires plowing, for example, and the growing crop must be weeded regularly in the crucial early stages. In order to provide this level of husbandry, either a tractor or trained draft animals must be available. Intensive maize is also very demanding of soil nutrients, whereas the region's soils are generally infertile. The cultivation of maize on a scale beyond garden plots therefore requires the use of chemical fertilizer, which must be accessible in an appropriate form and profitable to use. This implies the development of input delivery, credit and crop marketing systems.

In sum, a set of complementary investments in physical and human capital, together with institutional and policy innovations, must be in place before farmers can adopt intensive maize technology on a wide scale. The critical role played by these factors is confirmed by a comparison of maize technology adoption in two areas of southern Mali that differ in their levels of physical and human capital investment (the OHV and CMDT zones), and within the same zone over time as the institutional and policy environment changes (the CMDT zone).

The remainder of this section is divided into two parts. The first reviews the institutional background (organizations and policy) to the development of maize production in southern Mali. The second part documents the adoption process over time. Three distinct phases in the diffusion of maize technology are identified: the first phase concerns the period prior to any large-scale extension effort focussed on maize; the second the period from the launch of the CMDT's "Projet Maïs" in 1980 until the liberalization of cereal markets in 1986; and the final phase covers the period from price liberalization up until the present day. The chapter concludes with an assessment of the contribution of agricultural research to this process.

3.3.1 Development and policy background to the take-off of maize in

Southern Mali

Two types of institutions play an important role in the development of maize production in southern Mali. The first are the Opérations de Développement Rural (ODRs), government parastatals charged with rural development in a defined geographical area and generally having a particular cash commodity focus. The two ODRs charged with rural development in southern Mali are the Opération Haute Vallée (OHV) and the Compagnie Malienne pour le Développement des Textiles (CMDT). In both areas, cotton has been the vehicle for generating a cash surplus with which to mechanize and develop farming systems. The second dimension is government policy toward the production and marketing of cereals, which has undergone profound change in recent years. The two dimensions overlap in so far

as the ODRs have historically been an important instrument for the implementation of food production and marketing policy.

a) Rural development in Southern Mali: the CMDT zone

The development of agricultural extension activities in southern Mali began in 1952, under the auspices of the Compagnie Française pour le Développement des Fibres Textiles (CFDT) (de Wilde, 1969). Extension activities were confined to the promotion of cotton using a diffuse network of itinerant "moniteurs". Following an agreement with GRM in 1960, which made the CFDT responsible for agricultural extension work in the greater part of southern Mali,²¹ a denser, residential extension network was established. Although the CFDT's mandate was not confined to cotton, the company continued to focus on this crop: "...it is clear that for the most part the improved production of cotton has been introduced without significantly affecting farming as a whole" (de Wilde, 1969, p. 333).

The supply of agricultural equipment became an important part of the program, and over 13,000 plows and 3,000 carts were in use by 1964. This process of "capitalization" of the farming system, i.e., using the profits from cotton to pay for draft animals and equipment that subsequently permit an expansion of the cultivated area, is the hallmark of agricultural development in southern Mali.

The Compagnie Malienne pour le Développement des Textiles (CMDT) was created in 1974 to take over the activities of the CFDT, while retaining close

²¹ The CFDT was made responsible for the greater part of eight districts (cercles) in the administrative regions of Bamako (Dioïla, Fana), Ségou (Ségou, San and Tominian), and Sikasso (Koutiala, Yorosso and Kadiolo).

technical and commercial links with the latter. The CMDT was charged with a broader rural development mission than its predecessor. Specifically, its objectives include (CMDT, 1990):

- (i) to increase production of cotton and all crops grown in rotation with cotton, in order to promote a biologically and economically balanced cropping system;
- (ii) to provide an effective agricultural extension service, and credit for the purchase of equipment and other inputs necessary to raise income and improve food self-sufficiency;
- (iii) to improve the integration of livestock in farming systems;
- (iv) to train and educate the rural population by means of literacy training and the promotion of rural artisans and young farmers;
- (v) to encourage the development of a network of village organizations (pre-cooperatives) to undertake tasks currently performed by resident extension workers;
- (vi) to enable advanced village associations to become independent cooperatives;
- (vii) to modernize farms through the gradual introduction of motorized equipment (small tractors);
- (viii) to promote farm management skills through the development of simple accounting methods;
- (ix) to process cotton and market the fiber;
- (x) to develop the profitable use of agricultural by-products;
- (xi) to stock and market agricultural products according to policies in effect;

- (xii) to develop and promote appropriate technology for processing agricultural products.

The existence of a competent development administration has encouraged a high level of donor support for the CMDT, including three World Bank financed rural development projects. This investment has facilitated the development of a network of rural roads, while at the farm level the earnings from cotton have continued to permit the mechanization of farming systems and a rapid expansion of the cultivated area.

b) Rural development in Southern Mali: the OHV zone

The Opération Haute Vallée (OHV) is a smaller and younger organization, created in 1964. The comparative strengths and weaknesses of the OHV and the CMDT have been well documented by Dioné (1989, pp 41-45). He cites the following reasons for the superior performance of the CMDT compared to the OHV:

- 1) higher participation of farmers in rural development activities through the transfer of marketing functions to village organizations;
- 2) linkages with the French cotton development organization (CFDT) facilitates access to research results, marketing channels and credit;
- 3) after the dismantling of the agricultural credit and rural equipment parastatal (SCAER), the CMDT was the only ODR with direct access to purchased farm inputs and agricultural equipment.

Dioné reports that an estimated 75% of the CMDT farms have animal traction equipment against only 43% in OHV, and that the CMDT ensures an equipment

replacement rate of 10 - 15% as compared with virtually no replacement in the OHV zone. The CMDT also has a stronger extension program. In sum, the process of human and physical capital development necessary as a complement to rapid technological innovation was much further advanced in the CMDT zone than the OHV when maize was first identified as an important potential lever for raising cereal self-sufficiency in Mali. This brings us to the second dimension necessary to understanding the background to maize development, that of national cereals policy.

c) National food strategy and cereal marketing policy

In response to chronic food deficits during the 1970s and early 1980s, government policy has consistently stressed self sufficiency in cereals as a policy objective. While the goal has remained essentially unchanged, there have been radical changes in the policies used to seek to achieve this objective. Steffen (1992) identifies three main phases in cereals marketing policy over the last twenty-five years: 1) a period of official state monopoly over cereals marketing (1967-81); 2) the coexistence of official and private marketing channels (1981-85); and 3) an effectively liberalized cereal market (1985 to present). During the period 1965 - 1985, producer and consumer prices were fixed by decree. In general, official producer prices were held low in order to protect real urban wages (Steffen, 1992). Competition from parallel market channels made it increasingly difficult for the national grain board (OPAM) to obtain cereals, which resorted to forcing producers to make deliveries. Nevertheless, OPAM rarely handled more than 20% of the total

marketed surplus of cereals in Mali, with its market share of rice being higher than that of coarse grains (Humphreys, 1986).

The growing financial deficits of OPAM were unsustainable, and in 1981 GRM and donors put together a Cereals Market Reorganization Project (PRMC) with three objectives: 1) rapid increases in producer prices; 2) cereal market liberalization through legalized participation of cereal traders; 3) the reduction of costly subsidies by allowing consumer prices to rise to the point where OPAM's costs were covered (Steffen, 1992). Minimum producer prices replaced "official" producer prices and OPAM in effect became a buyer of last resort. Responsibility for the purchase of cereals from farmers on OPAM's behalf was transferred to the ODRs. It was this combination that enabled the CMDT, from 1981 onwards, to offer farmers an attractive guaranteed maize price. In 1985, however, there was a large cereal surplus which exhausted OPAM's financial reserves. With OPAM unable to make payments on grain the CMDT, in turn, was forced to suspend guaranteed prices to farmers.

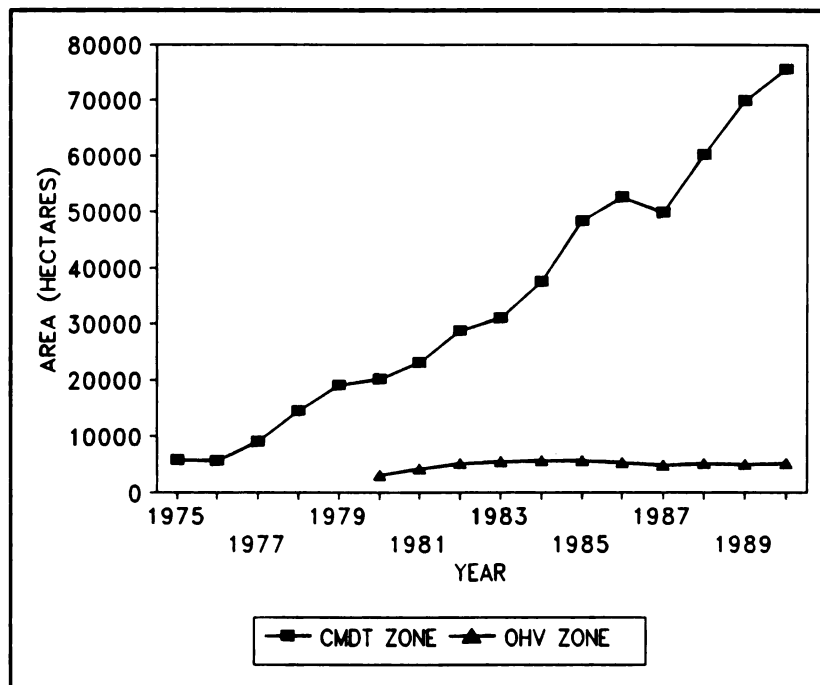
3.3.2 Technology adoption in the CMDT and OHV zones (1975 - 1990)

The decision by the CMDT to promote intensive maize production, in rotation with cotton, was taken against a background of chronic food deficits experienced during the early 1970s²². Initially promoted among farmers using small tractors, the program was quickly expanded to include farmers using animal traction.

²² The term "intensive" here refers to the use of improved varieties and husbandry practices together with chemical fertilizers.

Adoption was rapid (Figure 3.2). The factors that underpin this phenomenon clearly demonstrate the significance for the rate of technology adoption at farm level of interactions between the stage of development of farming systems and market opportunities.

Figure 3.2: Adoption of Improved Maize in the CMDT and OHV Zones



Source: CMDT and OHV Annual Reports

The stage of development of farming systems of Southern Mali had an important bearing on the rate of technology adoption. Since the late 1950s, the CMDT's predecessor (the CFDT) had been introducing mechanization as part of its program to expand cotton production. By the mid-1970s there were an estimated 110,000 draft oxen, 37,500 plows, 1400 seeders, and 20,000 weeders in service. In 1990, the level of mechanization had increased to 305,000 draft oxen, 112,000

plows, 39,000 seeders and 74,000 weeders. Farmers were able to pay for this equipment out of their profits from cotton production. Mechanization is crucial to a farmer's capacity to adopt intensive maize because of need to plow and weed frequently in a timely manner. Not surprisingly, the area of improved maize is highly correlated with level of mechanization over the period 1975-90.²³

A second factor encouraging the adoption of maize was the availability of residual fertilizer on the previous year's cotton fields. Maize is the most fertilizer-responsive rainfed cereal, and the presence of residuals implies a lower cash outlay for farmers.

While the level of mechanization and fertilizer residuals from cotton certainly facilitated adoption of maize at the outset, the process was greatly accelerated by the provision of an attractive guaranteed market price. With the transfer of responsibility for the purchase of cereals from the national grain board (OPAM) to rural development agencies, the CMDT was in a position to apply to maize the same integrated approach to technology delivery that it was already using so successfully for cotton. This approach ensured that all stages in the subsector both prior to farm-level production (seed multiplication and distribution, fertilizer and credit delivery, extension advice) and post harvest (purchase and collection, transport, storage, wholesaling) were coordinated through the administrative decisions and technical resources of a single organization.

²³ Bivariate correlations between the area of improved maize and the number of draft animals and equipment in service over the period 1975-1990 gives the following results (all significant at the .01 level): number of draft oxen 0.98; number of plows 0.99; number of weeders 0.98; number of seeders 0.98.

The implementation of an integrated approach was strengthened by the launch of a maize development project in 1980. Financed by French aid, this project included the establishment and operational budget for a seed multiplication farm, a large-scale program of maize demonstrations (varieties and cultural practices), a program of first-equipment loans for non-mechanized farmers,²⁴ and the construction of maize storage silos at CMDT regional depots. As discussed in the review of maize technology development, the Projet Maïs gave little attention to linkages with research. With the exception of the variety promoted, package components were based on research findings from elsewhere in the region.²⁵

The joint impact of a coordinated subsector interacting with farming systems characterized by a high level of mechanization and a profitable cash crop on farmer adoption can be clearly demonstrated by comparison of the CMDT and OHV zones. The OHV did not put an integrated maize technology development program in place, and farming systems have considerably lower levels of mechanization.

²⁴ The "Projet Maïs" was conceived in part as a means to facilitate the development of farming systems in the less-developed southern part of the CMDT where cotton was not being promoted. Maize is preferable to cotton as a cash crop in low population density areas because of its lower labor requirements. Farmers in areas with low population density would find it difficult to organize sufficient labor to harvest cotton. In addition, as a dual-purpose crop, maize has advantage of reinforcing food security. While the objective of capitalizing the farming system through maize alone was doomed with the liberalization of cereal markets in 1986, even today farmers who receive first equipment loans (prêts premier équipements) are obliged to cultivate one hectare of maize in order to release labor from cereal to cotton cultivation without undermining food security.

²⁵ M. Fok (formerly head of the Projet Maïs), personal communication, October 1991.

Consequently, the adoption curve for intensive maize in the OHV zone is almost flat (Figure 3.2).

Although dramatically effective in terms of adoption rates, the integrated approach to maize production and marketing implemented by CMDT was not financially sustainable. It required high subsidies on the part of the national grain board (which purchased the maize from CMDT), and the CMDT itself was subsidizing village-level collection of maize. With the removal of guaranteed prices for maize in 1986 (accompanied by the withdrawal of credit for maize inputs) farmers were exposed to highly variable market prices. The farmers' response to this situation also underlines the importance of interactions between commodity subsector and farming systems.

While the combination of technology delivery in the context of a highly coordinated subsector and mechanized farming systems had a dramatic effect on the rate of technology adoption, the withdrawal of marketing services and guaranteed prices after 1986 primarily affected farmers' choice of production techniques. Although the area of improved maize quickly resumed its growth trajectory, there is a consensus among farmers and extension workers that the choice of technology and degree of interaction with the market changed in the following ways:²⁶

²⁶ Time series data are not available to confirm or refute farmer and extension worker observations. However, Giraudy (1993) has confirmed that for farmers who use fertilizer on maize, rates applied are close to half those recommended by extension. The issue of fertilizer use is discussed in detail in chapter 8.

- 1) reduction in fertilization levels, substitution of manure for chemical fertilizer, and re-allocation of cotton fertilizer to maize;
- 2) substitution of early maturing varieties tolerant of low soil fertility conditions for medium or long-duration varieties with high fertilization requirements;
- 3) in the southern part of the CMDT zone, a rapid shift from sole cropping back to the traditional practice of maize-millet intercropping (a system more tolerant of lower soil fertility and drought, and with a higher gross margin because millet sold at a higher price than maize);
- 4) changes in marketing strategy: if the early maize harvest is good, and if the prospects for the millet/sorghum also look good, farmers will off-load their old millet and sorghum stocks on the market while prices are still high and eat maize instead.

In the face of erratic maize prices, and without a line of credit to purchase fertilizer, farmers effectively chose those technology options which enabled them to insulate themselves from the uncertainties of the market. Nevertheless, the continued expansion of maize production for on-farm consumption is an important contribution to improved food security in rural areas.

It would be difficult, if not heroic, to attempt to isolate the contribution of research from that of extension. Clearly in terms of initiative and resources devoted, the promotion of maize has been primarily an extension effort. Probably the most important contribution of research to date has been the identification of

the streak-resistant early-maturing variety TZESR-W,²⁷ which according to farmers is early maturing and performs relatively well with lower fertilizer doses. There is no evidence that the intercropping research carried out by IER has had any impact at farm level since the package was not promoted by the CMDT (because the farmers found the row-spacing too narrow for mechanical weeding). Nevertheless, the productivity of the traditional maize-millet intercropping system has undoubtedly been increased by the application of husbandry techniques initially learned by farmers through the earlier adoption of the sole maize package.

3.4 Costs and benefits of maize technology development and diffusion

This section assesses the impact of maize technology development and diffusion by comparing the costs incurred with the benefits derived. The analysis is conducted at two levels. The primary focus is on farm-level costs and benefits of improved maize technology in financial terms, and the effect of marketing policy changes on technology adoption incentives. Aggregate costs and benefits of maize technology development and diffusion in economic terms are presented in summary form.

3.4.1 Farm-level financial analysis

An appropriate way to evaluate farm-level incentives to adopt technology and the impact of adoption over time is to measure the additional costs incurred and

²⁷ A yellow counterpart to this variety, incorporating downy mildew as well as streak virus resistance (DMRESR-Y), was released in 1993.

benefits derived from the farmer's perspective. This requires the use of prices actually paid by farmers for inputs, and received for marketed produce. These prices are referred to as financial prices, and analysis based on them is referred to as financial analysis. Financial prices differ from those used in economic analysis by the value of any taxes paid or subsidies received by farmers, including, in the case of traded commodities, those implicit in the official exchange rate.

Many inputs used by farmers, and much if not all of the additional maize produced, may not be exchanged in the marketplace. Inputs may be provided, or produce consumed, by members of the farm household. In this case, a financial opportunity price is used to value the input or output. An opportunity price reflects the amount of money the household would have had to pay for an input, or could have received for produce, if it had been exchanged on the market.

Some benefits and costs may not be measurable in financial terms. Take increased food security, for example. Many farmers state that the adoption of maize as a field crop²⁸ has reduced the likelihood of food shortage. The value of reduced risk of hunger to the farmer cannot be estimated in financial terms, although it probably a major factor explaining the continued expansion of maize area after cereal market liberalization in 1986. On the cost side, farmers widely agree that maize is much more arduous for women to process than other cereals. Indeed

²⁸ Prior to the promotion of maize as a field crop in the early 1970s, it was confined to small plots around the house called "champs de case" which were cultivated entirely by hand. These plots benefitted from a high level of organic matter, receiving kitchen waste and sweepings from the compound yard.

it is often said that "maize causes divorce". This may be a contributory factor to lower prices for maize on rural markets at certain periods.

The analysis of farm-level financial benefits is carried out with partial budgets. A partial budget is a simple tool for estimating the net effect of a change in technology on household income. It is "partial" in the sense that only those elements of the farm household's production and marketing activities which have changed as a result of technology adoption are compared. A partial budget used to estimate the net effect of fertilizer use on a given crop, for example, might include the additional cost of fertilizer, the additional cost of labor for applying fertilizer, harvesting and marketing a greater amount of produce, and the value of the additional output obtained. In the present case, the task is a little more complex because the change involves the adoption of a technical package (i.e., a combination of practices) rather than a single component of a package, but the same principle applies. Only the aspects of crop production that have changed as a result of the adoption of the technology enter into the calculation of net benefits. The first step in preparing a partial budget therefore is to identify what physical changes in husbandry practices and production levels have occurred as a result of the adoption of improved maize technology.

The physical and financial results of adopting a technical package are time and location-specific. The additional yield obtained by using fertilizer, for example, varies according to soil type and rainfall. The value of additional production depends on market prices, which vary over time according to supply and demand conditions. Given the agro-climatic diversity of Southern Mali, and the important

changes in marketing arrangements that have taken place during the period under study, it is clear that the impact of maize technology adoption in Southern Mali cannot be accurately captured by a single partial budget. On the other hand, attempting to reflect every possible variation in physical and market conditions would require so many partial budgets that the analysis would become unmanageable. The challenge facing the analyst is to identify those factors that have an important effect on the financial outcome of technology adoption, and that can be captured in a manageable number of budgets. Furthermore, in order to be able to aggregate farm-level benefits for the region as a whole (a necessary step for economic analysis), the area of maize cultivated under each set of defined agro-climatic and market conditions over time must be known.

In the analysis which follows, an area with more or less similar maize production characteristics is referred to as a "Recommendation Domain", a concept widely used in farming systems research. Each recommendation domain (RD) is represented by one or more partial budgets that correspond to a set of production practices and prices applicable during a specified period of time.

A total of eight RDs have been identified for the farm-level financial analysis, six in the CMDT zone and two in the OHV zone. The criteria used to distinguish RDs include geographical location (northern versus southern parts of the study area), level of crop management (intensive versus semi-intensive), and cropping system (pure stand versus intercropping). Geographical location is an important criterion because the higher average rainfall in the southern part of the study area permits a fuller expression of yield potential. The level of management is an

important criterion because maize is responsive to improved husbandry in general, and fertilizer use in particular. The choice of pure stand versus intercropping is relevant not because of any expected difference in total grain yield, but because millet has generally commanded a price premium in rural grain markets since liberalization in 1986. The estimated area of each recommendation domain over the period 1975 - 1990 is provided in table 3.2, and a summary of their characteristics in table 3.3.

Different partial budgets are constructed to represent a given RD over time in order to take account of changes in variables that affect profitability, such as a change in fertilizer recommendations or use levels, or changes in input and output prices. For example, maize prices at harvest were lower following cereal price liberalization in 1986 compared to previous years.

Only one partial budget is used to represent each of the two OHV zone RDs. A partial budget for the years prior to 1980 is not included because no data are available on either area cultivated or production techniques during this period. A separate budget for the years after price liberalization is not included given the small area of improved maize, and farmers reports in interviews that virtually all of the improved maize area is cultivated for the purpose of assuring food self-sufficiency rather than for sale.

The issue of fertilizer residuals from the previous cotton crop is not reflected in the partial budgets for two reasons. First, there is a lot of controversy about the effective contribution of such residuals. This controversy explains, in part, the

Table 3.2: Maize Recommendation Domain Areas (Hectares) in Southern Mali**1975 - 1990**

YEAR	RECOMMENDATION DOMAINS									
	CMDT 1	CMDT 2	CMDT 3	CMDT 4	CMDT 5	CMDT 6	TOTAL CMDT	OHV 1	OHV 2	TOTAL OHV
1975	1099	1260	1391		1969		5719	na	na	na
1976	946	1414	1018		2129		5507	na	na	na
1977	2347	1194	2014		3397		8952	na	na	na
1978	3777	2847	3522		4323		14469	na	na	na
1979	4766	3678	4997		5535		18976	na	na	na
1980	5499	3973	5014		5633		20119	708	2336	3044
1981	6881	6309	4881		4969		23040	956	3155	4110
1982	8575	7609	6862		5634		28680	1204	3972	5176
1983	8891	8357	8767		4923		30938	1276	4210	5486
1984	9835	10454	12712		4512		37513	1281	4228	5509
1985	12908	11013	17894		6506		48321	1303	4300	5603
1986	9401	14822	8236	9720	4921	5428	52528	1216	4014	5230
1987	9564	12148	5956	10932	4302	6943	49845	1123	3705	4827
1988	14676	11568	9484	14938	4337	5167	60170	1167	3583	5020
1989	16942	13238	9470	19211	4560	6429	69849	1142	3767	4909
1990	17770	13801	12559	19164	5591	6624	75509	1177	3886	5063

Source: calculated on the basis of CMDT and OHV annual reports.

Table 3.3: Definitions and Characteristics of Maize Recommendation Domains (RD) in Southern Mali

CMDT 1	CMDT North Intensive: refers to the maize area supervised by the extension service in the Fana and Koutiala regions of CMDT which was plowed, received chemical fertilizer, and possibly organic fertilizer as well.
CMDT 2	CMDT North Semi-intensive: refers to the maize area supervised by the extension service in the Fana and Koutiala regions of CMDT which was plowed and received organic fertilizer only.
CMDT 3	CMDT South Intensive: refers to the maize area supervised by the extension service in the Bougouni and Sikasso regions of CMDT which was plowed, received chemical fertilizer, and possibly organic fertilizer as well.
CMDT 4	CMDT South Intensive (intercropped): refers to the maize area supervised by the extension service in the Bougouni and Sikasso regions of CMDT which was plowed, received chemical fertilizer, possibly organic fertilizer as well, and which was intercropped with a long-cycle cereal (usually millet).
CMDT 5	CMDT South Semi-intensive: refers to the maize area supervised by the extension service in the Bougouni and Sikasso regions of CMDT which was plowed and received organic fertilizer only.
CMDT 6	CMDT South Semi-intensive (intercropped): refers to the maize area supervised by the extension service in the Bougouni and Sikasso regions of CMDT which was plowed and received organic fertilizer only, and which was intercropped with a long-cycle cereal (usually millet).
OHV 1	OHV Intensive: refers to the maize area supervised by the extension service in the OHV zone receiving chemical fertilizer.
OHV 2	OHV Semi-intensive: refers to the maize area supervised by the extension service in the OHV zone receiving organic fertilizer.

CMDT's rationale for abandoning separate fertilizer recommendations for maize after cotton versus maize after another cereal from 1980 onwards. Second, no secondary data are available that record the area grown after cotton compared to other crops after 1980. The same problem arises in regard to the diversion of cotton fertilizer to maize reported by extension workers after the removal of maize fertilizer credit in 1986. Theoretically, the gain in terms of increased maize production should be offset by a reduction in cotton yields. There is no way of measuring either the yield consequences or the area affected by the practice.

The purpose of each partial budget is to estimate the additional gain to the farm household from the cultivation of maize in a particular RD. This gain, termed incremental net benefit (INB), is measured in francs per hectare of maize cultivated. The use of terms such as additional or incremental implies a comparison with some alternative enterprise or technique. What is the appropriate alternative against which improved maize should be compared?

Prior to the promotion of maize as an outer field crop in the mid-1970s, maize was confined to small parcels around the household. These parcels, called "champs de case", benefit from very high levels of organic matter that cannot be replicated over a large area. Since expansion of maize on the champs de case is not feasible, it would not be valid to compare improved maize production on outer fields with traditional maize production on household plots. The two enterprises are

closer to being complements than alternatives.²⁹ The most widely cultivated cereals on outer fields in southern Mali are millet and sorghum. For farmers who choose not, or who are not adequately equipped to grow maize on their outer fields, these represent the alternative rainfed cereal crops. Since virtually all farmers who grow maize on outer fields are mechanized (the majority with draft animals, a few with small tractors), we compare improved maize to millet or sorghum cultivated on outer fields with the use of animal traction.

The technical input/output relations for improved maize production, and the profitability of the enterprise over the last fifteen years, are summarized for each RD in Table 3.4.³⁰ The top half of the table presents the incremental inputs used and output obtained for maize as compared to millet or sorghum, while the bottom half presents the incremental net benefit (INB) obtained, together with measures of the sensitivity of the INB to changes in the price of maize. We first discuss the technical relationships in more detail, and then turn to the financial aspects.

a) Incremental production and input use

The top row of Table 3.4 presents the estimated yields of maize and the alternative rainfed cereal (millet/sorghum) for each recommendation domain. These yields are based on the opinions of research and extension workers, and yield data

²⁹ Many farmers who grow maize on outer fields continue to grow maize on their champs de case as well, the latter providing fresh maize during the "hungry season" while the outer fields provide grain maize for consumption and/or sale during the dry season.

³⁰ The reader should bear in mind that Table 3.2 presents a summary of the financial analysis. Detailed partial budgets for each recommendation domain are presented in Appendix 1.

Table 3.4: Input/Output Coefficients and Summary Partial Budgets for Improved Maize Compared to Millet/Sorghum in Southern Mali 1975 - 1990

		CMDT 1			CMDT 2		CMDT 3			CMDT4		CMDT 5		CMDT6		OHV1		OHV 2	
		pre-1980	1980-1986	post 1986	pre-1986	post 1986	pre-1980	1980-1986	post 1986	pre-1986	post 1986	pre-1986	post 1986	pre-1986	post 1986	pre-1986	post 1986	post 1980	post 1980
PARAMETER	UNITS																		
INCREMENTAL PRODUCTION																			
	MAIZE YIELD	1500	2000	1750	1400	1500	2000	2500	2250	2250	1750	1750	1750	1750	1750	1750	1500	1500	1500
	MILLET/SORGHUM YIELD	800	900	900	900	900	1000	1100	1100	1100	1100	1100	1100	1100	1100	1100	900	900	900
INCREMENTAL YIELD	KG/HA	700	1100	850	500	600	1000	1400	1150	1150	650	650	650	650	650	850	600	600	600
INCREMENTAL INPUT USE																			
	SEED	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	SEED DRESSING	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	COMPOUND FERTILIZER	0	100	50	0	0	0	100	50	50	0	0	0	0	0	0	50	0	0
UREA FERTILIZER	KG/HA	100	150	75	0	0	100	150	75	75	0	0	0	0	0	50	0	0	
INCREMENTAL INCOME																			
	INCREMENTAL BENEFIT	31500	60500	20500	27500	10500	45000	77000	29500	40750	35750	9500	17000	46750	33000	46750	33000	33000	33000
	INCREMENTAL COST	6861	27620	16976	1670	1226	6861	27620	16976	16976	1670	1226	1226	18426	1676	18426	1676	1676	1676
	INCREMENTAL NET BENEFIT	24639	32880	3524	25830	9274	38139	49380	12524	23774	34080	8274	15774	28324	31324	28324	31324	31324	31324
NET BENEFIT SENSITIVITY																			
	MAIZE YIELD/PRICE +/- 20%	13500	22000	14000	15400	12000	18000	27500	18000	12000	19250	14000	10000	19250	16500	19250	16500	16500	16500
	MAIZE YIELD/PRICE +/- 20%	55%	67%	397%	60%	129%	47%	56%	144%	50%	57%	169%	63%	79%	53%	79%	53%	53%	53%

Source: Boughton and Henry de Frahan (1994)

Notes:

- 1) For intercropped recommendation domains (CMDT 4 and CMDT 6) the maize yield includes the yield of the late cereal intercrop (i.e., the figure given represents the combined grain yield);
- 2) A maize price of 45 CFA F/kg is used prior to 1980, 55 CFA F/kg for the period 1980 to 1986, and 40 CFA F/kg thereafter (with the exception of the OHV zone). Millet/sorghum prices are the same as for maize prior to 1986, but remain at 55 CFA F/kg after 1986.
- 3) Changes in output or input prices will result in changes to the incremental net benefit even though physical input/output coefficients have not changed.

Table 3.4 (cont.): Maize Recommendation Domain (RD) Partial Budgets

- CMDT 1** CMDT North Intensive: refers to the supervised maize area in the Fana and Koutiala regions of CMDT which was plowed, received chemical fertilizer, and possibly organic fertilizer as well. This RD is represented by three partial budgets: one for the period before 1980 when only urea fertilizer was recommended by the extension service; one for the period 1980 to 1985 when compound and urea fertilizers were recommended and a guaranteed price of 55 CFA F/kg was in effect for maize; and one for the period since 1986 when guaranteed prices have not been available.
- CMDT 2** CMDT North Semi-intensive: refers to the supervised maize area in the Fana and Koutiala regions of CMDT which was plowed and received organic fertilizer only. This RD is represented by two partial budgets: one for the period before 1985 when a guaranteed price of 55 CFA F/kg was in effect for maize; and one for the period since 1986 when the guaranteed price has not been available.
- CMDT 3** CMDT South Intensive: refers to the supervised maize area in the Bougouni and Sikasso regions of CMDT which was plowed, received chemical fertilizer, and possibly organic fertilizer as well. This RD is represented by three partial budgets: one for the period before 1980 when only urea fertilizer was recommended by the extension service; one for the period 1980 to 1985 when compound and urea fertilizers were recommended and a guaranteed price of 55 CFA F/kg was in effect for maize; and one for the period since 1986 when the guaranteed price has not been available.
- CMDT 4** CMDT South Intensive (intercropped): refers to the supervised maize area in the Bougouni and Sikasso regions of CMDT which was plowed, received chemical and possibly organic fertilizer, and which was intercropped with a long-cycle cereal (usually millet). This RD is represented by a single partial budget for the period after 1986 when maize prices were lower than millet. Prior to 1986 the sole and intercropped areas are combined since the total grain yield is similar and the same guaranteed price was available for all coarse grains.
- CMDT 5** CMDT South Semi-intensive: refers to the supervised maize area in the Bougouni and Sikasso regions of CMDT which was plowed and received organic fertilizer only. This RD is represented by two partial budgets: one for the period before 1985 when a guaranteed price of 55 CFA F/kg was in effect for maize; and one for the period since 1986 when the guaranteed price has not been available.
- CMDT 6** CMDT South Semi-intensive (intercropped): refers to the supervised maize area in the Bougouni and Sikasso regions of CMDT which was plowed and received organic fertilizer only, and which was intercropped with a long-cycle cereal (usually millet). This RD is represented by a single partial budget for the period after 1986 when maize prices were lower than millet. Prior to 1986 the sole and intercropped areas are combined since the total grain yield is similar and the same guaranteed price was available for all coarse grains.
- OHV 1** OHV Intensive: refers to the supervised area in the OHV zone receiving chemical fertilizer. This RD is represented by a single partial budget since a high proportion of maize is consumed on the farm, and the value of output to the farm household (opportunity price) has not therefore significantly affected by the withdrawal of guaranteed prices.
- OHV 2** OHV Semi-intensive: refers to the supervised area in the OHV zone receiving organic fertilizer. This RD is represented by a single partial budget since a high proportion of maize is consumed on the farm, and the value of output to the farm household (opportunity price) has not therefore significantly affected by the withdrawal of guaranteed prices.

published in CMDT and OHV annual reports. Estimated yields of both maize and millet/sorghum are higher for southern RDs (CMDT 3 - 6) than northern RDs (CMDT 1,2 and OHV 1,2). Estimated yields of maize are higher for management-intensive RDs (CMDT 1,3,4 and OHV 1) than for semi-intensive RDs (CMDT 2,5,6 and OHV 2), within the same geographical zone. Millet/sorghum yields are higher for post-1980 budgets, to reflect the improvement in crop husbandry as a result of extension efforts for these cereals.

The second row of Table 3.4 presents the additional inputs required to cultivate maize in Southern Mali as opposed to millet/sorghum. The distinction between intensive and semi-intensive RDs is important here. Farmers considered to follow an intensive management regime use chemical fertilizer (and possibly organic fertilizer as well), while farmers considered to follow a semi-intensive regime are entirely dependent on organic fertilizer.³¹ The difference is more than one of the source and amount of plant nutrients applied to the crop. In contrast to semi-intensive management, the farmer who chooses an intensive management regime has to make an investment in the crop that requires a cash outflow in an economy where cash is scarce. The application of chemical fertilizer is therefore indicative of a degree of commitment to the crop that will likely be reflected in a higher standard of husbandry practices, in order to ensure an acceptable return on the farmer's investment. In all RDs, it is assumed that farmers do not use chemical fertilizer on millet or sorghum.³²

³¹ In both cases, plowing is a requirement to qualify as improved.

³² For both the CMDT and OHV zones, data published in annual reports indicate that chemical fertilizer use on millet and sorghum is negligible, due to the limited yield response with existing varieties.

Maize cultivation in intensive RDs is modeled by three partial budgets that represent the evolution of extension recommendations and fertilizer use over time. Prior to 1980, the CMDT recommended only urea top dressing at the rate of 100 kg/ha. This was due to the high fertilizer rate recommended for cotton, designed to ensure that the cereal crop following cotton in the rotation would benefit from residual nutrients. After 1980, the CMDT changed its extension policy from one of allowing cotton to "subsidize" cereal production, to one where each crop was expected to bear its own costs.³³ The reason for this policy change was the increased profitability of maize production following the dramatic cereal price rises of the late 1970s. Recommended fertilizer doses were accordingly reduced for cotton and increased for cereals. For maize, the recommended amount of urea top dressing was raised from 100 kg/ha to 150 kg/ha, and a basal application of 100 kg/ha of compound fertilizer was added. Following the liberalization of cereal markets in 1986, when maize prices fell even more sharply than other cereals, farmers reduced the amounts of fertilizer applied even though recommended doses were unchanged. With the termination of CMDT's specific credit program for maize, many farmers began to divert part of their cotton fertilizer to the maize crop. Giraudy (1993) found that, for the 1992 growing season, farmers who use fertilizer on maize apply half the recommended dose.

Aside from fertilizer, the only additional inputs required are seed and seed dressing, to account for the higher seeding rate for maize compared to sorghum.

No incremental labor has been budgeted for maize cultivation. Although maize requires plowing (whereas millet/sorghum is direct seeded), and the harvested

³³ A. Dolo (Cellule Recherche d'Accompagnement, CMDT), personal communication, November 1991.

ears are harder to thresh, the crop is easier to weed and harvest. The high variability in data on labor inputs for cereal production does not justify the assumption of a significant difference in labor requirement between maize and other cereals cultivated on outer fields. Sensitivity analysis was carried out to assess the effect of a 10 person-day per hectare difference in labor requirements on the profitability of maize production. At between 5,000 CFA F and 7,500 CFA F per hectare (depending on the opportunity cost of labor in the RD), the effect is small compared to that of variability in the price of maize (discussed below).

b) Incremental income and sensitivity

The third row of Table 3.4 presents the calculation of incremental net benefit (INB), measured in CFA F per hectare of maize cultivated. This is determined by subtracting the incremental cost of maize production from the incremental benefit. The incremental cost of maize production is determined by multiplying the additional inputs used for maize cultivation by their respective financial or opportunity prices. The incremental benefit of maize production is calculated by subtracting the value of millet or sorghum from the value of maize produced (where value is determined by multiplying cereal yields by their respective financial or opportunity prices). Only the results of these calculations are presented in Table 3.4.

The most striking result manifested in Table 3.4 is the dramatic fall in the profitability of maize cultivation following the liberalization of cereal markets in

1986.³⁴ The fall is estimated to be most severe in the sole-cropped intensive management RDs (89% in CMDT 1 and 75% in CMDT 3) and in the sole-cropped semi-intensive southern RD (77% in CMDT 5). The fall is less severe in the semi-intensive northern RD (64% in CMDT 2). This result is at odds with the reported pattern of expansion of area cultivated to improved maize in recent years.

According to the data in Table 3.2, growth has been more rapid in management-intensive RDs (CMDT 1,3,4) compared to semi-intensive RDs (CMDT 2,5,6). The reasons for this apparent contradiction are not clear.³⁵ The fall in profitability is estimated to be least severe for the RDs where maize is intercropped (61% in CMDT 4 and 55% in CMDT 6), reflecting the higher price for the late millet intercrop after 1986. This is consistent with the increasing popularity of intercropped versus sole maize (compare CMDT 4 and 3 in Table 3.2).

The vulnerability of incremental net benefits to fluctuations in the price of maize is further illustrated by sensitivity analysis. The bottom row of Table 3.4 indicates the absolute effect on incremental net benefits of a 20% change in maize price (i.e., an increase in the price will increase profits by the amount or percentage shown and a decrease in price will decrease profits by the amount or percentage

³⁴ This result is based on a market price of 55 CFA F/kg prior to liberalization and 40 CFA F/kg afterwards. The post-liberalization price approximates the average price reported by the Système d'Information du Marché for markets in producing areas during the four months after harvest (October - January). Assuming 50% of households consume additional maize production instead of purchasing from the market, and 50% of households sell the additional grain, additional transport costs for marketed produce are offset by transport savings of purchased foodgrains.

³⁵ There are several possible explanations. It is possible that extension workers are inflating the area receiving fertilizer in order to please their superiors. It is also possible that farmers are diverting more fertilizer from the cotton crop to maize in response to food security concerns and relatively stagnant cotton prices during the 1980s.

shown). It is salutary to note that for every sole cropped RD in the CMDT zone today, a drop in maize prices of 20% would result in a loss for the farmer. Only intercropped RDs would avoid loss, testifying to the value of this system as a means of mitigating the risk of price fluctuations.

3.4.2 Economic impact of maize technology development and diffusion in Southern Mali³⁶

Unlike financial analysis, an economic assessment of the impact of maize technology development and diffusion is concerned with the benefits to society as a whole rather than for specific groups. Estimation of the economic benefit of the program involves comparison of the time-valued aggregate economic costs and benefits over the relevant period. Economic costs and benefits are arrived at by valuing costs and benefits at economic prices. These differ from financial prices by the value of any taxes or subsidies including, for traded commodities, those implicit in official exchange rates.

Additional maize from each recommendation over time was valued at its import parity price (the economic cost of importing maize) since the country was in a food-deficit situation for most of the period under study, and maize becomes available when food shortages are at their most acute. The use of an import parity price for maize (considerably higher than financial price) reflects its contribution to improved food security. On-farm costs associated with the adoption of maize

³⁶ The economic analysis of the impact of maize technology development and diffusion is presented in summary form only. For a detailed analysis see Boughton and Henry de Frahan (1994).

technology, including millet/sorghum production foregone, are also valued at import parity prices.

The economic impact assessment also takes account of the cost of resources allocated to research and extension services in order to develop and diffuse maize technology. Research costs include the number of research person years devoted to maize over the period 1969 - 1990, multiplied by the economic cost per person year. Neither the costs of research carried out prior to 1969 (e.g., selection and/or improvement of local germplasm by the colonial administration), nor the costs of research undertaken in other West African countries or regional and international centers are included.

Extension costs include total salary and operational expenses of extension service multiplied by the proportion of maize in total cultivated area (after giving the cotton area a weight of 2 to account for the greater attention devoted to this crop) for the period 1975 - 1990.

The overall economic return (ROR) to maize research and extension over the period 1969 - 1990 was very high at 135%. The main factors accounting for this high rate of return are the high value of maize in a food-deficit situation, the low cost of maize research (germplasm and technical recommendations were borrowed from other countries or regional/international centers), and the rapid farm-level adoption rate. Sensitivity analysis indicates that this return is robust with respect to adverse changes in assumptions concerning overvaluation of the exchange rate, research costs, extension costs, and total area of improved maize. The estimated return is moderately sensitive to price and yield reductions (a 20% reduction pulls the ROR down to 106%, and a 38% reduction pulls the ROR down to 12%,

equivalent to the assumed opportunity cost of capital). The ROR is also sensitive to the start date of the research cost stream. A 1962 start date as opposed to 1969 (i.e., an additional seven year lag between the start of the cost and benefit streams) pulls the ROR down to 54%.

3.5 Implications for future agricultural technology development and diffusion

The weaknesses and the accomplishments identified by this historical analysis of the development path and impact of maize technology have implications for the future development of the maize research program.

The weaknesses relate to organizational constraints encountered in three areas: 1) linkages between research and extension, 2) monitoring of technology adoption, and 3) the lack of economic analysis underpinning technical research findings and extension recommendations. Each will be briefly considered in turn.

During the initial stages of maize technology diffusion, and particularly with the advent of the "Projet Maïs", there was very little interaction between research and extension. Although collaboration improved dramatically following the 1983 maize streak virus outbreak, the failure to develop an adoptable maize-millet intercropping package raises some difficult questions. Whereas the CMDT took the initiative to improve and promote sole-cropped maize, the initiative to improve the traditional system of maize-millet intercropping was taken by research. After on-station researchers had developed an "improved" system (planting maize and millet in separate rows), the package was tested on-farm and concluded to be sound despite complaints by farmers that the narrow between-row spacing made mechanical weeding difficult. Subsequently, the CMDT felt obliged to abandon

attempts to extend the system for this very reason. Yet no attempt was made by researchers to modify the package. The reasons for the failure of feedback on technology performance to be translated into improvements are not clear.

One contributing factor may be that current mechanisms for monitoring technology adoption do not provide the kind of information that can help focus research. For example, while new maize varietal introductions have been the most dynamic component of the package, no information is collected concerning their levels of adoption in the various agro-climatic zones. The CMDT's monitoring and evaluation unit, which is designed to provide information of a more diagnostic nature to CMDT management, with a staff of 40 enumerators and 5 supervisors in the field, has until recently operated largely in isolation from IER.

Effective evaluation of technology development requires the integration of economic analysis into the research program. The decisions by IER and CMDT not to multiply and distribute hybrid seed to farmers on the grounds that it was too costly were taken without any financial analysis. Similarly, none of the several changes that have been made to maize fertilizer recommendations in the CMDT zone has been subject to financial analysis. The decisions taken are not necessarily wrong, but they are uninformed.

The strengths of the maize experience are reflected in the high economic rate of return that can be attributed to three main factors: 1) the low cost of research, 2) the high economic value of the crop, and 3) the rapid rate of technology adoption. We will briefly review what lies behind each of these factors in turn, with particular attention to the issue of replicability in the future.

The low cost of research reflects the limited personnel resources allocated to maize since the inauguration of a cereals crop research program in 1964, under the management of IRAT. The low priority accorded to maize was justified by the small area cultivated relative to millet and sorghum.³⁷ It was only in 1969 that the decision was taken to give more emphasis to maize on the grounds of its potential contribution to increasing food security, and in any case this decision was not backed by any tangible increase in resources for almost a decade. The very limited resources allocated to maize research did not have a negative impact on the promotion of maize starting in the mid-1970s. In formulating recommendations for cultural practices, the CMDT was able to use the results of research undertaken elsewhere in West Africa. An emphasis on making the fullest possible use of research conducted elsewhere in the region will continue to be justified in the future, and is reflected in the proposal for collaborative regional research programs under the INSAH/SPAAR framework for action (Weijenberg et al., 1993).

The high economic value of maize, measured in terms of an import parity price, reflects the role of increased maize production in substituting for food imports. Throughout the 1970s and early 1980s Mali faced a chronic food deficit. Although Mali's aggregate cereal balance improved significantly in the second half of the 1980's, a large proportion of the maize crop continues to be consumed during the hungry season before the longer-cycle millet and sorghum crops are harvested. Informal discussions with cereal traders confirm that maize imports from Côte d'Ivoire during the hungry season are a frequent occurrence. Nevertheless,

³⁷ The principle of allocating resources between commodities according to their existing economic importance is referred to as the principle of congruity (Norton and Pardey, 1987).

such a situation will not persist indefinitely in the face of increasing cereal production. Eventually, if increased area and improved production techniques lead to increased cereal production *per caput*, there will be cereal surpluses. These surpluses will have a lower economic value than earlier increments in production, either because of the additional delivery costs in the case of export markets, or lower value in use in the case of domestic markets (as livestock feed for example). Thus, high historic economic returns to investment in research and extension are not necessarily a guide to the future, which will depend in part on market opportunities.

The high rate of maize technology adoption during the 1980s reflects complementary investments in physical capital, organizational capacity, and incentive policies. In terms of physical capital, high levels of mechanization greatly facilitated the adoption of maize as a field crop. The policy of allowing rural development agencies to purchase grain from farmers at an attractive guaranteed price allowed the CMDT to apply the same integrated approach to maize technology delivery that it had already successfully developed, over the course of many years, for cotton. This approach ensured that all stages in the subsector both prior to production (seed multiplication and distribution, fertilizer and credit delivery, extension advice) and post harvest (purchase and collection, transport, storage, wholesaling) were coordinated through the administrative decisions and technical resources of a single organization.

In the very different policy context of liberalized cereal markets, the coordination of investments over time, and between stages in the overall production process from input manufacture and distribution through to final consumption, has

to be achieved through the interaction of a large number of independent decision makers. In seeking to respond to market signals, each of these decision makers faces its own set of resource, information and technological constraints, risks, and transaction costs. In this context, technology adoption at the farm-level production stage for a given commodity will depend on the circumstances facing producers at other stages of a subsector, such as the availability of appropriate equipment for processors, the enforceability of contracts to assure appropriate quality for industrial uses, or the tax structure facing exporters. In the future, the agricultural research system will therefore need to develop a capacity to assess the needs of a much broader set of clients.

CHAPTER FOUR

OVERVIEW OF THE MAIZE SUBSECTOR IN MALI

The previous chapter showed how, in the past, rapid farm-level adoption of intensive maize production practices was closely associated with the institutional innovation of a vertically integrated system for input delivery and output marketing. The purpose of this chapter is to provide a descriptive analysis of the maize subsector today. The picture that emerges is one of a thin and weakly coordinated subsector by contrast with the pre-market liberalization period.¹ Strategic issues related to the future development of the subsector are defined and explored. The chapter concludes by identifying specific topics for in-depth study in order to evaluate opportunities for market expansion and improvements in vertical coordination consistent with the existing government policy of cereal market liberalization.

4.1 Approach and methods for the preliminary appraisal of the maize subsector

The objective of the preliminary subsector appraisal was to describe the organization and functioning of the maize subsector, and identify major constraints to, and opportunities for, increasing its contribution to the economy. The appraisal was carried out by an interdisciplinary team during the period February to April 1992. IER core researchers carried out literature review, and secondary data and market margin analysis for group discussion. All team members took part in the design and implementation of an informal survey of participants at different stages

¹ A thin market is one where only a small proportion of total produce passes through the spot market, which may result in unstable prices (Tomek and Robinson, 1993).

in the subsector.² An important output of the preliminary subsector appraisal was a Research Planning Matrix (IER, 1992b). This set out, for each stage of the subsector, the principal constraints, research questions and information needed (see Appendix 2). IER researchers used this matrix to identify key stages and questions to focus on for the in-depth phase of the study, which was divided into two components: a primary emphasis on urban consumption and a secondary emphasis on farm-level production. The potential for reducing marketing costs was not included as the Market Information System (SIM) is better placed to conduct the necessary investigations and analysis. The research proposal for in-depth study of opportunities to expand urban maize consumption was funded by the Cereal Market Restructuring Program (PRMC) and USAID/Mali (IER, 1992a).

4.2 Descriptive analysis of the maize subsector in Mali

As explained in chapter 3, maize research has historically been a very minor part of the total **agronomic research** effort (Figure 4.1).³ Since the early 1970s, the primary focus has been on varietal selection, initially based on linkages with French-operated research stations in West Africa, and more recently on linkages with regional and international centers/networks. By the end of the 1980s, several

² The team comprised representatives from IER, the Market Information System, The National Institute for Research in Nutrition and Public Health, the Ecole Normale Supérieure, and the CMDT. Participation of members from different organizations was encouraged in order to lay down foundations for longer-term collaboration. The PRISAS program of INSAH provided both financial support and technical advice on preparing the informal survey guidelines.

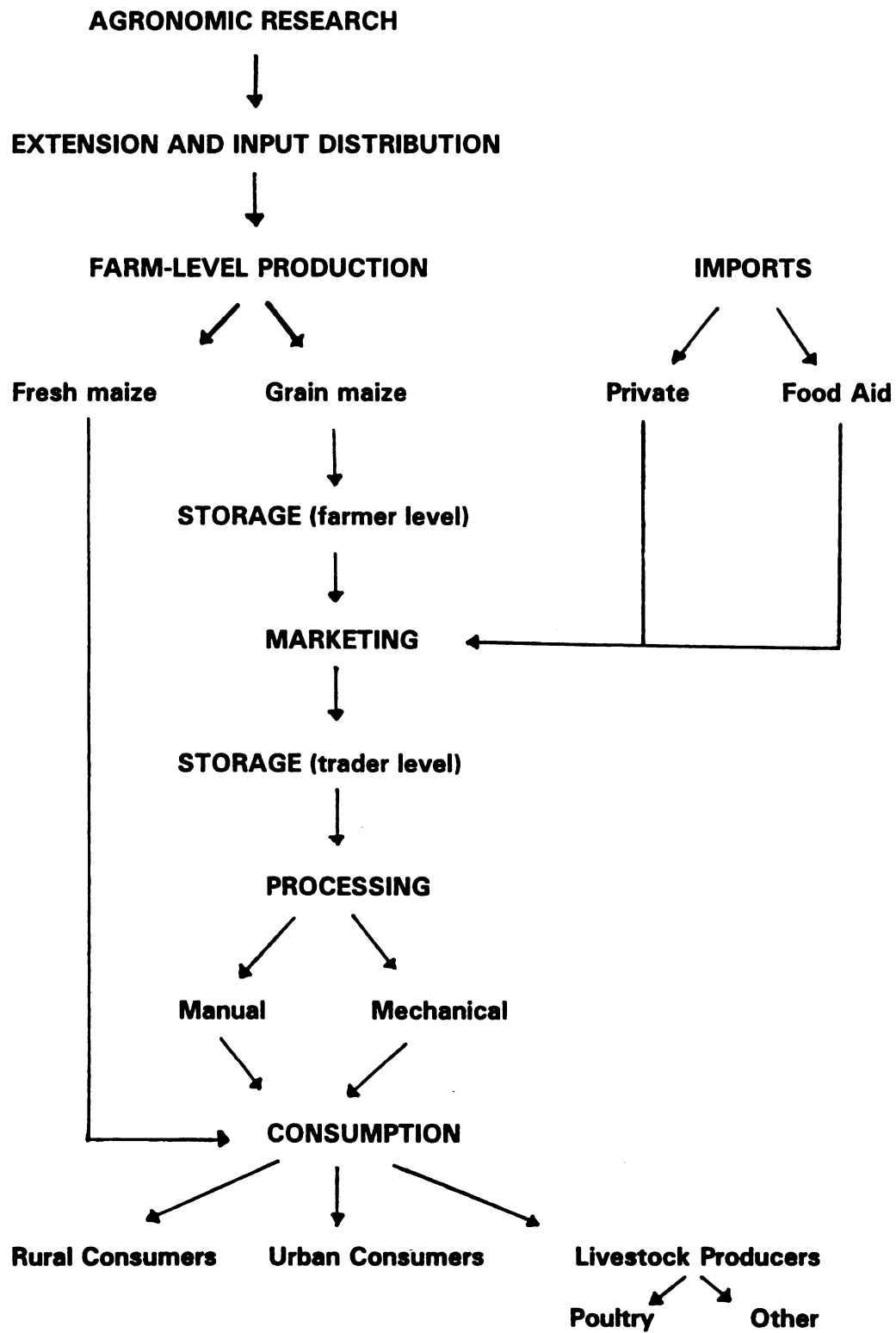
³ An activity or function that is boldfaced in the text refers to a stage in the maize subsector diagram (Figure 4.1).

improved varieties had been released, but there is a dearth of empirical information on adoption rates.

Extension services are provided by two parastatal organizations, the OHV and the CMDT. The supply of agricultural inputs has been liberalized, although the CMDT remains the main supplier of inputs because bulk purchasing and back haulage (lorries returning from cotton delivery to the Ivory Coast) permit lower input delivery costs than the private sector. Consequently, the CMDT's policy on what inputs to provide (varieties, fertilizer compositions) largely determines what is available. Credit for the purchase of inputs is supplied by an agricultural bank, and the supervision of disbursement and recovery is increasingly being undertaken by village associations.

At the **farm-level production stage**, maize represents about 5 - 10% of the total cereal area in Mali, and about 10 - 15% of cereal production. At a 7% rate of growth of output, it is the most rapidly growing cereal subsector, which could eventually have an effect on relative cereal prices (Holtzman et al., 1991). Approximately 80% of the total Malian maize crop is grown in southern Mali, where rainfall ranges from an average of 1200 mm in the south to 700 mm in the north. For non-mechanized farmers, lack of equipment, high cost of fertilizer and drought risk are the major constraints cited. For mechanized farmers (72% in the CMDT zone), the lack of a guaranteed price for maize is a key constraint. They are unwilling to lay out cash for fertilizer without a guaranteed price because of the risk of ending up in debt. Some farmers expressed that they were more concerned about the uncertainty of maize prices than rainfall. Quantitative information about

Figure 4.1: The Maize Subsector in Mali



costs of production and variability in returns is extremely scanty (Holtzman et al., 1991).

Fresh maize plays a vital role as a hungry season food source as early as mid-July, and is very popular in roasted form among urban dwellers. Consequently, it can be a valuable cash crop for farmers in peri-urban areas with good access to urban markets. In urban areas, fresh maize is marketed through the fresh vegetable subsector. Fresh maize wholesalers are exposed to high risks because of its perishability. **Grain maize**, available from the end of September, continues to be a key food source for rural consumers through to the arrival of the millet/sorghum harvest in November. Maize stover is generally left in the field and consumed by livestock during the dry season.

Farm-level **storage** is generally not a problem, partly because most of the crop is consumed in a relatively short period of time and partly because it is stored on the cob, making it more difficult for insects to penetrate the grain. A significant expansion of maize production might require changes in storage methods since the current practice is demanding in the amount of storage space required in relation to grain weight. The Large Grain Borer (*Prostephanus truncatus*), until recently confined to the Americas, is a potentially serious future storage pest. Outbreaks have been reported in Togo and Benin (GASGA, 1987).

The **marketing** of grain maize takes place through the same network of rural collectors and wholesalers, transporters, and urban wholesalers and retailers as other coarse grains.⁴ The limited availability of quantitative information on cereal marketings permits only qualitative impressions. According to traders, the volume

⁴ The term coarse grains refers in this context to the following cereals: millet, sorghum, maize and fonio.

of maize is small relative to millet and sorghum, and relative to the total maize harvest since much is consumed by farm households themselves. According to farmers, the tendency to consume increasing amounts of maize on-farm is due to the fact that millet and sorghum commands a higher price than maize in local markets. Given the relatively low coarse grain prices in recent years, and the high costs farmers incur to bring their cereal to market because of poor roads, even a small difference in selling price such as 5 CFA F/kg represents a big difference in net margin.⁵ Traders report that most maize marketed beyond rural markets goes to the capital city of Bamako.

The quantities marketed also vary considerably from year to year according to the size of the maize and millet/sorghum harvest. Maize production is more variable than other cereals. Over the period 1971-72 to 1990-91 the coefficient of variation was 0.56 for maize production, compared to 0.34 for other coarse grains and 0.32 for paddy (Holtzman et al., 1991). Furthermore, if the millet/sorghum harvest is poor, then maize marketings will be low even if the maize harvest was good as rural producers replace millet or sorghum with maize in their diet.

Marketing margins between rural producers and urban consumers are substantial. The pre-devaluation marketing margin of 35 CFA F/kg between Koutiala and Bamako is roughly 50% of the average retail price in Bamako during the study period. However, the high correlation between prices in rural markets and Bamako retail prices suggests that this margin is not due to a lack of competition

⁵ The effect of differences in prices for maize and sorghum, before and after the main coarse grain harvest, on incentives to grow and to market maize are examined in detail in chapter 8.

among traders.⁶ It is more likely due to high assembly and transportation costs that result from small, dispersed quantities of marketed produce, poor rural infrastructure, and the high cost of vehicles, fuel, and spare parts. Although the marketing margin is substantial, the lack of information concerning the components of this margin, and quantities traded, makes in-depth analysis difficult. From January 1993, the Market Information System began to collect cereal prices at different levels in the system, as well as quantities transacted, to permit such analysis.

Only very limited quantities of maize appear to be stored off-farm. The majority of traders do not use formal credit, and cash constraints oblige them to seek earnings through turnover rather than speculative storage. Furthermore, storage of maize at merchant level presents more difficulties than farm-level storage because it is more vulnerable to insect infestation in grain form than it is on the ear. Finally, the possibility of imports from Ivory Coast (where the maize harvest is earlier) effectively places a price ceiling on maize, limiting potential profits to storage.

Processing represents a constraint to maize consumption. The processing of coarse grains involves four main stages: 1) threshing to remove grains from the ear or cob; 2) dehulling to separate the pericarp from the endosperm (involving significant loss of the thin layers of protein between them); 3) milling to reduce the endosperm to flour and/or grits and 4) sieving to grade the milled endosperm into particles of different sizes. Between each of these stages cleaning activities will be

⁶ Theoretically, a high correlation between cereal prices at urban and rural markets could arise from monopoly power. The large number of independent wholesalers engaged in the domestic cereal trade makes this a highly unlikely possibility.

undertaken (e.g., winnowing after threshing, washing after dehulling). In rural areas, coarse grains are threshed, dehulled and milled using pestle and mortar, since mechanical processing is very costly relative to rural women's incomes (Fischer et al., 1992). In urban areas coarse grains are usually purchased in grain form, dehulled manually and then taken to a custom plate mill for grinding into flour (Holtzman et al., 1991).

One disadvantage of maize compared to sorghum and millet is that it has to be soaked for several hours after dehulling in order to obtain the fine flour preferred by Bamako housewives. This means that dehulling for the mid-day meal would have to be done very early in the morning, and for the evening meal in the early afternoon. Neither time is particularly convenient since early in the morning women are preparing breakfast, and in the early afternoon they are cleaning utensils used to prepare the mid-day meal and/or taking a rare opportunity to rest.

The milling of maize also involves additional cost. Urban mill operators charge more for processing maize than millet or sorghum because it is harder. But the additional financial costs of milling maize, approximately 2.5 CFA F/kg or 5 - 10 CFA F per meal, are small relative to the cost of grain. Since this amount represents only about 1 % of daily expenditures on sauce ingredients for an average family, it is hard to believe that the additional milling cost for maize is a serious impediment.

Although negligible in financial terms, the higher milling costs can give rise to additional transactions costs within the household. The household head is responsible for the provision of cereals and money for the purchase of condiments (meat, fish, cooking oil, spices etc.). Most commonly, household heads buy cereals

in bulk and provide a daily sum of money ("nassongo") to cover the cost of condiments to the woman responsible for preparing food on a given day.

Alternatively, the household head provides a sum intended to cover both cereal and condiment purchases. Cereal processing costs are paid for out of the daily sum allotted for the purchase of condiments. Some household heads report that their wives resent the additional processing costs of maize because it reduces the amount available to purchase ingredients for the sauce and demand an increase in the "nassongo" if the household head purchases maize. It may be difficult for a household head to increase the nassongo by an amount equal to the additional processing cost for two reasons. First, the household head usually has only a vague notion of what it costs to mill the daily quantity of cereals. Second, it is difficult to increase the nassongo by a trivial amount. It usually increases by at least 100 CFA F per day.⁷ Thus even if a household head could realize financial savings by purchasing maize (the difference between the price of maize and the price of sorghum or millet is greater than the additional processing costs), the costs of re-negotiating the nassongo may outweigh the benefits.

While the effect of transaction costs that arise from the interaction between maize processing difficulties and the prevailing institutions for household economic management should not be overemphasized, the cumulative effect of such "inconvenience factors" is to reduce the cross-price elasticity of substitution between maize and other cereals.

The availability of pre-processed products such as flour that could avoid the additional time, cash and transactions costs associated with maize processing is

⁷ A frequency distribution of nassongo reveals that most households are grouped in increments of 500 FCFA per day.

very limited. The same is true for millet and sorghum. Small quantities of flour are offered for sale by women retailers in urban markets, but consumers are very wary of such products. Housewives expressed concern about hygiene, since the flour is sold from open containers and cannot be washed prior to use like whole or dehulled grain. Furthermore, there is always the possibility that flour has been mixed with the cleanings from custom mills. Finally, women cannot be certain how fresh the flour is. In short, housewives who might wish to purchase coarse grain flour believe they run a high risk of adverse selection.⁸

The only other processed maize product available in urban markets is yellow maize grits. For the most part this product is manufactured artisanally and sold in clear plastic sachets as a high quality breakfast cereal or desert for relatively wealthy urban consumers. In contrast to flour, the grits can be washed prior to use, and their freshness can be judged by the color of the product. A donor-financed project called CERECOM that sought to promote urban consumption of grits manufactured in rural areas using hammer mills met with limited success.⁹ This is partly due to the high cost of the product. Only a small fraction of grits obtained from the hammer mill are of the desired size, leaving a high proportion of

⁸ A situation where effective demand for a product is frustrated by adverse selection begs the question as to why individual suppliers have not established a reputation for selling a quality product. One possible reason is that, to obtain the fine flour preferred by urban consumers, the grain must be moist at the time of milling. Consequently, the flour obtained has a very short shelf life. This would lead reputable suppliers of quality flour to enter into contracts with households rather than run the risk of being left with unsold stock in the marketplace. This does not explain the fact that the total quantity of flour procured by Bamako households from all sources is very small. The issue of effective demand for flour, and the processing services embodied in the product, is the central analytical focus of the dissertation.

⁹ CERECOM is a truncation of "commercialisation des céréales", which means cereal marketing.

by-products that can be sold only at relatively low prices. Apart from the high cost of the product, a further constraint on demand is the long cooking time.

Housewives report that maize grits take two to three times as long as rice to cook.

Attempts to market white maize grits as a rice substitute were unsuccessful in Bamako, where consumers regarded the product as inferior ("poor man's rice") since the substitution of white maize grits for rice is a common practice in rural maize growing areas.

Human consumption of maize in the form of traditional millet and sorghum-based dishes is a relatively recent phenomenon. Prior to the 1970s, most maize was consumed in the form of boiled or roasted ears. For some Malians, their first encounter with grain maize was during the famines of the early 1970s and 1980s, as food aid, and hence the cereal is associated with difficult times. Traditional coarse grain-based dishes include *toh* (a thick porridge made from flour and usually consumed in the evening), *bouillie* and *seri* (thin porridges, made from flour and grits respectively, and consumed at breakfast or supper), or *couscous* (made from steamed flour). Bamako consumers prefer yellow maize, in contrast to urban consumers in most other African countries. This is because of the relatively high proportion of maize presently consumed in the form of *seri*, a grits-based porridge that urban consumers traditionally prepare from yellow maize.¹⁰

Consumption of maize grain by livestock is mainly limited to the urban poultry subsector.¹¹ These enterprises are almost entirely confined to egg-laying

¹⁰ The processed form of the grain required to prepare a given dish is very important for the development of commercial coarse grain processing, and is discussed in detail in chapter 6.

¹¹ Maize is also used in small quantities for the manufacture of pre-mixed feed for dairy cows.

units, since intensive broiler production cannot compete with free range birds from rural areas. Poultry rearers also have a strong preference for yellow maize since this affects the color of egg yolks. Discussions with poultry unit operators indicate that flock health management is the major constraint, followed by low egg prices associated with imports from Senegal and Ivory Coast. With the closure of the government-subsidized hatchery, chicks have to be imported by air from France, adding further to costs. Until farmers can stabilize their flock numbers through effective health care, they are unlikely to enter into contracts for feedstock maize even if this institutional innovation permits them to secure supplies more cheaply.

In contrast to Bamako consumer preferences for yellow maize, whether for human consumption or for poultry, rural grain collectors were often observed not to make any special effort to separate maize by color. Urban consumer preferences were also irrelevant to farmers' choice of variety, which was exclusively based on agronomic characteristics. The one variety that seemed to be growing in popularity on the basis of its early maturity and lower fertilizer demand, TZESR-W, is a white variety. The failure to communicate consumer preferences through the different stages of the subsector is also a reflection of the relatively small volumes moving through the market.

Potential quantities of maize required for industrial use are limited. These include flour as a source of starch in battery and glue manufacture, and grits for brewing. Although small in volume terms, industrial demand could nevertheless represent a relatively stable source of revenue for processing units. Unfortunately, all these products require maize to be de-germed prior to milling, for which no small-scale equipment exists.

4.3 Strategic issues for the future development of the maize subsector

The initial subsector appraisal reveals many characteristics associated with a thin market (Holtzman et al., 1991). Farmers appear to produce maize primarily in order to achieve food self-sufficiency, not for the market. Urban consumers tend to buy maize only when it is significantly cheaper than other cereals, due in part to the difficulty and/or higher cost of processing and in part to lack of familiarity with this cereal. Traders consequently have little incentive either to assure a regular year round supply of maize, or to meet urban consumer preferences for color or quality.

The development of the maize subsector therefore requires an increase in both demand and supply, as well as an increase in their predictability (i.e., improved coordination). For demand to increase, consumers need to perceive an improvement in the value of the product and/or a reduction in cost (taking account of additional processing activities necessary to get the grain into a useable form such as flour or grits). An increase in marketed supply requires a higher and/or more stable profit margin for farmers. Improvements in net margins could be achieved through reductions in marketing costs (e.g., by vertical integration of farmers' organizations into the marketing of cereals), and/or by a reduction in unit costs of production at farm level. Stability in margins could be improved through contracts between maize producers and users. Such an innovation would require sufficiently strong effective demand for final products to induce the suppliers of those products to assure access to specific quantities and qualities of grain maize by planting time.

Development of the maize subsector, particularly through urban demand for processed maize products, could contribute to improved food security in both the

short and the long run. In the short run, increased availability of maize will help ease late rainy season coarse grain prices, and thereby reduce costs for food deficit rural families, because it is harvested up to two months earlier than millet and sorghum. It will also provide a hedge against the risk of an early end to the rains causing poor millet and sorghum yields. The availability of processed maize products could improve food security by increasing the substitutability between rice and coarse grains in urban cereal consumption patterns. Greater substitutability between rice and coarse grains will result in smaller cereal price fluctuations in response to stochastic rice and coarse grain production and import levels (Boughton and Sanogo, 1994).

In the long run, demand-led expansion of the maize subsector will improve food security through soil conservation and more rapid agricultural sector transformation. Land degradation is a serious problem in the middle to high potential areas of Mali where maize is cultivated because extensification has been the primary source of increased rainfed cereal production over the last decade (World Bank, 1993). Increasing the proportion of maize in total rainfed cereal production is one way to slow down degradation of the land resource base in Southern Mali because of the possibility to increase output per unit of land through fertilizer use.

In so far as demand-led expansion takes the form of processed products this will contribute to accelerated agricultural sector transformation and economic growth. The set of processed coarse grain products currently available to urban consumers is extremely limited in terms of product type, quality and price. The successful introduction of a processed maize product would expand the potential

product demand space, through the possibility to market the same product type using a different cereal base or bases, or different price/quality versions of the product using the same cereal base.¹²

The question as to whether maize will continue to be produced and consumed primarily as a rural food source (either for consumption during the hungry season or as a dry season staple), or whether alternative market opportunities will develop that will entail an expansion of maize production and consumption via the marketplace over time, is also strategic for the purpose of defining an agricultural research agenda.

The question is strategic because different answers imply quite different research agendas and disciplinary mixes. In the case of maize for consumption during the hungry season, appropriate criteria for varietal selection will include marginal improvements in earliness and drought tolerance. If required for consumption during the dry season, yield, storage quality and ease of processing may also be important. In the case of maize required for commercial flour or grit manufacture on the other hand, selection criteria could include factors such as the proportion of pericarp and grain hardness. Selection criteria that include manual or mechanical processing characteristics imply much greater involvement of food technologists than the former. While these technology development paths for maize are not mutually exclusive, differences in disciplinary mix and criteria in a context of

¹² Although apparently more severe for maize, processing costs are also a constraint on urban demand for coarse grains generally in West Africa (Reardon, 1993). Hence analysis of the possibilities for overcoming these constraints may be generalizable beyond the case of maize in Mali.

limited research resources require that the objectives for maize research need to be prioritized over time.

The sequencing of research objectives over time may have important implications for the economic impact of investments in maize research. Investment in the selection and promotion of varieties with desirable processing characteristics will not generate an attractive economic return if low consumer incomes severely constrain effective demand for processed products in the short and medium term. It might be more rewarding to focus research resources on expanding the availability of maize during the hungry season in the short run, and shift priorities toward processing objectives when incomes have risen sufficiently.

4.4 Key research questions for further investigation

The earlier sections of this chapter provided a descriptive analysis of the maize subsector in Mali today and identified strategic questions that need to be answered to determine appropriate directions for future maize research and identify necessary complementary innovations in regard to policy and institutional arrangements. This section lays out specific questions that will be the analytical focus of the remaining chapters.

The overall goal of the consumption component of the study is to assess the potential for expanding consumption of domestically produced maize through urban consumption of processed products. To achieve this goal, empirical information about both existing urban cereal utilization and consumer willingness-to-pay for processed products is required. Gaps in regard to empirical knowledge of existing urban cereal utilization include:

- (i) the type, quantity and form (processed or unprocessed) of cereals procured by households, and the role of income and demographic factors as determinants of demand;
- (ii) the relative importance of different forms of processed grain required by households, as implied by the dishes they prepare;
- (iii) the cost of processing and preparation of rice and coarse grain-based dishes using different processing methods.

The next chapter describes the survey instruments and sampling methods used to obtain this information from households in Bamako, the capital city. Bamako is an appropriate choice because of its size and the fact that it is already the main destination for marketed maize. Chapter 6 provides the results of the surveys, and justifies the choice of flour as a key potential processed product.

Gaps in regard to knowledge about consumer willingness-to-pay for flour include:

- (i) the quantity of flour consumers would be willing to buy at different prices, their willingness to trade quality for price, and the role of income and demographic factors as determinants of demand;
- (ii) the cost of supplying such products for different processing technologies.

Chapter 7 describes the methods used to determine consumer willingness-to-pay for different qualities of flour, the costs of alternative processing techniques, and the magnitude of demand at estimated retail prices before and after devaluation.

Chapter 8 examines the implication of post-devaluation fertilizer prices increases for incentives to supply maize, and the implications for agronomic research priorities.

CHAPTER FIVE

CEREAL UTILIZATION PATTERNS AMONG BAMAKO HOUSEHOLDS:

SURVEY METHODS

Chapter 4 argued that increases in the demand and supply of maize could enhance urban and rural food security in the short and long term, and enumerated the advantages of effective demand growth for processed products. The chapter concluded by identifying a set of empirical information gaps concerning urban cereal consumption patterns. This chapter has two objectives: 1) to present the survey instruments and sampling methods used to obtain information to fill those gaps, and 2) to describe sample household demographic characteristics and expenditures. The chapter begins with a brief review of cereal consumption studies in the Sahel to set the study in the context of current regional food policy issues.

5.1 Urban cereal consumption patterns in West Africa: concerns from the literature

Recent literature on urban cereal consumption patterns in West Africa has concentrated on describing and attempting to understand major structural changes in the demand for cereals. The two major themes treated are 1) factors underlying the rapid growth in wheat and rice consumption over time at the expense of locally-produced coarse grains, and 2) the degree and determinants of substitutability between rice and coarse grains. The main findings are summarized below.

5.1.1 Rapid growth in wheat and rice consumption over time at the expense of locally-produced coarse grains

The most notable trend in cereal consumption in West Africa has been the secular growth of mainly imported wheat and rice at the expense of locally produced coarse grains. Delgado and Reardon (1987) report that between 1960 and 1983 *per caput* consumption of rice and wheat in Sahelian countries increased by 16 kg whereas coarse grains decreased by 22 kg. Gabas and Giri (1987), cited by Reardon (1993), report that imports of rice and wheat into the Sahel have been increasing at 10% per year since independence. Reardon (1993) states that virtually all of the increase in consumption of rice and wheat into the region over the previous ten years was accounted for by imports.

The balance of payments burden imposed by rice and wheat imports led policymakers to examine the desirability of import tariffs as a means to discourage consumption of imported cereals in favor of locally-produced cereals. Research consequently focussed on understanding the determinants of wheat and rice consumption to evaluate the likely effectiveness of such a policy and its welfare consequences. Key parameters of interest were own-price, cross-price, and income elasticities. Price elasticities are important because they indicate to what extent tariffs on imported rice will achieve policymakers' objectives of reducing imported rice and wheat consumption and increasing consumption of locally-produced coarse grains. Income elasticity is important because it indicates whose welfare is likely to be affected.

Imported rice and wheat are consumed primarily, but not exclusively, in urban areas of the Sahel (Reardon, 1993). Since incomes in urban areas are higher

on average than incomes in rural areas it was assumed that the burden of tariffs on imported cereals would largely fall on the wealthier segment of Sahelian society. In Ouagadougou, Reardon et al., (1992) found that, while this assumption was true for wheat products (primarily bread), rice expenditure was unrelated to income level. Furthermore, incomes of the lowest tercile in the urban community were on a par or lower than average rural incomes. Consequently, a tariff on imported rice would likely be injurious to the urban poor.

5.1.2 Degree and determinants of substitutability between rice and coarse grains¹

Reardon et al. (1988) report negative cross-price elasticities between rice (grain and prepared form) and coarse grains for Ouagadougou (Burkina Faso), implying that an increase in the price of rice leads to a fall in the quantity of coarse grains purchased rather than an increase as desired by policymakers. For urban centers in Mali, Rogers and Lowdermilk (1988) found no significant effect of rice prices on coarse grain procurement.

The apparent low substitutability between wheat or rice and coarse grains is a matter of concern for policy makers, rural and urban consumers, and farmers. First, low substitutability undermines the effectiveness of fiscal policy as an instrument to discourage consumption of imported wheat and rice in favor of locally grown cereals. While higher prices for imported cereals would discourage their consumption through the negative effect on consumers' real incomes, consumption of local cereals might also decrease. Even for countries such as Mali with the

¹ This section is drawn from Dibley, Boughton and Reardon (1994).

potential to be self-sufficient in rice, achieving self sufficiency involves a balance of payments burden as a result of imported fertilizer, fuel, and spare parts. Second, the counterpart to low substitutability between grains is own-price inelasticity for each type of grain. Inelastic demand discourages the adoption of improved technology and constrains growth in marketed surpluses because small shifts in supply result in sharp price falls. Third, lack of substitution between rice and coarse grains in large urban centers will tend to increase price instability in cereal markets, undermining rural food security (Boughton and Sanogo, 1994). Finally, inability to switch to lower-priced coarse grains will aggravate the negative real incomes effects of the recent 50% devaluation of the CFA F for urban consumers. Thus, understanding the determinants of low substitutability between wheat or rice and coarse grains to design appropriate policies is a high priority.

Attempts to measure and explain the degree of substitution between rice and coarse grains are usually predicated on neoclassical consumption theory which predicts that consumption of different goods and services will depend on their relative costs. The cost of consuming a given cereal is made up of four components: (i) the cereal purchase price, (ii) processing costs, (iii) preparation costs, and (iv) complementary ingredients to make a sauce.² While many authors who seek to explain constraints to higher urban consumption of coarse grains in the Sahel emphasize that coarse grains are more costly and time consuming to process and prepare than rice (e.g., Thiombiano, 1986; Bricas and Sauvinet, 1989;

² Processing costs include all resources used to convert raw grain into the form in which it goes into the cooking pot (cleaning, dehulling, washing, milling, sieving), and preparation costs include all resources used to transform fully-processed grain into an edible dish.

Holtzman et al., 1991), there is no published empirical study that compares the complete set of costs for rice- and coarse grain-based dishes.

Rogers and Lowdermilk (1992) examine the relative cost of cooked rice and coarse grains for urban areas of Mali. They take account of milling costs and processing losses, but leave out fuel costs and the opportunity cost of women's time. Kennedy and Reardon (1994) incorporate proxy variables for the opportunity cost of women's time in quantitative analysis of cross-section determinants of household rice expenditures for Kenya and Burkina. They find that as opportunity cost of women's time rises, so does consumption of convenience foods (rice and wheat). This correlation implies that processing and preparation costs make rice more attractive and coarse grains less attractive as the opportunity cost of women's time rises.

But would a full accounting of rice and coarse grain processing and preparation costs confirm these explanations for low observed substitution? If complementary sauce costs are much higher for coarse grains than for rice, then a policy emphasis on reducing processing costs might be misplaced. Alternatively, if complementary sauce costs are lower for coarse grains, perhaps even more emphasis should be accorded to processing issues. If processing costs are not a major component when the opportunity cost of women's time is accounted for, perhaps more research on the way consumer preferences evolve in the urban environment is needed. If processing costs are a major component, then attention can be directed to opportunities to provide processing services at a lower cost. At the very least, a detailed breakdown of actual costs will help tailor the design of research and policy initiatives to the underlying structure of disincentives to

increased utilization of coarse grains. This gap in empirical studies to date underlines the need for the estimation of processing and preparation costs for rice and coarse grain-based dishes in the next chapter.

5.2 Objectives and methods of the Bamako cereal procurement and utilization surveys

The surveys had two closely related objectives: 1) to respond to the needs for detailed empirical information on cereal procurement and utilization identified in the last chapter, and 2) to provide a context for the design, implementation, and interpretation of results from consumer tests of processed maize products. This "context" can be broken down into three components. First, there was a need to identify a sample of respondent households diverse in the characteristics that could potentially influence demand for processed coarse grains in an important way (e.g., income level), and yet manageable in regard to the logistical requirements of consumer tests. Second, there was a need for preliminary information on household preferences that could help narrow down the range of processed products to be tested. Third, there was a need to establish rapport and confidence between the research team and the test households to improve the reliability of responses to questions concerning consumers' qualitative evaluation of and intentions to purchase test products.

To achieve these objectives a two-stage survey procedure was adopted. First, a single-visit survey of a representative sample of 640 urban consumption units³ was undertaken to obtain broad descriptive information on household

³ A formal definition of the unit of observation for the surveys is presented in the next section.

structure, demographic composition and cereal procurement and use. The second stage involved establishing a frequent-visit (weekly) survey of cereal procurement and utilization by 140 households selected to represent the range of variation in three key characteristics relevant to the potential demand for processed maize products: income, household size, and level of maize consumption. The methods for these two surveys are briefly described below. Empirical results are drawn primarily from the frequent-visit survey. Results from the first round survey are presented only where they usefully complement the frequent-visit survey.

5.2.1 Objectives, sampling method, and content of large sample single-visit survey⁴

The single-visit formal survey had three objectives:

- 1) to provide a sampling frame for the purposive selection of households to be included in consumer tests and the frequent-visit survey;
- 2) to obtain preliminary information on actual and potential use of pre-processed cereal products to inform the choice of products to be included in the consumer tests;
- 3) to obtain an initial but representative understanding of how maize fits into Bamako household cereal consumption patterns to serve as a benchmark for comparison with results from the smaller purposively selected frequent-visit survey sample.

The unit of observation for the survey is the "unité alimentaire" or food consumption unit (FCU). An FCU is defined by the Direction Nationale de la

⁴ This section draws heavily on Témé and Boughton (1993).

Statistique et de l'Informatique (DNSI) as the group of individuals who share at least one meal together per day (DNSI, 1991). This definition is an adaptation to the urban context of the traditional social unit "goua" (Bambara term for kitchen), comprising the group of individuals, usually related by blood, who eat from the same kitchen (Témé and Boughton, 1993). Thus an FCU could consist of a single individual (at the limit), or a single conjugal family unit (a married man with his wife or wives, his children and other dependents), or more than one conjugal unit. Regardless of the size of an FCU there is always a single acknowledged FCU head ("goua-tigi") responsible for ensuring the provision of cereals and condiments for the kitchen.⁵

The sampling frame for the single-visit survey was adapted from that developed by the DNSI for the national Enquête Budget Consommation conducted over 12 months during 1988 and 1989. In preparation for the 1987 population census, the entire country was mapped by the DNSI into geographical units termed "section d'énumération" (SE), encompassing 800 to 1000 inhabitants in rural areas and 1000 to 1500 inhabitants in urban areas (DNSI, 1991). Of the 560 SE that comprise the District of Bamako, 36 were randomly selected for the Enquête Budget Consommation. The reasons for adopting this sampling frame were twofold. The first was to avoid the enormously time consuming and costly task of creating one. The second was to be able to eventually compare results from the maize subsector

⁵ The term condiments refers to all the ingredients that are purchased to make the sauce to go with the cooked cereal. Such items include oil, tomato paste, onions, seasoning, herbs and spices, meat, dried fish and vegetables. Such items are generally purchased daily, in the morning, on neighborhood markets.

study with those of the Enquête Budget Consommation conducted five years previously.⁶

Although our single-visit survey was conducted in the same SE as the Enquête Budget Consommation, no attempt was made to interview the same FCUs. This was considered impractical in view of the high mobility of households within the District of Bamako, and between Bamako and rural areas. At the SE level, households were selected on a fixed interval. The interval was determined by dividing the estimated population of FCUs in the SE by the target number of FCUs to be interviewed. The target number of interviews was set at 18 FCUs per SE, the minimum considered necessary to be able to test for statistical differences between SE. The FCU population for a given SE was estimated as the average of the number of dwellings and the number of conjugal units in the SE (recorded by the DNSI for the 1987 census).⁷ Having determined the sampling interval, the first dwelling was selected at random and then all subsequent dwellings were selected on the basis of the fixed interval. All FCUs in a selected dwelling were interviewed. The process continued until the target number had been reached.

The questionnaire was divided into 7 sections as follows:

- **organization and management of the FCU**, including which meals are shared each day, daily expenditure on condiments (income proxy), and who contributes to food expenditures;

⁶ Definitive results from the Enquête Budget Consommation were not available at the time as the data were still in the process of being cleaned.

⁷ This crude approach to estimating of the number of FCUs was based on the simple logic that there could be more FCUs than the number of dwellings but not fewer, and there could be fewer FCUs but not more than the number of conjugal units.

- **demographic composition**, including age, sex, education, employment for each FCU member;
- **inventory of dishes consumed**, and frequency of consumption using different cereals by season;
- **actual and desired purchases of pre-processed cereals**, for each type of coarse grain and product;
- **cereal procurement strategies**, type of cereal, frequency of consumption, source, and whether purchased in bulk or in small quantities for each cereal;
- **cereal processing strategies**, type and method of processing undertaken for different cereals, and whether coarse grains are ever consumed without dehulling;
- **type of dwelling, durable goods and kitchen equipment inventory**

A total of 642 FCUs were interviewed in the 36 SE by a team of 4 female enumerators and two male supervisors in six weeks. Two DNSI cartographers also participated in delimiting the boundaries of the SE on the ground.

The survey fulfilled the objective of providing a sampling frame for the purposive selection of households for the consumer tests and in helping to focus the choice of products to include in the tests. In terms of generating an understanding of cereal consumption patterns, however, the survey proved difficult to analyze in a definitive way. Respondents, mainly housewives since the predominantly male household heads were usually absent, could not recall cereal procurement and use by season. Questions such as how frequently a given dish was prepared from a particular cereal were difficult to answer in general terms, because the woman prepared the dish using whatever cereal was in stock at the

time. It would have been better to focus on the specifics of consumption during the previous week, say, rather than trying to get an overview. Although there is an obvious risk of seasonal bias with such an approach, the results would have been more easy to interpret.

5.2.2 Objectives, sampling method, and content of the subsample frequent-visit survey

The frequent-visit survey had two objectives:

- 1) to provide a detailed understanding of cereal procurement in terms of type, form, quantities and sources of cereals procured over a 12-month period, and the utilization of cereals in terms of dishes prepared and processing methods employed;
- 2) to establish rapport and confidence between households and the survey team to improve the reliability of qualitative and quantitative responses to test products.

A purposive cluster sampling procedure was used for the selection of frequent-visit survey FCUs. A purposive approach was used to be able to estimate demand for groups of consumers with specific identifiable characteristics relevant to purchase decisions. A cluster sampling technique was appropriate to reduce the logistical demands of consumer tests of processed products. The natural cluster unit of selection is the SE, since by definition all FCUs belonging to a given SE are in close geographical proximity to one other.

With 4 female enumerators and an average of 18 FCUs per SE, it was considered that a maximum of 8 SE (i.e., 2 SE, or approximately 36 FCUs, per

enumerator) could be included in the frequent-visit survey out of the 36 SE covered by the single-visit survey.

The eight SE were selected as follows. FCUs in all 36 SE were classified according to level of daily condiment expenditure (income proxy), population, and frequency of maize consumption. SE were then classified according to whether they were comprised primarily of FCUs with high, medium, or low levels of these criteria. SE were then selected to represent the different combinations of income level and household size (with the exception of high income and high population that did not occur). Where more than one SE could represent a particular income/population combination, the SE with the higher frequency of maize consumption was chosen.

Information on cereal purchases and meals prepared was collected weekly. Quantity, type, form and cost information for all cereal, tuber, and fuel inflows, together with daily expenditures on condiments, were recorded from recall since the previous visit. All meals prepared during the preceding two days were recorded in terms of dish, staple, quantity used, form, processing methods and costs, and visitors/absentee family members. The household was visited every sixth day to avoid collecting information on meals prepared for the same days every week. FCU demographic information was updated monthly, except for two months when maize flour tests were in progress. Following the discovery of a correlation between daily condiment expenditures per adult equivalent and FCU total adult equivalent size, all non-food and away-from-home prepared food expenditures were recorded on a monthly recall basis after the third month to improve estimates of income.

5.3 Demographic characteristics of single-visit and frequent-visit survey households

This section compares the demographic characteristics of the single-visit and frequent-visit sample FCUs. Demographic characteristics include ethnic background, length of residence in Bamako, population, and employment. It will be seen that, with the exception of the proportion of household heads employed in the military, the small sample is very similar to the large sample in regard to most characteristics. The degree of similarity between the two samples is important for extrapolation of the potential demand for maize flour estimated in chapter 7.

Food consumption habits can vary according to ethnic group. Table 5.1 compares the ethnic background of FCU heads in the two samples. In both cases Bambara are the most prevalent, accounting for 39%. Peulh and Malinke follow, accounting for approximately a quarter in each sample. Soninke, Sonrai, Senoufo and Dogon together make up a fifth. FCU heads have lived in Bamako for an average of 19.2 years in the frequent-visit, and 19.1 years in the single-visit sample.

Table 5.2 presents the demographic characteristics for the large and frequent-visit samples in terms of total population, age and gender breakdown, and total adult equivalents. The only significant difference between the two groups is in regard to the mean number of children. Frequent-visit sample households have 0.8 more children on average. There is no evidence to suggest that there is any difference in the population variances for the two samples in regard to any demographic characteristic (Levene test).

Table 5.1: Ethnic Origin of Single-visit and Frequent-visit Survey Sample**FCU Heads**

Ethnic Group	Single-visit sample % FCU heads (N = 642)	Frequent-visit sample % FCU heads (N = 115)
Bambara	39.2	39.1
Peulh (Fulani)	13.4	15.7
Malinke	10.6	13.9
Soninke	8.1	5.2
Sonrai	6.1	3.5
Senoufo	4.0	5.2
Dogon	3.4	3.5
Others (<3% each)	15.2	9.6
Unknown	0	4.3
TOTAL %	100	100

Table 5.2: Age and Gender Composition of Single-visit and Frequent-visit Sample**FCUs**

Demographic variable	Single-visit sample	Frequent-visit sample
Women	2.80	2.71
Men	2.58	2.55
Children	3.96	4.78
Total persons	9.35	10.04
Adult equivalents	6.81	7.11
N	642	115

Note:

Adult equivalents: male > 14 years = 1.0; female > 14years = 0.8;
children = 0.5.

Table 5.3 presents the primary economic activity for household heads, women and men, for the single-visit and frequent-visit samples. Eighty primary economic activities were grouped into 13 categories for the analysis: none/retired, student, homemaker, unskilled labor, agriculture, technician, artisan/service, civil servant, military, professional, commerce, food seller and other. The most important categories for household heads are civil servant, military, merchant, none/retired, artisan/service and technician. The employment profile of household heads in the frequent-visit sample is similar to the single-visit sample with one exception. The frequent-visit sample has three times as many household heads in the military as the single-visit sample, but only two thirds the number of merchants. This is due to the fact that one of the frequent-visit survey SE incorporates a military base. The difference could have an impact on cereal consumption patterns as the military procures cereals for their employees, deducting the cost from their salary.

Excluding female heads of household, almost 80% of women are engaged in non-revenue generating primary activities. Among these, the most important category is homemaker, with student and none/retired accounting for the remainder. For the 20% of women engaged in revenue-generating activities, artisan/service, merchant and civil service are the most important. Frequent-visit survey households have proportionately 50% more women in the merchant category and 50% less in the artisan/service category, which could affect earnings. This may be related to the higher proportion of household heads with civil service posts. The stable income stream arising from this employment category could be a source of working capital for the purchase of women's inventory.

Table 5.3: Primary Economic Activity of FCU Heads, Women and Men in the Single-visit Survey (SVS) and Frequent-visit Survey (FVS) Samples

EMPLOYMENT CATEGORY	FCU HEADS		WOMEN		MEN	
	SVS	FVS	SVS	FVS	SVS	FVS
None/retired	16.8	12.2	14.9	11.0	21.4	15.9
Student	-	-	9.4	9.4	20.0	18.9
Homemaker	4.8	3.5	54.0	57.6	1.3	2.4
Unskilled Labor	3.1	4.3	-	-	0.5	-
Agriculture	5.9	4.3	0.8	-	3.4	4.3
Technician	11.7	13.0	0.1	0.4	18.4	23.2
Artisan/service	15.0	18.3	8.0	4.5	15.3	20.1
Civil Servant	13.2	11.3	3.3	3.7	3.9	2.5
Military	5.0	15.7	-	-	0.6	1.2
Professional	2.2	2.6	0.3	-	0.9	0.6
Merchant	17.9	13.0	6.2	10.2	11.7	11.0
Food Seller	1.1	1.7	1.9	2.9	0.2	-
Other	3.0	-	1.1	0.4	2.3	-
TOTAL	100	100	100	100	100	100

In contrast to women, 60% of non-household head men are engaged in revenue-generating activities. Of these, technician, artisan/service and merchant are the most important categories. There are no major differences between the single-visit and frequent-visit samples. Note that twice as many men are students than women for both samples.

Thirty percent of frequent-visit sample household heads are engaged in a secondary economic activity compared to only 20% for the single-visit sample (see Table 5.4). The main activities are agriculture, merchant, and artisan. The bulk of the difference between the two samples arises from the higher proportion of frequent-visit household heads engaged in agriculture as a secondary activity.

Nearly half of frequent-visit sample non-household head women are engaged in secondary economic activities compared to only a third for the single-visit sample. The most important activity is commerce, followed by food seller, homemaker, then artisan. The frequent-visit sample has proportionately more than half again as many women engaging in commerce as a secondary activity compared to the single-visit sample. Again, this may be related to the higher proportion of household heads employed as civil servants.

Table 5.4: Secondary Economic Activity of FCU Heads, Women and Men in the Single-visit Survey (SVS) and Frequent-visit Survey (FVS) Samples

EMPLOYMENT CATEGORY	FCU HEADS		WOMEN		MEN	
	SVS	FVS	SVS	FVS	SVS	FVS
None/retired	79.0	70.4	66.5	53.9	94.0	95.1
Student	-	-	0.1	-	-	-
Homemaker	0.8	-	3.7	5.7	-	-
Unskilled Labor	0.6	0.9	-	-	0.2	-
Agriculture	8.1	13.9	1.2	2.4	2.5	1.2
Technician	1.1	1.7	-	-	0.4	0.6
Artisan/service	3.1	5.2	3.9	4.9	0.6	0.6
Civil Servant	-	-	0.1	-	0.2	-
Military	-	-	-	-	-	-
Professional	0.3	0.9	-	0.4	0.2	-
Merchant	5.0	4.3	18.5	26.5	1.1	0.6
Food Seller	0.5	0.9	5.0	5.7	0.1	0.6
Other	1.6	1.7	1.0	0.4	0.6	-
TOTAL	100	100	100	100	100	100

In sharp contrast to women, only 6% of non-household head men are engaged in a secondary economic activity. Agriculture is the most important. Twice as many men in the single-visit sample are engaged in agriculture compared to the frequent-visit sample. Combining household heads and other men, the difference in the proportions of all males engaged in agriculture as a secondary activity is less marked: 6.5% for the frequent-visit survey and 4.7% for the single-visit survey.

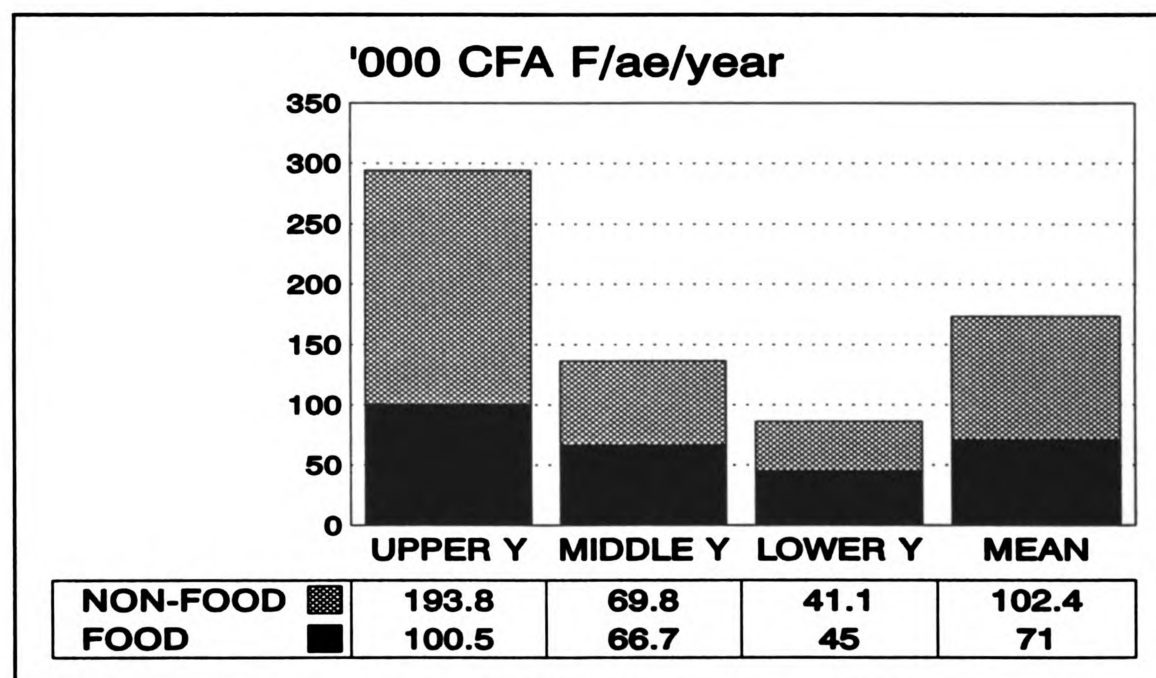
An important consideration is whether the difference in employment patterns is likely to have a significant impacts on income between the two samples. Daily expenditures on condiments (non-cereal ingredients) per adult equivalent (ae) were used as a proxy for income in the single-visit survey. Average daily condiment expenditures per ae were marginally lower for frequent-visit FCUs: 109.1 CFA F/ae compared to 114.6 CFA F/ae for the single-visit sample. Neither the difference in mean daily condiment expenditures between the two samples, nor in their variances, is statistically significant.

The small arithmetic difference in condiment expenditures between the two samples is due in part to the slightly larger family size of the frequent-visit sample. There exists a negative correlation between daily condiment expenditure per adult equivalent and household size, implying condiment cost economies in family size. This does not necessarily undermine the effectiveness of the proxy since income estimated on the basis of total expenditure per adult equivalent is also negatively correlated with family size.

5.4 Food and non-food expenditures of frequent-visit survey households

Average total FCU expenditure per adult equivalent amounted to U.S. \$ 294 on an annual basis (converted at the post-devaluation exchange rate of CFA F 590 = 1 U.S. \$). Ranking all households by total expenditure per adult equivalent and dividing into three groups (income terciles) reveals a highly skewed distribution with upper income tercile households spending more than three times the amount spent by lower income tercile households. The share of food and fuel in total expenditure also varies widely. Figure 5.1 shows that, compared to an average of 41% of total expenditure allocated to food and cooking fuel for the sample as a whole, upper tercile FCUs devote 34%, middle tercile FCUs 49%, and lower tercile FCUs 52% to this category.

Figure 5.1: Food and Non-food Expenditures per Adult Equivalent per Year by Income (Y) Tercile for Frequent-Visit Sample FCUs

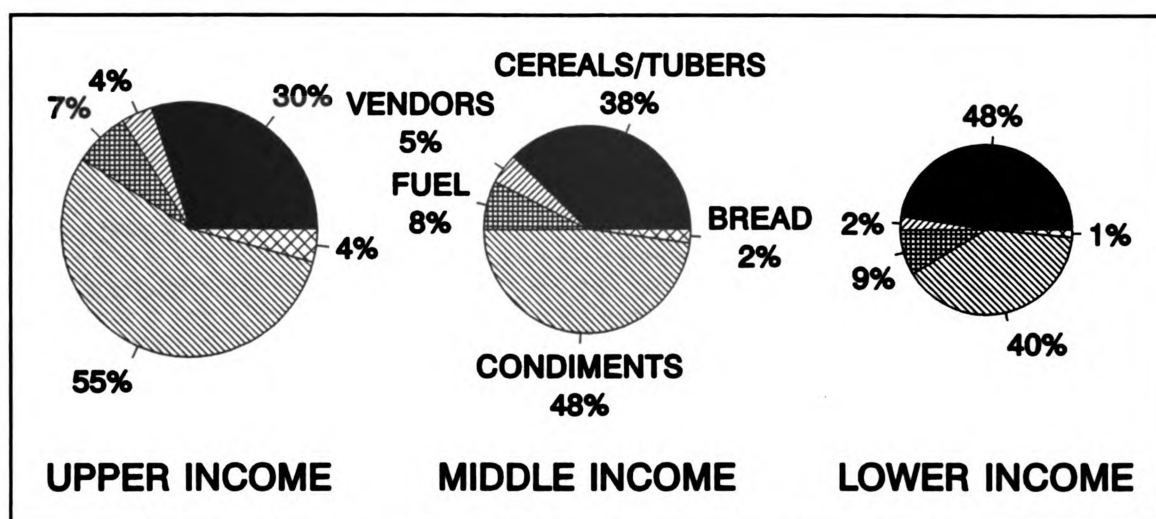


Expenditure shares for specific types of food also vary widely between income terciles (Figure 5.2 and Table 5.5). Average food and cooking fuel expenditures can be broken down as follows: cereals 34.5%, tubers 1%, bread 4%, condiments 50%, away from home meals 4%, and cooking fuel 7.5%. The expenditure share for cereals is highest for lower income tercile FCUs at nearly 50%, and declines to less than 30% for upper tercile FCUs, indicating that cereals are income-inelastic. On the other hand, average expenditure on condiments, bread and tubers rises with income tercile. Expenditure on condiments rises from less than 40% of all food and fuel expenditures for lower tercile FCUs to 55% for upper tercile FCUs. In absolute terms, expenditure on condiments rises dramatically with income, upper income tercile households spending three times as much per adult on condiments as lower tercile FCUs. Expenditure on vendor (away-from-home) meals rises with income in absolute terms, but the share decreases slightly from middle-income to upper income tercile FCUs. These results are consistent with findings of urban studies elsewhere in the Sahel (e.g., Reardon et al., 1988).

Part of the reason why total expenditure is so skewed may be due to an interaction between income and FCU population. Table 5.6 presents the number of FCUs in each income tercile in relation to the number in each population tercile. Over half of all lower income tercile FCUs are in the upper population tercile. Similarly, half of all upper income tercile FCUs are in the lower population tercile.

This distribution may have been accentuated by the fact that the respondent for the questionnaire on FCU expenditures was the FCU head. He or she may not be aware of all expenditures by family members, particularly those from independent and possibly undisclosed income sources. The larger the size of the

Figure 5.2: Food Expenditure Shares for Frequent-Visit Sample FCUs



Note: Cereal and tuber expenditure shares are combined in the figure

Table 5.5: Food and Energy Expenditures by Income Tercile for Frequent-visit Sample FCUs (CFA F per adult equivalent)

EXPENDITURE CATEGORY	INCOME TERCILE							
	UPPER (N = 39)		MIDDLE (N = 38)		LOWER (N = 38)		ALL (N = 115)	
	CFA F	p	CFA F	p	CFA F	p	CFA F	p
Cooking fuel	7190	.07	5020	.08	3865	.09	5375	.08
Cereals	28000	.28	24390	.34	21020	.47	24500	.34
Condiments	55270	.55	31900	.48	17915	.40	35200	.50
Bread	4190	.04	1420	.02	656	.01	2107	.03
Tubers	1842	.02	775	.01	444	.01	1028	.01
Food vendors	4010	.04	3220	.05	1120	.02	2800	.04
All food	100510	1	66730	1	45020	1	71010	1
All food	100510	.34	66730	.49	45020	.52	71010	.41
All non-food	193800	.66	69850	.51	41050	.48	102370	.59
TOTAL	294300	1	136580	1	86070	1	173380	1

Table 5.6: Relationship between Population and Income Terciles for Frequent-visit Sample FCUs

INCOME TERCILE	POPULATION TERCILE			TOTAL
	UPPER	MIDDLE	LOWER	
UPPER	4	16	19	39
MIDDLE	14	14	10	38
LOWER	21	8	9	38
TOTAL	39	38	38	115

family the more likely it is that expenditures take place without the knowledge of the FCU head. If true, this would introduce a downward bias in the estimation of total expenditure for large FCUs. However, the total expenditure per adult equivalent income proxy remains valid for the purpose of analyzing food expenditure and cereal procurement and utilization patterns since the FCU head is primarily responsible for providing the financial and/or in-kind resources to nourish the FCU regardless of its size. Thus, total expenditure per adult equivalent reflects the available resources for communal food provision even if it underestimates total disposable income of FCU members as FCU population increases.

5.5 Summary

This chapter described the survey instruments and sampling methods for the urban cereal procurement and utilization surveys in Bamako, and described the sample characteristics. From a demographic standpoint, the purposively selected frequent-visit survey sample is broadly representative of the characteristics in the larger random sample, with the exception of the higher proportion of military

households. This factor must be controlled for in estimates of demand for processed products. The sample varies widely in terms of total expenditure and food expenditure per ae, and especially in regard to expenditure on condiments.

CHAPTER SIX

CEREAL UTILIZATION PATTERNS AMONG BAMAKO HOUSEHOLDS:

SURVEY RESULTS

Chapter 5 described the survey methods used to capture cereal utilization patterns in Bamako, together with the characteristics of sample households. This chapter presents the principal results. The first section presents information from the large-sample single-visit survey on preferences for pre-processed coarse grain products. Respondents were asked about processed coarse grain products the household had purchased in the past, products they would like to purchase in the future, and the dishes to be prepared from those products. This information was the basis for the maize subsector team's decision to focus on urban demand for flour, estimated in the next chapter, as a means to broaden the market for maize grain.

The remaining sections provide an empirical description of household cereal procurement and utilization during the period December 1992 to November 1993, based on results from the frequent-visit survey. The analyses are guided by the maintained hypothesis that the demands for cereals and complementary processing services are jointly derived from the demand for meals (chapter 2). Section two provides an empirical overview of household cereal procurement by season and income group, and the form (unprocessed or processed) in which coarse grains are procured. The third section examines coarse-grain-based dishes consumed at principal mealtimes, and the processed form (flour or grits) required for

preparation.¹ Finally, the costs of household preparation of rice and toh (the principal coarse-grain-based dish), are estimated taking account of labor requirements, and processing costs and losses. For toh, the cost of the prepared dish using the modal practice of manual dehulling and custom milling is compared to the cost using grain purchased in dehulled form or as flour at estimated retail prices.

Together the analyses confirm that while the majority of coarse-grain-based dishes are prepared from flour, virtually all coarse grains are purchased in unprocessed form. The processed coarse grain products that consumers expressed a hypothetical demand for in the large-sample survey are for the preparation of traditional principal coarse-grain-based dishes rather than novelty or luxury products, or direct rice substitutes.² The detailed study of the costs of dish preparation reveals that household processing of coarse grains is cheaper than procurement of pre-processed coarse grains at the prevailing opportunity cost of women's time. Together these analyses provide a context for interpreting the econometric analysis of maize flour demand presented in chapter 8.

As background for the chapter it is useful to recall the steps required to prepare a typical coarse-grain-based dish from unprocessed grain. To make toh, for

¹ Grits are particles of flinty endosperm that vary in size according to the desired use. The proportions of grits and flour obtained from milling depends on the cereal and variety, and how closely the plates on the grinding mill are adjusted.

² The term "direct rice substitute" in this context implies the use of a processed coarse grain product in place of rice in a rice-based dish. The Cereals Technology Laboratory of IER developed a dehulled parboiled sorghum product called "SORI", a truncation of the French words for sorghum and rice, with support from INTSORMIL. Test marketed as a direct substitute for rice, it was regarded as an inferior product by consumers. An alternative strategy to facilitate substitution for rice would be to encourage the consumption of a higher proportion of coarse-grain-based dishes in the diet through the availability of cheap processed coarse grain products.

example, the outer layer of the grain (pericarp) must first be removed by a process called dehulling. Although mechanical (Engleberg-type) custom dehullers are available in the city, the majority of women dehull manually with pestle and mortar. The grain is then winnowed to separate it from the bran, and washed. The clean, dehulled grain (now at approximately 80% of the original whole-grain weight) is then ground into flour. Although this task can also be accomplished manually, the practice of taking dehulled grain to a local custom plate mill is almost universal. The flour is taken back to the home, sieved, and boiled into a thick paste. The cooked *toh* is eaten by dipping little cakes or patties of *toh* into an accompanying sauce. Rice, by contrast, need only be cleaned before cooking (hand-removal of small stones and other foreign material followed by washing).

6.1 Preferences for pre-processed coarse grains expressed in the single shot survey³

The 640 FCUs interviewed in the course of the single-visit formal survey were asked about processed coarse grain products they had bought in the past, and the kind of products they would like to be able to purchase on the market.

A high proportion of households had used pre-processed coarse grain products at some time, but did so infrequently. Of the 640 households interviewed, 73% had consumed at least one coarse-grain-based pre-processed product. Figure 6.1 shows the percentages of households that have used dehulled grain, grits or flour by type of cereal. Maize-based products account for the largest share, followed by sorghum, with millet-based products having the smallest. Looking at

³ This section is based on Témé and Boughton (1993).

coarse grains as a whole, dehulled grain was the most widely used product by sample households (46%), followed by grits (35%). Flour was the least common product, accounting for 19% of products cited.

While millet and sorghum have a similar product-mix, maize stands out because of the high proportion of households that have consumed grits and flour (Figure 6.1). The frequency of maize flour is due to the periodic availability of food aid cornmeal on Bamako markets during the two years prior to the maize subsector study.⁴ This product accounted for nearly 60% of all households who reported having procured flour (from any cereal, but excluding bread). The high proportion of households with experience of maize grits is due to the artisanal industry located in Bamako, described in chapter 4.⁵

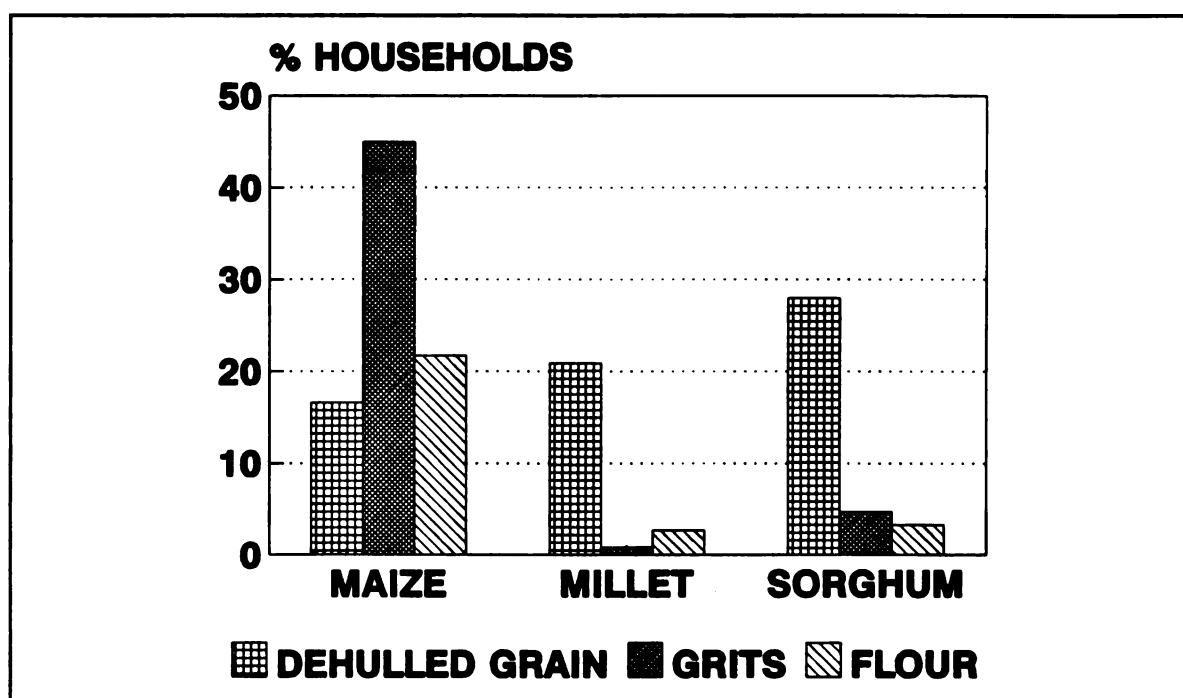
Although a high proportion of households have some experience with pre-processed coarse-grain-based products, consumption is relatively infrequent. For the majority of households, pre-processed products are consumed once a month or even less frequently. Among households that reported purchases of dehulled grain, those who consume it once a week or more range from 24% to 32% depending on

⁴ The product is degermed, vitamin-enriched cornmeal of USA origin supplied by the World Food Program. Packed in paper sacks, the stocks remaining in the market at the time of the study were heavily infested with weevils and could not be used in the consumption tests. Supplies on Bamako markets tended to be irregular.

⁵ As mentioned in chapter 4, the CERECOM project attempted to establish hammer mills in rural areas to compete with artisanal processors in Bamako. It has been unsuccessful because of several problems, including quality of raw material (the artisanal industry uses dark yellow, flinty varieties, mainly grown in the Kayes region), cleanliness of the final product, and the low proportion of medium-sized grits (the size preferred by consumers) obtained with hammer mills.

the cereal. Among households who purchase maize grits, 30% claimed to consume them once a week or more.⁶

Figure 6.1: Percentage of 640 Households Having Purchased Specific Processed Coarse Grain Products



Source: IER-MSU Maize subsector survey of 640 households (FCUs)

Information about constraints to the consumption of pre-processed products was difficult to obtain through the formal-survey instrument, with many respondents simply saying that they were not familiar with a given product. Flour provoked the strongest reactions, however, with 25% of respondents reporting a "lack of confidence" in flour sold in the market. The corresponding figure for the

⁶ This estimate proved to be somewhat high compared to results from the frequent-visit survey. This may be related to the seasonal nature of the artisanal maize grit industry. Maize grits from the new crop harvest were just arriving on the market at the time of the single-visit survey.

food aid cornmeal was less than 5%. For dehulled grains and grits, cost was the most commonly cited constraint after lack of familiarity.

In addition to providing an overview of current use of pre-processed coarse grain products, the survey also sought to find out the kinds of product consumers would like to procure. Respondents were asked the following open-ended question: "If good quality processed products were available on the market which would you like to buy?". Those specifying a product were also asked what type of cereal the product should be made from, and the kind of dish that would be prepared from it. Respondents were free to cite as many products as they wished. A total of 1840 product/dish combinations were enumerated by 570 respondents (89%). Figure 6.2A shows the percentage of respondents indicating a desire to purchase a specific product. With the exception of sorghum and millet flour, which show a significant increase over current utilization patterns, the results are similar to Figure 6.1. For dehulled grain, the proportion of respondents desiring to purchase is slightly higher than the current situation for all three grains. For maize grits, the proportion is slightly lower.

Processed products vary in the number and type of dishes that can be made from them. A respondent may indicate a desire to use one product for two or more dishes. Figure 6.2B shows the total number of dishes that respondents indicated they would prepare from different products. Flour and dehulled grain account for a higher proportion of dishes relative to grits.⁷

⁷ For flour, the number of dishes per respondent averaged 1.42, 1.49 and 1.43 for maize, millet and sorghum respectively. For dehulled grain, the corresponding averages are 1.75, 1.64, and 1.82. For maize and sorghum grits, the average number of dishes was 1.16 and 1.24.

Figure 6.2A: Percentages of 640 Households Wishing to Purchase Specific Processed Coarse Grain Products

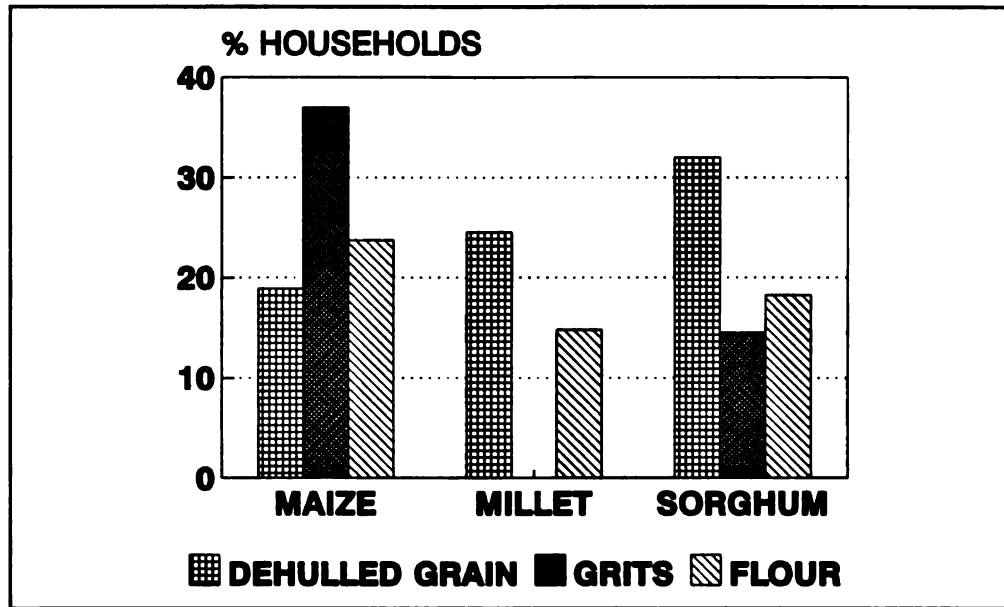
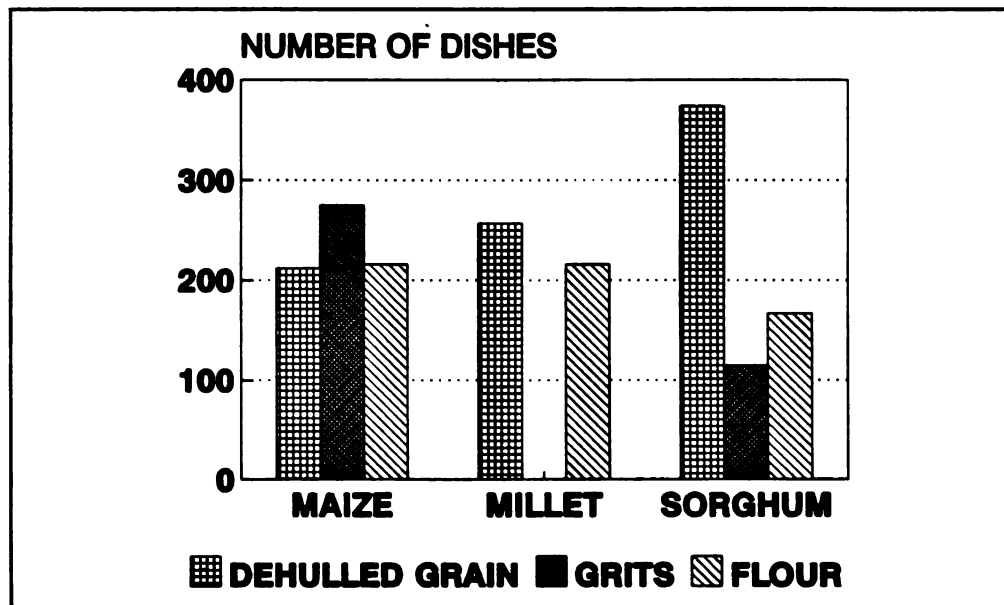


Figure 6.2B: Number of Dishes to be Prepared by Households Wishing to Purchase Specific Processed Coarse Grain Products



Source: IER-MSU Maize Subsector Study single-visit survey.

Perhaps the most surprising finding was that, in the majority of cases, respondents wishing to purchase dehulled grains and those wishing to purchase flour intended to use them to make the same dishes. Table 6.1 shows a breakdown of the percentage of households willing to purchase a given product (cereal and form) for the preparation of a specific dish. In the majority of cases, dehulled grains are intended for the preparation of flour-based dishes rather than grits-based dishes. This implies that the total (or latent) demand for flour is much higher than that indicated by the percentage of respondents indicating a willingness to purchase flour.

Two main reasons for the purchase of dehulled grains to make flour-based dishes emerged in the course of informal discussions. The first is a concern for product cleanliness. Dehulled grains, like grits, can be washed thoroughly prior to preparation. Flour cannot. Second, many housewives prefer to prepare meals from freshly milled flour. The implications for the potential demand for pre-processed flour are difficult to quantify. Casual observation suggests that packaging goes a long way to alleviating concerns about product cleanliness, as in the case of food aid cornmeal. The implications of preferences for freshly milled flour are much harder to quantify *a priori*, and therefore freshness was included as a criterion in the evaluation of test flours (chapter 7).

6.2 Household cereal procurement in Bamako

This section provides an overview of cereal procurement, including the type, amount and form of cereals procured by season and income group.⁸ The evolution

⁸ Procurement here refers to all sources, including purchases, gifts, remittances from family in the rural areas, and own-production.

Table 6.1: Percentage of Households Wishing to Purchase a Given Processed Product to Make a Specific Dish

DISH	MAIZE			MILLET			SORGHUM		
	Dehulled	Grits	Flour	Dehulled	Grits	Flour	Dehulled	Grits	Flour
FLOUR-BASED DISHES									
Moni	3.4	NA	6.7	14.1	NA	10.8	9.4	NA	6.1
Toh	15.2	NA	15.3	11.1	NA	6.1	26.9	NA	10.9
Couscous	7.7	NA	11.1	6.1	NA	3.3	15.9	NA	8.9
Other	0	NA	0	6.1	NA	2.0	0	NA	0
GRITS-BASED DISHES									
Seri	3.8	34.4	NA	2.0	0	NA	1.6	8.9	NA
Nyenye Kini	2.5	5.2	NA	0	0	NA	4.1	5.9	NA
Other	0.6	2.0	NA	0	0	NA	0	2.3	NA

Source: IER-MSU Maize Subsector Study single-visit survey.

of rice and coarse grain prices paid by frequent-visit sample households over the period December 1992 to November 1993 is described first. This is followed by an analysis of the quantities of different cereals purchased by season and level of income. For coarse grains, the analysis is disaggregated by form (unprocessed versus processed grain). The section closes with modified Engels curve analysis to quantify the importance of income and demographic factors as determinants of cereal demand.

6.2.1 Evolution of cereal prices paid by sample households from December 1992 to November 1993

Figures 6.3 A and B show the evolution of weighted monthly prices for coarse grains and rice respectively. Figure 6.4 shows the ratio of the price of rice to the price of sorghum, which can be conveniently interpreted as the number of kilos of sorghum that could be purchased for one kilo of rice in any given month at weighted average prices paid by sample households.

Prices for millet and sorghum were stable during the first five months of the year due to an adequate farm-level marketable surplus and large carryover stocks of coarse grains (Boughton and Sanogo, 1994). The fluctuation in maize prices paid by sample households does not reflect retail price levels in Bamako reported by the market information system (SIM), that show maize and sorghum prices to be almost identical over the period. The fluctuation is due to the combination of bulk purchases on rural markets by a small number of sample households and the small total volume of maize purchases by the entire sample. Coarse grain prices rose steadily between May and August, as farmers withheld stocks from rural markets

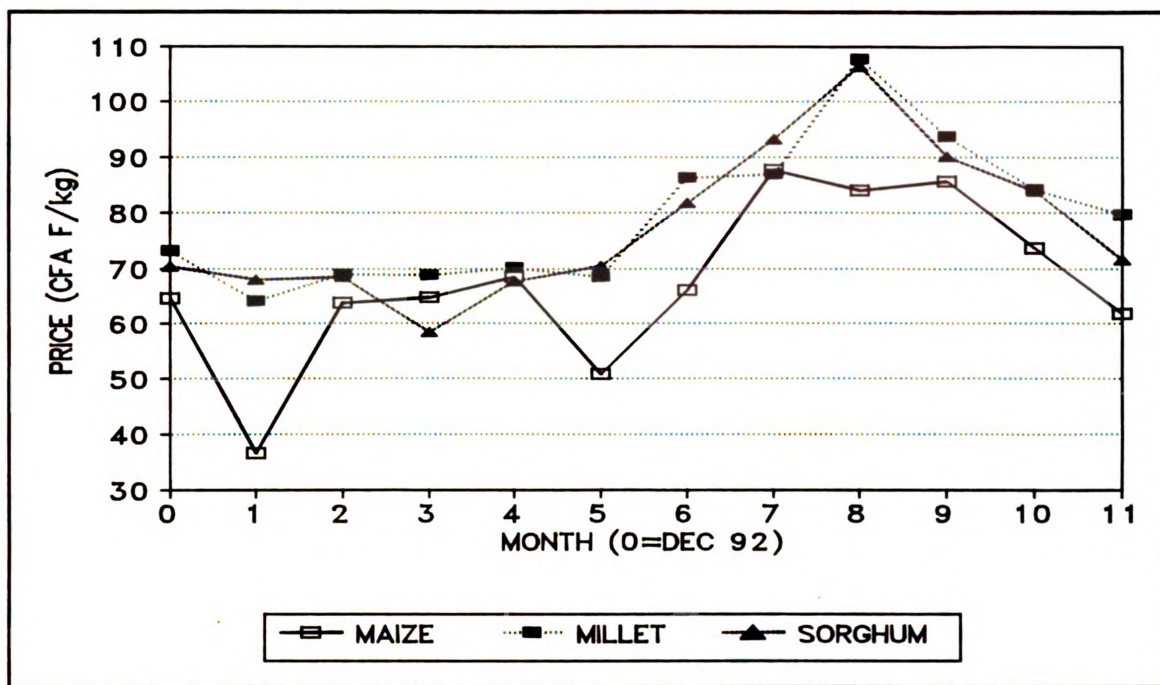
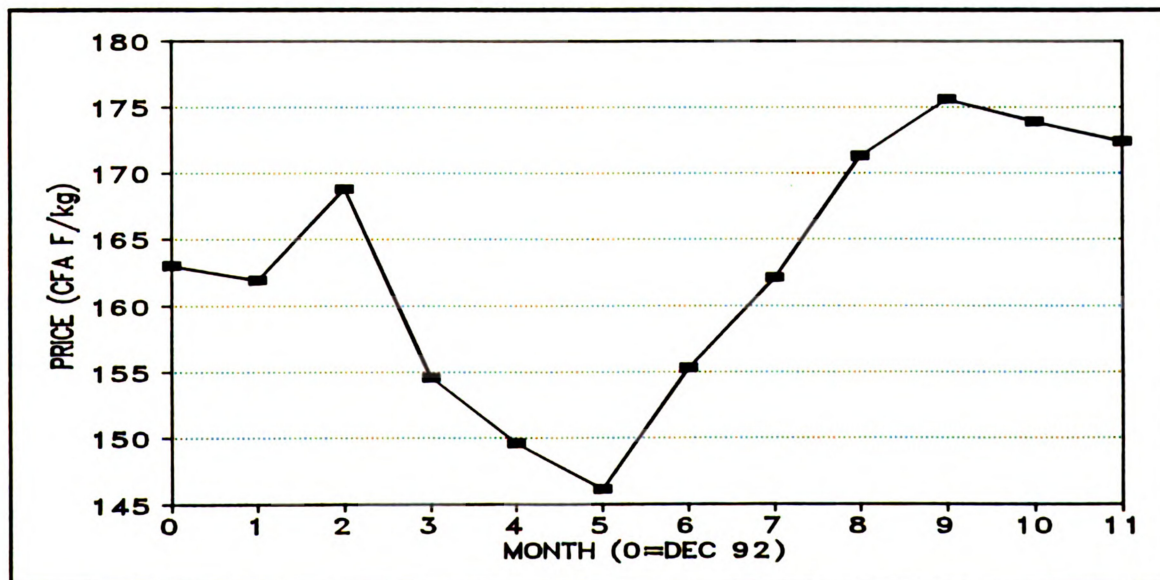
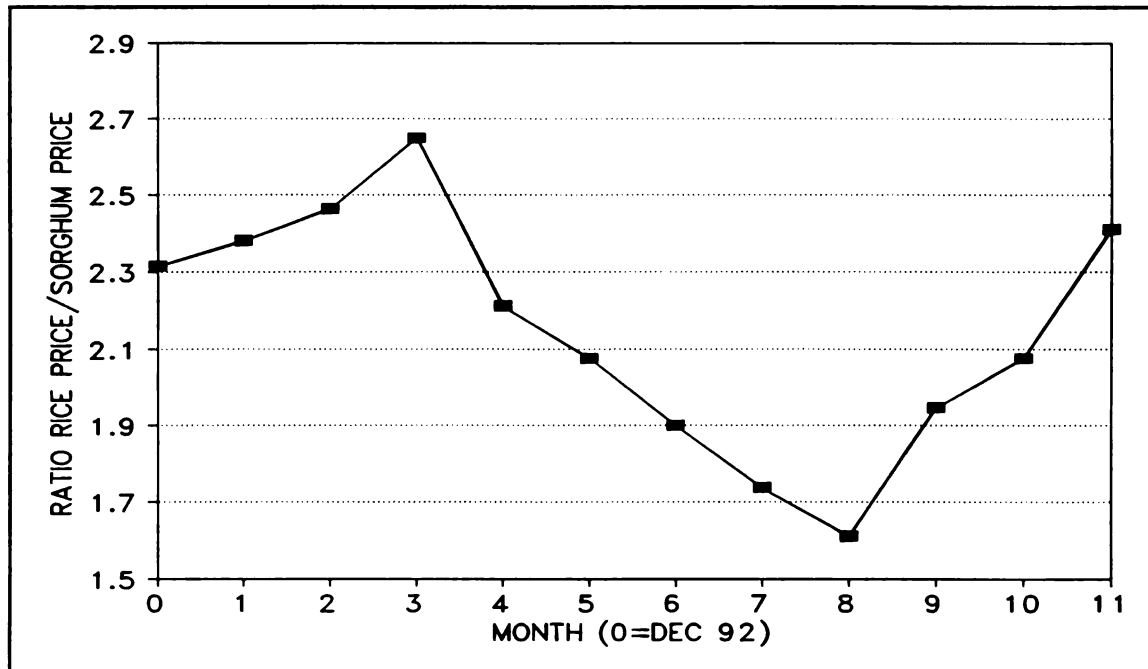
Figure 6.3A: Weighted Average Coarse Grain Prices Paid by Sample Households**December 1992 - November 1993****Figure 6.3B: Weighted Average Rice Prices Paid by Sample Households December****1992 - November 1993**

Figure 6.4: Ratio of Weighted Average Prices for Rice and Sorghum Paid by Sample Households December 1992 to November 1993



due to uncertainty about the rains, prompting imports of maize to Bamako from Côte d'Ivoire. Farmers' confidence improved when the rains became more regular during August. As coarse grains became more available on rural markets, facilitated by the arrival of local maize on the market, prices declined steadily during the remainder of the survey period.

In contrast to the relative stability of coarse grain prices during the first half of 1993, rice prices were turbulent. The price of local rice (the dominant category purchased by sample households) fell sharply during the period February through May, coinciding with the harvest of off-season paddy in the Office du Niger irrigated perimeters. Once local supplies became scarce the price quickly rose again, to the level of imported rice by July, and continued to rise through September in response to generally tight cereal stocks brought on by uncertainty concerning the rains.

As a result of considerable variation in rice prices throughout the year, and coarse grain prices during the rainy season, the ratio of the price of rice to the price of sorghum fluctuated widely (Figure 6.4). Rice initially became more expensive compared to sorghum until March, and then became progressively cheaper due to the availability of local rice. Despite increases in local rice prices from June onwards, rice continued to become relatively cheaper because sorghum prices rose even faster due to uncertainty about the rains. Only in September, when the local rice price peaked and the new maize harvest started to enter the urban market, did rice start to become relatively more expensive again.

In anticipation of the seasonal analysis of cereal procurement in the next section, Table 6.2 provides a synthesis of weighted average cereal prices by season for small and large volume purchases. The cold season refers to the four-month period November to February, coinciding with the arrival of the new coarse grain harvest on urban markets.⁹ The hot season is the four-month period March to June, which included most of the month of Ramadan.¹⁰ The wet season is the four-month period July to October. Viewed in a seasonal perspective, the price of sorghum relative to rice was about 14% lower during the cold season, and 13% higher during the wet season, compared to an average of 2.09 kg sorghum per kilo

⁹ Because the first full month of data was collected in December 1992, cold season analyses are based on the four months December 1992 until February 1993 plus November 1993. Although maize entering consumption in November 1993 is from a different crop year than that entering consumption in December 1992, the crop years were sufficiently similar as to justify this combination of months.

¹⁰ Ramadan is the lunar month when Moslems fast, neither eating nor drinking between dawn and dusk. Millet porridge (moni) is a traditional pre-dawn breakfast meal during this period.

Table 6.2: Weighted Seasonal Average Cereal Prices Paid by Sample Households (CFA F/kg)

CEREAL	COLD SEASON	% TOTAL	HOT SEASON	% TOTAL	WET SEASON	% TOTAL	ANNUAL AVERAGE	% TOTAL
WHITE MAIZE								
Q < 25 kg	63.6	12.2	74.4	3.8	76.4	3.6	68.2	6.3
Q > 25 kg	55.1	87.8	53.1	96.2	74.3	96.4	58.3	93.7
Mean	56.1	100	53.9	100	74.4	100	58.9	100
YELLOW MAIZE								
Q < 25 kg	62.7	18.9	68.5	13.3	79.9	8.0	68.4	13.1
Q > 25 kg	57.0	81.1	58.0	86.7	78.0	92.0	67.0	86.9
Mean	58.1	100	59.4	100	78.2	100	67.2	100
MILLET								
Q < 25 kg	75.1	11.5	74.7	18.6	89.1	15.8	78.4	14.9
Q > 25 kg	70.5	88.5	70.4	81.4	92.9	84.2	75.7	85.1
Mean	71.0	100	71.2	100	92.3	100	76.1	100
SORGHUM								
Q < 25 kg	72.9	24.4	74.5	27.4	93.8	34.6	81.6	28.8
Q > 25 kg	69.0	75.6	66.5	72.6	93.9	65.4	75.6	71.2
Mean	70.0	100	68.7	100	93.9	100	77.3	100
RICE (RM 40)								
Q < 25 kg	176.7	27.3	156.8	33.1	180.5	33.5	169.9	31.6
Q > 25 kg	162.7	72.7	148.0	66.9	165.3	66.5	157.9	68.4
Mean	166.5	100	150.9	100	170.4	100	161.7	100
RICE/SORGHUM								
Q < 25 kg	2.42	NA	2.10	NA	1.92	NA	2.08	NA
Q > 25 kg	2.36		2.23		1.76		2.09	
Mean	2.38		2.20		1.81		2.09	

Source: IER-MSU Maize Subsector Study frequent-visit survey.

of rice for the year as a whole. For both sorghum and rice, prices were approximately 8% higher for small quantities than for large (more than 25 kg). Approximately 70% of sorghum and rice was purchased in large quantities, and 85% or more for millet and maize.

6.2.2 Cereal quantities procured by season and income group

Despite seasonal variation in the absolute and relative prices of sorghum and rice, there was little variation in total household cereal procurement of coarse grains or rice between seasons (Table 6.3). The share of coarse grains by weight remained close to the year-round average of 44.6%. While the cold season peak share of 48% coincided with a period when coarse grain prices were low in absolute terms and relative to rice, it also coincided with the harvest of home-produced millet by sample households.

There is greater seasonal variation in the mix of coarse grains than between coarse grains and rice. The share of millet in total coarse grains is highest during the cold season at 32%, and declines to almost half that level in the wet season. Sorghum rises from 58% in the cold season to 68% in the hot and wet seasons. Grain maize reached a peak of almost 13% of coarse grain procurement during the wet season in response first to imports of maize from Côte d'Ivoire, and subsequently to the arrival of domestically produced maize on Bamako markets ahead of the millet and sorghum harvest. With the arrival of newly harvested millet and sorghum at the end of the wet season, the share of maize declined to 9% in the cold and 5% in the hot seasons, by which time grain maize supplies were relatively scarce.

Table 6.3: Seasonal Household Cereal Procurement in Bamako (kg/ae)

Sample		COLD SEASON PROCUREMENT (November-February)						
Income	N	Maize	Millet	Sorghum	Fonio	All CG	Rice	TOTAL
Low	38	3.0	11.9	23.3	0.11	38.3	25.2	63.5
Middle	38	2.0	6.2	16.8	0.12	25.1	38.4	63.5
High	39	3.3	12.5	15.7	0.30	31.7	39.1	70.8
All	115	2.7	10.2	18.6	0.18	31.7	36.3	66.0
		HOT SEASON PROCUREMENT (March - June)						
Income	N	Maize	Millet	Sorghum	Fonio	All CG	Rice	TOTAL
Low	38	0.9	4.2	24.9	0.09	30.0	27.1	57.1
Middle	38	1.0	5.7	18.8	0.38	25.9	39.3	65.1
High	39	2.8	11.7	14.8	0.74	30.1	44.8	74.9
All	115	1.6	7.2	19.4	0.40	28.7	37.1	65.8
		RAINY SEASON PROCUREMENT (July - October)						
Income	N	Maize	Millet	Sorghum	Fonio	All CG	Rice	TOTAL
Low	38	3.7	2.1	28.8	0.14	34.8	29.4	64.2
Middle	38	3.4	4.4	15.4	0.27	23.5	37.5	61.0
High	39	3.6	7.5	12.6	1.10	24.8	42.3	67.0
All	115	3.5	4.7	18.9	0.50	27.6	36.5	64.1
		YEAR ROUND PROCUREMENT						
Income	N	Maize	Millet	Sorghum	Fonio	All CG	Rice	TOTAL
Low	38	7.6	17.8	71.8	0.29	97.6	79.9	177.4
Middle	38	6.2	16.3	51.1	0.74	74.4	115.3	189.7
High	39	9.4	32.0	42.4	2.12	85.8	125.1	210.9
All	115	7.8	22.1	55.0	1.06	85.9	106.9	192.8

Source: IER-MSU Maize Subsector Study frequent-visit survey.

Notes:

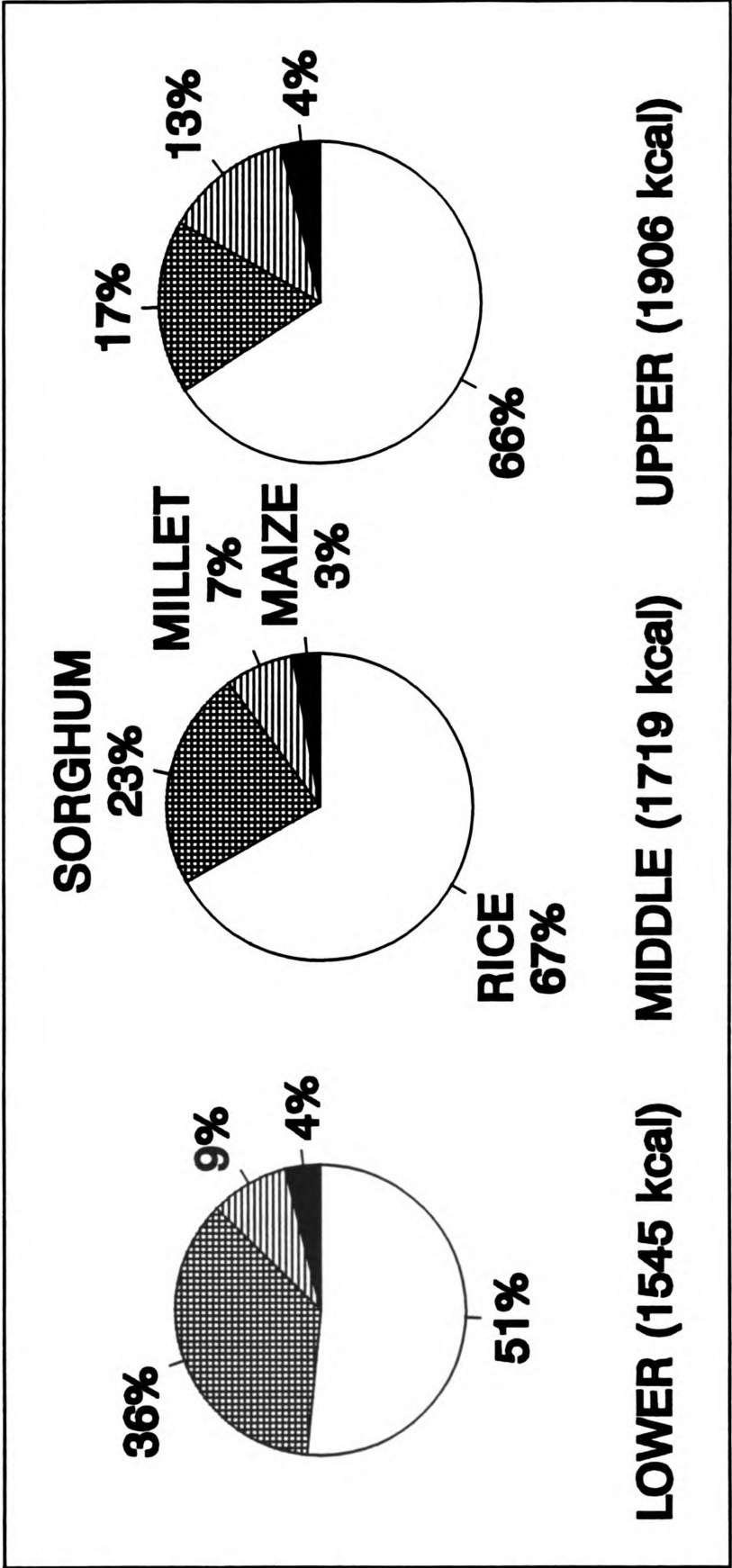
1. All procurement expressed in kilograms per adult equivalent. Coarse grains are expressed in the form of whole grain.
2. Adult equivalents: male > 14 years = 1.0; female > 14 years = 0.8; children = 0.5.
3. Period analyzed is December 1992 to November 1993. The cold season implies December 1992 to February 1993 and November 1993.
4. All CG = All Coarse Grains (Maize + Millet + Sorghum + Fonio).
5. Excludes maize flour provided for consumption tests.

There is notable variation in both the quantity and mix of cereal procurement between income terciles (Table 6.3). Total cereal procurement from all sources, including own production and gifts, was 6% less for lower income tercile households compared to the average of 193 kg per adult equivalent (ae), and 11% greater among households in the upper tercile. The share of coarse grains in total cereal procurement is highest for the lower income tercile at 55%, compared to roughly 40% for the middle and upper terciles.

The mix of coarse grains also varies between income terciles. Sorghum accounts for 74% of coarse grain procurement by households in the lower income tercile, compared to 49% for the upper tercile. Millet shows the reverse tendency. Millet accounts for 37% of upper income tercile coarse grain procurement, compared to 22% and 18% for the middle and lower terciles respectively. According to consumers, the main reason given for the dominance of sorghum relative to millet is the lower losses incurred in processing sorghum (Témé and Boughton, 1993). Maize does not show any consistent trend between income terciles.

Differences in the proportions of coarse grains and rice in total cereal procurement between income terciles result in larger differences in calorie availability than differences in total cereal procurement might suggest. This is due to processing losses incurred in the preparation of coarse grains for human consumption. Figure 6.5 shows average calorie availability per adult equivalent by cereal type for each income tercile. Whereas the low income tercile have 6% less cereals per adult equivalent than the sample average in terms of weight, they have 10.5% less when measured in available calories.

Figure 6.5: Average Daily Calorie Availability from Cereals per Adult Equivalent by Income Tercile



Source: IER-MSU Maize Subsector Study frequent-visit survey.

Note: Figures in parentheses are average daily calorie availability from cereals per adult equivalent available from cereals.

The relative contribution of rice and coarse grains also changes when cereal procurement is measured in calorie terms. The share of rice in total cereal calorie availability rises to two thirds for the middle and upper income terciles, and to half for the lower tercile. Maize falls to 4% for the lower and upper terciles, and 3% for the middle income tercile.

6.2.3 Form in which coarse grains are procured by season and income tercile

In order to prepare coarse-grain-based dishes, cereals must first be processed into flour and/or grits. Households can either purchase cereals in a semi-processed (dehulled) or fully-processed (grits or flour) form in the market, or purchase unprocessed grain and organize processing at the household level. A very high proportion of coarse grains are purchased in unprocessed form.

Table 6.4 shows the proportion of different cereals purchased in processed or unprocessed forms by season and income tercile. Proportions for processed products are expressed in whole-grain equivalent terms. Average proportions for a given cereal are weighted by the amount of that cereal procured by each household in the income tercile. For millet and sorghum, unprocessed and dehulled grains account for 99% of annual procurement. Other processed products (accounting for the remaining 1%) are not included in the table.

Looking at year-round procurement for all coarse grains, 91% are obtained in unprocessed form. The proportion varies considerably with income. Upper income tercile households procure double, and lower tercile households half, the sample average proportion of cereals in processed form. The proportion also varies

Table 6.4: Form of Procurement by Type of Coarse Grain (Percent Each Grain)

Sample		COLD SEASON PROCUREMENT (November - February)									
Income	N	Maize				Sorghum		Millet		All CS	
		Grain	Dehull	Grits	Flour	Grain	Dehull	Grain	Dehull	Grain	Dehull
Lower	38	.87	.01	0	.13	.97	.03	.97	.03	.96	.03
Middle	38	.73	.12	.14	.01	.93	.07	.95	.05	.92	.07
Upper	39	.88	.02	.09	.02	.89	.11	.86	.14	.88	.11
All	115	.83	.04	.06	.07	.94	.06	.93	.07	.93	.06
		HOT SEASON PROCUREMENT (March - June)									
Income	N	Maize				Sorghum		Millet		All CS	
		Grain	Dehull	Grits	Flour	Grain	Dehull	Grain	Dehull	Grain	Dehull
Lower	37	.82	.02	0	.16	.99	.01	.90	.02	.97	.01
Middle	37	.89	.02	0	.09	.90	.08	.88	.11	.90	.08
Upper	37	.97	.03	0	0	.82	.18	.79	.21	.82	.18
All	111	.91	.025	0	.07	.94	.06	.84	.13	.91	.07
		RAINY SEASON PROCUREMENT (July - October)									
Income	N	Maize				Sorghum		Millet		All CG	
		Grain	Dehull	Grits	Flour	Grain	Dehull	Grain	Dehull	Grain	Dehull
Lower	37	.91	.0	.02	.07	.94	.06	.91	.01	.94	.05
Middle	37	.68	.20	.12	.01	.93	.05	.88	.12	.88	.08
Upper	37	.89	.03	.08	.0	.83	.17	.86	.14	.85	.14
All	111	.82	.08	.07	.03	.92	.07	.88	.11	.90	.08
		YEAR ROUND PROCUREMENT									
Income	N	Maize				Sorghum		Millet		All CG	
		Grain	Dehull	Grits	Flour	Grain	Dehull	Grain	Dehull	Grain	Dehull
Lower	38	.88	.01	.01	.10	.97	.03	.94	.02	.96	.03
Middle	38	.73	.15	.10	.02	.92	.06	.91	.09	.90	.08
Upper	39	.91	.03	.06	.01	.85	.15	.83	.17	.85	.15
All	115	.84	.06	.05	.05	.93	.06	.89	.10	.91	.07

Note: 8% of millet procured by low income households in hot season, and 9% in rainy season, was procured in the form of flour (3.3% year round average).

considerably between cereals. Maize has the highest proportion of processed products at 16%, followed by millet with 12%, and sorghum the smallest at 7%. This is the reverse order to the total quantity consumed for each cereal.

There is no marked seasonal trend in the procurement of all processed products. Rather, seasonal effects appear to be cereal- or income tercile-specific. Demand for processed millet was highest in the hot season, when Ramadan took place, and particularly high among upper income tercile households. In contrast, no purchases of maize grits were recorded during the same period, compared to 6% of all maize in the cold season and 7% in the wet season. Middle income tercile households purchased the highest proportion of maize in this form. Demand for maize flour was highest among the lower income tercile, but almost 60% of all purchases were made by a single household. This indicates the particular difficulty of drawing inferences about a minor commodity with a small sample.

The principal conclusions from this analysis are that a very high proportion of coarse grains are obtained in unprocessed form, and dehulled products account for the majority of the remainder. As for total quantity and mix of coarse grains, income appears to play an important role in the form in which coarse grains are procured. The next section undertakes a quantitative analysis of the role of income in the demand for coarse grain products.

6.2.4 Engel curve analysis

An Engel curve can be defined as "the relationship between total income and the quantity purchased or amount spent on a particular food or commodity group" (Tomek and Robinson, p. 19). In this section we use regression analysis to

construct modified Engels curves similar to the procedure used by Kennedy and Reardon (1993). The dependent variable is the quantity of a given cereal/form procured in a given season (kg per adult equivalent). As in the previous section, processed coarse grains are measured in terms of whole grain equivalent. The independent variables include, in addition to income, the same demographic variables that will be used in the analysis of flour demand in the next chapter, together with seasonal dummy variables. Demographic variables include household size and composition, employment characteristics of the household head, and proxy variables for the opportunity cost of women's time. A full list of variable names and definitions is given in Table 6.5.

Since Ordinary Least Squares (OLS) regression gives biased estimates when the dependent variable has zero value for some observations, modified Engels curves are estimated using maximum likelihood estimation of a standard censored Tobit model.¹¹ The only exception to this is for rice where, because the product is consumed by almost all households in all seasons, OLS regression is appropriate. Models were estimated with and without squared income terms. The decision on which model to present was based on the value of the Likelihood Ratio test statistic for the explanatory power of the squared income term, using the .05 level of significance as a threshold. For OLS estimation of rice, the corresponding F-statistic was borderline significant and results for models with and without the squared income term are presented.

¹¹ The statistical structure of the Tobit model, and its application to the demand for cereal products, is discussed in detail in the next chapter. The reader should note, however, that because of the model's latent variable structure the estimated coefficients cannot be directly interpreted as partial effects.

Table 6.5: Variables Included in the Engel Curve Regressions

VARIABLE NAME	VARIABLE DEFINITION	TYPE	UNIT
C	Constant		
EXPTOTAE	Income per ae	continuous	CFA F/ae
EXPTOTSQ	Income per ae squared	continuous	CFA F
MEANAE	Household size	continuous	ae
MEANAESQ	Household size squared	continuous	ae
FEMRATIO	Women ratio	proportion	
KIDRATIO	Child ratio	proportion	
MAID	Domestic employee present	dummy	Maid employed = 1
FINACT	Women with primary cash activity	proportion	
CHEFSEXE	Household head gender	dummy	Female HH head = 1
REGION	Region of origin	dummy	Sikasso region = 1
CIVSERV	Civil servant	dummy	Household head CS = 1
MILITARY	Military	dummy	HH head military = 1
MILXYAE	Military by income	interaction	CFA F/ae
MILXY2AE	Military by income squared	interaction	CFA F
HOT_SEAS	Hot season dummy	dummy	Hot season = 1
WET_SEAS	Wet season dummy	dummy	Wet season = 1

Regression results are presented in Table 6.6. We look first at the results for rice, then unprocessed coarse grains, and finally processed coarse grains.

Unlike coefficients estimated using the Tobit model, the OLS estimates for rice can be interpreted as partial effects. In the model with only a linear income term, household rice procurement increases by 0.6 kg/ae/season (1.8 kg/ae/year) for each additional 10,000 CFA F/ae/year increase in household income as measured by total expenditure. In the model with a quadratic income term, the corresponding estimate for the linear component of income is 0.816 kg/ae/season (2.45 kg/ae/year). The quadratic income term itself is not significantly different from zero, however. The model's additional explanatory power, just significant at the .05 level, comes from the interaction between squared income and the dummy variable indicating a household head in the military, which procures rice for employees and their families. Households where the head is employed in the military procure 11.3 kg/ae/season more than non-military households.

Tobit regression estimates of the relationship between income and the procurement of different types of unprocessed coarse grains closely reflects the earlier empirical description by income tercile. The addition of demographic variables reveals some striking differences between millet and sorghum, however.

For sorghum the linear income term is negative and highly significant. Sorghum procurement is positively related to family size (significant at the .01 level). Procurement is also positively related to employment of a maid, which can be thought of as putting a ceiling on the opportunity cost of women's time in the

Table 6.6: Modified Engel Curve Regression Results

VARIABLE	MAIZE GRAIN	MAIZE DEHULLED	MAIZE GRITS	MILLET GRAIN	MILLET DEHULLED	SORGHUM GRAIN	SORGHUM DEHULLED	RICE R ² = .26	RICE R ² = .25
CONSTANT	-16.29***	-10.4**	-7.969***	17.92**	-5.111	4.882	0.798	41.31***	40.24***
EXPTOTAE	0.045	0.543*	0.095**	0.617***	0.815***	-1.148***	0.122	0.604*	0.816***
EXPTOTSQ	NA	-0.014	NA	NA	-0.008**	0.0143*	NA	0.003	NA
MEANAE	0.346	-0.07	0.443	-0.712	-0.048	2.424***	-0.231	-2.006***	-1.848***
MEANAESQ	-0.023	-0.015	-0.042	0.016	0.002	-0.497***	0.005	0.04***	0.038***
FEMRATIO	9.74	-0.958	0.697	-30.85**	-16.3***	16.732	-15.59**	-19.589**	-24.71***
KIDRATIO	15.77***	5.488	4.858*	-16.15*	-6.618*	8.7187	-4.592	1.369	-1.561
MAID	-0.01	-0.407**	-0.016	-0.014	-0.005	0.03**	0.021	-0.001	0.001
FINACT	-0.01	0.001	0.778***	0.015**	0.007**	-0.003	0.013**	0.001	0.001
CHEFSEXE	1.154	2.16	1.88	-9.831	-1.547	-10.697*	5.495*	-4.973	1.15
REGION	0.007	-0.002	-0.001	-0.013	-0.005	3.637*	0.027	0.002	0.001
CIVSERV	-1.246	-0.797	-2.134*	2.934	-1.96	6.758*	0.358	-5.175*	-2.877
MILITARY	0.011	87.78**	2.885	6.973	3.672	0.251	-6.123	11.31*	0.05
MILXYAE	0.039	-92.95**	-3.487	-0.687	-0.99	1.22	0.0893	-1.907	0.838**
MILXAESQ	NA	3.699**	NA	NA	0.018	-0.048	NA	0.119**	NA
HOT_SEAS	-3.798**	-1.177	-3.838***	-1.083	1.198	0.741	0.525	3.123	3.124
WET_SEAS	2.352	1.111	1.345**	-10.86***	-1.416	-3.132	0.92	1.045	1.024

Notes:

1. Regression models are Standard Censored Tobit except rice which is OLS.

2. Inclusion or exclusion of squared income terms is based on Likelihood Ratio test.

3. For rice, the equivalent F-test is borderline at the .05 level and therefore specifications with and without squared income terms are reported.

4. Coefficients significant at the .01 level are denoted ***, at the .05 level **, and at the .10 level *.

household.¹² The small proportion of female-headed households in the sample procure less sorghum (significant at the .10 level). Households where the head is from the Sikasso region (sorghum is the region's dominant cereal in area and production terms) procure more, as do households where the head is employed in the civil service (both coefficients significant at the .01 level).

Millet procurement patterns stand in sharp contrast to sorghum, despite very similar market prices during the year. With the exception of seasonal dummy variables, the sign on most coefficients is reversed from the estimates for sorghum. The linear income term is positive and highly significant. Whereas sorghum procurement is positively (but not significantly) related to the proportion of women in the household, an indicator of the opportunity cost of women's time, millet is negatively related to the proportion of women and children in the household (significant at the .05 and .01 levels respectively). This is consistent with the positive coefficient on the proportion of women in the household with a cash-earning primary activity (significant at the .01 level). The sharp differences observed between millet and sorghum raise a warning signal for interpretation of the results of urban consumption analyses that combine millet and sorghum into a single dependent variable (e.g., Rogers and Lowdermilk, 1991).

Other than the expected signs on the seasonal dummy, the regression for unprocessed maize provides few insights. The highly significant coefficient on the ratio of children in the household may reflect a common belief that maize is more

¹² In the last section we estimate the opportunity cost of a maid, generously, at 50 CFA F/hour (approximately 0.70 US dollars per day at the post-devaluation rate of exchange).

nutritious than other coarse grains, but with such low levels of maize grain consumption any attempt at inference would be heroic.

The regression results for processed coarse grains lend support to the hypothesis that demand for processed cereals (including rice) is positively related to the opportunity cost of women's time (e.g., Kennedy and Reardon, 1993). As in the case of rice, demand for dehulled millet and sorghum is negatively related to the proportion of women in the household (significant at the .01 level for millet, and at the .05 level for sorghum). Kennedy and Reardon argue that the higher the proportion of women in the household the greater the availability, and hence lower the opportunity cost, of labor for processing household cereals. Thus a negative coefficient indicates a positive relationship between opportunity cost of women's time and purchase of processed cereals that take less time to prepare.¹³ Further evidence in support this relationship is the positive coefficient on the proportion of women in the household with a primary cash-earning activity (significant at the .05 level for both millet and sorghum). For dehulled millet the coefficient on the linear component of income is positive and highly significant. The coefficient on the quadratic income component is negative (significant at the .05 level) indicating that demand eventually peaks and subsequently falls as income progressively rises.

Procurement of processed maize shows similar traits to that of millet and sorghum, although the small proportion of households with non-zero procurement suggests a need for caution in regard to inference. The linear income term is positive (significant at the .05 level for grits, and at the .10 level for dehulled grain). The proportion of women with a primary cash-earning activity is positive and highly

¹³ In the last section we show that the preparation of *toh* from dehulled coarse grain can be accomplished as quickly as cooked rice.

significant for women. Employment of a maid in the household is negatively related to procurement of dehulled maize (significant at the .05 level). Procurement of dehulled maize was focussed among military households, a variable which also has a significant effect on estimated demand for maize flour (chapter 7).

In general, the regression results confirm the role of income observed in the empirical description of procurement by income tercile. Incorporation of demographic variables lends support for the hypothesis that the demand for processed cereals is positively correlated with the opportunity cost of women's time in the household.

6.3 Cereal consumption patterns: mealtimes and dishes prepared

Households have a choice in the procurement of processing services for coarse grains. One option is to purchase products with those services already embedded in the product, as in the case of maize grits. Another option is to procure whole grain in the market and process it at the household level, buying some manual or mechanical custom services outside the household for certain stages (e.g., dehulling, milling). Still another option is to purchase semi-processed products such as dehulled millet or sorghum in the market, and complete the remaining processing stages under household supervision.

Whatever option for the provision of processing services households choose from the available opportunity set, the services necessary are implicit in the choice of dish. Some coarse-grain-based dishes are flour-based, others are grits-based. The difference lies in the fineness with which the endosperm is ground. This section will examine the dishes consumed at different mealtimes in order to derive

the proportions in which coarse grains are required in particular forms. This is important information given that the maize subsector was diagnosed as a thin market (chapter 4). If demand for a processed maize product is to have a significant impact on broadening the subsector (i.e. increasing the proportion of farm-level production that is marketed), it must by definition address a volume rather than a "niche" market.

The analysis proceeds as follows. First, the proportion of each main meal prepared from different cereals is presented by income tercile. Coarse grains are dominant at breakfast and dinner. Next the analysis focuses on the coarse grains group. An overview of the proportion of different coarse-grain-based dishes prepared from flour and grits is calculated for each type of coarse grain. Flour is dominant for all coarse grain types. The analysis is disaggregated further to identify key dishes prepared from grits and flour at different meals, the latter informing the design of consumer tests of maize flour in the next chapter. The section concludes with a reflection on the historical emphasis of donor efforts on the promotion of maize grits.

Table 6.7 presents the percentage of main meals prepared by frequent-visit survey households from different cereals over a one-year period by income tercile. For the sample as a whole, maize and other coarse grains combined represent the primary source of cereal calories for breakfast and dinner meals, accounting for 61% and 56% respectively. Taken on its own, maize accounts for 6% of breakfast meals and 7% of dinner meals. Analysis by income tercile reveals, as expected from coarse grain procurement, that the share of coarse grains at breakfast and dinner declines consistently as income rises. Rice is the primary source of cereal

Table 6.7: Frequency of Cereal Consumption at Principal Mealtimes by Income**Tercile (proportions of meals prepared)**

INCOME GROUP	CEREAL	BREAK-FAST	LUNCH	COMBINED MEAL	DINNER
LOWER N = 38	MAIZE	.06	.03	.04	.06
	MILLET/SORGHUM and FONIO	.68	.27	.40	.60
	RICE	.17	.62	.54	.25
	BREAD	.06	.01	0	.02
	NON-CEREAL	.03	.07	.02	.07
MIDDLE N = 38	MAIZE	.05	.02	0	.07
	MILLET/SORGHUM and FONIO	.52	.14	.23	.50
	RICE	.30	.79	.75	.27
	BREAD	.12	.02	0	.04
	NON-CEREAL	.01	.03	.02	.12
UPPER N = 39	MAIZE	.06	.03	.05	.07
	MILLET/SORGHUM and FONIO	.47	.14	.21	.37
	RICE	.16	.76	.71	.24
	BREAD	.30	.02	.01	.11
	NON-CEREAL	.01	.05	.02	.21
ALL N = 115	MAIZE	.06	.02	.04	.07
	MILLET/SORGHUM and FONIO	.55	.19	.27	.49
	RICE	.21	.72	.67	.25
	BREAD	.16	.02	<.01	.06
	NON-CEREAL	.02	.05	.02	.13

Source: IER-MSU Maize Subsector Study frequent-visit survey.

calories at lunch or for combined lunch/dinner meals (i.e., household prepares only one main meal a day in addition to breakfast), accounting for 72% and 67%, respectively, averaged over the sample as a whole. The poorest income tercile has the lowest proportion of rice-based meals at lunch and lunch/dinner combined.

Table 6.8 shows the proportions of coarse-grain-based dishes prepared from flour and grits by type of coarse grain over the year. The average proportion of flour-based dishes, weighted by the proportion of dishes prepared from each coarse grain type, is 0.84. Maize is disaggregated into yellow and white maize, as the latter was used in the consumer tests discussed in the next chapter. The proportion of flour-based dishes is highest for millet and lowest for yellow maize. This is consistent with their grain structures, maize having the highest proportion of horny endosperm and millet the lowest. Even in the case of yellow maize, however, almost two thirds of dishes consumed were prepared from flour.

Table 6.8: Proportions of Coarse-grain-based Dishes Prepared from Flour and Grits

COARSE GRAIN	WHITE MAIZE	YELLOW MAIZE	MILLET	SORGHUM	ALL COARSE GRAINS
SHARE ALL DISHES	.02	.07	.23	.68	1
FLOUR SHARE	.74	.65	.90	.85	.84
GRITS SHARE	.26	.35	.10	.15	.16

Although flour is a key processed product for all coarse grains, people do not eat flour. People eat prepared dishes. Since the qualities sought from flour by consumers may differ from one dish to another, it is important to identify the most frequently prepared dishes at each mealtime. Table 6.9A presents this information for white and yellow maize, Table 6.9B the corresponding information for millet and

sorghum. At breakfast, moni, a thin porridge with small flourballs in it, is the most common dish for all coarse grain types. At lunch, dinner or combined lunch/dinner, toh, a thick porridge served as round patties that can be dipped in a sauce, is the most common dish for all coarse grain types. Couscous, made from small steamed flourballs, is also frequently consumed at these mealtimes, accounting for up to 19% for millet or sorghum. The concentration of flour use on a few key dishes greatly facilitates consumer tests.

But if flour is so important, why have past donor efforts focussed on maize grits? Donors have been attracted by maize grits and parboiled dehulled sorghum as potential substitutes for higher-priced rice.¹⁴ Grits-based dishes can be made from either coarse grain grits or broken rice. In Bamako, competition is focused on "seri", a thicker form of porridge than moni. Rice is virtually never used in Bamako to make "Nyenye kini", popular in rural areas where rice is more expensive relative to coarse grains than in Bamako, or other coarse-grain-based dishes prepared from grits. But rice dominates in the preparation of seri, accounting for 55% of seri dishes consumed at dinner, and 62% of seri dishes consumed at breakfast time. Although a higher proportion of maize is used for the preparation of seri than other coarse grains, the small total quantity of maize procured leaves it with a diminutive market share of only 8% of all seri dishes.

The constraints to successful penetration of the household market for seri by maize grits appear to be threefold. First, it takes considerably longer to cook maize grits than rice. Second, because there is always a small proportion of grits in flour

¹⁴ In French, the word "brisures" can be used for either coarse grain grits or broken rice, encouraging the idea that the two are potentially close substitutes.

**Table 6.9A: Form in which White and Yellow Maize are Prepared
by Mealtime, Cereal and Dish**

WHITE MAIZE				
FORM/DISH	BREAKFAST (N = 45)	LUNCH (N = 10)	COMBINED MEAL (N = 24)	DINNER (N = 23)
FLOUR				
Moni	.72	0	0	.07
Toh	0	.90	.84	.70
Couscous	0	.10	.14	0
Other flour	0	0	0	.02
All flour	.72	1	.98	.79
GRITS				
Seri	.28	0	0	.19
Nyenye Kini	0	0	.02	.02
Other grits	0	0	0	0
All grits	.28	0	.02	.21
YELLOW MAIZE				
FORM/DISH	BREAKFAST (N = 68)	LUNCH (N = 22)	COMBINED MEAL (N = 33)	DINNER (N = 55)
FLOUR				
Moni	.54	.05	0	.09
Toh	.01	.73	.74	.48
Couscous	0	.15	.15	.04
Other flour	0	.04	.01	.04
All flour	.55	.97	.90	.65
GRITS				
Seri	.45	0	0	.34
Nyenye Kini	0	.03	.10	.01
Other grits	0	0	0	0
All grits	.45	.03	.10	.35

Source: IER-MSU Maize Subsector Study frequent-visit survey.

**Table 6.9B: Form in which Millet and Sorghum are Prepared
by Mealtime, Cereal and Dish**

MILLET				
FORM/DISH	BREAKFAST (N = 104)	LUNCH (N = 38)	COMBINED MEAL (42)	DINNER (N = 102)
FLOUR				
Moni	.78	.04	0	.47
Toh	0	.60	.63	.27
Couscous	0	.12	.23	.04
Other flour	.09	.16	.09	.08
All flour	.87	.92	.95	.86
GRITS				
Seri	.13	.04	.02	.13
Nyenye Kini	0	.03	.03	0
Other grits	0	.01	0	.01
All grits	.13	.08	.05	.14
SORGHUM				
FORM/DISH	BREAKFAST (N = 102)	LUNCH (N = 65)	COMBINED MEAL (N = 84)	DINNER (N = 88)
FLOUR				
Moni	.82	.03	0	.23
Toh	.03	.63	.65	.47
Couscous	0	.18	.23	.14
Other flour	0	.01	.01	.01
All flour	.85	.85	.89	.84
GRITS				
Seri	.15	.03	.02	.12
Nyenye Kini	0	.10	.07	.03
Other grits	0	.01	.01	.01
All grits	.15	.15	.11	.16

Source: IER-MSU Maize Subsector Study frequent-visit survey.

after milling, households accumulate grits over time as a by-product of sifting flour to make toh and moni. Third, maize grits are expensive to produce because only 50% - 60% of the grain is comprised of horny endosperm, depending on the variety. The rest is bran or floury endosperm that has a very low commercial value.¹⁵ While the local plate mills used by artisanal manufacturers of maize grits can be adjusted to capture a high proportion of horny endosperm as grits of the size preferred by consumers, hammer mills can only recover about 30% of the initial whole grain weight. This combination of disadvantages has led to maize grits fulfilling a "niche" market position, consumed by higher income households or as a treat.

The historic focus of donors on maize grits as a direct substitute for rice in the preparation of a given dish ignores a major dimension of substitution: that of coarse-grain-based dishes in place of rice-based dishes. The argument has frequently been made that if coarse-grain-based dishes could be made significantly cheaper to prepare than rice, then this would lead to greater substitution of coarse grains for rice. Regardless of the prospects for substitution between coarse grains and rice, flour is a more appropriate choice of processed coarse grain product than grits for the purpose of broadening the maize subsector given their respective volumes in the preparation of coarse-grain-based dishes.

¹⁵ For reasons that are not fully understood, flour obtained as a by-product of grit manufacture cannot be used to make toh or moni. In the case of hammer mills set up by the CERECOM project, this is probably due to the high proportion of bran and germ that ends up in the flour. But even artisanal manufacturers of maize grits consume the flour by-product in their own households rather than attempting to sell it.

6.4 Costs of preparing principal rice and coarse grain based dishes¹⁶

Chapter 5 observed that many studies of cereal consumption in the Sahel cited the additional processing costs of coarse grains as a likely cause of low substitutability with rice, but that there were no empirical studies that took into account all the relevant costs of preparing rice and coarse-grain-based dishes. This section will address this research gap by answering three key questions:

- 1) What are the relative costs of rice and coarse grain based dishes, with and without complementary sauce costs?
- 2) What are the shares in total cost of individual processing and preparation stages?
- 3) Are pre-processed coarse grains (e.g., dehulled grain or flour) cheaper to consume than coarse grains processed in the household?

Contrary to prevailing opinion, the results show that, despite higher processing costs, coarse-grain-based dishes are cheaper than rice-based dishes. The main contributory factors to the higher cost of rice-based dishes are sauce cost, cereal cost and preparation (cooking) time. Although sauce costs magnify the difference in cost between rice and coarse-grain-based dishes, the latter are still cheaper when differences in sauce cost are ignored (i.e., comparing only the costs of the prepared cereal). The result holds true over a wide range of rice and coarse grain prices, and opportunity costs of women's time, suggesting that the finding may apply more generally to the urban Sahel than just Bamako. Coarse-grain-based dishes need not take longer to process and prepare than rice-based dishes if the dehulling step is mechanized. However, pre-processed coarse grains are not

¹⁶ This section is drawn from Dibley, Boughton and Reardon (1994).

competitive with household processing given present technology and opportunity costs of women's time.¹⁷ Nor will coarse-grain-based dishes retain the extent of their cost advantage over rice-based dishes as incomes and labor opportunity costs rise without improvements in the efficiency of processing services.

Differential sauce costs are an important determinant of relative total dish costs. Flexibility in rice sauce composition and quality provides households with the option to absorb increases in rice prices in part through lower expenditure on sauce. Similarly for *toh*, the principal coarse-grain-based dish, households have the option to prepare one or two sauces. This flexibility may be a contributory factor to low observed cross-price elasticities of substitution between rice and coarse grains.

The analysis proceeds as follows: (i) discussion of research methods and measurement of women's opportunity cost of time, (ii) comparison of processing and preparation costs for *toh* and rice at the household level, and (iii) comparison of costs for home and pre-processed coarse grains.

6.4.1 Research methods

The study was undertaken for a subset of 30 households. A female enumerator observed and timed all aspects of the processing and preparation of 18 *toh* and 12 rice dishes, one in each household.¹⁸ All costs incurred from market

¹⁷ Household processing does not imply manual processing at all stages. Household processing means that all processing stages from grain to cooking pot are under the supervision of the household. Mechanical or manual processing services could be purchased at one or more stages (e.g., custom milling).

¹⁸ Although *toh* and rice dishes were not prepared by the same households, the households are located in the same areas of the city and hence have similar socio-economic characteristics. The reason for the larger number of observations for *toh* is the higher expected variability in total cost for this dish due to multiple processing tasks.

purchase to final consumption were measured in terms of money and time. These include the cost of grain, potash,¹⁹ sauce ingredients, fuelwood used to prepare the dish, dehulling, cleaning, milling, sifting, and cooking. Transport costs were recorded but are ignored in the analysis because all cereals and ingredients are available in the same local market and hence do not vary by dish. These costs are grouped into four cost categories for the analysis: cereal, processing, preparation and sauce.²⁰ A summary of costs accounted for is given in Table 6.10.

For each dish and component of expenditure the average time or cash outlay per kilogram of cereal prepared is calculated for the whole sample, weighted by the quantity of cereal prepared in each household. Labor input (time) per kilo of cereal prepared is valued at the opportunity cost of women's time (see below). The sauce consists of a base made from water, tomato paste, onions and seasoning, to which meat and fish can be added according to the level of the household income. Only expenditures for the basic sauce are included.

Toh was prepared from sorghum in 10 cases, maize in 6, and millet in 2. The purchase price and processing costs did not differ widely among the three cereals.²¹ Observations on toh prepared from different coarse grains are therefore

¹⁹ Potash is used to improve and preserve the consistency of toh, a portion of which may be kept overnight for consumption the following morning.

²⁰ Differences in the amortization of kitchen equipment used to prepare rice and toh are insignificant and therefore ignored. Additional equipment needed for coarse grains are a wooden mortar, pestle and sieves. Sieves are replaced annually at a cost of 200 CFA F, while a mortar and pestle lasts a minimum of ten years, replaced at 2000 CFA F. Differential amortization amounts to less than one CFA F per meal.

²¹ Maize must be soaked for approximately four hours after dehulling and before the grain is milled. This does not preclude other activities and hence is not counted as a time cost. Nevertheless, the added inconvenience is one factor limiting more widespread consumption of maize in urban areas.

pooled. Preparation costs vary according to whether one sauce (11 cases) or two sauces (7 cases) were prepared. Preparation of an additional sauce did not affect total preparation time but involved additional expenditure on sauce ingredients. The total cost of the prepared dish is reported for both one and two-sauce options.

Table 6.10: Cost Items and Categories Accounted for in Estimation of the Cost of Rice and Coarse-grain-based Dishes

COST CATEGORY	CEREAL		CASH EXPENDITURE		TIME EXPENDITURE
	RICE	COARSE GRAIN	GOOD	SERVICE	
CEREAL	✓	✓	✓		✓
PROCESSING					
Dehulling/winnowing		✓			✓
Cleaning	✓				✓
Milling/sieving		✓		✓	✓
PREPARATION					
Preparation	✓	✓			✓
Fuelwood	✓	✓	✓		
Potash	✓	✓	✓		
SAUCE	✓	✓	✓		✓

Three methods of valuing the opportunity cost of women's time were considered: (i) the legal minimum wage, (ii) the cost of domestic help, and (iii) women's reported earnings in the informal sector. The legal minimum wage was rejected for two reasons. First, it is only relevant to a minority of women working in the formal sector. Second, even for this group the minimum wage does not accurately reflect opportunity cost since the four salaried employees in the sample all hired a maid to prepare and cook meals. Average remuneration for domestic help of 9000 CFA F per month (wage plus board) implies an opportunity cost of time of

50 CFA F per hour.²² This figure is similar to earnings in the informal sector more generally. Sample women engaged in petty commerce, for example (the most common secondary activity), reported an average daily income of 300 CFA F (range 125 CFA F to 500 CFA F). Assuming six hours of commerce daily, the opportunity cost of time is again 50 CFA F per hour. Thus, whether a maid is hired to prepare food or whether income from informal sector activities is foregone, an estimate of 50 CFA F/hour seems reasonable.

6.4.2 Processing and preparation costs for coarse grains and rice

The computation of the costs for prepared rice and toh was carried out in two steps. First, average cash and labor costs per kg of rice or unprocessed coarse grain were calculated, weighted according to the quantity of cereal prepared by the household. Second, weighted average costs per kg were converted into costs per 1,000 kcal assuming an energy content of 3630 kcal/kg for rice and 2810 kcal/kg unprocessed coarse grains (Kelly et al., 1993).²³ Figure 6.6 displays the shares in total dish cost of cereal, processing, preparation and sauce costs for toh and rice.

²² Wages are 4000 CFA F per month. We value board at 200 CFA F per day, the cost of two meals. Assuming 25 days worked per month, the total wage is 9000 CFA F per month, or 45 CFA F per hour based on eight hours work per day. We adjust up to 50 CFA F per hour. 9000 CFA F per month is roughly equal to one-third of the minimum wage.

²³ The denominator of consumable energy is the most objective basis of comparison. Comparing the costs of cooked rice and toh per kilo of raw grain consumed would ignore the processing losses for coarse grains and underestimate their true cost. Comparing the costs of cooked rice and toh per kilo of cooked cereal would be determined in part by relative water absorption rather than nutritional content. The estimate of 2810 kcal/kg of unprocessed coarse grains incorporates an adjustment for 20% processing losses.

Table 6.11 presents the average cost of toh and prepared rice dishes, expressed in CFA F per 1,000 kcal of consumable cereal.

The total cost of prepared rice is higher than toh, although the share of processing and preparation in total cost is lower. The price of uncooked rice is nearly 1.7 times that of coarse grains, whereas the cost of prepared rice (ignoring sauce costs) is only 1.3 times that of toh. This reflects the higher processing costs of coarse grains (15% of the total cost of toh compared to less than 3% for rice). But rice sauce costs more than sauce for toh. Taking account of sauce costs, the total cost of prepared rice rises to almost 1.6 times the total cost of toh.

Figure 6.6: Cost Components for Rice and Toh

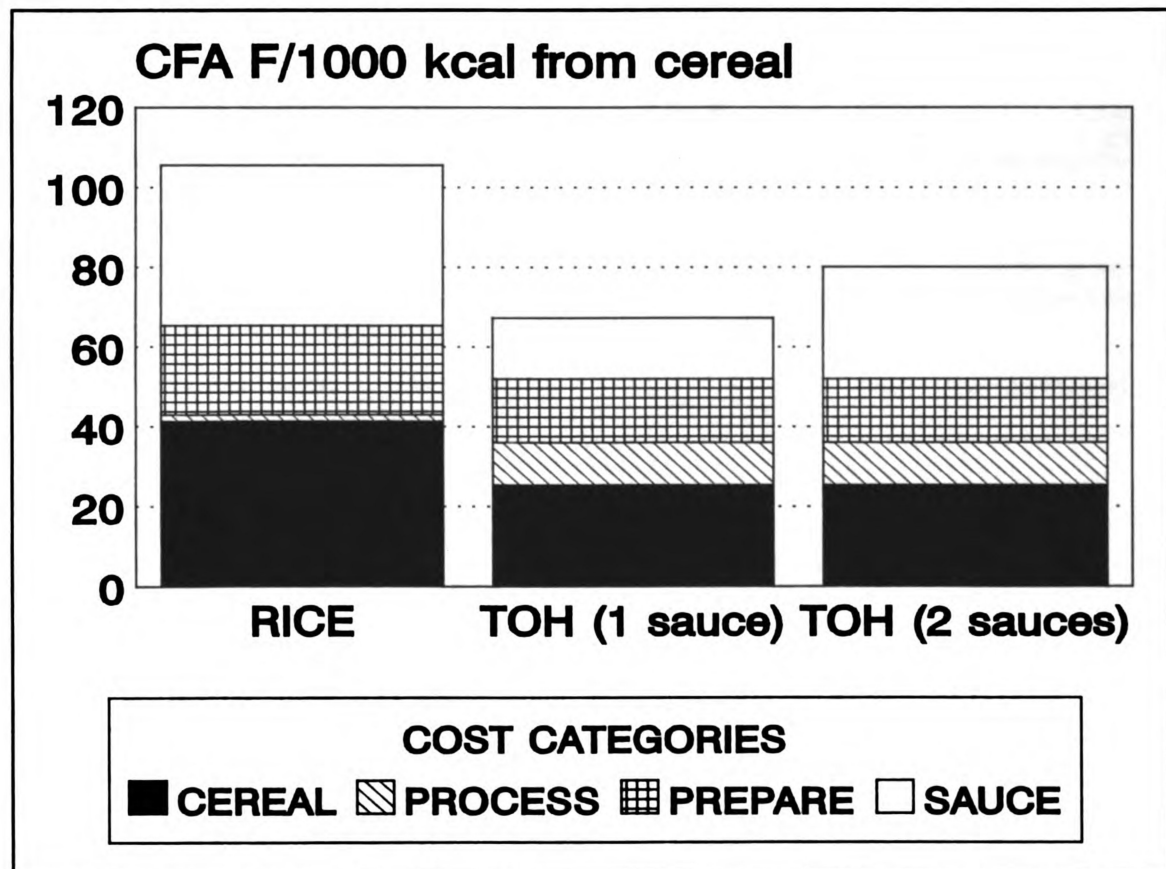


Table 6.11: Costs of Prepared Rice and Toh (CFA F/1000 kcal)

Cost Item	RICE (N = 12)	TOH (N = 18)	RICE/TOH
CEREAL COST	41.3	25.3	1.66
PROCESSING COSTS			
Dehulling time	0	3.6	
Cleaning time	1.6	0.9	
Milling time	0	2.7	
Milling cost	0	3.6	
SUB-TOTAL PROCESSING COST	1.6	10.7	0.15
PREPARATION COSTS			
Preparation time	13.1	7.4	
Fuelwood cost	9.4	7.5	
Potash cost	0	1.1	
SUB-TOTAL PREPARATION COSTS	22.5	16.0	1.41
TOTAL COST PREPARED STAPLE	65.4	51.9	1.26
Sauce cost	40.2	15.3	2.63
(with optional second toh sauce)	40.2	28.1	1.43
TOTAL COST PREPARED Dish	105.6	67.2	1.56
(with optional second toh sauce)	105.6	80.0	1.32

Notes:

- All costs are converted from CFA F/kg to CFA F/1,000 kcal assuming an energy content of 3630 kcal/kg for rice and 2810 kcal/kg for unprocessed coarse grains, adjusted for processing losses (Kelly et al., 1993)
- Costs are based on the following average household labor time (minutes) and cash expenses (CFA F) per kilo of cereal prepared:

	RICE	TOH
Cereal purchase price (CFA F)	150	71
Milling charges (CFA F)	-	10
Firewood (CFA F)	34	21
Potash (CFA F)	-	3
Sauce ingredients (CFA F)	146	43
2nd toh sauce ingredients (CFA F)	-	36
Dehulling time (minutes)	-	12
Cleaning time (minutes)	7	3
Milling time (minutes)	-	9
Preparation time (minutes)	57	25

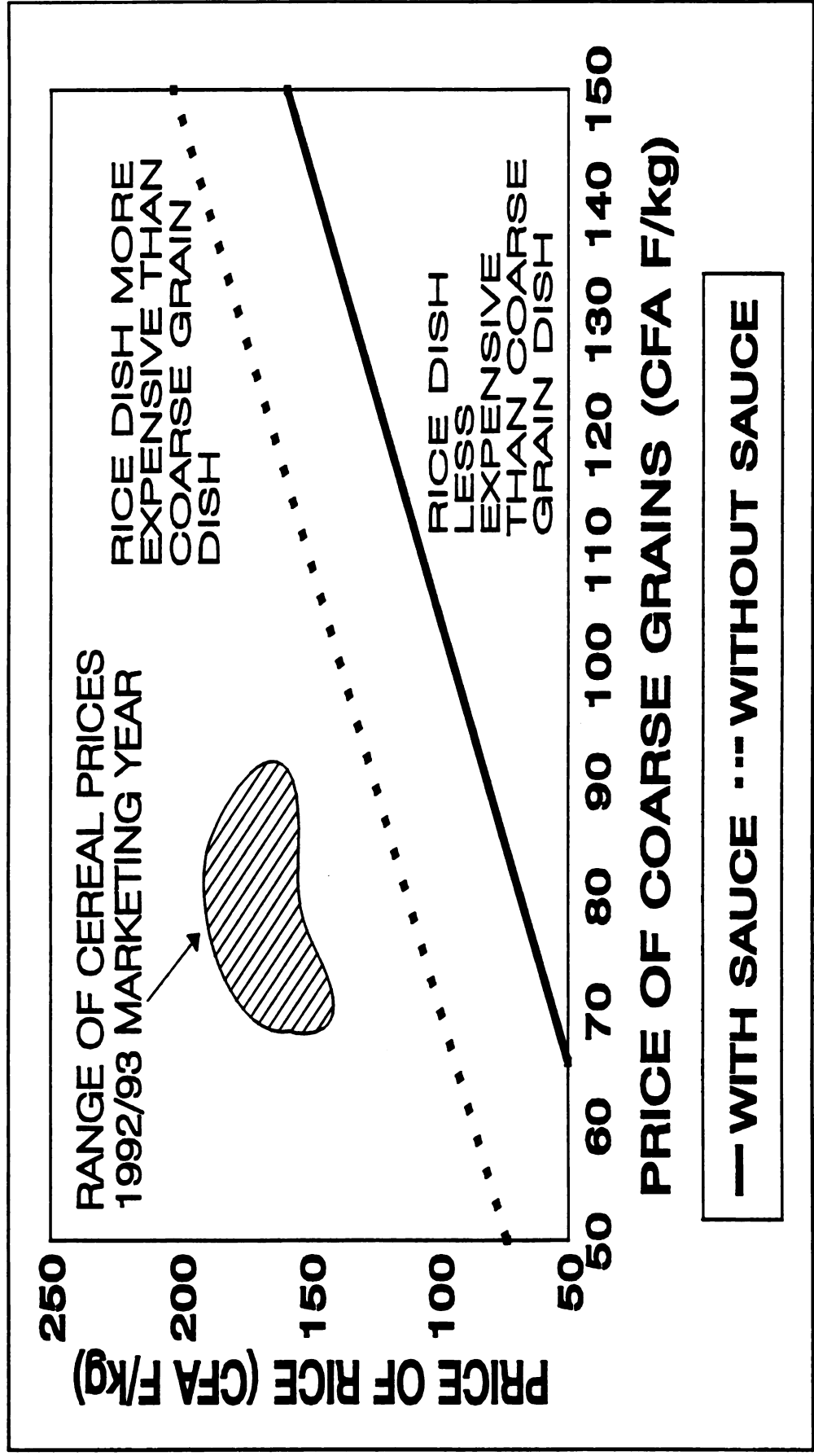
- The large difference between rice and toh in regard to preparation time per kilo is primarily a reflection of the average quantity of cereal prepared (2.1 kilos for rice and 3.5 kilos for toh). Also, milling time is deducted from preparation time for toh to avoid double counting the time cost for tasks carried out concurrently.

The finding that prepared rice is more expensive than *toh* is robust with respect to sensitivity analyses for changes in the opportunity cost of labor and relative cereal prices. A doubling of the opportunity cost of labor reduces, but does not eliminate, the cost disadvantage of prepared rice from 1.26 to 1.21. Halving the opportunity of labor (appropriate to the availability of unemployed family members or children for processing tasks) increases the cost disadvantage to 1.31.

Sensitivity analysis for relative cereal prices reveals that prepared rice is more expensive than *toh* for all combinations of cereal prices observed during the period December 1992 to November 1993 (the cereal marketing year). Following devaluation in January 1994, rice prices in Bamako rose sharply to nearly 200 CFA F/kg for high quality and 170 CFA F/kg for low quality rice by March. Coarse grain prices ranged from 70 - 75 CFA F/kg, close to their level at the time of our study (OPAM/SIM, 1994).

Figure 6.7 illustrates results of the sensitivity analyses graphically. The two lines represent all combinations of rice and coarse grain prices that equate the cost of prepared rice and *toh* (the lower line including, and the upper line excluding sauce cost). For all combinations of prices above and to the left of a given line, prepared rice is more expensive than *toh*. For prices below and to the right, prepared *toh* is more expensive than rice. The shaded area above and to the left of the upper line is the region in which retail prices for rice and coarse grains in Bamako fluctuated during the 1992/1993 cereal marketing year. The entire area is above and to the left of the upper line, indicating that at no time in the 1992/1993 cereal marketing year was prepared rice less expensive than *toh*, even excluding the higher sauce costs of rice.

FIGURE 6.7: ISOCOST LINES FOR RICE- AND COARSE GRAIN-BASED MEALS FOR DIFFERENT CEREAL PRICES



Notes:

1. For toh, the cost of sauce includes the basic green and optional red sauce.
2. The hatched area represents cereal prices observed during the 1992/1993 cereal marketing year.

The wide difference between the two lines reflects the difference in the cost of ingredients for the base sauce. The sauce for rice dishes was generally richer (inclusion of oil, peanut butter, tomato concentrate), and the quantity prepared greater, than sauce for toh. Households can vary the quality of sauces, and this provides an option to keep the relative cost of rice and coarse grain based dishes stable in the face of fluctuating relative cereal prices, contributing to low substitutability between rice and coarse grains.

A "snapshot" of the costs of rice and coarse-grain-based dishes at a particular point in time is not sufficient to explain the secular decline in consumption of traditional cereals in the urban environment over the past two decades, but it does challenge the notion that processing costs for coarse grains offset the lower price of unprocessed coarse grains compared to rice. Although the present cost advantage of prepared coarse grains is unlikely to be reversed by rising opportunity costs of women's time in the short run, it will be gradually eroded unless processing costs can be reduced. This leads us to examine the competitiveness of pre-processed versus household processing of coarse grains under varying opportunity costs of women's time.

6.4.3 Cost competitiveness of processed and unprocessed coarse grains

Table 6.12 presents the cost of toh prepared from home and pre-processed coarse grains. Two pre-processed products are included in the analysis: grain purchased in dehulled form and grains purchased in the form of flour. Purchasing grain in dehulled form enables the consumer to avoid the time and processing losses incurred in dehulling and cleaning. Purchasing flour enables the consumer to avoid

the time and expense of milling as well. Starting with either dehulled grain or purchased flour, all remaining tasks for toh can be accomplished in the same amount of total time as for a rice dish.²⁴ Because processing services are embodied in the products, they naturally cost more. At a price of 70 CFA F/kg for unprocessed grain, corresponding retail prices (pre-devaluation) would be approximately 115 CFA F/kg for dehulled grain and 150 CFA F/kg for refined (dehulled and degermed) flour given existing technology.²⁵

Table 6.12: Relative Costs of Toh Prepared from Whole Grain, Dehulled Grain and Flour (CFA F/1000 kcal)

COST ITEM	WHOLE GRAIN (A)	DEHULLED GRAIN (B)	RATIO B/A	FLOUR (C)	RATIO C/A
CEREAL COST	24.9	32.6	1.31	42.5	1.71
PROCESSING COSTS					
Dehulling time	3.6	0		0	
Cleaning time	0.9	0.9		0	
Milling time	3.0	3.0		0	
Milling cost	3.6	3.6		0	
SUB-TOTAL PROCESSING COST	11.0	7.4	0.68	0	0
PREPARATION COSTS					
Preparation time	7.4	7.4		7.4	
Fuelwood cost	7.5	7.5		7.5	
Potash cost	1.1	1.1		1.1	
SUB-TOTAL PREPARATION COSTS	16.0	16.0	1.00	16.0	1.00
TOTAL COST PREPARED STAPLE	51.8	55.9	1.08	58.4	1.13

²⁴ Although dehulled grain must first be taken to a custom mill for grinding, the time required for this activity is offset by the fact that rice sauces take longer to prepare than toh sauces.

²⁵ The cost structure for dehulled grain is presented in Sanogo et al., 1993. Flour processing costs are examined in detail in chapter 7.

At the estimated opportunity cost of women's time (50 CFA F/hour), *toh* prepared from grain purchased in dehulled form is 8%, and from purchased flour 13%, more expensive than *toh* prepared from home-processed grain (bottom line of Table 6.12). At a lower opportunity cost of 25 CFA F/hour for women's time (applicable to families with unemployed members or children available to perform processing tasks), *toh* prepared from grain purchased in dehulled form is 13% more expensive, and from purchased flour 23% more expensive, than *toh* prepared from home-processed grain. The opportunity cost of labor would have to rise to 100 CFA F/hour for grain purchased in dehulled form to become competitive with home-processed grain given existing dehulling technology.²⁶

Three conclusions can be drawn from this analysis. First, pre-processed coarse grains are not competitive with household processing at the prevailing opportunity cost of women's time. Second, pre-processed coarse grains will become more attractive compared to household processing of coarse grains as the opportunity cost of women's time increases. Third, assuming constant relative prices for rice and coarse grains, the cost advantage of coarse-grain-based dishes will be eroded as the opportunity cost of women's time rises unless there are improvements in the efficiency of coarse grain processing services.

Achieving reductions in the cost of coarse grain processing services is important if the urban market share of coarse grains is to be maintained in the medium to long run. Sanogo et al. (1993) estimated that costs savings of 10% in the provision of dehulling services are possible through technological innovation and

²⁶ Given generally higher incomes in urban areas, this finding is consistent with that of a 1991 study of coarse grain processing in rural areas of Mali which found that milling charges were three times the opportunity cost of women's time (Fischer et al., 1992).

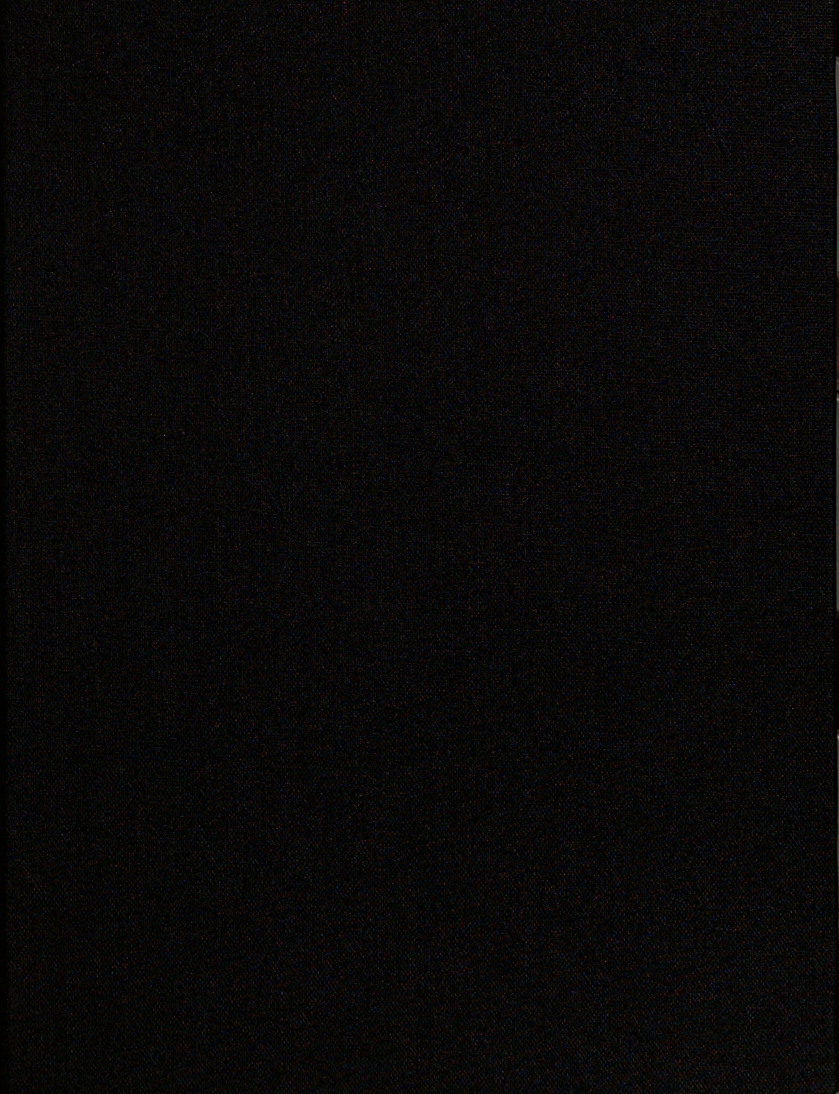
changes in market organization.²⁷ Analyses presented in the next chapter indicate that the only opportunity to significantly reduce the cost of flour in the near term is through the use of whole grain maize (which avoids the cost of dehulling and has a 98% extraction rate). Although presently used only in exceptional circumstances in Mali, this product is gaining widespread acceptance in urban areas of southern and eastern Africa (Jayne and Rubey, 1993; Mukumbu and Jayne, 1994). It was therefore included in the consumer tests of maize flour presented in the next chapter.

²⁷ Holtzman et al. (1991) recommend the promotion of more efficient abrasive disc dehullers in place of Engleberg dehullers (designed for rice). Sanogo et al. (1993) further advocate the re-location of dehulling services to the wholesaler instead of retail level to save on transport and energy costs, and permit more effective utilization of by-products for livestock feed.

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CHAPTER SEVEN

URBAN DEMAND FOR COARSE GRAIN PROCESSING SERVICES: THE POTENTIAL DEMAND FOR MAIZE FLOUR IN BAMAKO

Chapter 4 discussed how development of the maize subsector could contribute to improved food security in both the short and the long run. In addition, demand-led expansion in the form of processed products would contribute to accelerated agricultural sector transformation and economic growth. Chapters 5 and 6 presented the methods and results of surveys of current cereal utilization patterns among urban households, the main source of potential demand for processed cereal products. These surveys reveal that most coarse-grain-based dishes require flour, yet cereals are purchased in raw form. Only very small quantities of coarse grains are purchased in dehulled form or as flour.

This chapter will estimate potential demand for maize flours of different quality, derive demand schedules, and compare them to estimates of retail prices based on existing processing technologies. The chapter proceeds as follows. The first section justifies the choice of the contingent valuation approach. Section 7.2 describes how the approach was implemented in collaboration with potential maize processors and urban households. The first part of 7.2 describes existing firms that could be potential sources of maize flour, and the estimated costs of flour using alternative technologies. The second part describes the household test procedure and the results of housewives' qualitative evaluation of alternative flours. Section 7.3 presents a set of hypotheses relevant to maize flour demand, and specifies an econometric model. Section 7.4 derives demand schedules for dehulled and whole grain flour using the results of the econometric model, and computes price and

income elasticities of demand. The final section estimates aggregate maize flour demand for the District of Bamako and, in view of the high cost of flour relative to the opportunity cost of women's time, briefly reviews opportunities for encouraging the market in dehulled grains as an intermediate product.

7.1 Approaches to the estimation of potential demand for maize flour

The problem faced by the study is how to estimate the demand for a product not currently available in the marketplace, and hence for which cross-section and/or time series data on quantities purchased at different prices by households with different income and demographic characteristics are unavailable. Approaches to this problem have been developed separately by economists and business schools.

Approaches developed by business schools have focussed primarily on markets for private goods. One of the most frequently used tools is conjoint analysis (Green and Wind, 1975; Louviere, 1988). Conjoint analysis is used to estimate consumer's willingness to pay for particular product attributes (e.g., quality, size, safety). Consumers are presented with a product available with different attribute combinations, such as a car with two doors, four doors or a station wagon, and with a large or a small engine. Each of these attribute combinations is listed with several prices. Consumers are asked to rank a list of N attribute combinations by M prices in order of preference. The consumer will obviously start with the preferred attribute combination at the lowest price and end with the least preferred combination at the highest price. Intermediate rankings will involve a compromise between attribute combination and price. Algorithms are

applied to rankings supplied by a sample of consumers to estimate the average value of an attribute to the consumer group in question.

Conjoint analysis is usually applied where consumers have some familiarity with the basic product, often a durable good. Thus, they are being asked to value some incremental utility from the services provided. The approach is appealing for business applications because the (incremental) attribute value can be compared directly to the (marginal) cost of supplying it. The approach is also valuable for identifying relevant consumer target groups in designing marketing strategies.

Approaches developed by economists have focussed primarily on the demand for public goods and services. The two principal methods used by economists are hedonic pricing and contingent valuation (Hoehn and Krieger, 1988).

Hedonic pricing involves estimation of the value of a good or service by aggregating the values of the attributes embodied in it (Senauer et al., 1991). The values of these attributes are derived from their value embodied in other goods or services. For the purpose of estimating maize flour demand in urban Mali, hedonic pricing is not feasible because attributes do not exist in alternative products used for the same purpose.¹

Contingent valuation (CV) involves estimation of the value of a good or service on the basis of individuals' willingness to pay for, or not to lose, a good or

¹ Wheat flour is available, but virtually all of it is sold to bakers for bread. Cases where wheat flour was used to prepare principal household meals were extremely rare, although it can be used to prepare couscous (couscous marocain). As reported in the next section, however, couscous is the least technically demanding meal to prepare and can even be made from dehulling residues. Even if wheat flour were used widely to prepare household meals, it would be difficult to value the convenience attribute because of price distortions (the Grands Moulins du Mali (GMM) obtains most of its wheat in the form of commodity aid from the USA, Canada and France, and until recently benefitted from high external tariffs on imported flour).

service. Willingness to pay can be estimated on the basis of individuals' self-reports, observations of what resources they currently give up to obtain a good (e.g., travel and/or costs), or some combination of these methods. The principal difficulty when asking consumers or potential consumers to express their willingness to pay is how to verify the accuracy of such responses. The two principal sources of inaccuracy are cognitive difficulties encountered by respondents in giving an accurate response to a hypothetical situation, and strategic bias (lying). The extent of inaccuracy due to these sources can vary considerably depending on the nature of the good or service being valued and the way the CV experiment is structured (Mitchell and Carson, 1991).

Although conjoint analysis is intuitively appealing because of its extensive application to private goods markets, the contingent valuation approach has been selected because it can generate the data necessary to calculate price and income elasticities relevant to the proposed hypotheses and potential demand estimates. The way in which the CV experiment was structured to minimize inaccuracy is discussed in the next section.

7.2 Operationalizing the contingent valuation method: manufacture and household tests of maize flours in Bamako

The in-depth maize subsector research proposal called for IER food technologists and economists to work with urban consumers and potential maize processors to develop technologically feasible and financially viable products (i.e., products adapted to consumer preferences and for which they would be willing to pay a price in excess of the costs of manufacture and distribution). We first

describe potential maize processing firms and the costs of production for alternative technologies. Second, we describe the development of household testing procedures and housewives' evaluation of alternative flours in terms of their suitability for different dishes.

7.2.1 Collaboration with potential maize processors

Two potential private-sector maize processors currently operate in or near Bamako: the Grands Moulins du Mali (GMM) and a groupement d'intérêt économique (GIE) operating under the trade name of SAMA.² Both potential collaborators had limitations due to technological scale and versatility, respectively.

The principal activities of GMM are wheat milling and rice dehulling. GMM has the only wheat mill in Mali, and has historically benefitted from high import tariffs on imported wheat flour on the one hand and monopsony purchase of commodity aid wheat from the USA, Canada and France on the other.³ GMM also has the technical capacity to produce dehulled and degermed grits of a range of sizes (including coarse and fine flour) from maize, millet and sorghum. An attempt to market maize flour in 1986 failed because of the use of poor quality maize (old imported food aid stock). Malian maize, which is considered to be of high quality

² A groupement d'intérêt économique is a form of cooperative.

³ GMM's margins on wheat flour milling have been squeezed in recent years through the reduction of external tariffs on wheat flour, illegal imports of wheat flour from Mauritania, and most recently by coordinated selling of commodity aid wheat by donors. When Canadian commodity aid wheat flour was auctioned by OPAM in late 1993, GMM shut down its wheat milling operations and laid off most of its employees for a week to bring pressure on the government (Le Républicain, December 1st, 1993). This continuing squeeze on historically fat milling margins, in excess of the average farm-gate price of maize, has made GMM management more receptive to new possibilities such as maize flour.

by the chief miller of GMM, has never been processed by this state-of-the-art plant. Neither has millet or sorghum.⁴

The principal drawback to market testing of GMM products is the minimum quantity of maize that must be processed. Because the equipment has been idle for so long, it would be necessary to process at least ten tons in order to ensure a clean, uniform set of processed products. The team considered the financial and logistical hurdles too great and decided to "simulate" the GMM product range using food aid cornmeal. If consumer evaluation of this simulated product range suggested that processing by GMM could be profitable, then a market test using the necessary quantity of raw material could be proposed as a follow-on activity to the maize subsector study. Unfortunately, all stocks of food aid cornmeal were exhausted and the closest substitute that could be found was dehulled (but not degermed) flour manufactured by SAMA.

SAMA started out as a groupement d'intérêt économique (GIE) that marketed processed maize products in Bamako supplied by ten small-scale hammer mills set up in rural areas by the CERECOM project. The mills had been set up with heavy subsidies to provide farmers with additional market opportunities for maize following the liberalization of cereal markets in 1986. The products included medium and small grits, and flour obtained as a by-product of grit manufacture. SAMA began to process its own products in Bamako using equipment loaned by

⁴ GMM was obliged to install coarse grain milling equipment together with the wheat mill by the Malian government, which has underwritten GMM's capital debt. GMM management had no interest in, or intention to use, this equipment at the time.

CERECOM after experiencing a number of shortages of stocks due to village mill liquidity and pricing problems.⁵

Only the medium-sized grits used to make "seri", a porridge eaten for breakfast or as a desert, found a ready market.⁶ The flour obtained as a byproduct of grit manufacture proved very difficult to sell, and often became rancid in store (Holtzman et al., 1991). The scope for improving existing SAMA products is limited by the processing equipment available to the GIE. Due to the non-spherical shape of the maize grain, the abrasive disk dehuller cannot remove a high proportion of either pericarp or germ without also losing a high proportion of endosperm, resulting in a low yield of marketable product. The hammer mill produces grits in a range of sizes, with little flexibility for increasing the proportion of grits of the preferred size. Only a radical change in the type of equipment used could overcome these constraints (e.g., introduction of roller mill and degermer), the same kind of equipment already available, but not utilized, at GMM. It appeared unlikely that SAMA, assuming a market for products made from improved equipment could be successfully developed, would be able to survive competition from GMM once the latter decided to enter the market.

⁵ Village mills provided SAMA with processed products at fixed prices. If local grain maize prices rose above a certain level, the mills had to stop processing in order to avoid financial losses. The mills had neither the liquidity nor the storage capacity to purchase an entire year's stock at harvest time when prices are generally lower (B.Goïta, personal communication). The reason for the fixed processed product price policy is not clear.

⁶ Even in the relatively small market for medium-sized grits, SAMA faced stiff competition from artisanal manufacturers who produce a bright, clean product by selecting hard endosperm yellow maize kernels and repeatedly washing and sieving the product during processing.

Three avenues of collaboration with SAMA were feasible given the existing equipment. These were:

- 1) identify possibilities for improving the quality and marketability of flour obtained as a by-product of grit manufacture;
- 2) contrast consumer evaluation of flour obtained as a by-product of grit manufacture with flour obtained as a primary product from dehulled grains;⁷
- 3) assess whether there is a market niche for flour obtained from whole grains.

7.2.2 Costs of maize flour processing with alternative technologies

The main components of flour cost are raw material (grain), transport of grain to the site of processing, fixed and variable processing costs, cleaning and processing losses (adjusted for the value of any marketable by-products), and retail distribution. The total cost for any given process can vary widely depending on the assumptions made for each component. For refined flour (dehulled and degermed), cost estimates were developed in collaboration with GMM's accountant. For dehulled and whole grain flour produced with a hammer mill, estimates are based on Mali-specific secondary sources (Holtzman et al., 1991; Ashraf, 1992; Freud and Le Moigne, 1992).

a) Grands Moulins du Mali (industrial mill)

Table 7.1 presents pre- and post-devaluation estimated costs of refined maize flour at retail level. Cost estimates are based on three alternative prices for grain maize and the following scenarios: with and without overhead costs and value

⁷ This idea was first proposed by Holtzman et al., 1991, in their study of opportunities to expand coarse grain utilization with a focus on urban consumption.

added tax (VAT), large (50kg) and small (5kg) packaging options, and two levels of milling efficiency (75% and 80% yield).⁸ Fixed parameters include 3% cleaning losses, a 10% net margin for GMM and a 15% gross margin for the retailer (a detailed breakdown of these calculations can be found in appendix 3). In the body of the table, underlined figures indicate scenarios within the range of prices used in the contingent valuation questionnaire.

Flour costs are sensitive to the cost of raw material. A 10 CFA F/kg increase in the price of maize results in a 20 CFA F/kg increase in the price of flour. Costs of flour are also sensitive to the type of packaging. Small packages increase the retail price of flour by roughly 10 CFA F/kg before and 15 CFA F/kg after devaluation. Improvements in milling efficiency bring price reductions roughly proportionate to the gain in flour yield, but the scope for improvement is limited to around 5% without noticeably altering the quality of the product.

It should be possible to persuade the government to rescind value added tax (VAT) on maize processing for two reasons. First, the government has already done so for rice dehulling to promote the use of locally produced rice. Thus there is a precedent for suspending a tax to promote domestic cereal production and consumption. Second, the tax is generating no revenue anyway at the present time, so there would be no revenue loss in the short run. GMM would be willing to ignore overhead costs in the short run, since these are joint with wheat milling and rice dehulling activities. Theoretically, it should also be willing to overlook

⁸ Overhead costs refer to administrative costs that are joint with other activities such as wheat milling and rice dehulling (e.g., management salaries and benefits, office rents and electricity, property taxes). Depreciation on equipment specific to the maize processing line is a separate cost item (see appendix 3).

Table 7.1: Cost of Maize Flour at Retail Level Manufactured by Grands Moulins du Mali (CFA F/kg)

Package Size	Milling Yield	With VAT and Overhead costs			With Overhead costs			No VAT or Overhead costs		
		Price of maize (CFA F/kg)			Price of maize (CFA F/kg)			Price of maize (CFA F/kg)		
		40	50	60	40	50	60	40	50	60
50 kg	75 %	<u>141</u>	160	180	128	<u>146</u>	164	114	<u>131</u>	<u>150</u>
	80 %	<u>133</u>	151	170	<u>121</u>	<u>138</u>	155	<u>108</u>	<u>124</u>	<u>141</u>
5 kg	75 %	<u>150</u>	169	190	<u>137</u>	154	173	<u>122</u>	<u>140</u>	158
	80 %	<u>142</u>	160	179	<u>130</u>	<u>146</u>	163	<u>116</u>	<u>133</u>	<u>150</u>
PRE-DEVALUATION										
POST-DEVALUATION										
50 kg	75 %	176	195	215	161	178	196	<u>140</u>	157	176
	80 %	166	184	203	182	168	185	<u>133</u>	<u>149</u>	166
5 kg	75 %	191	210	230	174	191	210	154	171	189
	80 %	182	199	218	166	182	199	<u>147</u>	163	180

Notes:

- Underlined figures in the body of the table indicate prices at or lower than the highest price in the contingent valuation questionnaire.
- Based on information provided by GMM financial director. For detailed budgets see Appendix 3.
- Maize grain purchase price based on lots of approximately 30 tons, including sacks.
- Milling by-products are valued at 16 CFA F/kg wholesale ex-factory before devaluation and 21.3 CFA F/kg after devaluation.
- Post-devaluation costs assume an 80% pass through on the tradable component.
- Tradable component assumed to be 80% for transport, depreciation, packaging; 100% for technical assistance; and 50% for overhead and variable costs.
- Labor costs after devaluation are assumed to rise 10% in line with public sector salaries.

depreciation in the short run, but it is not clear whether this cost category includes some allowance for replacement parts (e.g., rollers). In the long run, for maize milling to be sustainable, fixed costs such as depreciation would also have to be covered.

Given a short-run marketing scenario of small packages (to encourage consumer experimentation with the product), a maize price of 50 CFA F/kg (implying a farm-gate price of 40 - 45 CFA F/kg after rural assembly), and no overhead or VAT, the pre-devaluation price to the consumer would be approximately 140 CFA F/kg. Were it not for devaluation, this price could have been maintained in the longer run, even with overhead costs included, by a combination of bulk packaging combined with small gains in milling efficiency.

A significant increase in the retail price of flour following devaluation is inevitable. Post-devaluation cost estimates are based on an 80% increase in price for the tradable component.⁹ The tradable component is assumed to be 80% for transport, depreciation and packaging, and 50% for overhead and variable costs. Although coarse grain prices have not changed significantly since devaluation, even a 10 CFA F/kg increase in maize prices would not compensate farmers for the likely increase in fertilizer prices (chapter 8). Assuming even this minimal price increase for raw material, the retail price of flour would rise to 189 CFA F/kg under the short-run scenario, and could again be maintained or reduced slightly with overhead costs included by small gains in milling efficiency combined with bulk packaging.

⁹ A 50% devaluation implies a doubling of prices of imported goods in terms of the local currency. However, it is unlikely that the full amount of the increase would be paid by consumers. Some overseas exporters will reduce prices in order to maintain sales in the face of importers' lower purchasing power.

If it is difficult to predict with accuracy the effect of devaluation on flour prices, it is even more so to predict the effect of post-devaluation flour prices in demand. On the one hand, the price of rice has increased very substantially. On the other hand, coarse grain prices and the opportunity cost of labor in the informal sector have not changed. These changes will affect the potential demand for flour in opposite directions, but with unknown magnitudes. Nevertheless, it is clear that the increase occurs at the most price-sensitive portion of the estimated demand schedule and will therefore most likely result in a decrease in the quantity demanded.

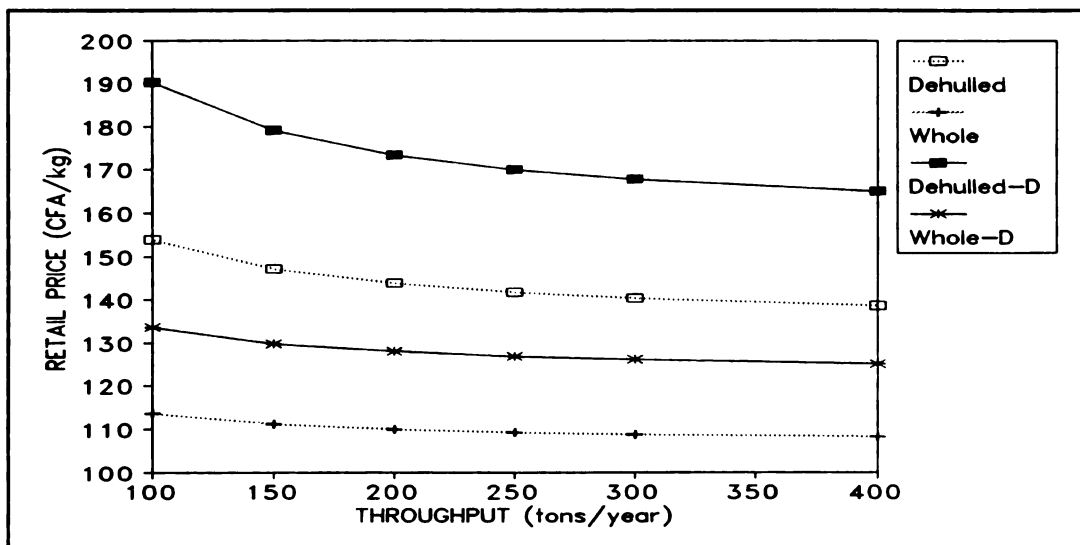
b) SAMA (hammer mill)

Cost estimates for the production of dehulled and whole grain flour using a hammer mill are also based on three alternative prices for grain maize, for ease of comparison with industrial production. The scenarios are adapted to the specific opportunities and constraints facing small-scale maize milling, in particular the sensitivity of unit costs to throughput. The before- and after-devaluation costs of each type of flour are estimated for volumes of 100 tons, 200 tons and 300 tons per annum. Fixed parameters include 3% cleaning losses, a milling efficiency of 75% for dehulled flour and 98% for whole grain, and 50 kg packaging. We assume margins of 15% for both processor and retailer on dehulled flour, to compensate the processor for the risk of possible losses in storage due to rancidity. For whole grain flour, margins of 12.5% are assumed because the lower price is likely to result in a higher sales volume, reducing risks of stock loss for the processor and handling

costs for the retailer. Post-devaluation assumptions are the same as for GMM except that we accord rent and electricity a 33% import content.¹⁰

Costs of flour production are sensitive to throughput, particularly for volumes below 200 tons (Figure 7.1). Dehulled flour is more sensitive than whole grain flour because of the additional equipment and space required. Devaluation increases the sensitivity of flour costs to volume for the same reason (increased equipment cost), and magnifies the difference between dehulled and whole grain.

Figure 7.1: Hammer Mill Unit Costs of Production for Dehulled and Whole Grain Flour Before and After Devaluation



Notes:

1. Dehulled: flour made from dehulled grains pre-devaluation.
2. Whole: flour made from whole grains pre-devaluation.
3. Dehulled-D: flour made from dehulled grains post-devaluation.
4. Whole-D: flour made from whole grains post-devaluation.
5. Assumed grain purchase price of 50 CFA F/kg

¹⁰ This lower import content reflects the fact that land in the capital city is a higher proportion of building value than in Koulikoro where GMM's factory is located, and electricity is from an hydroelectric source not requiring imported fuel.

In the body of Table 7.2, underlined figures indicate scenarios that generate a retail price for dehulled flour at or below 150 CFA F/kg (the highest price in the contingent valuation survey instrument), and 115 CFA F/kg for whole grain flour (the price that induces a similar percentage of respondents to purchase whole grain flour as would purchase dehulled flour at 150 CFA F/kg).

SAMA cannot produce dehulled flour more cheaply than GMM can produce refined flour in either the short or long run, even assuming a throughput of 300 tons. In addition, the unit is vulnerable to stock losses from rancidification and high unit costs during the initial market development phase. The unit can produce whole grain flour at a considerably lower price, however (ranging from a minimum of 27 CFA F/kg before devaluation to a maximum of 62 CFA F/kg after depending on the scenario). Unit costs of whole grain flour are more robust (less sensitive) to both volume and devaluation.

7.2.3 Development and implementation of consumer tests

The third point of the action research triangle was the urban consumers. Housewives were asked to prepare the most common coarse-grain-based meals using flour made by SAMA, and then to evaluate the flour's suitability.¹¹ Both housewives and household heads were separately asked about the quantity of flour they would be willing to purchase at specific prices. This approach evolved in three stages: a pre-test with a limited number of households, an initial large-scale test with four products (each household randomly allocated one of the four), and finally a large-scale comparative test of two products. Significant improvements were

¹¹ All flours used in the test were processed by SAMA, although modifications to processing methods were made progressively to respond to consumer criticisms.

Table 7.2: Cost of Maize Flour at Retail Level Manufactured by SAMA (CFA F/kg)

SCENARIO AND FLOUR TYPE	Volume 100 tons/year			Volume 200 tons/year			Volume 300 tons/year		
	Price of Grain (CFA F/kg)			Price of Grain (CFA F/kg)			Price of Grain (CFA F/kg)		
	40	50	60	40	50	60	40	50	60
PRE-DEVALUATION									
Dehulled	<u>135</u>	154	173	<u>125</u>	<u>144</u>	152	<u>127</u>	160	159
Whole Grain	<u>100</u>	<u>114</u>	<u>127</u>	<u>96</u>	<u>110</u>	<u>124</u>	<u>95</u>	<u>110</u>	<u>123</u>
POST-DEVALUATION									
Dehulled	171	190	209	155	173	192	<u>149</u>	168	186
Whole Grain	<u>120</u>	<u>134</u>	<u>147</u>	<u>114</u>	<u>128</u>	<u>142</u>	<u>112</u>	<u>126</u>	<u>140</u>

Notes:

1. Underlined figures in the body of the table indicate prices at or lower than the highest price in the contingent valuation questionnaire.
2. Based on secondary sources (Holtzman et al., 1991; Ashraf, 1991; Freude and Le Moigne, 1992). Detailed budgets can be found in Appendix 3.
3. Maize grain purchase price based on lots of approximately 10 tons, including sacks.
4. Milling by-products are valued at 25 CFA F/kg wholesale ex-factory before devaluation and 30 CFA F/kg after devaluation.
5. Post-devaluation costs assume an 80% pass through on the tradable component.
6. Tradeable component assumed to be 80% for transport, depreciation, packaging; 100% for technical assistance; 50% for overhead and 33% for electricity (hydro).
7. Straight line depreciation, 10-year life for mill and dehuller; 5-year life for electric motor, 15% interest.

made to the qualitative and contingent valuation instruments after the pre-test and initial large-scale test. These are described below. For each test, the food technology laboratory undertook a set of analyses in order to relate housewives' qualitative evaluations to measurable parameters such as particle size (Bruinsma, 1993; Mestres, 1993).

a) The pre-test

A pilot test with ten households was carried out in January 1993 with assistance from a consultant food technologist (Bruinsma, 1993). Two types of flour supplied by SAMA were compared in the test: a standard flour obtained as a by-product of grit manufacture and a finer version obtained by sieving the standard flour using a 150 micron mesh.¹² Each household was given sufficient quantities of the two flours to make *toh*, *couscous* and *bouillie* (the three principal coarse grain dishes), and 250 CFA F per meal to defray additional firewood and condiment expenses¹³. Housewives were asked to evaluate the flour qualitatively before preparation, and the quality of the dish after preparation. Following the test, researchers met with all the female participants in two focus groups to discuss in detail the problems encountered with using the flours for different meals. These discussions proved very insightful to the researchers, and considerably deepened their understanding of the qualities necessary for preparing different dishes.

¹² Laboratory tests had shown the SAMA flour to be considerably coarser than flour obtained from custom plate mills used by the majority of urban households.

¹³ Condiments is a general term for the ingredients of a sauce such as Maggi cubes, spices, onions, leaves, pepper, oil, meat or dried fish.

A contingent valuation component was included in the questionnaire but could not be rigorously tested because of time limitations and the serious quality problems encountered with the flours chosen for the pre-test.

In light of the pre-test experience, and laboratory analyses, it was decided not to attempt to improve the flour obtained as a by-product of grit manufacture. The flour contained high levels of lipids and ash, implying that a large part of the germ and pericarp separated from the grits had ended up in the flour (the residual product obtained from the sieving process). Furthermore, housewives stated that the flour was either itself old stock or had been made from old maize. The women claimed that it is not possible to make a good *toh* from old maize, confirming the finding of GMM in its 1986 experiment. A number of flour samples were found to contain insect larvae.

The pilot test permitted several improvements to be made to the qualitative evaluations of the product by adopting a standard five-point hedonic scale for each criterion, as well as a reduction in the number of dishes that need to be prepared (only *toh* and *bouillie*, for which flour quality has a significant effect on the prepared dish, were retained).

b) First large-scale test

The first large-scale test was carried out in February 1993 with 130 households. Each household was randomly allocated 2kg of one of four qualities of maize flour (white and yellow, de-hulled and whole grain) manufactured by SAMA expressly for the tests. The flours were manufactured from grain purchased from Bamako wholesalers. Each household prepared *toh* and *bouillie* using the flour, and

received 500 CFA F (250 CFA F per meal) to defray additional firewood and condiment costs. The housewife was asked to keep part of the dish to one side in order to see how well it can be conserved.¹⁴ The housewife was also asked to make sure the household head, often absent from family meals due to work, tasted the prepared dish.

Housewives evaluated the flour in regard to pre-cooking attributes (such as color, texture, cleanliness and freshness) and attributes specific to the prepared dishes. For each criterion, respondents were asked to give a score on an hedonic scale of 1 (very poor) to 5 (very good). The results are presented in Table 7.3. Since each household received only one type of flour, the scores do not represent a direct comparison between test flours. Each flour is implicitly compared to the respondents home-prepared flour.¹⁵

In regard to pre-cooking attributes (top section in Table 7.3), whole grain flours have a lower score than their dehulled counterparts for all criteria, including freshness. Given that these flours were manufactured from the same grain at the same time, this reveals the strength of consumer perceptions of the quality difference. Whole grain yellow flour has a noticeably lower score than its dehulled counterpart in regard to odor. For dehulled flours, white flour generally received similar scores to yellow flour, while for whole grain flours white generally outperformed yellow. The only criterion for which scores gave rise to serious

¹⁴ Toh from the mid-day meal can often be re-heated in the evening, and toh from the evening meal can often be re-heated for the following breakfast.

¹⁵ Respondents were not asked to score home-prepared flour for the different criteria. In retrospect, this was an important omission since such scores would have provided an empirical benchmark against which to evaluate the manufactured product.

quality concerns was for texture. Most respondents considered the flours to be coarse compared to their own flour, regardless of color or dehulling. This is due to the use of a hammer mill to manufacture the flour rather than the plate mills universally found in residential areas of the city.¹⁶

Scores for prepared *toh* are presented in the middle section of Table 7.3. For dehulled flours, the gap between white and yellow maize scores is generally small. In the case of whole grain flour, white out-performed yellow in regard to most criteria. As in the pre-cooking evaluation, yellow whole grain maize flour had a less pleasant odor than its dehulled counterpart. For prepared *bouillie* (breakfast porridge), white dehulled flour out-performed its yellow counterpart, and equalled it for whole grain flour (bottom section of Table 7.3). The main problem encountered by respondents was that the small flour balls that characterize this dish often disintegrated during cooking. This appeared to be even more of a problem in the case of whole grain flour made from yellow maize.

To indicate which evaluation criteria are important to consumers, ordinary least squares regressions were estimated with the overall scores for *toh* and *bouillie* as dependent variables. The results are presented in Table 7.4. For *toh* (adjusted $R^2 = .43$), color, consistency, conservation and taste are all significant at the .05 level or higher. Smell, yield and cooking time did not significantly affect the overall score. For *bouillie* (adjusted $R^2 = .35$), taste, ease of preparation, and color are all significant at the .05 level or higher. Ease of sifting, conservation, sweetness, and

¹⁶ Plate mills are not suitable for commercial flour manufacture because the process involves wetting the dehulled grain prior to grinding. This makes the flour impossible to preserve unless the flour is subsequently dried, adding time and cost to the process.

Table 7.3: Consumer Evaluation of Maize Flours

Variable	Yellow dehulled		White dehulled		Yellow whole grain		White whole grain	
Evaluation of Flour Before Cooking								
Color	4.72	(.45)	4.63	(.49)	4.29	(.71)	3.94	(.77)
Smell	4.62	(.49)	4.48	(.57)	3.96	(.88)	4.23	(.63)
Texture	2.86	(.64)	2.87	(.67)	2.76	(.58)	2.77	(.68)
Taste	4.46	(.51)	4.34	(.55)	4.05	(.71)	4.22	(.58)
Cleanliness	4.71	(.46)	4.74	(.51)	4.28	(.75)	4.47	(.82)
Freshness	4.04	(.93)	4.22	(.70)	3.62	(1.13)	3.72	(1.10)
Evaluation After Preparing Toh								
Color	4.71	(.46)	4.73	(.45)	4.21	(.69)	4.03	(.82)
Smell	4.68	(.48)	4.5	(.57)	4.07	(1.02)	4.45	(.57)
Consistency	4.79	(.57)	4.63	(.72)	4.36	(.95)	4.28	(1.10)
Conservation	4.86	(.36)	4.86	(.44)	4.48	(1.01)	4.70	(.54)
Taste	4.79	(.50)	4.73	(.52)	4.39	(.83)	4.41	(.68)
Yields	4.79	(.57)	4.67	(.61)	4.43	(.88)	4.59	(.68)
Time	3.11	(.74)	2.97	(.72)	2.93	(.47)	2.97	(.78)
Overall	4.83	(.47)	4.45	(1.12)	4.10	(1.09)	4.23	(1.12)
Evaluation After Preparing Bouillie (porridge)								
Color	4.67	(.48)	4.71	(.53)	4.31	(.62)	4.08	(.64)
Ease of Sifting	4.00	(.93)	4.14	(.52)	4.26	(.53)	4.00	(.87)
Conservation	4.70	(.47)	4.67	(.48)	4.41	(.73)	4.55	(.51)
Ease of Preparation	3.58	(1.14)	3.64	(.95)	3.15	(1.35)	3.54	(1.22)
Taste	4.67	(.64)	4.83	(.38)	4.27	(.92)	4.31	(.97)
Sweetness	3.74	(.45)	3.31	(.74)	3.36	(.70)	3.17	(.78)
Time	3.25	(.68)	2.97	(.63)	3.08	(.74)	3.19	(.57)
Overall	4.29	(1.12)	4.48	(.69)	3.96	(1.06)	3.96	(1.22)

Scale: 5 = Very Good
 4 = Good
 3 = Average
 2 = Poor
 1 = Very Poor

3.26 = Mean
 (.63) = Standard Deviation

Table 7.4: OLS Regression Results for Prepared Toh and Bouillie Quality Criteria

VARIABLE	COEFFICIENT	SE	t-STATISTIC	SIGNIFICANCE
DEPENDENT VARIABLE: OVERALL SCORE FOR TOH				
COOKING TIME	.0232	.1063	0.219	.827
TASTE	.3546	.1257	2.820	.006
YIELD	.1352	.1139	1.187	.238
CONSISTENCY	.2157	.0875	2.463	.015
CONSERVATION	.2507	.1261	1.988	.049
COLOR	.3263	.1196	2.727	.007
SMELL	.0595	.1129	.527	.599
CONSTANT	-1.712	.7171	-2.388	.019
DEPENDENT VARIABLE: OVERALL SCORE FOR BOUILLIE				
COOKING TIME	.1635	.1333	1.227	.223
TASTE	.3071	.1581	1.942	.056
EASE OF SIEVING	.1120	.1294	0.866	.389
SWEETNESS	-.1268	.1297	-0.978	.331
EASE OF PREPARATION	.2995	.0838	3.575	.001
COLOR	.4031	.1534	2.628	.010
CONSERVATION	-.0546	.2055	-0.265	.791
CONSTANT	-.2376	.8987	-0.264	.792

Notes:

1. For toh, adjusted $R^2 = .428$, $F = 13.496$ with 110 d.f.
2. For bouillie, adjusted $R^2 = .354$, $F = 7.896$ with 81 d.f.

cooking time did not significantly affect the score. These results should be interpreted with caution for two reasons. First, the dependent and independent variables are discrete rather than continuous. Second, there is a high probability of missing variables, such as consumer preferences for *toh* and *bouillie* in general, and the level of experience in preparing those dishes. The results are merely indicative.

The contingent valuation part of the questionnaire was designed as follows. In order to confine measurement error to the dependent variable (quantity) as far as possible it was decided that respondents should be asked how much they would buy in relation to a specific price. But who should determine the price - the respondent or the researcher? The (male) researchers decided that respondents should first be asked at what price they would be willing to purchase flour and then, having announced a price, how much they would be willing to buy each week. The rationale for letting the respondent choose the price was that consumers usually have some reference price for a particular good that they consider to be reasonable (hence the frequently heard statements in everyday conversation about something being a bargain or expensive). The question relating to how much the respondent would buy each week was repeated for two price reductions of 10 CFA F/kilo relative to the first price announced by the respondent.

Two main problems were encountered with this approach. First (contrary to the researchers' expectations), some women found it hard to propose a price since they had never purchased flour before. Second, women found it difficult to estimate the quantity of flour required to prepare a given number of meals in terms of kilos. For household heads, the problem was one of access. Household heads often leave home very early in the morning and return after dark when it is not

appropriate for female enumerators to be in the field. While the data obtained might have some value, there was clearly considerable scope for improving the method.

c) Second large-scale test

A second large scale test in which households directly compared two qualities of white maize flour (dehulled and whole grain) was undertaken in April/May. White maize was chosen for two reasons. First, consumers appeared to have fewer problems with white whole grain flour than yellow, finding the latter to have an unpleasant odor and causing cooked toh to have a distinct orange color. Second, varieties of white maize suited to both kinds of flour production were available on the market. In order to reduce losses in dehulling, a round-grained variety is preferred (e.g., TZESRW), whereas many maize varieties tend to have flat surfaces that force a trade-off between degree of bran removal and endosperm loss.¹⁷ For whole grain maize flour, a soft variety (e.g., Tuxpeno) is desirable in order to avoid a coarse-textured product. Furthermore, Tuxpeno is noted for its high proportion of pericarp (Goïta, 1991). This would serve to heighten the contrast between dehulled and whole grain flour. If consumers found whole grain flour made from a Tuxpeno-type variety satisfactory then they would likely find any white whole-grain maize flour satisfactory.¹⁸

¹⁷ The abrasive disk dehullers were originally designed for sorghum, which has a spherical grain.

¹⁸ Both Tuxpeno and TZESRW are varieties introduced since 1980 (chapter 3). Tuxpeno is CIMMYT material originally obtained from Ghana and introduced by the CMDT. It is a long-duration fertilizer-responsive variety that was very popular when there was a guaranteed price. TZESRW (Tropical Zea Early Striga-Resistant White) is an IITA variety introduced following striga outbreaks in the early 1980s. Farmers appreciate the variety because it is early maturing and does reasonably well under moderate soil-fertility conditions.

A number of changes were made to SAMA's processing methods to improve the quality of flour. To improve the cleanliness of the product, mechanical and manual pre-cleaning was undertaken to remove stones, and shrivelled or off-color grains. To improve flour texture, a 1 mm screen was fitted and the rate of processing slowed down. Manual sieving, using the same sieves as those used by housewives, was introduced. Grits retained by the sieves were recycled in order to reduce processing losses.

Minor changes were also made to the qualitative evaluation questions. For evaluation pre-cooking, texture was evaluated in relation to each dish, and taste and smell were dropped. Cooking time was dropped for *toh*, and ease of sifting for *bouillie*. Whereas in the first test housewives evaluated one flour, in the second they made a direct comparison between two qualities, dehulled and whole grain, prepared from white maize grain.

The results of the qualitative evaluation are presented in Table 7.5. Texture scores, which ranged from 2.76 to 2.87 in the first test, were considerably improved as a result of the changes made in SAMA's processing techniques. The scores are significantly higher for *toh* than for *bouillie*, reflecting the difference in flour fineness required by the two dishes. Housewives traditionally sieve flour obtained from custom plate mills through a very fine mesh sieve, keeping the finer portion for *bouillie* and the coarser portion for *toh*. The scores are significantly lower for whole grain compared to dehulled grain, which may be due to a less complete disintegration of the endosperm in the hammer mill due to the presence of the protective pericarp layer.

Table 7.5: Consumer Evaluation of White Maize Flours

Variable	White dehulled		White whole grain		Difference		t-statistic	
Evaluation of Flour Before Cooking								
Color	4.89	(.34)	3.86	(.63)	1.02	(.64)	17.9	[.01]
Texture (toh)	4.23	(.96)	3.89	(.98)	0.33	(.77)	4.83	[.01]
Texture (bouillie)	3.58	(1.13)	3.26	(1.00)	0.32	(.78)	4.50	[.01]
Cleanliness	4.79	(.47)	4.23	(.87)	0.56	(.73)	8.57	[.01]
Freshness	4.32	(.56)	3.74	(.91)	0.58	(.91)	7.09	[.01]
Evaluation After Preparing Toh								
Color	4.95	(.22)	3.87	(.83)	1.08	(.85)	14.08	[.01]
Smell	4.73	(.50)	4.20	(1.03)	0.53	(.94)	6.16	[.01]
Consistency	4.79	(.70)	4.24	(.95)	0.55	(.95)	6.41	[.01]
Conservation	4.89	(.37)	4.56	(.80)	0.33	(.78)	4.53	[.01]
Taste	4.74	(.53)	4.16	(.89)	0.58	(.96)	6.60	[.01]
Yields	4.78	(.51)	4.75	(.55)	0.03	(.59)	0.62	[ns]
Overall	4.82	(.52)	4.01	(1.01)	0.81	(1.06)	8.50	[.01]
Evaluation After Preparing Bouillie (porridge)								
Color	4.85	(.39)	3.78	(.92)	1.07	(.95)	12.14	[.01]
Conservation	4.65	(.68)	4.22	(1.11)	0.43	(1.00)	4.53	[.01]
Ease of Preparation	2.91	(1.14)	2.61	(1.23)	0.29	(1.35)	2.69	[.05]
Taste	4.42	(.86)	3.73	(1.27)	0.69	(1.27)	5.82	[.01]
Sweetness	2.63	(.87)	2.53	(.91)	0.10	(.65)	1.58	[ns]
Time	2.96	(.87)	2.92	(.83)	0.04	(.60)	0.78	[ns]
Overall	3.87	(1.11)	2.97	(1.20)	0.90	(1.42)	6.82	[ns]

Scale: 5 = Very Good
 4 = Good
 3 = Average
 2 = Poor
 1 = Very Poor

3.26 = Mean
 (.63) = Standard deviation
 [.05] = One-tailed significance level

The direct comparison of dehulled and whole grain flour generated quite large differences compared to average scores on the first test. For all three components of the evaluation (before cooking, after preparing *toh* and after preparing *bouillie*), the largest differences are observed for color. In focus group discussions after the pre-test, women explained that color is an indicator of cleanliness and freshness. It is the brightness as much as the tint that is important. White maize flour made from whole grains has a slightly grayish appearance. Flour from dehulled grains scored significantly higher than whole grain flour for all criteria except yield of cooked *toh*, and sweetness and time required to prepare *bouillie*. An important question that needs to be addressed is to what extent are consumers willing to give up preferences for flour from dehulled grain in return for a cheaper product?

The intention-to-purchase portion of the questionnaire was also revised to address problems encountered with the quantitative demand estimation procedure in the first test (Figure 7.2). First, a grid of prices was proposed: 150 CFA F/kg (corresponding to the retail price of milled rice at the time of the test), 115 CFA F/kg, 90 CFA F/kg, and 70 CFA F/kg (corresponding to the retail price of unprocessed coarse grains). The housewife was asked first whether she would be prepared to buy maize flour at 150 CFA F/kg (the enumerator pointing out that this is equivalent to the price of milled rice). If she replied no, then the question was repeated for 115 CFA F/kg. If the housewife replied yes, then she was asked how many times per week she would prepare the principal coarse-grain-based dishes (*toh*, *couscous*, *bouillie*) with this flour. Since the quantity of flour required by each

household to prepare each dish could be estimated from the consumption survey, it was not necessary to pose the quantity question explicitly.

In order to increase the household head response rate, male enumerators engaged in the collection of monthly expenditure data were assigned the task of obtaining contingent valuation responses using the same questionnaire. This enabled a much higher proportion of male household heads to be interviewed compared to the first test.

7.3 The demand for maize flour: hypotheses and model specification

This section is divided into two parts. The first briefly defines hypotheses of interest. The second justifies the choice of a standard censored Tobit model and specifies the model to be estimated. The next section presents the results of maximum likelihood estimation of the Tobit model, and derives price and income elasticities and demand schedules for the two flour types. Section 7.5 compares the costs of different qualities of flour to demand and determines the approximate magnitude of equilibrium flour quantities, and considers appropriate marketing strategies.

7.3.1 Hypotheses concerning the demand for maize flour

The principal objective of the contingent valuation household tests is to estimate the potential effective demand for maize flours of different quality. In order to capture the broader policy implications of the tests for coarse grain processing, four hypotheses are specified. With one exception, these cannot be tested in a formal statistical sense because the non-linear estimation procedure does

not generate single-valued expectations upon which to construct conventional confidence intervals. The values generated by the model can nevertheless be evaluated for their economic rather than statistical significance.

- (i) *the demand for maize flour is more price- and income-elastic than the demand for maize grain at estimated retail prices;*

This hypothesis is motivated by the fact that if the demand for maize flour is more price-elastic than the demand for maize grain, then the aggregate demand for maize grain will become more elastic with the introduction of commercial maize flour manufacture. A more price-elastic demand schedule for maize implies that a larger proportion of the benefits of farm-level production technology will remain with maize growers (*ceteris paribus*), and will reduce inter-annual supply-induced price fluctuation (chapter 2). A higher income elasticity of demand implies that producers will derive benefits from improved farm-level production technology over a longer period of time as incomes rise with economic development than would be the case without the introduction of commercial flour manufacture.

- (ii) *consumers are willing to purchase more whole grain flour than flour made from dehulled grain at retail prices that reflect their respective costs of manufacture and distribution;*

This hypothesis is contrary to the prevailing opinion in Mali, since coarse grains are generally dehulled prior to milling in urban and rural areas of Mali.¹⁹ Flour made from whole grains appears contaminated by dirt in the eyes of urban consumers and hence they are willing to purchase less at any given price. Nevertheless whole grain maize flour is significantly cheaper to manufacture than dehulled maize flour, and could be a cheap source of ready-to-prepare cereal for low-income households. Thus it is important to evaluate willingness to pay for refined and whole grain flour at their respective costs of manufacture in order to determine whether there is a market niche for whole grain maize flour.

(iii) *the demand for whole grain maize flour has a negative income elasticity;*

A negative income elasticity of demand for whole maize flour would suggest its use as a self-targeting food aid commodity.

(iv) *men are willing to purchase less maize flour than women at any given price;*

Differences between men's and women's willingness to pay arise because of differences in the intra-household allocation of benefits and costs from procurement

¹⁹ There are two exceptions to this generalization. First, certain dishes in the *Pays Dogon* (in the fifth Region of Mali) are prepared from whole millet. Second, *toh* prepared from hungry season maize is made with whole maize because the pericarp cannot be separated from the endosperm of the immature grain prior to milling. Even in this case, the larger particles of pericarp are often removed from the flour by sieving.

of processed grain under prevailing household management institutions (chapter 4).²⁰ For planning purposes, estimates of current demand should be based on household head willingness to pay. As these institutions evolve over time with economic development, and specifically with higher levels of education for and workforce participation by women, these differences may narrow. Thus women's willingness to pay may be a better indicator of long-run potential demand for maize flour.

7.3.2 Choice of estimation technique and specification of the equation

The key statistical property of the variable of interest, quantity of maize flour a household will purchase at a given price, is that it displays both discrete and continuous characteristics. Specifically, flour demand takes the value zero with positive probability, but is essentially continuous over positive values. Given these characteristics, ordinary least squares (OLS) estimators are biased (Kmenta, 1986).²¹

Censored regression models have a common statistical structure that can provide consistent estimators under certain assumptions. Specifically, the standard censored Tobit model can be defined in the population as:

²⁰ Under prevailing institutional arrangements, the household head is responsible for purchasing coarse grains and women are responsible for processing them. Procurement of processed coarse grains would increase costs for the household head and reduce costs for women. The point should not be pushed too far, however. The Engels curve regressions in chapter 6 showed that demand for processed coarse grains rises with income independently from the proportion of women with primary cash earning activities. This suggests that household heads derive some utility from reducing women's workload.

²¹ This is true whether or not the estimation is restricted to positive non-zero values of the dependent variable (Wooldridge, 1994a).

$$y^* = x\beta + u \quad u | x \sim \text{Normal}(0, \sigma^2)$$

$$y = \max(0, y^*)$$

The problem at hand can be formulated with this structure.

The objective is to estimate an equation:

$$E(c_i | x_i)$$

where c_i is the amount of flour household i is willing to purchase in a specified time period. The problem can be cast as a monthly flour demand model.²² In order to simplify the algebra, utility is maximized for the household rather than for the household head.²³

$$\max_{c, g} U_i(c, g) \text{ subject to } pc + g = y_i$$

where:

U_i	=	utility of household i
c	=	monthly consumption of flour
g	=	monthly consumption of other goods and services
p	=	price of flour (price of other goods and services normalized to unity)
y_i	=	income of household i

Equivalently,

$$\max_{c \geq 0} u_i(c, y_i - pc)$$

Let $r_i(c) \equiv u_i(c, y_i - pc)$. Then the solution can be $c_i = 0$ if $dr_i/dc(0, y_i) \leq 0$, or $c_i > 0$ if $dr_i/dc(0, y_i) > 0$. But,

$$dr_i/dc(0, y_i) = -p \cdot mu_i^g(0, y_i) + mu_i^c(0, y_i),$$

²² The following parallels the example of a model of household charitable contributions set out by Wooldridge (1994b).

²³ This is consistent with utility maximization by a household head whose utility function includes the utility of household members derived from consumption paid for out of the household head's income (chapter 2) so long as the household utility function is a positive monotonic transformation of the household head's utility function.

so $dr_i/dc > 0$ can be expressed as $(\mu_i^c/\mu_i^0) > p$. Accordingly, the solution can be $c_i = 0$ if $(\mu_i^c/\mu_i^0) \leq p$, or $c_i > 0$ if $(\mu_i^c/\mu_i^0) > p$. The foregoing permits us to write a statistical model in the form of a standard censored Tobit as:

$$c_{ij}^* = x_i\beta + u_i \quad u_i | x_i \sim \text{Normal}(0, \sigma^2)$$

$$c_{ij} \equiv \max(0, c_{ij}^*)$$

$$\text{and } x_i \equiv (z_i, y_i, p_j)$$

where p_j = price of flour quality j

y_i = income of household i

z_i = a vector of demographic variables for household i

The dependent variable is quantity of flour (kg per adult equivalent per month). It is estimated by multiplying the number of meals that the respondent indicated would be prepared from maize flour at a given price by the average quantity of flour per adult equivalent used by the household to prepare the meal in question during the 12 months duration of the frequent-visit survey, and aggregating over the different meals (tofu, couscous, bouillie).

The core independent variables (and expected signs) include price (-), income (+), flour quality (+ for dehulled), respondent gender (+ for females), demographic variables, and interaction terms among core variables (e.g., gender by income). Demographic variables include household size (-), sex of household head (+ for females), region of origin (+ for maize growing area), current level of maize consumption (+), and proxy variables for women's opportunity cost of time. Following Kennedy and Reardon (1994), these proxy variables include proportion of women in the household (-), proportion of children in the household (-), proportion

of women with primary and secondary income generating activities (+), and the presence of a maid in the household (-). An additional demographic variable identifies whether the household head is employed in the civil service or the military, organizations that frequently provide interest-free credit for the purchase of cereals, either directly to the employee or through employee cooperatives. Finally, the housewife's overall evaluation scores for *toh* and *bouillie* quality (discussed in the previous section) are included as independent variables. A list of variable names and definitions is provided in Table 7.6.

7.4 The demand for maize flour: results of the Tobit estimation

This section presents the results of the Tobit estimation of maize flour demand. The first part presents the parameter estimates and discusses their significance. The second part calculates expected demand for maize flour (kg per adult equivalent per month). Part three presents price and income elasticities of demand for maize flour and compares them to elasticities of demand for cereals for the urban Sahel from secondary sources. The final part briefly reviews specification issues relating to the Tobit model estimated. Section 7.5 then examines the implications of these results for the commercial feasibility of maize flour in Bamako.

7.4.1 Parameter estimates and significance

The estimated coefficients and significance levels for independent variables are presented in Table 7.7. Since the maximum likelihood estimation procedure is non-linear, these coefficients cannot be interpreted directly as partial effects. The derivation of expected values for the dependent variable, and partial effects and

Table 7.6: Full Specification of the Tobit Model Estimated

INDEPENDENT VARIABLE NAME AND DEFINITION		TYPE	UNIT	EXPECTED SIGN
C	Constant			
PRIX	Price	continuous	CFA F/kg	Negative
GENDER	Gender	dummy	Female = 1	Positive
FLOURTYP	Flour quality	dummy	Dehulled = 1	Positive
GENXPRIX	Gender by price	interaction	CFA F/kg	
GENXTYPE	Gender by quality	interaction dummy		
EXPATYPE	Income by quality	interaction	CFA F/ae	
GENINCAE	Gender by income	interaction	CFA F/ae	
YXGENTYP	Gender by income by quality	interaction	CFA F/ae	
EXPTOTAE	Income per ae	continuous	CFA F/ae	Positive
EXPTOTSQ	Income per ae squared	continuous	CFA F	Negative
MEANAE	Household size	continuous	ae	Negative
MEANAESQ	Household size squared	continuous	ae	Positive
FEMRATIO	Woman ratio	proportion		Negative
KIDRATIO	Child ratio	proportion		Negative
FINACT1	Women with primary cash activity	proportion		Positive
FINACT2	Women with secondary cash activity	proportion		Positive
MZKG_AE	Maize consumption	continuous	kg/ae/year	Positive
REGION	Region of origin	dummy	Maize growing = 1	Positive
GENXREG	Gender by region	interaction dummy		
REAGENTYP	Gender by region by quality	interaction dummy		
CIVSERV	Civil servant	dummy	Household head CS = 1	Positive
MILITARY	Military	dummy	HH head military = 1	Positive
MILXTYPE	Military by quality	interaction dummy		
MILXYAE	Military by income	interaction	CFA F/ae	
MILXY2AE	Military by income squared	interaction	CFA F	
MILXGEND	Military by gender	interaction dummy		
MXGENINC	Military by gender by income	interaction	CFA F/ae	
MXGENTYP	Military by gender by quality	interaction dummy		
MYGENTYP	Military by gender by income by quality	interaction	CFA F/ae	
MILXPRIX	Military by price	interaction	CFA F/kg	
CHEFSEXE	Household head gender	dummy	Female HH head = 1	Positive
BONNE	Maid	dummy	Maid employed = 1	Negative
TOBQUAL	Toh quality	discrete	{1 = very poor	Positive
BOUIQUAL	Bouillie quality	discrete	{5 = very good	Positive

elasticities for independent variables of interest, are presented below. We first briefly compare the sign and significance level of estimated coefficients with predicted values.

The coefficient on price (PRIX) has the expected sign and is highly significant ($t = -13.99$). The coefficient on income (EXPTOTAE) is not significantly different from zero, but the coefficient on the squared income term (EXPTOTSQ) is negative and significant.

The coefficient on flour quality (FLOURTYP) is not significantly different from zero, while the coefficient on gender (GENDER) is highly significant ($t = -3.99$) but not with the expected sign. In both cases the expected effects are captured through interaction terms. The coefficient on the income by flour quality interaction term (EXPXTYPE) is positive and significant, indicating that there is a positive demand response to income for dehulled flour. The gender by income interaction (GENINCAE) is also positive and significant, while the significant coefficient for the gender by income by quality interaction term (YXGENTYP) is of similar magnitude with the opposite sign. This implies that women have a higher demand response to income than men for whole grain flour, but this response is not significantly affected by flour quality. The coefficient on the gender by price (GENXPRIX) interaction term is positive and significant, indicating that women's demand is less price-responsive than men's.

Among demographic variables of interest, the coefficient on household size (MEANAE) is negative and significant at the .05 level ($t = -2.27$). The coefficient on the squared household size term (MEANAESQ) is not significantly different from

Table 7.7: Results of Standard Censored Tobit (Maximum Likelihood Estimation)

Log-Likelihood..... -2891.361						
Threshold values for the model: Lower= 0.0000 Upper=+Infinity						
Variable	Coefficient	Std. Error	t-ratio	Prob t >x	Mean of X	S.D.of X

C	21.262	1.918	11.086	0.00000	1.0000	0.00000
PRIX	-0.15111	0.1080E-01	-13.993	0.00000	106.25	29.880
GENDER	-6.8085	1.705	-3.993	0.00007	0.62717	0.48373
FLOURTYP	0.12770E-01	1.200	0.011	0.99151	0.50361	0.50017
GENXPRIX	0.50095E-01	0.1271E-01	3.942	0.00008	66.637	56.582
GENXTYPE	1.6117	1.475	1.093	0.27460	0.31575	0.46498
EXPXTYPE	0.21740	0.7973E-01	2.727	0.00639	6.7886	9.0911
GENINCAE	0.28819	0.7619E-01	3.782	0.00016	8.3067	9.3873
YXGENTYP	-0.21300	0.9321E-01	-2.285	0.02231	4.1915	7.8619
EXPTOTAE	-0.29061E-01	0.8510E-01	-0.342	0.73272	13.475	8.6014
EXPTOTSQ	-0.35288E-02	0.1174E-02	-3.005	0.00265	255.51	481.50
MEANAE	-0.20876	0.9190E-01	-2.272	0.02311	7.1017	5.3448
MEANAESQ	0.29427E-02	0.2111E-02	1.394	0.16332	78.981	212.93
FEMRATIO	-8.7645	1.946	-4.503	0.00001	0.28225	0.15133
KIDRATIO	-0.76090	1.442	-0.528	0.59769	0.44745	0.17903
FINACT1	1.4419	0.3738	3.857	0.00011	0.127	175.36
FINACT2	-1.4445	0.3737	-3.865	0.00011	0.4315	175.41
MZKG_AE	-0.97399E-01	0.1680E-01	-5.796	0.00000	7.4353	11.191
REGION	-0.21541E-02	0.1250E-02	-1.723	0.08487	0.2294	150.23
GENXREG	1.8279	0.7194	2.541	0.01106	0.15029	0.35748
REGENCY	0.28495	0.9756	0.292	0.77022	0.75145E-01	0.26372
CIVSERV	-0.67493	0.5585	-1.209	0.22684	0.13295	0.33964
MILITARY	5.6055	5.035	1.113	0.26558	0.12139	0.32669
MILXTYPE	-2.0103	2.088	-0.963	0.33576	0.60694E-01	0.23885
MILXYAE	1.2180	0.5731	2.125	0.03356	1.5306	4.4651
MILXY2AE	-0.53206E-01	0.1719E-01	-3.095	0.00197	22.265	79.918
MILXGEND	-23.313	3.793	-6.147	0.00000	0.98266E-01	0.29778
MXGENINC	0.60132	0.2474	2.431	0.01507	1.1847	3.8533
MXGENTYP	6.7565	3.757	1.798	0.07211	0.49133E-01	0.21622
MYGENTYP	-0.11580	0.2340	-0.495	0.62070	0.59235	2.7884
MILXPRIX	0.39659E-01	0.1684E-01	2.355	0.01853	12.897	36.239
CHEFSEXE	2.0717	1.181	1.755	0.07927	0.40462E-01	0.19711
BONNE	0.47612E-03	0.2538E-02	0.188	0.85119	0.211	75.777
TOHQUAL	0.38731E-02	0.1409E-02	2.749	0.00598	4.454	168.17
BOUIQUAL	-0.66136E-03	0.9505E-03	-0.696	0.48653	3.4493	222.69
σ	5.5698	0.1509	36.912	0.00000		

zero. The proportion of women in the household (FEMRATIO) has a large and highly significant ($t = -4.5$) negative coefficient as expected. The proportion of children in the household (KIDRATIO) is not significantly different from zero. The proportion of women with primary cash-earning activities (FINACT1) has a positive and highly significant coefficient, but the proportion of women with secondary cash-earning activities (FINACT2) has a negative and highly significant coefficient of roughly equal magnitude. A possible explanation for these apparently conflicting results is that coarse grain processing tasks do not compete for time with secondary activities but do in the case of primary activities. The coefficient on employment of a maid (MAID) is not significantly different from zero. The coefficient on the variable representing female-headed households (CHEFSEXE) is positive and significant at the .10 level.

The characteristics of households where the household head is in the military give rise to a substantially different demand pattern. Military by income (MILXYAE), military by gender by income (MXGENINC), and military by gender by flour quality (MXGENTYP) are all positive and significant at the .10 level or higher. The military by price (MILXPRICE) interaction term is positive and significant at the .02 level ($t = 2.36$). These results imply that flour demand for military households is more income-responsive and less price-responsive than civilian households. Possible explanations for this are that the army provides interest-free credit for the purchase of cereals, and male household heads are frequently absent for long periods of time on training or other military duties, making these households, in effect, female-headed for a large part of the time. This suggests that military bases located in and near Bamako (e.g., Kati) could be an important market segment to target during the

initial market development phase. In contrast to military households, the coefficient for households where the head is employed in the civil service (CIVSERV) is not significantly different from zero.

The coefficient on the dummy variable representing a household from a maize growing area (REGION) is negative (significant at the .01 level), but very small. The coefficient for women from a maize growing area (REGENTYP) is positive, significant at the .01 level, and very large compared to the coefficient for men. The coefficient on the quality of toh prepared from flour (TOHQUAL) is positive and significant, but the magnitude of the coefficient is very small. The coefficient on the quality of porridge prepared from flour (BOUIQUAL) is not significantly different from zero. This suggests that most of the total variation in flour quality relevant to consumer demand has been captured by the flour quality and flour quality interaction terms. It does not imply that flour quality is unimportant.

7.4.2 Estimated demand for dehulled and whole grain flours

The objective of the Tobit model specified is to estimate the expected monthly purchase of maize flour (of specific quality) per adult equivalent per month at a given price, income and set of demographic variable values. We distinguish between conditional and unconditional demand for the sample. Conditional demand refers to the expected quantity of flour purchased per adult equivalent by those sample households consuming a positive quantity. Unconditional demand refers to the expected quantity of flour purchased per adult equivalent for all sample households, including those that do not consume any. In this section we calculate

expected demand for maize flours of different quality before and after devaluation, and use that information to evaluate hypotheses (ii) and (iv).

We are primarily interested in unconditional demand, but calculate conditional demand as an intermediate step. The conditional demand for a given flour type can be estimated by:

$$E(c | x, c > 0) = x\beta + \frac{\sigma \phi(x\beta/\sigma)}{\Phi(x\beta/\sigma)}$$

where $\phi(x\beta/\sigma)$ is the standard normal density, and $\Phi(x\beta/\sigma)$ the cumulative normal density, evaluated at the expression in parentheses.²⁴ The unconditional demand can be obtained by multiplying the expression for conditional demand by the probability that consumption is positive:

$$E(c | x) = \Phi(x\beta/\sigma) \{x\beta + \sigma\lambda(x\beta/\sigma)\}$$

where $\lambda(x\beta/\sigma)$, the inverse Mills ratio, equals $\phi(x\beta/\sigma)/\Phi(x\beta/\sigma)$. For the remainder of the chapter, expected demand refers to unconditional expected demand unless specifically stated otherwise.

In order to determine expected demand the sample is divided into six sub-groups: military and civilian, each with three income terciles. The reason for dividing the sample into military and civilian is to be able to correct for the over-representation of military personnel in the sample compared to the population. For frequent-visit survey sample households participating in flour consumption tests, 15.5% of household heads are in the military, compared to 5% in the single-shot representative sample of 640 households. The reason for dividing the sample into income terciles is that household size, a key determinant of demand, is negatively correlated with income (chapter 6). Thus, when estimating expected demand we

²⁴ For the derivation of these formulae see Wooldridge (1994b).

want to take account of the fact that high-income households are of smaller than average size, and low-income households are of larger than average size. For each of the six sub-groups, the quantity $x\beta$ is evaluated for male respondents (i.e., all gender interaction terms restricted to zero) at the sub-group mean value of each independent variable. Evaluation of expected demand for male respondents reflects the prevailing household economic institution that the household head is responsible for cereal purchases (chapter 4). An average expected demand for the whole sample can be calculated as a weighted sum of the individual sub-group expected demands.

The expected demand for each flour type and sub-group is calculated before and after devaluation of the CFA franc to take account of the short-run income effect of this policy change.²⁵ On the basis of average price increases in the first three months following devaluation, we assume a 40% decline in real income for civilian sub-groups, and a 33% for military (civil servants received a 10% pay increase to compensate for the rise in cost of living).²⁶ The estimates of demand for the post-devaluation scenario must be interpreted with great caution, however. The implicit reference prices (e.g., the price of rice) to which consumers are comparing hypothetical flour prices have changed since the time of the survey. It is quite conceivable that, if the survey was repeated in the post-devaluation environment, a different set of results would be obtained.

²⁵ The long-run intended outcome of devaluation is that real incomes will rise faster than they would have otherwise.

²⁶ At a workshop on the impact of the devaluation of the CFA franc on incomes and food security in the Sahel, organized by the Institut du Sahel (PRISAS) in July 1994, the representative of the West African Central Bank (BCEAO) reported that the post-devaluation annual rate of inflation was 38%. J. Staatz, personal communication, August 1994.

Expected demands for each flour type, sub-group, and the sample as a whole are presented in Table 7.8. Part a of Table 7.8 presents pre-devaluation expected demand and part b post-devaluation expected demand. Expected demand for military households is substantially higher than civilian at all income levels, before and after devaluation. This justifies the decision to correct for their over-representation in the sample.

Demand for each flour type for the sample as a whole is presented graphically in Figure 7.3 for both pre- and post-devaluation scenarios. Expected demand for dehulled flour is greater than for whole grain flour at any given price. However, it is clear that consumer preferences are sensitive to price. Before devaluation, if whole grain flour is approximately 20 CFA F/kg cheaper than dehulled, consumers would be willing to buy similar quantities of either flour.²⁷ With devaluation, the demand for dehulled flour shifts to the left (decrease in quantity demanded at any given price), while the demand for whole grain flour shifts to the right (increase in quantity at any given price), implying that dehulled flour is a normal good, and whole grain flour an inferior one. For the post-devaluation scenario, a price discount in the order of only 10 CFA F is adequate incentive for consumers to be willing to buy similar quantities of either flour. Thus consumer preferences are even more sensitive to price following devaluation. This willingness of consumers to trade quality for price is consistent with maize flour

²⁷ This is obviously an approximation. The price difference at which consumers will be indifferent between dehulled and whole grain flour will vary with the price of dehulled flour, and the income and other demographic characteristics of any given sub-group (see Table 7.8). Given that the results are based on a contingent valuation test rather than observed behavior in the marketplace, it is realistic to consider orders of magnitude rather than exact differences.

**Table 7.8A: Expected Demand for Maize Flour Pre-devaluation
(kg/ae/month)**

DEHULLED FLOUR								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
LOWY-CIV	0.11	0.47	1.19	2.11	3.39	4.43	5.61	6.89
MIDY-CIV	0.15	0.61	1.47	2.51	3.91	5.03	6.26	7.59
HIY-CIV	0.17	0.66	1.55	2.63	4.06	5.20	6.45	7.79
LOWY-MIL	0.32	1.42	2.85	4.35	6.14	7.46	8.86	10.30
MIDY-MIL	0.64	2.30	4.16	5.92	7.92	9.33	10.78	12.27
HIY-MIL	0.22	1.09	2.33	3.68	5.36	6.76	7.97	9.39
TOTAL	0.16	0.63	1.49	2.53	3.92	5.04	6.27	7.59
WHOLE GRAIN FLOUR								
GROUP	PRICE							
	175	150	130	115	100	90	80	70
LOWY-CIV	0.06	0.27	0.77	1.45	2.49	3.38	4.42	5.60
MIDY-CIV	0.05	0.26	0.73	1.40	2.40	3.28	4.31	5.47
HIY-CIV	0.02	0.11	0.36	0.76	1.45	2.09	2.90	3.87
LOWY-MIL	0.36	1.53	3.04	4.58	6.41	7.75	9.15	10.60
MIDY-MIL	0.54	2.05	3.81	5.51	7.46	8.85	10.30	11.77
HIY-MIL	0.11	0.64	1.52	2.58	4.00	5.12	6.37	7.71
TOTAL	0.06	0.28	0.73	1.36	2.31	3.14	4.12	5.24

Group definitions and weights:

LOWY-CIV	Lower income tercile - civilian	0.3167
MIDY-CIV	Middle income tercile - civilian	0.3167
HIY-CIV	Upper income tercile - civilian	0.3167
LOWY-MIL	Lower income tercile - military	0.0176
MIDY-MIL	Middle income tercile - military	0.0176
HIY-MIL	Upper income tercile - military	0.0147
TOTAL		1

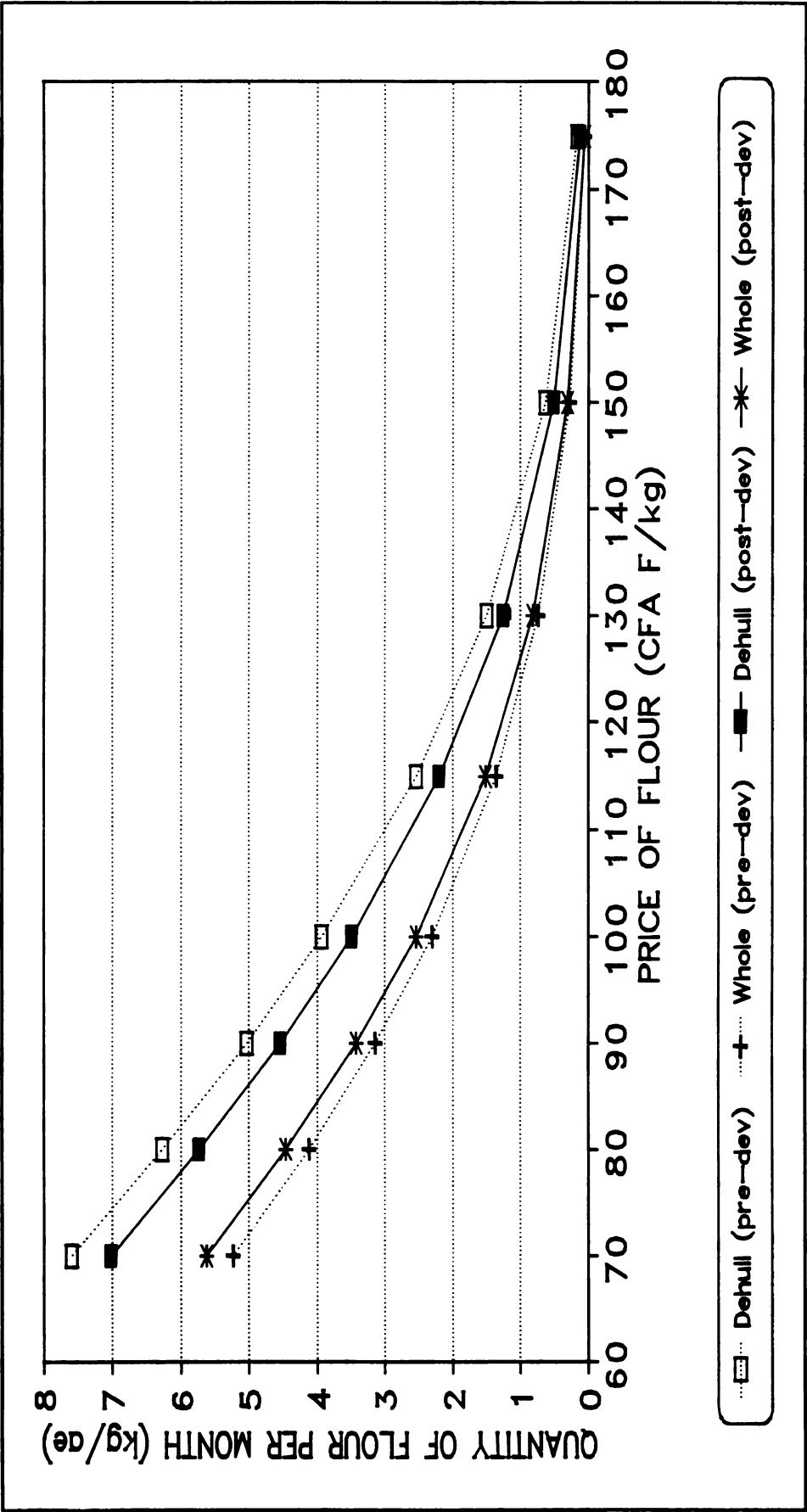
**Table 7.8B: Expected Demand for Maize Flour Post-devaluation
(kg/ae/month)**

DEHULLED FLOUR								
GROUP	PRICE							
	175	150	130	115	100	90	80	70
LOWY-CIV	0.09	0.40	1.05	1.89	3.10	4.10	5.24	6.49
MIDY-CIV	0.12	0.51	1.27	2.22	3.53	4.59	5.79	7.09
HIY-CIV	0.12	0.51	1.26	2.21	3.52	4.58	5.77	7.07
LOWY-MIL	0.16	0.85	1.91	3.11	4.67	5.88	7.18	8.56
MIDY-MIL	0.23	1.10	2.35	3.70	5.38	6.65	8.01	9.42
HIY-MIL	0.42	1.54	3.04	4.58	6.41	7.75	9.16	10.61
TOTAL	0.12	0.51	1.25	2.19	3.48	4.54	5.72	7.01
WHOLE GRAIN FLOUR								
GROUP	PRICE							
	175	150	130	115	100	90	80	70
LOWY-CIV	0.06	0.29	0.80	1.51	2.57	3.48	4.54	5.73
MIDY-CIV	0.06	0.30	0.83	1.56	2.63	3.55	4.62	5.82
HIY-CIV	0.03	0.17	0.53	1.06	1.91	2.68	3.61	4.69
LOWY-MIL	0.22	1.10	2.34	3.69	5.37	6.64	7.99	9.41
MIDY-MIL	0.26	1.22	2.54	3.94	5.67	6.96	8.33	9.76
HIY-MIL	0.30	1.35	2.75	4.21	5.99	7.30	8.69	10.13
TOTAL	0.06	0.30	0.81	1.51	2.54	3.42	4.46	5.63

Group definitions and weights:

LOWY-CIV	Lower income tercile - civilian	0.3167
MIDY-CIV	Middle income tercile - civilian	0.3167
HIY-CIV	Upper income tercile - civilian	0.3167
LOWY-MIL	Lower income tercile - military	0.0176
MIDY-MIL	Middle income tercile - military	0.0176
HIY-MIL	Upper income tercile - military	0.0147
TOTAL		1

Figure 7.3: Male Respondent (Household Head) Demand for Maize Flours Pre- and Post-devaluation



- Notes:
- 1. Dehull (pre-dev) refers to maize flour made from dehulled grain prior to devaluation of the CFA F.
 - 2. Whole (pre-dev) refers to whole grain maize flour prior to devaluation of the CFA F.
 - 3. Dehull (post-dev) refers to maize flour made from dehulled grain after devaluation of the CFA F.
 - 4. Whole (post-dev) refers to whole grain maize flour after to devaluation of the CFA F.

demand in other countries undergoing structural adjustment in Eastern and Southern Africa (Rubey, 1993; Mukumbu and Jayne 1994).

In order to evaluate hypothesis (ii), that consumers are willing to purchase more whole grain flour than flour made from dehulled grain at prices that reflect their costs of production, we need to compare the differences in willingness to pay in the preceding paragraph to differences in cost of manufacture. Prior to devaluation, whole grain flour would retail at between 110 CFA F/kg and 114 CFA F/kg, depending on annual throughput and assuming a grain purchase price of 50 CFA F/kg (Table 7.2). Dehulled flour would retail at between 138 CFA F/kg and 146 CFA F/kg depending on milling efficiency, including overhead costs but not VAT, and 50 kg packaging (Table 7.1). A difference in retail price between flour qualities of 28 - 32 CFA F/kg is half as much again as the difference in price at which consumers are on average indifferent between them as measured by the quantity they would be willing to buy (20 CFA F/kg). This finding supports the hypothesis that consumers would be willing to purchase more whole grain flour than dehulled at pre-devaluation prices.

Post-devaluation costs of manufacture add further support to the hypothesis. With the same assumptions as for the pre-devaluation case, whole grain flour would retail at between 128 CFA F/kg and 134 CFA F/kg, while dehulled flour would retail at between 168 CFA F/kg and 178 CFA F/kg depending on milling efficiency. This difference of 40 - 44 CFA F/kg is substantially greater than the approximate 10 CFA F/kg difference in price at which consumers are on average indifferent between the two flour qualities as measured by the quantity they would be willing to buy.

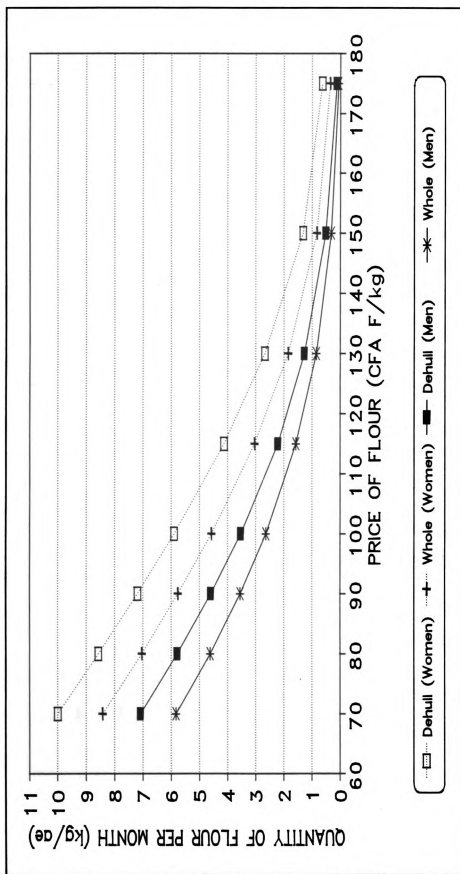
In order to evaluate hypothesis (iv) we contrast gender differences in demand for each flour type post-devaluation for the middle-income tercile (Figure 7.4). At any given price, women clearly have a higher level of demand than men for both whole grain and dehulled flour. Indeed, women would buy more whole grain flour than men would buy dehulled flour at the same price.

Figure 7.5 contrasts women's demand for whole grain and dehulled flour before and after devaluation. The demand schedules for both types of flour shift to the left (decrease in quantity purchased at any given price). This suggests that, for women, both whole grain and dehulled flours are normal goods. The fact that whole grain flour is a normal good for women and an inferior good for men is an indicator of the potential improvement in wellbeing for women from not having to perform arduous and repetitive processing tasks. The results lend strong support to hypothesis (iv), and suggest that changes in household economic institutions as a result of increased full-time participation by women in the workforce would lead to a significant increase in effective demand for processed products.

7.4.3 Price and income elasticities for dehulled and whole grain flours

In this section we compute price and income elasticities of demand for male respondents to evaluate hypotheses (i) and (iii). Although cross-price elasticities to evaluate whether processed maize products can improve substitutability with rice cannot be calculated, analysis of the meals at which maize flour would be used provides a preliminary indication. As maize flour price decreases, increased consumption occurs primarily at meals where coarse grains are already predominant

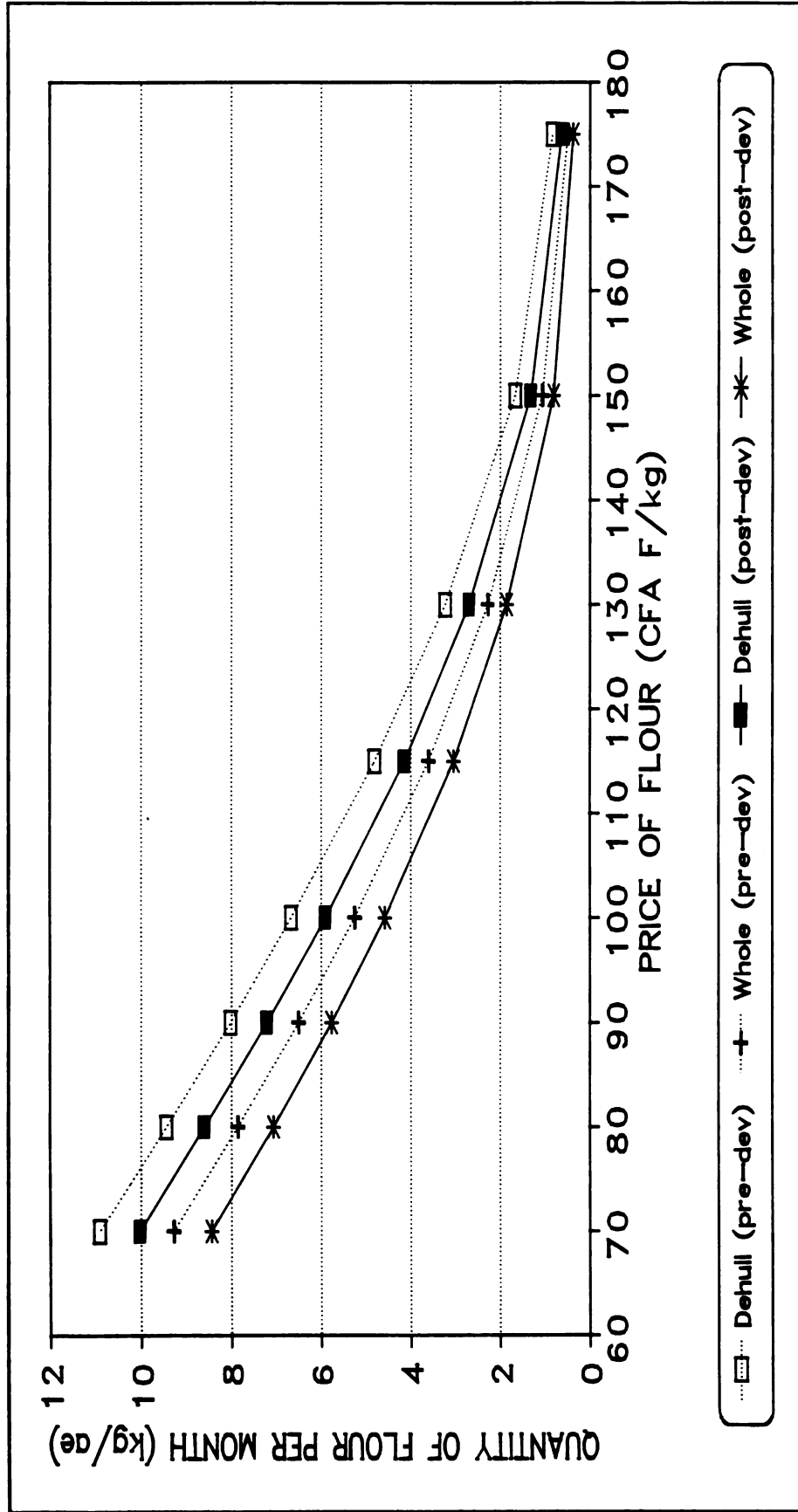
Figure 7.4: Male and Female Demand for Different Quality Maize Flours Post-devaluation



Notes:

1. Dehull (Women) refers to women's demand for maize flour made from dehulled grain after devaluation of the CFA F.
2. Whole (Women) refers to women's demand for whole grain maize flour after devaluation of the CFA F.
3. Dehull (Men) refers to men's demand for maize flour made from dehulled grain after devaluation of the CFA F.
4. Whole (Men) refers to men's demand for whole grain maize flour after devaluation of the CFA F.

Figure 7.5: Female Demand for Different Quality Maize Flours Pre- and Post-devaluation



Notes:

1. Dehull (pre-dev) refers to maize flour made from dehulled grain prior to devaluation of the CFA F.
2. Whole (pre-dev) refers to whole grain maize flour prior to devaluation of the CFA F.
3. Dehull (post-dev) refers to maize flour made from dehulled grain after devaluation of the CFA F.
4. Whole (post-dev) refers to whole grain maize flour after devaluation of the CFA F.

(breakfast, dinner). There is little increase in consumption of maize flour at meals where rice is predominant (lunch, lunch and dinner combined).

a) Price elasticities of demand

The own-price elasticity of demand for a commodity (E_p) measures the percentage change in quantity demanded in response to a one percent change in price (Tomek and Robinson, 1990). It can be calculated using the usual formula:

$$E_p = (\delta Q / \delta P) * (P/Q)$$

where $(\delta Q / \delta P)$ measures the partial effect of price on quantity demanded other factors held constant, and P and Q are the price level and corresponding quantity at which the partial effect is measured. Conditional and unconditional own-price elasticities of demand can be calculated from conditional and unconditional partial effects and their corresponding expected demands.

Our primary interest is in the unconditional own-price elasticity of demand.

We first calculate the conditional partial effect as an intermediate step:

$$(\delta Q_c / \delta P) = (\Sigma \beta_i) * [1 - \lambda(x\beta/\sigma) \{ (x\beta/\sigma) + \lambda(x\beta/\sigma) \}]$$

where $\lambda(x\beta/\sigma)$ is the inverse Mills ratio as before. The unconditional partial effect is then:

$$(\delta Q_u / \delta P) = [(\Sigma \beta_i / \sigma) \phi(x\beta/\sigma) Q_u] + [\Phi(x\beta/\sigma) (\delta Q_c / \delta P)]$$

where Q_u is the unconditional expected demand calculated in the previous section.

The unconditional own-price elasticity of demand can now be computed as:

$$E_{pu} = (\delta Q_u / \delta P) (P/Q_u)$$

Technically, this is an uncompensated unconditional own-price elasticity of demand.

However, since the implied proportion of total income spent on flour is small within

the range of estimated retail prices of maize flour, the difference between compensated and uncompensated price elasticities is likely to be small.

In order to evaluate whether the own-price elasticities of demand for maize flours are higher than for maize grain (hypothesis [i]) we need estimates of the latter. The only urban Sahel study to report an own-price elasticity of demand for maize is that by Reardon et al. (1992) using cross-section consumption data for Ouagadougou in 1984/85. They estimate a compensated own-price elasticity of demand -1.64 (uncompensated -1.68). This is higher than the (not significant) elasticity they report for other coarse grains (compensated -1.27, uncompensated -1.34). These estimates in turn are higher than those found by other studies. Kite (1993) estimates an uncompensated own-price elasticity of demand for coarse grains in urban Senegal of -0.362 using time-series data for 1966-86. Rogers and Lowdermilk (1991) estimate an uncompensated own-price elasticity of demand for coarse grains of -0.526 for eight urban areas of Mali in 1985/1986. Thus, although Reardon et al. is the only available own-price elasticity of demand for maize, there is no reason to believe that it is on the low side.

Estimated own-price elasticities of demand for dehulled flour before and after devaluation are presented in Table 7.9a, and for whole grain flour in Table 7.9b. With the exception of one sample sub-group (middle income military) own-price elasticities of demand are greater than 2 in absolute value at all prices greater than or equal to 90 CFA F/kg for both dehulled and whole grain flour. For flour prices close to estimated retail prices, pre-devaluation elasticities are approximately -5 for dehulled flour and -4.5 for whole grain flour, and post-devaluation -11 for dehulled flour and -6 for whole grain flour. This lends fairly strong support to the hypothesis

Table 7.9A: Price Elasticities of Demand for Dehulled Maize Flours

DEHULLED FLOUR PRE-DEVALUATION								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
CIVILIAN								
Lower Y	-11.45	-7.72	-5.38	-3.98	-2.87	-2.26	-1.76	-1.35
Middle Y	-10.93	-7.32	-5.07	-3.74	-2.68	-2.11	-1.65	-1.26
Upper Y	-10.79	-7.21	-4.98	-3.67	-2.63	-2.07	-1.62	-1.24
MEAN	-11.06	-7.42	-5.15	-3.80	-2.73	-2.15	-1.67	-1.28
MILITARY								
Lower Y	-12.25	-7.47	-5.07	-3.69	-2.63	-2.08	-1.62	-1.25
Middle Y	-10.69	-6.36	-4.27	-3.09	-2.21	-1.75	-1.38	-1.07
Upper Y	-13.02	-8.03	-5.48	-4.01	-2.86	-2.26	-1.76	-1.35
MEAN	-11.99	-7.29	-4.94	-3.60	-2.57	-2.03	-1.59	-1.23
DEHULLED FLOUR POST-DEVALUATION								
CIVILIAN								
Lower Y	-11.77	-7.97	-5.57	-4.14	-2.98	-2.36	-1.84	-1.41
Middle Y	-11.31	-7.61	-5.30	-3.91	-2.81	-2.22	-1.73	-1.33
Upper Y	-11.32	-7.62	-5.30	-3.92	-2.82	-2.23	-1.73	-1.33
MEAN	-11.46	-7.73	-5.39	-3.99	-2.87	-2.27	-1.77	-1.35
MILITARY								
Lower Y	-13.75	-8.57	-5.89	-4.32	-3.09	-2.43	-1.90	-1.46
Middle Y	-12.99	-8.01	-5.47	-4.00	-2.85	-2.25	-1.75	-1.35
Upper Y	-10.25	-7.28	-4.93	-3.59	-2.56	-2.02	-1.58	-1.22
MEAN	-12.33	-7.95	-5.43	-3.97	-2.83	-2.23	-1.74	-1.34

Table 7.9B: Price Elasticities of Demand for Whole Grain Maize Flours

WHOLE GRAIN FLOUR PRE-DEVALUATION								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
CIVILIAN								
Lower Y	-12.50	-8.54	-6.03	-4.50	-3.26	-2.58	-2.02	-1.54
Middle Y	-12.61	-8.63	-6.09	-4.55	-3.30	-2.62	-2.04	-1.57
Upper Y	-14.12	-9.84	-7.06	-5.34	-3.92	-3.13	-2.45	-1.89
MEAN	-13.08	-9.00	-6.39	-4.80	-3.49	-2.78	-2.17	-1.67
MILITARY								
Lower Y	-12.00	-7.29	-4.94	-3.59	-2.56	-2.02	-1.58	-1.22
Middle Y	-11.07	-6.63	-4.46	-3.23	-2.31	-1.83	-1.43	-1.11
Upper Y	-14.53	-9.15	-6.34	-4.67	-3.35	-2.64	-2.06	-1.58
MEAN	-12.53	-7.69	-5.24	-3.83	-2.74	-2.16	-1.69	-1.30
WHOLE GRAIN FLOUR POST-DEVALUATION								
CIVILIAN								
Lower Y	-12.39	-8.46	-5.96	-4.44	-3.22	-2.55	-1.99	-1.52
Middle Y	-12.31	-8.40	-5.91	-4.40	-3.19	-2.52	-1.97	-1.51
Upper Y	-13.31	-9.19	-6.54	-4.91	-3.58	-2.85	-2.23	-1.71
MEAN	-12.67	-8.68	-6.14	-4.59	-3.33	-2.64	-2.06	-1.58
MILITARY								
Lower Y	-13.01	-8.02	-5.48	-4.00	-2.86	-2.25	-1.76	-1.35
Middle Y	-12.70	-7.80	-5.31	-3.88	-2.76	-2.18	-1.70	-1.31
Upper Y	-12.40	-7.57	-5.14	-3.75	-2.67	-2.11	-1.65	-1.27
MEAN	-12.70	-7.80	-5.31	-3.88	-2.76	-2.18	-1.70	-1.31

that the demand for maize flour is more elastic than for maize grain. Only when the price of maize flour is more or less equal to the price of grain (70 CFA F/kg) are own-price elasticities of demand in the vicinity of the value reported by Reardon et al.

The high unconditional price elasticity of demand at estimated retail prices is a reflection of the small quantity purchased. This small quantity reflects the small proportion of buyers in the population and the smaller quantities purchased by those buyers at higher prices. As prices fall, both the number of buyers and quantity purchased per buyer increase. Conditional price elasticities of demand, which measure only the change in quantity purchased by existing buyers in response to a change in price, are smaller than unconditional price elasticities (see Appendix 4).

b) Income elasticities of demand

Income elasticities are computed in the same way as own-price elasticities, with the coefficients on income variables and interaction terms replacing those for price, and income levels replacing price levels. Reardon et al. (1992) report an expenditure elasticity of demand of 1.2 for maize in Ouagadougou. Kite (1993) reports 0.8 for coarse grains in urban Senegal. Rogers and Lowdermilk (1991) report 0.52 for coarse grains in urban Mali.

Income elasticities of demand for dehulled flour before and after devaluation are presented in table 7.10a, and for whole grain flour in table 7.10b. For dehulled flour, income elasticities of demand are generally less than one for the civilian population before devaluation, and less than 0.35 after devaluation. For military

Table 7.10A: Income Elasticities of Demand for Dehulled Maize Flours

DEHULLED FLOUR PRE-DEVALUATION								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
CIVILIAN								
Lower Y	0.56	0.44	0.30	0.23	0.18	0.16	0.14	0.13
Middle Y	0.85	0.67	0.46	0.35	0.28	0.25	0.22	0.20
Upper Y	1.64	1.28	0.88	0.68	0.54	0.48	0.43	0.39
MEAN	1.02	0.79	0.55	0.42	0.34	0.30	0.27	0.24
MILITARY								
Lower Y	3.74	2.66	1.81	1.42	1.16	1.04	0.95	0.87
Middle Y	4.81	3.34	2.30	1.83	1.52	1.38	1.25	1.15
Upper Y	8.87	6.38	4.36	3.39	2.75	2.48	2.22	2.03
MEAN	5.81	4.13	2.82	2.21	1.81	1.63	1.47	1.35
DEHULLED FLOUR POST-DEVALUATION								
CIVILIAN								
Lower Y	0.18	0.14	0.10	0.07	0.06	0.05	0.05	0.04
Middle Y	0.28	0.22	0.15	0.11	0.09	0.08	0.07	0.07
Upper Y	0.54	0.42	0.29	0.22	0.18	0.16	0.14	0.13
MEAN	0.33	0.26	0.18	0.14	0.11	0.10	0.09	0.08
MILITARY								
Lower Y	1.80	1.31	0.90	0.69	0.56	0.50	0.45	0.41
Middle Y	2.51	1.81	1.23	0.96	0.78	0.70	0.63	0.58
Upper Y	3.00	2.49	1.70	1.33	1.09	0.98	0.89	0.82
MEAN	2.44	1.87	1.28	0.99	0.81	0.72	0.66	0.60

Table 7.10B: Income Elasticities of Demand for Whole Grain Maize Flours

WHOLE GRAIN FLOUR PRE-DEVALUATION								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
CIVILIAN								
Lower Y	-0.12	-0.10	-0.07	-0.05	-0.04	-0.04	-0.03	-0.03
Middle Y	-0.20	-0.16	-0.11	-0.08	-0.07	-0.06	-0.05	-0.05
Upper Y	-0.43	-0.35	-0.25	-0.19	-0.15	-0.13	-0.11	-0.10
MEAN	-0.25	-0.20	-0.14	-0.11	-0.09	-0.07	-0.06	-0.06
MILITARY								
Lower Y	3.04	2.16	1.47	1.16	0.95	0.85	0.77	0.71
Middle Y	4.14	2.89	1.98	1.57	1.31	1.18	1.07	0.98
Upper Y	8.24	6.05	4.16	3.21	2.56	2.26	2.03	1.85
MEAN	5.14	3.70	2.54	1.98	1.61	1.43	1.29	1.18
WHOLE GRAIN FLOUR POST-DEVALUATION								
CIVILIAN								
Lower Y	-0.07	-0.06	-0.04	-0.03	-0.02	-0.02	-0.02	-0.02
Middle Y	-0.11	-0.09	-0.06	-0.05	-0.04	-0.03	-0.03	-0.03
Upper Y	-0.24	-0.20	-0.14	-0.11	-0.08	-0.07	-0.06	-0.06
MEAN	-0.14	-0.11	-0.08	-0.06	-0.05	-0.04	-0.04	-0.03
MILITARY								
Lower Y	1.41	1.02	0.69	0.54	0.44	0.39	0.35	0.32
Middle Y	2.04	1.46	1.00	0.78	0.63	0.57	0.51	0.47
Upper Y	3.01	2.14	1.46	1.14	0.94	0.84	0.76	0.70
MEAN	2.15	1.54	1.05	0.82	0.67	0.60	0.54	0.50

households, income elasticities of demand are generally greater than the Reardon et al. estimate before devaluation, but fall sharply with devaluation. For civilian households, the evidence suggests that the demand for flour is not more income-elastic than the demand for grain.

For whole grain flour, income elasticities of demand are negative before and, albeit smaller in absolute value, after devaluation. This is fairly strong evidence that for the civilian population whole grain flour is an inferior good (hypothesis [iii]). However, it is unlikely that it is sufficiently inferior to make it a self-targeting food aid commodity.²⁸ At prices that food insecure urban families could afford to pay, there would likely be significant demand from better-off segments of the population. For military personnel, whole grain flour has positive income elasticities of demand before and after devaluation, but smaller than for dehulled grain.

The combination of relatively high own-price elasticities of demand and relatively low or negative income elasticities of demand for maize flour suggests that, at least for male respondents, the primary objective is to obtain processing services at the lowest cost possible. There is nothing inherently superior in buying a pre-processed product compared to a home-processed product.

The relatively high income elasticities of demand for military households warrant further examination. In contrast to the positive and significant coefficient on the interaction term between military and income for maize flour, the same term in the Engels curve regressions presented in chapter 6 is insignificant for unprocessed grain and grits, and negative for dehulled grain. Thus, there is no statistical evidence that military households have learned to like maize more than

²⁸ Yellow whole grain maize flour would be more suitable for this purpose because of its unpleasant odor and distinct orange coloration when prepared as toh.

civilian households (e.g., as a result of assistance with procurement), although the possibility should not be discounted given the very small sample size (18 households). The high income elasticities of demand could be related to the fact that household heads are often away from home for long periods for training or duties related to the civil war in the north of the country. Given the large number of military households in and near Bamako (there is a large military base at Kati, about 20 km from Bamako), and the geographic concentration of this market (low distribution costs), it would be worth studying in detail with a larger sample, perhaps in conjunction with a market test of the products.

c) Substitution between maize flour and other cereals

In the contingent valuation test, the reference prices of rice (150 CFA F/kg) and coarse grains (70 CFA F/kg) were held constant as the price of flour was varied. Thus it is not possible to formally compute a cross-price elasticity between maize flour and rice, which is generally considered to be low or even negative for coarse grains (implying that rice and coarse grains are complements rather than substitutes). However, we can make an informed guess by comparing the meals at which maize flour will be used as the price of flour falls and the quantity of flour consumers are willing to purchase increases with current cereal use patterns.

Table 6.7 presented the percentage of main meals prepared by frequent-visit survey households from different cereals over a one-year period by income tercile. Recall that coarse grains are the primary source of cereal calories for breakfast and dinner, accounting for 61% and 56% respectively averaged over the sample as a whole. Taken on its own, maize accounts for 6% of breakfast meals and 7% of

dinner meals. Analysis by income tercile reveals that the share of coarse grains at breakfast and dinner declines consistently as income rises. Rice is the primary source of cereal calories at lunch or for combined lunch/dinner meals (i.e., household prepares only one main meal a day in addition to breakfast), accounting for 72% and 67% respectively averaged over the sample as a whole. The poorest income tercile has the lowest proportion of rice-based meals at lunch and lunch/dinner combined. Thus, if maize flour is more substitutable for rice than coarse grains generally, we would hope to see an increasing proportion of lunch and lunch/dinner combined meals made from maize flour as its price decreases, particularly among the middle and high-income terciles.

Table 7.11 presents the percentage of main meals that would be prepared from dehulled and whole grain maize flour at different prices. Figures in parentheses are for female respondents. For both male and female respondents and for both types of flour, expansion of consumption in response to price is most marked at breakfast and dinner, meals where coarse grains are already the primary source of calories. Expansion of consumption at lunch, where rice is predominant, is negligible. There is considerably more expansion in maize flour consumption for the combined lunch/dinner meal than for lunch, but even here the proportion of meals prepared from maize flour never exceeds the proportion currently prepared from coarse grains, even at the lowest flour price.

Table 7.12 presents the percentage of main meals that would be prepared from dehulled and whole grain maize flour by income tercile averaged over all prices. Again, consumption of maize flour follows rather than challenges the

Table 7.11: Intention to Purchase Dehulled and Whole Grain Maize Flours at Different Prices for Use at Principal Mealtimes (proportion each mealtime)

A) DEHULLED FLOUR

PRICE (CFA/kg)	BREAKFAST (PORRIDGE) ALL CG = .74	LUNCH ALL CG = .30	COMBINED MEAL ALL CG = .44	DINNER ALL CG = .66
150	.15 (.22)	0 (.02)	.05 (.09)	.08 (.09)
115	.30 (.38)	.02 (.03)	.06 (.16)	.19 (.17)
90	.60 (.52)	.04 (.06)	.11 (.21)	.37 (.25)
70	.80 (.57)	.04 (.06)	.17 (.25)	.51 (.30)

B) WHOLE GRAIN FLOUR

PRICE (CFA/kg)	BREAKFAST (PORRIDGE) ALL CG = .74	LUNCH ALL CG = .30	COMBINED MEAL ALL CG = .44	DINNER ALL CG = .66
150	.09 (.12)	0 (.01)	.04 (.06)	.05 (.05)
115	.22 (.22)	.02 (.02)	.04 (.12)	.13 (.11)
90	.33 (.31)	.02 (.05)	.07 (.15)	.23 (.17)
70	.54 (.38)	.03 (.06)	.12 (.20)	.40 (.24)

Notes:

1. Figures in the table headings (e.g., ALL CG = .30) are the proportion of meals currently prepared from coarse grains (see Table 6.7 for more details).
2. Figures in the body of the table are proportions of different meals (e.g. lunch) that would be prepared from maize flour at a given price, averaged across all income terciles. Figures without parentheses are responses from male household heads, figures in parentheses are responses from women.
3. Households generally prepare either lunch and dinner or a combined meal (i.e., one principal meal per day).
4. Porridge is not the only meal that can be consumed at breakfast, and porridge (bouillie) can be consumed at other mealtimes (e.g., as a dessert in the evening). However, most porridge is consumed at breakfast time and no attempt was made to estimate potential demand for maize flour for porridge at other meals.

Table 7.12: Intention to Purchase Dehulled and Whole Grain Maize Flours by Income**Tercile for Use at Principal Mealtimes (proportion each mealtime)****A) DEHULLED FLOUR**

PRICE (CFA/kg)	BREAKFAST (PORRIDGE) ALL CG = .74	LUNCH ALL CG = .30	COMBINED MEAL ALL CG = .44	DINNER ALL CG = .66
LOWER	.51 (.48)	02 (.05)	.09 (.22)	.33 (.15)
MIDDLE	.46 (.38)	.04 (.01)	.10 (.18)	.30 (.17)
UPPER	.43 (.40)	.01 (.07)	.11 (.13)	.25 (.29)

B) WHOLE GRAIN FLOUR

PRICE (CFA/kg)	BREAKFAST (PORRIDGE) ALL CG = .74	LUNCH ALL CG = .30	COMBINED MEAL ALL CG = .44	DINNER ALL CG = .66
LOWER	.42 (.32)	.02 (.03)	.04 (.19)	.30 (.10)
MIDDLE	.23 (.19)	.03 (.02)	.07 (.11)	.18 (.10)
UPPER	.26 (.27)	0 (.06)	.08 (.09)	.15 (.23)

Notes:

1. Figures in the table headings (e.g., ALL CG = .30) are the proportion of meals currently prepared from coarse grains (see Table 6.7 for more details).
2. Figures in the body of the table are proportions of different meals (e.g. lunch) that would be prepared from maize flour by a given income tercile, averaged across flour prices. Figures without parentheses are responses from male household heads, figures in parentheses are responses from women.
3. Households generally prepare either lunch and dinner or a combined meal (i.e., one principal meal per day).
4. Porridge is not the only meal that can be consumed at breakfast, and porridge (bouillie) can be consumed at other mealtimes (e.g., as a dessert in the evening). However, most porridge is consumed at breakfast time and no attempt was made to estimate potential demand for maize flour for porridge at other meals.

prevailing cereal utilization patterns. Consumption of maize flour is highest for the low-income tercile and declines as income rises. The only important exceptions to this trend are women respondents for dinner and male respondents for the combined lunch/dinner meal (although the increase across income terciles is very small in the latter case).

In sum, the response of maize flour consumption to price appears to follow prevailing coarse grain utilization patterns by meal and income group. There is little evidence to suggest that maize flour is significantly more substitutable with rice than unprocessed coarse grains generally.²⁹ This is consistent with the finding of low or negative income elasticities for maize flour. It is also consistent with the high observed own-price elasticities of demand, suggesting that the primary concern of (male household-head) consumers is to obtain processing services at lowest cost.

The possibility that maize flour may not improve substitutability with rice should not deter policymakers from seeking to reduce coarse grain processing costs. The significantly higher, but presently ineffective, demand for maize flour for women is indicative of the high social returns to mechanizing labor-intensive cereal processing tasks. This is reinforced by the finding that even whole-grain maize flour has a positive income elasticity for women consumers. Possibilities for reducing the cost of coarse grain dehulling services, as an additional option, are briefly reviewed in section 7.5.

²⁹ The apparent lack of substitutability of maize flour for rice does not imply that this is also the case for other processed maize products. In chapter six it was reported that both maize grits and rice can be used for seri, although the mixture of floury and horny endosperm makes maize an expensive source of grits, and housewives report that they take considerably longer than rice to prepare.

7.4.4 Specification issues

Two types of specification check were carried out for the Tobit model presented in Table 7.7. First, the model was compared to alternative specifications to identify the simplest model without loss of explanatory power, using the log-likelihood ratio test.³⁰ Second, estimated coefficients from the Tobit model were compared to the corresponding probit model.

Alternative specifications of the linear price term, either in log form or through the inclusion of a squared price term, did not improve the explanatory power of the model. Subsequent evaluation of alternative specifications focused on income and households where the head is employed by the military. First, four alternative specifications for income were compared using a simple dummy variable for military. Second, more detailed specifications for capturing the effect of a household head belonging to the military were formulated. The four specifications compared in the first stage, and their log-likelihood values, were:

- 1) a full set of linear and squared income interaction terms (-2949.393);
- 2) a squared income term and no squared income interaction terms (-2950.526);
- 3) no squared income term (-2955.595);
- 4) no income interaction terms (-2963.432).

Model 2 has significantly greater explanatory power than models 3 and 4 on the basis of the log-likelihood ratio test (Table 7.13). However, there is no significant difference between model 1 and model 2, and hence the latter is preferred on the basis of simplicity.

³⁰ The value of the log-likelihood ratio test-statistic is equal to twice the difference between the log-likelihoods of the restricted and unrestricted models, and has a chi-square distribution with number of degrees of freedom equal to the number of restrictions (Greene, 1993).

Table 7.13: Likelihood Ratio Test Statistics for Alternative Specifications for Income

Model	2	3	4
1	2.27 (ns)	12.4 (.025)	28.08 (.005)
2		10.1 (.005)	25.8 (.005)
3			15.67 (.005)

Note: chi-square significance level in parentheses

A similar procedure was used to determine the appropriate specification for capturing the effect of a military household, using model 2 above as the simplest version. The four specifications compared in the second stage, and their log-likelihood values, were:

- 5) price, income and flour quality interaction terms with military (-2891.316);
- 6) no complex price interaction term (military by gender by price) (-2891.338);
- 7) no price or quality interaction terms (-2899.254);
- 8) no interaction terms, equivalent to model 2 above (-2950.526).

Model 6 has equivalent explanatory power to model 5 but significantly greater explanatory power than models 7 and 8 on the basis of the log-likelihood ratio test (Table 7.14) and was used to derive estimated demand for maize flours.

**Table 7.14: Likelihood Ratio Test Statistics for Alternative Specifications for
Military Household**

Model	6	7	8
5	0.09 (ns)	15.9 (.01)	118.4 (.005)
6		15.8 (.005)	118.3 (.005)
7			102.0 (.005)

Note: chi-square significance level in parentheses

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A second type of check is to compare the results of probit and Tobit models with the same specification.³¹ The Tobit model provides separate estimates of β and σ , while the probit model estimates (β/σ) . Comparison of the ratio of β to σ from the Tobit model to the values of (β/σ) from the probit model thus provides an informal specification check. Table 7.15 presents ratios obtained from the Tobit and probit models. The values are similar except where the standard error of the estimate is high. For none of the significant explanatory variables does the difference give rise to concern (e.g., a sign change).³²

Although the Tobit model is conceptually well suited to the problem of estimating demand for a new product, one possible concern is violation of the assumption of constant variance (heteroskedasticity). Such a violation would theoretically result in biased parameter estimates (Greene, 1993). An intuitive reason for suspecting the violation might occur is that when respondents are asked about behavior in hypothetical situations, the further the situation is removed from their present experience the more difficulty they have in predicting their own behavior, leading to higher variance in the error term. The problem goes beyond one of biased parameter estimates, however. Heteroskedasticity in the latent variable model would imply different formulae for the calculation of partial effects and expected demands. These formulae would depend on the specific functional form of the heteroskedasticity. The cost of identifying the specific form of the heteroskedasticity, and deriving the partial effects and expected demands for the

³¹ For the probit model the dependent variable takes on a binary (0 or 1) value whereas for the Tobit model the dependent variable is continuous for non-zero quantities.

³² The estimated probit model correctly predicts zero purchases in 67% of cases and positive purchases in 84% of cases.

Table 7.15: Comparison of Tobit and Probit Coefficients

VARIABLE	TOBIT MODEL		PROBIT MODEL	
	estimated β	estimated β/σ	estimated (β/σ)	s.e. (β/σ)
C	21.2620	3.8174	3.9714	0.4667
PRIX	-0.1511	-0.0271	-0.0322	0.0026
GENDER	-6.8085	-1.2224	-1.2765	0.4154
FLOURTYP	0.0128	0.0023	-0.0286	0.2729
GENXPRIX	0.0501	0.0090	0.0095	0.0031
GENXTYPE	1.6117	0.2894	0.2525	0.3467
EXPXTYPE	0.2174	0.0390	0.0511	0.0180
GENINCAE	0.2882	0.0517	0.0704	0.0169
YXGENTYP	-0.2130	-0.0382	-0.4301	0.0224
EXPTOTAE	-0.0291	-0.0052	-0.0204	0.0197
EXPTOTSQ	-0.0035	-0.0006	-0.0005	0.0003
MEANAE	-0.2088	-0.0375	0.0042	0.0216
MEANAESQ	0.0029	0.0005	0.0001	0.0005
FEMRATIO	-8.7645	-1.5736	-1.5419	0.4721
KIDRATIO	-0.7609	-0.1366	-0.2172	0.3427
FINACT1	1.4419	0.2589	0.2533	0.0894
FINACT2	-1.4445	-0.2593	-0.2534	0.0894
MZKG_AE	-0.0974	-0.0175	-0.0172	0.0039
REGION	-0.0022	-0.0004	-0.0012	0.0003
GENXREG	1.8279	0.3282	0.0932	0.1626
REAGENTYP	0.2850	0.0512	0.1963	0.2339
CIVSERV	-0.6749	-0.1212	-0.0687	0.1333
MILITARY	5.6055	1.0064	3.1749	2.1840
MILXTYPE	-2.0103	-0.3609	-0.8706	0.7432
MILXYAE	1.2180	0.2187	-0.0673	0.2144
MILXY2AE	-0.0532	-0.0096	-0.0008	0.0058
MILXGEND	-23.3130	-4.1856	-5.0755	1.5450
MXGENINC	0.6013	0.1080	0.1956	0.0898
MXGENTYP	6.7565	1.2131	1.7913	1.1680
MYGENTYP	-0.1158	-0.0208	-0.0283	0.0769
MILXPRIX	0.0397	0.0071	0.0060	0.0045
CHEFSEXE	2.0717	0.3720	0.3996	0.2916
BONNE	0.0005	0.0001	0.0005	0.0006
TOHQUAL	0.0039	0.0007	0.0009	0.0003
BOUIQUAL	-0.0007	-0.0001	0.0000	0.0002
Sigma (σ)	5.5698			

heteroskedasticity-robust case, would be high. On the other hand, since both the estimated coefficients and the formulae for deriving partial effects and expected demands change, the results obtained may not differ greatly from those generated by a model that ignored the violation.³³ In view of the increasing use of contingent valuation techniques in forward-looking policy analysis, the question of the magnitude of error in predictions of the actual rather than latent dependent variable is one that requires further research.

7.5 Commercial feasibility of maize flour

This section is divided into two parts. The first part estimates the magnitude of aggregate demand for dehulled and whole grain flours at estimated retail prices, and discusses possible market development strategies. The second part briefly discusses alternative options for alleviating coarse-grain processing constraints, specifically the possibility to reduce the cost of mechanical dehulling services.

7.5.1 Aggregate demand for maize flour and alternative marketing strategies

In order to project aggregate demand for dehulled and whole-grain maize flour we first need to estimate the adult equivalent population for the District of Bamako. The last population census, conducted April 1 - 14th, 1987 reported 186,375 men, 184,066 women, and 284,889 children aged 14 or less (DNSI, 1990). This represents 476,072 adult equivalents using the same weights used for the cereal and flour consumption analyses (adult male = 1; adult female = 0.8;

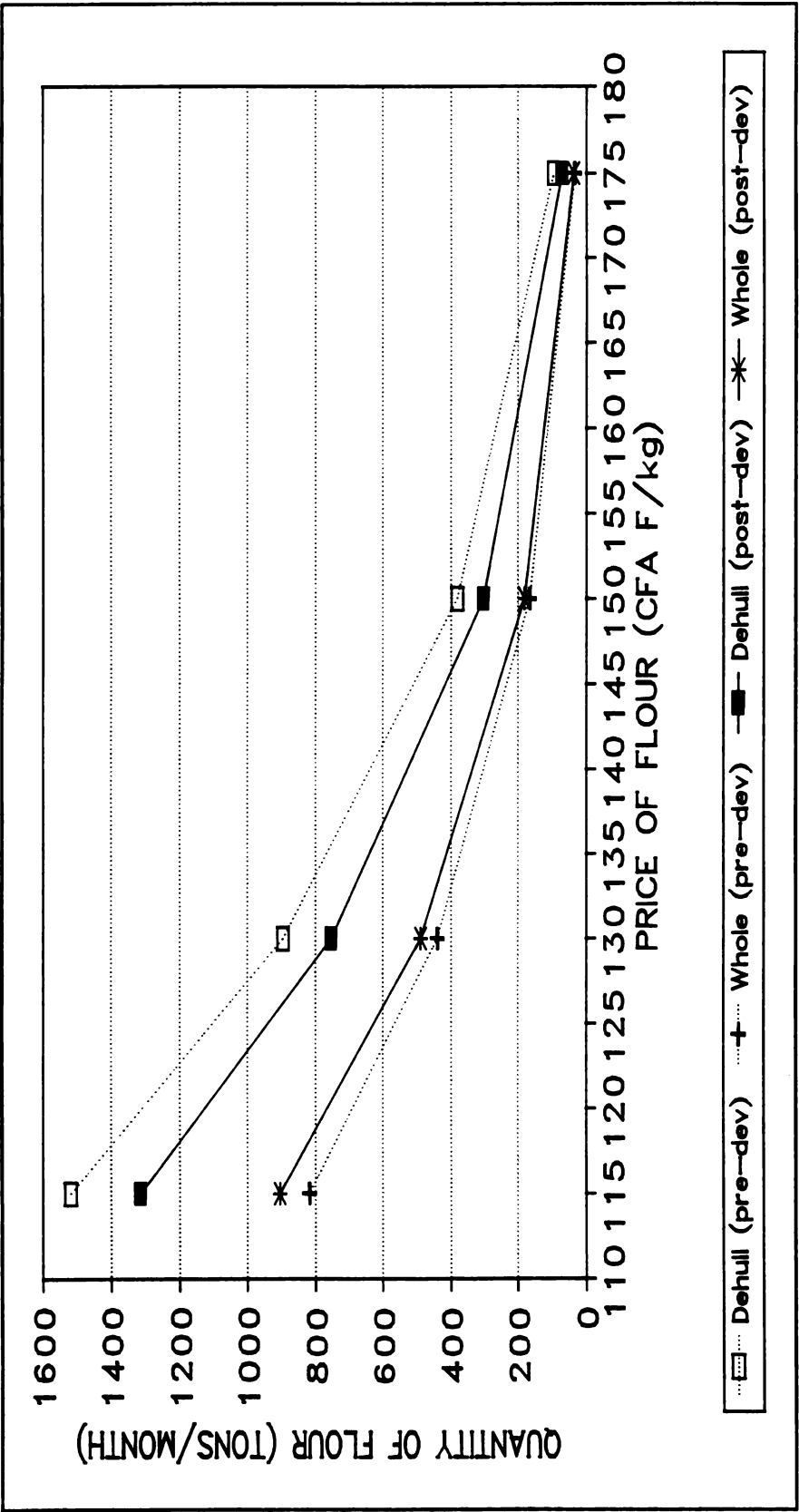
³³ The extent of the difference would depend on the range of independent variable values for which predictions are of interest, with differences becoming increasingly important toward extreme values.

child = 0.5). Urban population growth rates are believed to be between 3% and 4% per annum. At the lower bound, the population for the District of Bamako would be 585,508 ae in 1994; at the higher rate 626,478 ae. For the purposes of this analysis we will assume a population of 600,000 ae. Each kg/ae/month translates into an aggregate projected demand of 600 tons per month.

Figure 7.6 and Table 7.16 present aggregate monthly demand for dehulled and whole grain flour at different prices before and after devaluation. Devaluation affects quantity demanded in two ways. First, it reduces consumer real incomes in the short run. Second, it increases processing costs and therefore retail prices. Given relatively low income- and relatively high price-elasticities of demand for maize flour, the increase in processing costs has a more significant effect on aggregate demand than the reduction in real incomes. Prior to devaluation, assuming prices of 150 CFA F/kg for dehulled and 115 CFA F/kg for whole grain flour, projected demand would be approximately 380 tons per month for dehulled and 815 tons per month for whole grain flour.

Post-devaluation, assuming a price of 175 CFA F/kg for dehulled and 130 CFA F/kg for whole grain flour, projected demand falls sharply to 70 tons per month for dehulled and 490 tons per month for whole grain flour. For whole grain flour, this is approximately equal to current levels of maize grain consumption. However, these prices assume bulk (50 kg) packaging. During the promotional phase, with small (5 kg) packages, prices would be approximately 10 CFA F/kg higher unless subsidized. This would reduce demand still further to (interpolating using the elasticities for the civilian sample in section 7.4.3.a) 26 tons per month for dehulled

Figure 7.6: Aggregate Demand for Maize Flour for the District of Bamako, Mali (Tons/month)



- Notes:
- 1. Dehull (pre-dev) refers to maize flour made from dehulled grain prior to devaluation of the CFA F.
 - 2. Whole (pre-dev) refers to whole grain maize flour prior to devaluation of the CFA F.
 - 3. Dehull (post-dev) refers to maize flour made from dehulled grain after devaluation of the CFA F.
 - 4. Whole (post-dev) refers to whole grain maize flour after to devaluation of the CFA F.

Table 7.16: Monthly Aggregate Flour Demand per Adult Equivalent (kg/ae) and for the Population of the District of Bamako (tons)

PRICE (CFA F/kg)	175	150	130	115	100	90	80	70
	PRE-DEVALUATION							
DEHULLED FLOUR								
Kg/ae/month	0.156	0.632	1.492	2.529	3.923	5.036	6.265	7.592
Tons/month	94	379	895	1517	2354	3021	3759	4555
WHOLE GRAIN FLOUR								
Kg/ae/month	0.056	0.275	0.730	1.359	2.310	3.138	4.119	5.238
Tons/month	34	165	438	816	1386	1883	2471	3143
	POST-DEVALUATION							
DEHULLED FLOUR								
Kg/ae/month	0.117	0.505	1.252	2.188	3.484	4.538	5.722	7.013
Tons/month	70	303	751	1313	2090	2723	3433	4208
WHOLE GRAIN FLOUR								
Kg/ae/month	0.061	0.303	0.812	1.506	2.537	3.423	4.459	5.627
Tons/month	37	182	487	903	1522	2054	2675	3376

Notes:

1. The small increase in demand for whole grain flour after devaluation arises because whole grain flour is an inferior good for the civilian component of the population (95%). A 40% decline in real incomes was assumed to simulate the effect of devaluation.
2. Post-devaluation demand estimates assume no change in relative cereal prices, or equivalently, zero cross-price elasticity of substitution. These estimates may therefore err on the pessimistic side.

and 260 tons per month for whole grain flour. Even for whole grain flour, this is approximately half the present level of maize grain consumption in Bamako.

These estimates of the impact of devaluation need to be treated with some caution. Estimated consumer response is contingent upon a reference price of 150 CFA F/kg for rice and 70 CFA F/kg for coarse grains. Rice prices are likely to rise significantly in the medium term, both absolutely and relative to coarse grains. The CIF cost of imported rice has doubled in CFA franc terms, and the cost of domestically-produced rice will also rise due to increases in the price of imported inputs such as fertilizer and fuel. However, given the high sensitivity of maize flour demand to retail prices, and the lack of any obvious improvement in substitutability with rice, it is difficult to conclude that devaluation has not had a major negative impact in the short run on potential demand for maize flour.

There are three main options open in terms of market development strategies. Option 1 is first to promote refined maize flour to build consumer confidence and then introduce whole grain flour as a low-cost competitor. Option 2 is to forget about refined flour and push whole meal flour, possibly with subsidies in connection with an urban food aid distribution program. Option 3 would be to push both flours simultaneously without direct subsidies.

The first option has three advantages and one major drawback. The first advantage is that Grands Moulins du Mali already has a state-of-the-art maize mill installed. Since the investment is a sunk cost, GMM is likely to be willing to price the product very competitively in the short run in order to obtain at least some return on the investment. This is especially true as milling margins on wheat are progressively squeezed by the removal of tariffs on flour imports and coordinated

donor selling of commodity-aid wheat. Second, GMM would be willing to purchase maize from farmers on a forward contract basis if the PRMC would be willing to finance a maize flour promotion campaign. Farmers repeatedly stated that the lack of a guaranteed price was the principal reason for not investing in fertilizer for maize production. Since improved returns for cereal growers is a major objective of the PRMC, there would be solid justification for using PRMC funds to promote maize flour marketing if linked to maize procurement contracts from maize grower associations. Third, there are other industrial needs for maize products that are currently being met through imported products (e.g., starch for glue, batteries and preserves; grits for brewing) that could be supplied locally once GMM's maize production line was up and running.

The main disadvantage with this option is that the volume of demand at estimated post-devaluation retail prices may too small to make it worthwhile. One possible way to overcome this problem option would be to incorporate maize flour with wheat flour intended for baking bread. For example, a mix of 95% wheat and 5% maize flours would generate a requirement of 1500 tons of maize flour per year, based on pre-devaluation demand for wheat flour. If the technical and financial feasibility of maize flour incorporation with wheat flour can be confirmed, the next step would be to undertake a test of consumer acceptability.³⁴ In view of the acrimonious history of relations between GMM and the bakers, it would be useful to have some outside encouragement and supervision of such a test (e.g., by the PRMC) to ensure that it is undertaken and evaluated in good faith.

³⁴ According to GMM's CEO, maize flour can be incorporated with wheat flour up to 5% without affecting bread quality. R.Achkar, personal communication, January 1994.

The second option has two key advantages. First, it would involve small-scale processors immediately rather than after a delay. Second, consumers need and are receptive to lower-cost products as a result of the fall in real incomes following devaluation. Even the lower post-devaluation level of demand of 490 tons per month is sufficient to keep up to 20 hammer mills in business. Nevertheless, this strategy also has disadvantages that must be overcome. First, there may be strong consumer resistance, at least initially, to purchasing flour from retailers unless it is in sealed packages. This would drive up the cost significantly, undermining the very basis on which the product could compete - cheapness. Second, whole grain flour has a relatively short shelf life. It can become rancid in as little as three weeks. Unless a very rapid and effective distribution system is established, the product could quickly lose credibility with consumers. Third, owners and/or operators of coarse-grain processing equipment currently have very little experience in combining processing and product marketing operations (vertical integration).

The difficulties associated with the promotion of a whole grain flour processing and distribution could be overcome through innovative forms of organization. For example, rapid low-cost distribution could be achieved by networks of women retailers residing in the densely populated suburbs ("quartiers populaires"). Through their detailed knowledge of households in their locality, such retailers could establish a regular clientele. Knowing their clients personally, and being in a position to verify the quality of flour supplied to them and distribute it quickly, they could avoid the need for costly disposable packaging and deliver the product in re-usable containers instead. These retailers could be supplied on a

regular basis either by an existing GIE such as SAMA, or purchase grain and have it milled at a hammer mill installed alongside an existing custom plate mill, or form their own GIE for processing the flour. Such an approach would create badly needed part-time informal sector employment opportunities for women, as well as providing households with a low-cost ready-to-use coarse grain product.

The third option is the most ambitious, seeking to capture the advantages of options 1 and 2. Option 3 has the advantage that the costs of a promotional campaign would not necessarily be significantly higher for two types of flour than for one, and could be designed to target the flours to different market segments. It would be difficult to promote whole grain flour using subsidies without undercutting GMM, however, since whole grain flour is only weakly self-targeting.

Whichever option is chosen, there will be a need to for strong technical backstopping. For both types of flour it will be necessary to monitor flour storage quality at different times of year. For potential hammer mill operators, there is a need to identify mills that can provide sufficiently fine flour without having to manually sieve the product as carried out for the second large-scale consumption test. Recommendations have been made by Mestres (1993), but consideration should also be given to machinery suppliers in Zimbabwe where maize is milled primarily for human consumption rather than for animal feed. For option 2 or 3, organizational support from a specialized microenterprise development unit will also be necessary. In addition to facilitating the establishment of whole grain flour processing and distribution networks, assistance will also be needed to secure a year-round supply of maize grain of appropriate quality (floury endosperm) from urban wholesalers or farmer associations.

7.5.2 An additional option: reducing the cost of de-hulling services

An additional option for the promotion of coarse grain processing is to reduce the cost of dehulling services. Sanogo et al. (1993) undertook a rapid appraisal of the market for dehulled coarse grains, and costs and processing losses. They found the existing system for marketing dehulled coarse grains to be inefficient because of high processing losses and transport costs. Dehulled coarse grains are supplied only at the retailer level in Bamako. Retailers purchase coarse grain from semi-wholesalers, transport it to their stores, transport part of the grain to a dehuller, and then transport the dehulled grain back again. The team found average processing losses of 25%, confirming the hypothesis of Holtzman et al. (1991) that the Engleberg-type dehullers, originally designed for dehulling rice, are poorly suited to coarse grains. Losses were also highly variable from one machine to another. The study estimated that the cost of dehulled grains to the retailer could be cut by 10% through the installation of electric-powered abrasive disk dehullers at the semi-wholesaler level.

Informal interviews with semi-wholesalers revealed that they were hesitant to invest in dehulling equipment because of the low volume of demand. On the basis of Tables 6.4 and 6.5, an estimated 6 kg/ae/year of coarse grains were procured in dehulled form by sample households. If representative of Bamako, aggregate demand for the District would be approximately 3,500 tons/year, or 10 tons per day. While this is technically adequate to keep 3 - 4 abrasive disk dehullers operating full time, demand is highly dispersed geographically and it could take time to build up marketing channels. Also, semi-wholesalers have no experience in processing activities, and frequently do not have access to formal

bank credit. Despite the small size of the market at present, PRMC credit to wholesalers combined with support from micro-enterprise development projects could help it to develop more rapidly given the potential for cost reductions. This could have positive effects on coarse grain marketing channels as a whole because semi-wholesalers engaged in dehulling would have an incentive to pay a premium for clean grain, and for varieties with good dehulling attributes.

7.6 Summary findings

This chapter estimated the demand for dehulled and whole-grain maize flour before and after devaluation for male (household head) respondents. The demand for maize flour is highly price-elastic compared to the demand for maize grain. The demand for dehulled flour has a low income elasticity of demand relative to grain, and for whole grain flour the income elasticity of demand is negative for the civilian population. Demand for maize flour by women is higher than men at all prices, and both dehulled and whole grain flour are normal goods for women. The opportunity to purchase maize flour does not appear likely to have a significant effect on improving substitutability with rice. In addition to price, income and gender, demographic factors such as household size, proportion of women in the household, and whether or not the household head is in the military have important effects on demand. Commercial opportunities to develop urban maize flour processing exist, although they are unlikely to have a significant effect on aggregate maize consumption in the short run. Policies to encourage coarse grain dehulling should also be considered in view of the potential systemic effects on coarse grain marketing, and the potential for reductions in dehulling unit costs.

CHAPTER EIGHT

FARM-LEVEL DEMAND FOR MAIZE TECHNOLOGY AND IMPLICATIONS FOR AGRONOMIC RESEARCH

Maize has two agronomic attributes that distinguish it from millet and sorghum. It is early maturing and fertilizer responsive. The first attribute results in an increase in output value because coarse grain prices are above average during the two months before sorghum and millet are harvested. The second attribute results in an increase in the physical product per unit of land and labor when fertilizer is applied. For farmers, the attractiveness of the maize enterprise compared to millet or sorghum depends on the extent to which additional benefits generated by these attributes outweigh additional costs. The issue is important to examine for two reasons. First, the recent 50% devaluation of the CFA franc will result in a significant increase in the cost of imported fertilizer that may in turn lead to reductions in the already small volume of maize coming to market (Dioné, 1987). Second, if increases in the cost of fertilizer result in a shift to more land-extensive cropping patterns and/or crop management practices this will lead to more rapid soil degradation, a major concern in Mali (World Bank, 1993).

The chapter is divided into three parts. The first re-visits the financial analysis in chapter 3 to examine the consequences of increases in the price of fertilizer for the profitability of intensive maize. The results suggest a need to focus agronomic research effort on ways to increase the productivity of fertilizer on maize. Since the physical and financial performance of improved technology is often site-specific, the second part combines a descriptive analysis of land use patterns with logistic curve

analysis of maize adoption at the subzone level to project future growth in the area of intensive maize in the CMDT zone.¹ The results indicate that maize research investments, particularly on-farm agronomic and varietal testing, should be focussed on realizing productivity gains in the high-potential southern part of the CMDT zone. The final section briefly reviews technology options for improved farm-level productivity of the maize enterprise that need to be explored by agronomic research.

8.1 Returns to fertilizer use on maize

This analysis builds on the financial analysis undertaken in chapter 3 in three ways. First, the analysis examines the impact of post-devaluation financial prices for fertilizer on the relative profitability of maize and sorghum in different recommendation domains. Second, it distinguishes between the profitability of maize for net buyers and net sellers of cereals. Finally, it distinguishes between the value of maize during the hungry season and its value after the main coarse grain harvest, based on rural market prices in the CMDT zone.² These distinctions are important because they affect the incentives for farmers to adopt intensive maize technology. The effect of these incentives on technology adoption will in turn have repercussions for the profitability of urban commercial maize processing activities.

¹ The degree of yield response to added fertilizer depends on environmental factors (e.g., soil, rainfall, pest challenge) and their interactions with crop management practices (in particular weed control and land preparation).

² For the purposes of this analysis, the terms pre- and post-harvest are relative to the harvest of millet and sorghum during November and December. The pre-harvest period is defined as August - October inclusive. These three months coincide with the period when maize is available for consumption either fresh or in grain form, and prior to the harvest of millet and sorghum. The post-harvest period is defined as December - February.

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For example, potential maize processors would find a reliable supply of low-cost maize an incentive to undertake processing activities. But if maize is relatively unattractive to grow and sell compared to sorghum at prices prevailing after the main coarse grain harvest, farmers are unlikely to expand marketed supply.

Scarcity or unpredictability of the quantity and/or quality of marketed surpluses would in turn constrain a maize-led expansion of the urban coarse grain processing sector. This reflects the interdependence between incentives for adoption of farm-level technology and the development of new market opportunities for grain maize discussed in chapter 2.

We first analyze pre- and post-harvest prices for maize and sorghum in the CMDT zone over the four seasons 1989/90 to 1992/93, and then use the results in an analysis of the profitability of fertilizer use on maize before and after devaluation.

Table 8.1 presents average prices for maize and sorghum in rural markets of the CMDT zone based on weekly data collected by the Market Information System (SIM/OPAM) for the four growing seasons between April 1989 and January 1993. Average prices are presented for two periods (before and after the main coarse grain harvest), and for two geographical areas (the northern and less-developed southern parts of the CMDT zone).

In Table 8.1, prices for maize are 9.8 CFA F per kg less than for sorghum averaged across seasons and locations (significant at the .01 level). Averaged across locations, the difference in price between sorghum and maize is greater pre-harvest than post-harvest (12.6 CFA F/kg compared to 5.9 CFA F/kg). Even the smaller post-harvest difference is likely to be a significant disincentive for farm households to take maize to market. The difference may not necessarily be a

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disincentive to grow maize, since maize can be substituted for sorghum in home consumption and sorghum sold instead. The strategy of substituting maize for sorghum in household consumption in order to sell more sorghum was reported by farmers during informal interviews in both Koutiala (north) and Sikasso (south). The financial analysis that follows accounts for this possibility.

Table 8.1: Average Weekly Maize and Sorghum Prices Before and After Harvest in the CMDT Zone (CFA F/kg)

Cereal	MAIZE			SORGHUM		
Location	PRE-HARVEST	POST-HARVEST	Mean	PRE-HARVEST	POST-HARVEST	Mean
NORTH	41.3 (14.8)	41.3 (15.0)	41.3	54.6 (22.2)	46.8 (18.3)	51.5
SOUTH	46.4 (17.7)	38.7 (11.8)	42.6	58.6 (19.2)	44.6 (12.9)	51.6
Mean	42.9	40.3	41.7	55.5	46.2	51.5

Notes:

1. Average weekly prices April 1989 - January 1993 (figures in parentheses are standard deviations).
2. The three months August - October are classified as pre-harvest, and the three months December - February are classified as post-harvest.
3. The Bougouni-Sikasso road was chosen as the dividing line between northern and southern markets. Thus, rural markets classified as "north" are: Béléko, Bla, Dioïla, Dogo, Fana, Kimparana, Kouri, Koutiala, Massigui, Zangasso; those classified as "south" are Kadiolo, Kolondiéba, Koumantou, Loulouni, and Manankoro.

Differences between pre- and post-harvest prices are larger for sorghum than for maize, and larger in the south than the north. The higher spread between pre- and post-harvest prices in the south (14 CFA F/kg for sorghum and 7.3 CFA F/kg for maize) reflects the combination of a higher proportion of net buyer households

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relative to the northern part of the zone, and the underdeveloped road network.³

With the exception of maize in the northern part of the CMDT zone, differences between pre- and post-harvest prices for maize grain are significant. Pooling price data before and after harvest, there are no significant differences in average prices for millet and sorghum between geographical zones. The prices in Table 8.1 are used to value maize and sorghum in the analysis that follows.

Table 8.2 presents a financial analysis of the profitability of fertilizer use on maize in the CMDT zone before and after devaluation. The three recommendation domains presented (north sole crop, south sole crop, and south intercropped) correspond to the three intensive recommendation domains in Table 3.3 (i.e., recommendation domains 1, 3, and 4). For each recommendation domain, the profitability of fertilizer use is compared for three types of farmer: net cereal buyer pre-harvest, net cereal seller pre-harvest, and net cereal seller post-harvest. For net buyers, maize is valued at the pre-harvest price of maize in the respective zone plus transport costs of 5 CFA F/kg. This reflects the opportunity price of maize for own consumption during the "hungry season" compared to purchasing maize on the market. For net sellers pre-harvest, maize is valued at the pre-harvest price of sorghum, less transport costs. This reflects the strategy reported by farmers of selling old sorghum stocks and consuming the new maize harvest instead in order to

³ The basis for the assertion that the proportion of net buyer households is likely to be greater in the southern part of the zone is that the proportion of households without animal traction is higher than average in the two CMDT regions (Bougouni and Sikasso) that make up this area (Goïta, 1993). Dioné (1989) found a positive correlation between level of mechanization and household food production per person. The problems of seasonal inaccessibility are well-known, and the Mali Sud III rural development project plans to construct 500 km of feeder roads in the area (World Bank, 1990).

benefit from the higher price of sorghum.⁴ For this case, an additional processing of 2.5 CFA F/kg is added to reflect the greater difficulty of processing maize instead of sorghum for household consumption. For net sellers post-harvest, maize and sorghum are valued at their respective post-harvest prices in the recommendation domain less transport costs.

The analysis uses the same partial budget approach as chapter 3, where two alternative farm production opportunities are compared taking account only of parameters that differ between them (CIMMYT, 1988). For pre-harvest sole crop scenarios, maize with fertilizer is compared to maize without fertilizer (Table 8.2 A and B). With fertilizer, yields are the same as for the ex-post impact assessment in Table 3.3; without fertilizer, yields are derived from a fertilizer response function estimated by Posner and Crawford (1992) for southern Senegal, an area with similar rainfall to Southern Mali. For post-harvest sole crop net sellers, maize is compared to sorghum, the predominant coarse grain in terms of area cultivated. For maize intercropped with sorghum in the south, the system is compared with and without fertilizer, using prices appropriate to the time of sale.

A marginal rate of return of 100% on investment in cash inputs, equivalent to a value cost ratio (VCR) of 2.0 in the present analysis, is considered necessary for

⁴ Farmers could sell maize rather than sorghum pre-harvest. This would apply in the case of farmers who wish to sell cereals pre-harvest but who have exhausted their old sorghum or millet stocks, or who are reluctant to sell them because of a taste preference. This scenario is not explicitly examined here because, given the lower price for maize compared to sorghum, the analysis would only serve to further reinforce the conclusions drawn.

widespread adoption of a farm-level technology.⁵ The analysis assumes moderate fertilizer doses, equivalent to half the recommended rate.

Prior to devaluation, incremental net benefits to fertilizer use are generally positive but uninspiring.⁶ For only one scenario, sole crop maize for net buyers in the southern part of the CMDT zone (Table 8.2 B), does the VCR exceed this threshold. For other scenarios, with the exception of intercropped maize for net sellers post-harvest, VCRs are likely to provide adequate incentives for adoption only in the case of less risk-averse farmers and/or on fields with particularly responsive soils.

At post-devaluation fertilizer prices, incremental net benefits are still positive but unlikely to encourage adoption except by a small minority of farmers.⁷ For sole crop maize in the northern part of the CMDT zone (Table 8.2 A), VCRs fall from a range of 1.65 - 1.70 to a range of 1.19 to 1.26, a level that can only be characterized as marginally profitable. For sole crop maize in the southern CMDT (Table 8.2 B), the most profitable group of scenarios, VCRs fall from a range of 1.82 - 2.17 to a range of 1.37 to 1.57. The low VCRs for intercropped maize in

⁵ The marginal rate of return (MRR) is the incremental net benefit divided by the incremental cost, expressed as a percentage. The Value Cost Ratio (VCR) is the incremental output value divided by the incremental cost. Where the number of technology options exceeds two, the MRR between options with successively higher levels of investment is the appropriate indicator of relative incentives to adopt (Boughton et al., 1990). Since only two options are compared in each scenario, the two measures give equivalent results.

⁶ Incremental net benefit is the difference between additional value of output generated and additional cost incurred in shifting from a less intensive to a more intensive production opportunity.

⁷ Post-devaluation fertilizer prices are based on retail prices announced by the CMDT for the 1994 crop season, plus 10% short-term finance charges.

**Table 8.2 A: Profitability of Fertilizer Use on Maize Before
and After Devaluation: CMDT North (Sole Crop Maize) (a)**

	NET BUYER PRE-HARVEST	NET SELLER PRE-HARVEST	NET SELLER POST-HARVEST
YIELDS (kg/ha) (b)			
Maize yield with fertilizer	1750	1750	1750
Maize yield without fertilizer	1250	1250	NA
Sorghum yield with fertilizer	NA	NA	NA
Sorghum yield without fertilizer	NA	NA	900
NET PRICES (CFA F/kg) (c)			
Maize	46.3	47.1	36.3
Sorghum			41.8
PRE-DEV COSTS AND BENEFITS (CFA F/kg)			
Incremental cost (d)	14050	14050	15250
Incremental output value	23150	23550	25905
Incremental net benefit	9100	9500	10655
Value Cost Ratio	1.65	1.68	1.70
POST-DEV COSTS AND BENEFITS (CFA F/kg)			
Incremental cost	19430	19430	20630
Incremental output value	23150	23550	25905
Incremental net benefit	3720	4120	5275
Value Cost Ratio	1.19	1.21	1.26
POST-DEVALUATION MAIZE YIELD -20%			
Incremental cost	19430	19430	20630
Incremental output value	18520	18840	20724
Incremental net benefit	-910	-590	94
Value Cost Ratio	0.95	0.97	1.00
POST-DEVALUATION GRAIN PRICE +20%			
Incremental cost	19430	19430	20630
Incremental output value	27780	28260	31086
Incremental net benefit	8350	8830	10456
Value Cost Ratio	1.43	1.45	1.51

**Table 8.2 B: Profitability of Fertilizer Use on Maize Before
and After Devaluation: CMDT South (Sole Crop Maize) (a)**

	NET BUYER PRE-HARVEST	NET SELLER PRE-HARVEST	NET SELLER POST-HARVEST
YIELDS (kg/ha) (b)			
Maize yield with fertilizer	2250	2250	2250
Maize yield without fertilizer	1750	1750	NA
Sorghum yield with fertilizer	NA	NA	NA
Sorghum yield without fertilizer	NA	NA	1200
NET PRICES (CFA F/kg) (c)			
Maize	61.1	51.1	33.7
Sorghum			39.6
PRE-DEV COSTS AND BENEFITS (CFA F/kg)			
Incremental cost (d)	14050	14050	15250
Incremental output value	30550	25550	28305
Incremental net benefit	16500	11500	13055
Value Cost Ratio	2.17	1.82	1.86
POST-DEV COSTS AND BENEFITS (CFA F/kg)			
Incremental cost	19430	19430	20630
Incremental output value	30550	25550	28305
Incremental net benefit	11120	6120	7675
Value Cost Ratio	1.57	1.31	1.37
POST-DEVALUATION MAIZE YIELD -20%			
Incremental cost	19430	19430	20630
Incremental output value	24440	20440	22644
Incremental net benefit	5010	1010	2014
Value Cost Ratio	1.26	1.05	1.10
POST-DEVALUATION GRAIN PRICE +20%			
Incremental cost	19430	19430	20630
Incremental output value	36660	30660	33966
Incremental net benefit	17230	11230	13336
Value Cost Ratio	1.89	1.58	1.65

**Table 8.2 C: Profitability of Fertilizer Use on Maize Before
and After Devaluation: CMDT South (Intercrop Maize/Sorghum) (a)**

	NET BUYER PRE-HARVEST	NET SELLER PRE-HARVEST	NET SELLER POST-HARVEST
YIELDS (kg/ha) (b)			
Maize yield with fertilizer	1500	1500	1500
Maize yield without fertilizer	1250	1250	1250
Sorghum yield with fertilizer	750	750	750
Sorghum yield without fertilizer	500	500	500
NET PRICES (CFA F/kg) (c)			
Maize	61.1	51.1	33.7
Sorghum			39.6
PRE-DEV COSTS AND BENEFITS (CFA F/kg)			
Incremental cost (d)	14050	14050	15250
Incremental output value	25175	22675	18325
Incremental net benefit	11125	8625	3075
Value Cost Ratio	1.79	1.61	1.20
POST-DEV COSTS AND BENEFITS (CFA F/kg)			
Incremental cost	19430	19430	20630
Incremental output value	25175	22675	18325
Incremental net benefit	11125	8625	3075
Value Cost Ratio	1.30	1.17	0.89
POST-DEVALUATION MAIZE YIELD -20%			
Incremental cost	19430	19430	20630
Incremental output value	22120	20120	16640
Incremental net benefit	2690	690	-3990
Value Cost Ratio	1.14	1.04	0.81
POST-DEVALUATION GRAIN PRICE +20%			
Incremental cost	19430	19430	20630
Incremental output value	30210	27210	21990
Incremental net benefit	10780	7780	1360
Value Cost Ratio	1.55	1.40	1.07

Notes to Table 8.2:

- (a) For sole-cropped maize in CMDT north and south, pre-harvest scenarios compare maize with fertilizer to maize without fertilizer.

For sole-cropped maize in CMDT north and south, post-harvest scenarios compare maize with fertilizer to sorghum without fertilizer.

For intercropped maize in CMDT south, all scenarios compare intercropped maize/sorghum with and without fertilizer.

- (b) Yield estimates for sole-crop maize with fertilizer, and for maize/millet intercropping with and without fertilizer, based on Table 3.3.

Yield estimates for sole-crop sorghum in CMDT south increased by 100 kg/ha compared to Table 3.3 to reflect higher rainfall in recent years.

Yield estimates for sole-crop maize without fertilizer based on estimated response functions in southern Senegal (Posner and Crawford, 1992).

- (c) Average seasonal market price plus/minus transport costs (5 CFA F/kg).

For pre-harvest sellers, net maize price equal to net sorghum price less 2.5 CFA F/kg additional processing cost.

- (d) Fertilizer costs based on pre- and post-devaluation CMDT prices for 50 kg/ha cereal complex and 75 kg/ha urea (equivalent to half recommended doses) and 10% short-term (seasonal) credit charge.

Post harvest net seller incremental costs include 15 kg/ha additional seed cost.

the south (Table 8.2 B) reflect the relatively high yields that can be obtained without fertilizer in the short run from areas recently brought under cultivation in this high rainfall zone.⁸ In none of the post-harvest net seller scenarios, the principal source of potential surpluses for purchase by urban processors, are VCRs adequate to encourage intensive farm-level production of maize for the market. This implies that urban processors must either accept considerable uncertainty concerning price and availability of maize on urban spot markets or enter into fixed price contracts with farmer organizations at planting time.

Sensitivity analysis was carried out for a 20% reduction in yields and a 20% increase in price following devaluation. The 20% reduction in yields simulates the effect of a prolonged dry spell. The 20% increase in price simulates a possible increase in the average level of coarse grain prices as a result of the increase in the price of imported rice.⁹ A 20% yield reduction predictably reinforces the negative effect of devaluation on incremental net benefits and VCRs for fertilizer use. In the northern CMDT zone (Table 8.2 A) farmers would break even at best (VCRs range from 0.95 to 1.00). Sole crop maize growers in the southern CMDT zone (Table 8.2 B) barely break even, and for intercropped maize post-harvest, net sellers (Table 8.2 C) losses almost double.

A 20% price increase restores incremental net benefits to levels slightly higher than those before devaluation, but leaves VCRs still too feeble to expect widespread

⁸ Only 22% of the potentially cultivable area in Bougouni was under cultivation in 1989/90, compared to 66% in Koutiala (Goïta, 1993).

⁹ In the four months following devaluation, coarse grain prices initially rose but subsequently fell back to pre-devaluation levels. The long-run equilibrium price of coarse grains will depend on the elasticity of supply of (locally-produced) paddy and milling services with respect to input and product prices, and the urban cross-price elasticity of substitution between rice and coarse grains.

adoption. While a 20% price increase would help to restrain an otherwise more rapid slide to extensive cropping patterns and cultural practices, higher prices for grain maize would lead to a significant decrease in potential demand for maize flour (chapter 7).

In conclusion, the increase in fertilizer prices will result in a significant decrease in the profitability of intensive maize. Unless there is an increase in the price of maize, or a reduction in price risk via contracts, or an increase in the productivity of fertilizer use, farmers are likely to opt for more extensive cropping patterns or crop management practices. While an increase in maize prices would help to restore profitability, it would also make it more difficult for maize-led development of the urban market for processed coarse grains to occur. It is therefore important to identify potential sources of increased productivity.

8.2 Future location of expansion in maize area

Farm-level maize productivity depends on crop management practices (including variety) and the agro-climatic environment. Because agronomic research is environment-specific to varying degrees, so also is the economic payoff to that research investment. The payoff will be positively correlated with the total area over which the improved technology is adopted, the increase in net benefits per unit area, and the rate of adoption. But the CMDT zone covers nearly 118,000 km² (ten times the size of The Gambia). Average annual rainfall doubles between its northern and southern boundaries. Given such variation it is important to identify where within the CMDT zone lies the greatest potential for increased production.

Two simple analyses are used to address this question. The first is a

descriptive analysis of land use intensity and cropping patterns in different parts of the CMDT zone. Historically, the expansion of maize has been part of an overall expansion of area cultivated to cereals as a result of mechanization. This process is continuing with support from the Mali-Sud III agricultural development project. Thus, other things being equal, maize area is likely to expand fastest where land use intensity is low, or maize has an important share of the cropping pattern, or particularly where both occur. The second analysis fits logistic "growth" functions to historic maize area data to project future expansion in cultivated area in different parts of the CMDT zone. These two approaches to analysis of the locus of future maize area expansion can then be compared for consistency.

8.2.1 Land use intensity and cropping patterns within the CMDT zone

The CMDT zone is divided into five subzones for management purposes: San, Fana, Koutiala, Bougouni and Sikasso. For the purposes of this analysis, we group San, Fana, and Koutiala subzones as the northern part of the CMDT zone, and Bougouni and Sikasso as the southern part. This division corresponds approximately to the 1000 mm rainfall isohyet during the period 1980-1985 (Pieri, 1989).

Table 8.3 presents information on land use intensity for different subzones within the CMDT zone. Southern subzones have on average 26% more people per cultivated hectare, and 34% more people per hectare of cereal, than northern subzones. Yet southern subzones cultivate only 23% of the potentially cultivable

Table 8.3: Land Use Intensity in the CMDT Region

SUBZONE	POPULATION	CULTIVABLE AREA (HA)	PERCENT CULTIVATED	POPULATION PER HECTARE CULTIVATED	POPULATION PER HECTARE CEREAL	PERCENT HOUSEHOLDS IN PROGRAM	PERCENT MECHANIZED HOUSEHOLDS
San	536007	486870	40	2.72	3.44	61	68
Fana	340238	672395	32	1.57	3.24	95	79
Koutiala	484231	430622	66	1.70	2.61	93	80
Total north	1360476	1589887	44	1.95	3.05	81	76
Bougouni	440080	787308	22	2.57	4.14	78	67
Sikasso	455790	785220	25	2.37	4.05	96	71
Total south	895870	1572528	23	2.46	4.10	87	69
Total CMDT	2256346	3162415	34	2.13	3.39	84	72

Source: Goïta (1993)

Notes:

- 1) A mechanized household is defined as one owning at least one animal traction implement and a pair of draft animals.
- 2) Percent households in program refers to the percentage of households enrolled in extension activities.

area, compared to 44% in the north.¹⁰ This is partly a reflection of lower levels of mechanization among farming households in the Bougouni, due to lower levels of participation in extension programs and lower levels of mechanization among participating households (Table 8.3).¹¹ In the case of Bougouni, the low proportion of cultivated land reflects the fact that large parts of the subzone have been uninhabitable until recently due to the presence of onchocerciasis (river blindness) (World Bank, 1990). With in-migration to the Bougouni subzone now that onchocerciasis has been eliminated, and increasing levels of participation in extension programs and mechanization as a result of the Mali-Sud III agricultural development project, expansion of cropped area will be considerably more rapid in southern subzones than in northern areas. But whether faster expansion of cropped area in the south also implies more rapid expansion of maize in the south than in the north depends on the relative importance of maize in cropping patterns.

Table 8.4 presents cultivated cereal area and the proportion allocated to different cereals in the five subzones that make up the CMDT zone. Maize accounts for almost 40% of the total cereal area in southern subzones, compared to just 12% in the north. Thus, not only is cropped area likely to expand fastest in the southern subzones, but maize is the single most important cereal in area terms. But while

¹⁰ Although these cropping intensities may appear low for developed countries, it should be recalled that, for farming systems in the fragile savannah ecology, a high proportion of the cultivable land area needs to be under fallow for the system to be sustainable (Pieri, 1989).

¹¹ A farm household must participate in the extension program (be "encadrée") to be eligible for credit for the purchase of farm implements and draft animals. In general the proportion of participating households, and the percentage of participating households with animal traction, are a reflection of how long the region has benefitted from development efforts, usually spearheaded by cotton-based agricultural development projects. The current Mali-Sud III project, for example, is targeting the Bougouni region.

Table 8.4: Cereal Cropping Patterns in the CMDT Zone

SUBZONE	CEREAL AREA (ha)	PERCENT MAIZE	PERCENT MILLET	PERCENT SORGHUM	PERCENT FONIO	PERCENT RAINFED RICE	PERCENT IRRIGATED RICE	TOTAL
San	155933	3.1	45.5	38.3	10.8	0.7	1.6	100
Fana	105134	17.8	16.8	60.2	0.9	3.7	0.6	100
Koutiala	185664	15.8	35.4	46.8	0.5	1.2	0.2	100
Total north	446731	11.8	34.6	47.0	4.2	1.6	0.8	100
Bougouni	106172	41.5	9.2	33.2	5.6	5.0	5.6	100
Sikasso	112500	38.6	23.4	25.1	1.7	2.8	8.5	100
Total south	218672	40.0	16.5	29.0	3.6	3.9	7.1	100
Total CMDT	665403	21.1	28.6	41.1	4.0	2.4	2.9	100

Source: Golta (1993)

maize may be the dominant cereal in the south now, is it likely to expand more rapidly in the southern subzones than in the north in the future? The next section addresses this question by examining growth trends in maize area.

8.2.2 Maize area growth trends

In order to project future trends in the area cultivated under improved maize, a logistic function was fitted to historical data on area adopted in the southern and northern parts of the CMDT zone. The approach used is the same as that by Henry de Frahan (1990) to project technology adoption in northeastern Mali.

The logistic function takes the form $P(t) = K/[1 + \exp\{-(a + bt)\}]$ where $P(t)$ is the cumulative growth in the proportion of the potential area over which the technology is adopted at time t ; K is the adoption ceiling or potential area; and t is time measured in years. In the present context, b can be interpreted as a measure of the rate of acceptance of the new technology.

A simple way to fit the logistic curve is to select the value of K , the adoption ceiling, that gives the best fit for the OLS regression:

$$\log (A/[K-A]) = a + b (\text{YEAR}) + u$$

where A is the area adopted, and the dependent variable is the proportion of the potential area over which adoption has occurred. Using the area data in table 3.1 for the period 1974 - 1990, the following results were obtained (figures in parentheses are standard errors):

a) NORTH

$$\log (A/[K-A]) = -610.79 + .308 (\text{YEAR}); R^2 = .987 \text{ at } K = 35,000 \text{ ha}$$

(29.07) (.015)

b) SOUTH

$$\log (A/[K-A]) = -443.77 + .223 (\text{YEAR}); R^2 = .987 \text{ at } K = 73,500 \text{ ha}$$

$$(29.07) \quad (.015)$$

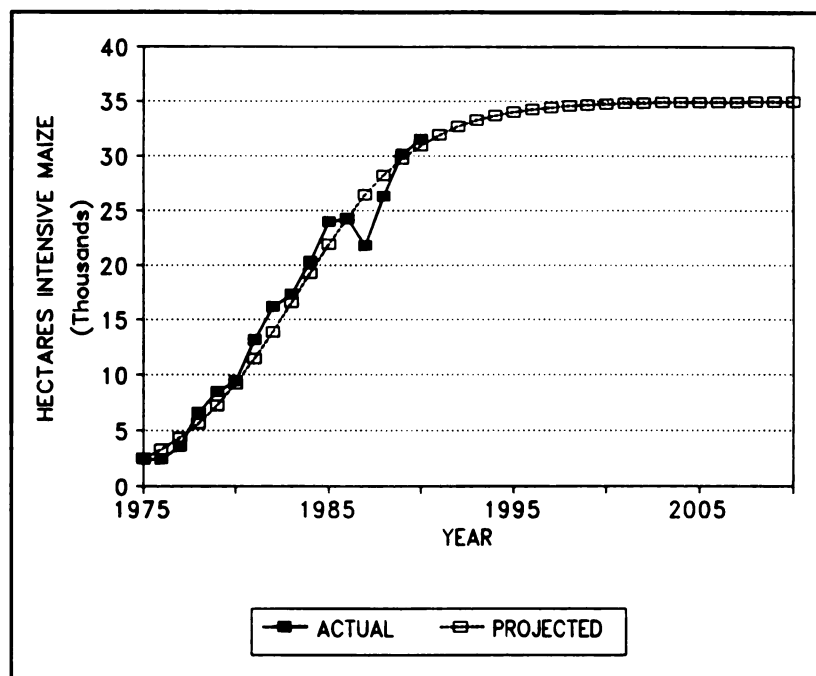
The estimated equations were used to project area under improved maize for the period 1991 - 2010.

Figure 8.1 shows actual and projected areas of improved maize over the period 1974 - 2010. For the northern part of the zone, an increase of 3,800 hectares is projected for the period 1990 - 2000, rising to almost 4,000 hectares by 2010. For the southern part of the zone, the corresponding figures are 25,650 hectares for the first decade, rising to 30,400 by the end of the projection period. What is important here is the relative rather than the exact magnitudes. Expansion in the south is projected to be more than 6 times as great as in the north, indicating a much higher potential return on research investments *ceteris paribus*.

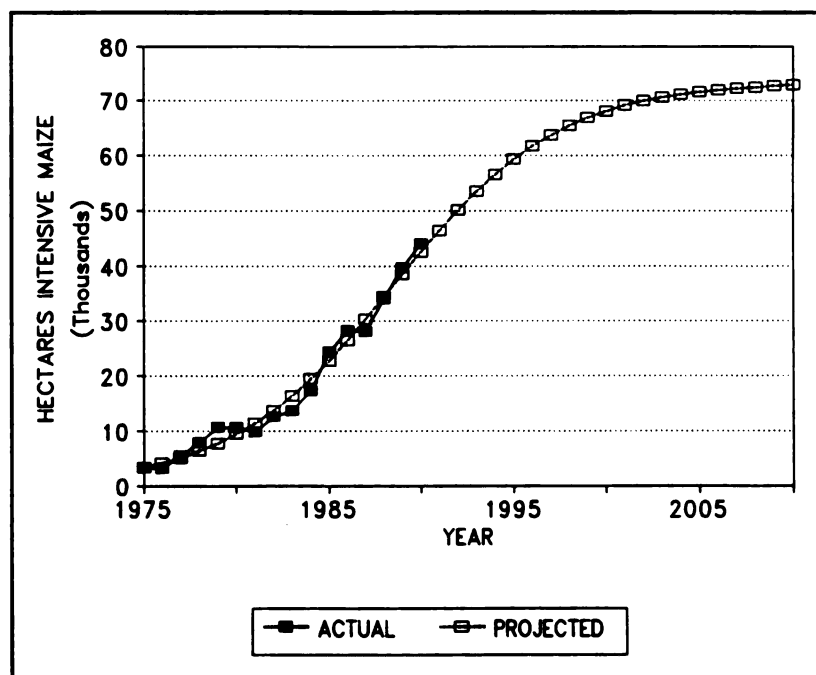
Other factors that influence the return to research investments are also more favorable in the south than in the north. Bougouni is the focus of investment in farm-level mechanization and rural infrastructure development within the CMDT zone under the Mali-Sud III agricultural development project. This will have the effect of raising the adoption ceiling in the southern part of the zone.

The higher rainfall and longer growing season in the south create particular opportunities and challenges for agricultural research. These are briefly reviewed in the next section. The final section considers implications for the way maize research is organized and implemented in Mali.

**Figure 8.1 A: Actual and Projected Improved Maize Area in the
Northern CMDT Zone**



**Figure 8.1 B: Actual and Projected Improved Maize Area in the
Southern CMDT Zone**



8.3 Opportunities to increase the productivity of maize: focusing the agronomic research agenda

The previous section highlighted technical and environmental foci for maize research in Mali over the next decade: to increase the profitability of fertility amendments on maize and to capture the production potential of the southern part of the CMDT zone. Given these foci, what researchable opportunities exist? An improvement in the profitability of fertility amendments can be achieved through a reduction in the cost of fertility amendments, an increase in their productivity (increased yield per unit of nutrient), or some combination of the two. The following sections highlight opportunities that need to be explored by research.

8.3.1 Options for reducing the cost of fertility amendments

There are three options for reducing the cost of fertility amendments in response to increases in the cost of chemical fertilizer: (i) use less chemical fertilizer; (ii) use less expensive formulations of chemical fertilizer; and (iii) substitution of organic fertilizer for chemical fertilizer.

Reduction in the use of fertilizer is more a question of re-aligning extension recommendations with financially optimal levels of fertilizer use than one of developing new innovations. Given the quadratic term in fertilizer response functions, Posner and Crawford (1992) found that half recommended fertilizer doses gave farmers a considerably higher marginal rate of return than full recommended doses in southern Senegal. Malian farmers appear to have reached the same conclusion. Giraudy (1993) analyzed data on 394 maize parcels cultivated in 41 villages in the CMDT zone. He reports that the average dose for parcels receiving

the basal application of complete formula fertilizer was 46% of the recommended rate, and 48% of the recommended rate for parcels receiving urea top dressing.¹²

Another possible revision of extension recommendations is to differentiate fertilizer recommendations on the basis of the preceding crop (cotton or cereal). Until 1980, the CMDT recommended only urea top-dressing at 100kg/ha for maize grown after cotton because it was considered that adequate fertilizer residuals remained to dispense with a basal application of complete formula fertilizer. With the introduction of an attractive guaranteed price for maize in 1980, the CMDT recommended a basal application of 100 kg/ha complete fertilizer on all fields, regardless of the previous cropping history, and increased the urea top dressing rate to 150 kg/ha.¹³

The question of the most economic type and levels of fertilizer on maize in different crop rotations is an empirical one. Unfortunately, there is a dearth of data on fertilizer response at farm-level. The limited number of fertilizer trials on maize have been carried out almost exclusively on research stations. Fertilizer recommendations have been derived without any formal financial analysis on the basis of on-station results and results obtained elsewhere in the region. The exception is on-farm maize intercropping trials involving fertilizer use carried out by the Sikasso farming systems team in the second half of the 1980s. The results

¹² Complete fertilizer was used on 48% of parcels, and urea on between 30% and 79% depending on the region and level of mechanization.

¹³ Prior to the introduction of guaranteed prices for cereals, cotton fertilizer recommendations were kept high as a means of ensuring that some fertilizer was available to the following cereal crop. The introduction of a guaranteed price for maize was seen as opportunity to dispense with this "subsidy" from one crop to another (Abdoulaye Dolo, Cellule Liaison Recherche-Développement, CMDT, personal communication).

have been presented on an annual basis, but no synthesis has been undertaken across years.

Since farmers already appear to be adapting fertilizer levels to their local circumstances (Giraudy, 1993), and given the large number of other research questions discussed below, a formal verification of optimal recommendations through on-farm trials is probably not the best use of limited personnel. However, there is equally no basis for assuming that existing recommendations are an appropriate background level for maize varietal trials and on-farm demonstrations. Where practical, the incorporation of multiple fertilizer levels in on-farm and on-station factorial trials as a secondary objective would help build up a database over time to derive economically appropriate recommendations.

An opportunity to use less expensive types of chemical fertilizer exists for the basal application of complete formula fertilizer. The purpose of a basal application at planting time is to promote root growth and early vegetative development. The current recommendation of 100 kg/ha complete formula cereal fertilizer, costing 165 CFA F/kg, provides 15kg N, 15kg P and 15 kg K.¹⁴ Yet complete formula cotton fertilizer, costing just 10 CFA F/kg more, provides 14kg N, 22kg P and 12kg K (nearly 50% more P for almost the same price). Farmers with fields that are primarily deficient in phosphorus would find this option more cost-effective. It is not entirely surprising, therefore, that Giraudy (1993) reports that 17% of maize fields receive complete formula cotton fertilizer! For soils that are not deficient in K, particularly newly cleared land or land coming out of fallow, di-ammonium phosphate (18kg N, 46kg P and 0kg K per 100kg) would be an even cheaper source

¹⁴ N stands for nitrogen, P for phosphorus and K for potassium.

of phosphorus. Although 40% more expensive than complete cereal fertilizer, this binary formula provides three times as much phosphorus.

The issue of complete versus binary formula fertilizers is a long-standing controversy (Gigou, 1989). A maize crop removes a total of 20kg N, 7kg P and 5kg K per ton of grain from the soil, or 26kg N, 12kg P and 21kg K including the straw. Researchers have argued about the dangers of a steadily increasing K deficiency over time if complete formula fertilizers are not used. But Gigou points out that researchers find K deficiency on research stations because they remove straw from the research plots whereas farmers leave it in place. He argues that a net trend in K deficiency, after allowing for recycling of straw, and replenishment from rain and subsoil strata, cannot be proven. Furthermore, if a farmer chooses to grow sorghum instead of maize because fertilizer is too expensive, the rate of removal of nutrients could be even higher. Sorghum exports similar quantities of nutrients to maize in the grain, and significantly more when straw is included (30kg N, 22kg P and 53kg K) because of sorghum's lower grain to straw ratio. Finally, Gigou (1989) points out that physical erosion of soil may be a more serious problem than chemical nutrient losses.

The objective here is not to resolve the complex issues between short-run and long-run benefits and costs from the use of alternative fertilizers. But the question requires careful economic analysis that takes account of the effect of fertilizer prices on farmer incentives to adopt intensive versus extensive cropping patterns or husbandry practices rather than just hypothetical soil nutrient balances.¹⁵ Furthermore, what is appropriate in the southern part of the zone, with higher

¹⁵ For long-run analysis of the economics of fertilizer use it is important to include the production effects of residual nutrients.

rainfall and a lower proportion of cultivated to cultivable area, may be quite different to what is appropriate in northern zone where most of the agronomic research on food crop crops has been undertaken.¹⁶

A third approach to reducing the cost of fertilizer is greater use of organic fertilizer amendments. A considerable amount of research has been undertaken on the use of "parc amélioré", where manure is concentrated by penning cattle at night on straw. But only one in four farm households has a herd of more than six cattle, and only one in five of those had adopted the "parc amélioré" by 1993 (Goïta, 1993). But the 40% increase in the cost of chemical fertilizer will make labor-intensive organic sources relatively less expensive. The majority of farmers have some draft animals, and opportunities to fatten cattle before export to the south may further increase the availability of manure for composting. Thus, incentives to adopt composting technologies will likely become more attractive.

In addition to exploring opportunities to reduce the cost of fertilizer amendments, it is equally important to find ways to increase the productivity of fertilizer use.

8.3.2 Options for increasing the productivity of fertility amendments

Just as the southern part of the CMDT zone has specific considerations that will affect the most cost-effective source of additional nutrients, there are also locale-specific factors that affect improvements in the productivity of nutrient use.

¹⁶ Most on-station research has been carried out at Sotuba, N'Tarla and, more recently Cinzana. All are in the northern part of the CMDT zone. N'Tarla, where most of the research on cotton is undertaken, carried out a multi-year program on cereals, but dropped maize after the first year. Most of the research in the south has been carried out by farming systems teams at Bougouni and Sikasso.

They derive from the high rainfall and length of the growing season. First, the higher rainfall increases the weed challenge. Unless weeds can be effectively controlled in the early phases of crop growth, the productivity of fertilizer nutrients will be reduced. Second, the longer growing season permits the use of longer cycle varieties with higher yield potential, and intercropping of maize with millet, sorghum, legumes, or horticultural products. These factors increase the scope and complexity of research in the southern subzone.

Varietal development remains an underexploited source of potential productivity gains in two ways. First, available maize varieties have not been marketed aggressively enough. A survey of varietal use designed by the IER maize subsector team and implemented by CMDT enumerators in 1992 in the same 41 villages for which Giraudy (1993) reported fertilizer use, found that adoption was considerably lower than expected (Boughton, 1993). Of 627 varieties sown in 532 fields, only 31% were reported to be improved varieties.¹⁷

Further research by the Sikasso farming systems teams has confirmed that at least some improved varieties consistently outperform farmers' varieties under farmers' management (DRSPR, 1994). The streak-resistant TZESR-W was particularly noted for performing well even in low management environments. Yet while this variety accounted for 50% of improved varieties used by farmers in Sikasso, it accounted for only 16% in Bougouni.

A major reason for low and patchy adoption is the loss of momentum in varietal promotion following cereal market liberalization. The CMDT's Cellule Liaison Recherche-Développement greatly reduced the size of its on-farm

¹⁷ For the 95 fields sown to 2 varieties, at least one was an improved variety in 50% of cases.

demonstration program after 1986. Bosc and Freud (1994) note that maize seed production by the CMDT is low compared to the area under cultivation. For the 1992 growing season, the CMDT distributed the equivalent of 1 kg of seed for each hectare planted, enough to cover just 4% of the maize area (Goïta, 1993). The exception to this downward trend in promotional efforts is the Mali-Sud III investment program focusing on Bougouni. In 1993, 55% of all maize seed distributed in the CMDT zone went to the Bougouni subzone.

Given the availability of improved varieties, the low and geographically unbalanced levels of adoption, and the rapidly growing area under maize, there would appear to be a high potential payoff to more aggressive promotion of improved varieties through on-farm demonstrations. This promotion should take account of both the need for early-maturing varieties as a hungry season food source and for intercropping, as well as long-duration high potential varieties. Given the rapid introduction of varieties (three new varieties were made available to the CMDT by research in 1993), it is important to monitor adoption. CMDT extension agents continue to record the area that has been mechanically plowed or weeded, practices that reached near universal adoption many years ago, but record no information about varietal use.

A second area in which varietal development is underexploited is hybrid varieties. Historically, the research service has considered hybrid seed to be too expensive to justify multiplication. The CMDT, which runs the seed farm, has not opposed this view. Yet this opinion has never been subject to empirical scrutiny, and hybrid seed production by both the public and private sector has been found profitable in other African countries. Furthermore, the conventional wisdom that

hybrids only perform well under high management is increasingly under challenge (Byerlee and Heisey, 1993). In view of the high potential of southern Mali it is important that the cost effectiveness of hybrid seed under different levels of fertilizer use be verified empirically through on-farm trials.

There are no maize varieties that do well in a field of weeds. That is why the expansion of the maize area is highly correlated with mechanization. The high rainfall in southern part of CMDT zone increases weed challenge, often causing farmers to apply fertilizer late. Weed management practices should be considered in conjunction with fertilizer application. For example, pre-emergence herbicide and moderate fertilizer doses may be more cost-effective than high fertilizer doses applied without adequate weed control.

8.4 Implications for the organization of maize research

The technical content and environmental specificity of the research challenges discussed in the previous section have important implications for the disciplinary mix, geographical location and organization of maize research.

In terms of disciplinary mix, there is a need for greater emphasis on fertilizer agronomy than hitherto. Economics, hitherto almost absent from the determination of fertilizer recommendations or decisions such as whether to promote hybrid varieties, also needs to be systematically integrated into the design and evaluation of agronomic research. An important potential contribution of social scientists is to

identify whether farmers with different resource endowments have different technology needs, particularly in relation to varieties.¹⁸

In both varietal development and agronomy there needs to be a much closer linkage between on-farm and on-station research efforts. The new decentralized organization of the research service, where both on-station and on-farm researchers are located at the same centers, should theoretically facilitate such collaboration. Unfortunately, the maize research program is based at the Sotuba research center near Bamako, just outside the northwestern edge of the CMDT zone. Most of the on-farm research is being undertaken by the farming systems team operating from the Sikasso research center. Finally, there is a logistical problem of how to serve the Bougouni subzone adequately, which, while located in the same agro-ecological zone as Sikasso, is nearly as far from the Sikasso station as Sotuba.

8.5 Summary

This chapter has analyzed the implications of increased fertilizer prices as a result of devaluation on farm-level incentives to cultivate intensive maize. The results suggest that increasing the productivity of fertilizer use is an urgent priority for the maize program in order to avoid a shift to more extensive (and soil mining) cropping patterns and husbandry techniques. The technological opportunities for increased productivity and the likely geographical locus of future expansion of maize call for changes in the disciplinary mix and organization of the program. In regard to both varietal development and fertilizer agronomy there is a need for close

¹⁸ For example, a recent study of farmer varietal preferences for maize concluded that earliness was low on farmers' list of priorities overall, but failed to distinguish between farmers on the basis of whether they were food deficit or surplus (DRSPR, 1994).

collaboration between on-farm and on-station research, and between research and extension.

CHAPTER NINE

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR AGRICULTURAL RESEARCH IN MALI

This chapter summarizes the principal results of the study, implications for the future development of Mali's maize subsector, and implications for the future size, scope and priorities of maize research within IER. In view of the pilot nature of the maize subsector study, methodological and organizational implications for IER's new Commodity Subsector Economics Program are also considered.

9.1 Background to the study

In order to compete effectively for shrinking donor and government funds, African National Agricultural Research Systems (NARS) must demonstrate that agricultural research is a worthwhile public investment. The rate of adoption of improved technology at the farm level is an important factor affecting the level of economic returns to agricultural research. Farm-level technology adoption rates are determined in part by constraints and opportunities in the off-farm economy, communicated through agricultural input and output markets. The introduction of market liberalization and structural adjustment policies in many African countries over the past decade has dramatically changed farm-level adoption opportunity sets (e.g., through withdrawal of guaranteed producer prices and subsidized marketing services, and/or currency devaluation). Thus, the methodological and organizational challenge of how NARS take account of market opportunities and constraints in the design of agricultural research has become a critical issue.

The dissertation has addressed this issue through a pilot study of the maize subsector in Mali, undertaken within the Institut d'Economie Rurale (IER), one of the first African NARS to include both farming systems research and commodity subsector studies in its strategic plan as a means to improve the economic impact of agricultural research programs. The dissertation presented a conceptual framework that integrates market and farm-level dimensions of the food system and used a commodity subsector approach to analysis of agricultural production and processing technologies for maize. The framework and results demonstrate how conditions at one level of a subsector influence constraints and opportunities for innovation at other levels, and the need to integrate technology, policy and institutional innovations.

9.2 Summary of results

9.2.1 Historical impact of maize technology development

The application of a commodity subsector approach to the analysis of constraints to and opportunities for technological, institutional and policy innovation in the Malian maize subsector was motivated by an examination of the historical impact of maize research and extension in Mali. The initiative to promote maize as a field crop instead of its traditional place as a garden crop was taken by the cotton parastatal (CMDT) in response to chronic food deficits during the mid-1970s. The CMDT promoted a sole crop maize package consisting of an improved local variety and a set of husbandry practices (land preparation, row seeding, fertilization) based on research findings generated in other West African countries (Senegal, Burkina

Faso, Côte d'Ivoire). Additional varieties were released over time, including a streak-resistant variety from IITA (TZESR-W).

Transfer of responsibility for cereal procurement from the national grain board (OPAM) to area development authorities enabled the CMDT to use, during the period 1980 - 1986, the same integrated technology delivery system for maize that it was already successfully using for cotton (including the provision of seed, fertilizer, credit, extension, crop purchase and evacuation). Adoption of the improved maize package was particularly rapid during this period when an attractive guaranteed price was offered, and extension activities were reinforced by a maize project that included the establishment of a seed multiplication program. Following cereal market liberalization in 1986, maize prices fell in absolute terms and relative to millet and sorghum prices, and have experienced considerable variability. The area cultivated to maize continued to expand, but farmers reduced fertilizer use, switched back to maize-late millet or sorghum intercropping, and substituted robust, early maturing varieties such as TZESR-W in place of long-duration varieties with higher yield potential.

The estimated internal rate of return (IRR) to investment in maize research and extension in southern Mali over the period 1969 to 1990 is 135%. This high rate can be attributed to low research costs (much of the technical package was borrowed from research conducted elsewhere in West Africa), rapid farm-level adoption, and the high economic value of maize as an import substitute. Sensitivity analysis indicates that the IRR is robust with respect to adverse changes in assumptions concerning overvaluation of the exchange rate, research costs, extension costs, and area of improved maize. It is moderately sensitive to price and

yield reductions. A seven-year delay in the farm-level adoption profile causes the largest decrease in IRR, to 57%.

The high IRR achieved in the past to a focussed, integrated maize technology delivery program in Mali is not necessarily a guide to future returns. These depend on whether market opportunities exist that can offer farmers an attractive return to farm-level maize technology adoption. The subsector study therefore focussed on the identification of demand-side constraints and opportunities, and their implications for agricultural research and related policy and institutional innovation.

9.2.2 Role of maize in urban cereal consumption

In accordance with the findings of an earlier coarse-grain study by Holtzman et al. (1991), a rapid appraisal of the maize subsector revealed many characteristics usually associated with a thin market. Farmers appear to produce maize primarily in order to achieve food self-sufficiency, not as a cash crop. Urban consumers tend to buy maize grain mainly when it is significantly cheaper than other cereals (i.e., the wet season), due in part to the difficulty and/or higher cost of processing and in part to lack of familiarity with the cereal. Traders consequently have little incentive either to assure a regular year-round supply of maize, or to meet urban consumer preferences for color or quality.

Given the importance of the rapidly growing urban population as a potential source of future demand growth for maize, subsequent in-depth studies focussed on possibilities for overcoming constraints to increased urban consumption through the supply of pre-processed maize products. A formal survey of 640 households in the capital city of Bamako revealed that, in direct contrast to the exclusive donor

emphasis on the promotion of maize grits and parboiled sorghum as substitutes for rice, consumers also want to buy dehulled grains and/or flour in order to make traditional coarse-grain-based dishes more easily. In regard to quality criteria, housewives attached high priority to the cleanliness of processed coarse grain products.

A frequent-visit survey of a sub-sample of 115 households was undertaken over one year to quantify cereal procurement and use. Household income has an important effect on the types, quantity and form of cereal procured. Rice procurement is positively correlated with household income, accounting for 51% of cereal calorie procurement by lower-income and 67% by upper-income terciles. Among the coarse grains, sorghum accounts for 64% of procurement by weight, millet 26% and maize 9%. Sorghum is more heavily consumed by lower-, and millet by upper-income tercile households. The share of maize is relatively even across terciles. Ninety-two percent of coarse grains are procured in unprocessed and 7% in dehulled form. Upper- and middle-income terciles procure a higher proportion of coarse grains in dehulled form compared to the lower income tercile.

Modified Engels curves were estimated to quantify the effect of income and demographic variables on the amount of each cereal type and form procured per adult equivalent. The statistical significance of the effect of income on procurement was confirmed except in the case of dehulled sorghum. The quantity of sorghum procured in grain form was found to be positively correlated, and the quantity of rice negatively correlated, with household size. Procurement of dehulled millet and sorghum was negatively correlated with the proportion of women household members, and positively correlated with the proportion of women in the household

having a cash-earning primary activity. This is fairly strong evidence that procurement of coarse grains with processing services already embodied is positively correlated with the opportunity cost of women's time. Procurement of maize grits is also positively correlated with the proportion of women in the household with a cash-earning primary activity, and shows strong seasonality. Like dehulled sorghum and millet, the quantity of rice procured is negatively correlated with the proportion of women household members, but bears no relation to the proportion of women with cash-earning primary activities.

The frequent-visit survey also recorded dishes prepared at different mealtimes. Coarse-grain-based dishes are dominant at breakfast and dinner, rice at lunch and also for households that prepare only one main meal a day. Eighty-four percent of all coarse-grain-based dishes are prepared from flour. Even for yellow maize, whose grits are commercially processed by women and by hammer mills, two-thirds of all dishes are prepared from flour. For the purpose of overcoming the thin market impediment to development of the maize subsector, flour is the most appropriate processed product to promote because of the high potential volume of demand.

A detailed study of the cost of preparing rice and *toh* (the most frequently prepared coarse-grain-based dish at main meals) was undertaken for a subset of frequent-visit survey households. *Toh* is cheaper to prepare than rice, with or without sauce costs included. Using either dehulled grain or flour, *toh* can be prepared as quickly as rice. But at prevailing opportunity costs of women's time, both dehulled grain and flour are more expensive than coarse grain processed under household supervision. The search for lower cost processing technologies is important if the present cost advantage of prepared coarse-grain-based dishes is not

to be eroded as the opportunity cost of women's time rises with economic growth. This component of the study helps to fill an important empirical gap in the literature on urban cereal consumption in the Sahel.

9.2.3 The potential demand for pre-processed maize flours

The study of the cost of prepared *toh* also provides a benchmark for the estimation of potential flour demand. There are considerations that would lead households to purchase pre-processed flour even if it were more expensive than the estimated cost of flour processed under household supervision. First, there are the inconvenience factors described in chapter 4 that are difficult to cost in a budget. These include the need to soak maize for several hours after dehulling before it is milled,¹ and the difficulty of finding good quality maize on the market at certain times of year. Second there is the higher milling cost for maize. Although only 2.5 CFA F/kg, and insignificant in the total prepared dish cost, some household heads explained that it was a source of friction with their wives because it reduces the amount of money available for condiments. Third, there is a novelty effect. Some households which do not consume maize might buy maize flour occasionally as a change from eating sorghum or millet every day. Finally, every household encounters periods when the opportunity cost of women's time rises significantly (e.g., if someone is ill, or if there is a social event). Nevertheless, one would not

¹ It will be recalled that it is not the labor requirement that creates the inconvenience. It takes only a few moments to fill a bucket with water and tip the maize in. The problem is that it must be done four to five hours ahead of time. Left for too long, the maize starts to ferment. Left for not long enough, the flour obtained from milling will not be as fine as desired.

expect demand for pre-processed flour to be much greater than existing consumption levels at prices that exceed the cost of flour prepared by households.

To estimate the potential demand for pre-processed maize flour, a contingent valuation experiment was conducted with the participation of frequent-visit sample households using two qualities of flour (dehulled and whole grain) manufactured by a local hammer mill. A standard censored Tobit model was estimated with monthly flour demand as the independent variable. Price, income, flour quality, gender, household size and composition, the opportunity cost of women's time, employment in the military, and familiarity with maize were all found to have statistically significant effects on quantity demanded.

The results of the Tobit estimation were used to calculate, for each flour type before and after devaluation, expected quantity demanded, and price and income elasticities of demand for male household heads. Price elasticities of demand are high within the range of estimated retail prices for flour, reflecting the small quantity demanded at those prices. Income elasticities of demand are low for dehulled flour, and negative for whole-grain flour. In contrast to the pre-devaluation situation, demand for whole-grain flour is greater than for dehulled flour at prices that reflect their respective post-devaluation processing costs. For women, expected quantity demanded is higher than for men at any given price, and both flour types are normal goods.

The design of the contingent valuation experiment does not permit the calculation of cross-price elasticities between maize flour and rice. Nevertheless, analysis of the meals at which sample households intend to use maize flour indicates that the product would be used primarily at mealtimes where coarse grains

are already widely consumed (breakfast and dinner), and rarely at mealtimes where rice is predominant (noon). This indicates that the availability of maize flour, even at very low prices relative to the price of unprocessed coarse grains, will have only a modest impact on substitution of coarse grains for rice.

To estimate aggregate demand schedules for dehulled and whole-grain maize flour for the district of Bamako, expected demand per adult equivalent for six population sub-groups (civilian and military households each with three income levels) was weighted according to each group's demographic share and multiplied by the total number of adult equivalents in the population. Aggregate demand for dehulled flour pre-devaluation, at an estimated retail price of 150 CFA F/kg, implies a slightly higher consumption of maize grain than at present (380 tons per month, equivalent to 10.1 kg/ae/year in grain equivalent terms,² compared to 7.8 kg/ae/year in the frequent-visit survey).³ For whole-grain flour (significantly cheaper at 115 CFA F/kg), aggregate demand is 815 tons per month, equivalent to 16.3 kg/ae/year of maize grain. Aggregate demand post-devaluation is significantly smaller, at least in the short run. For the more expensive dehulled flour (175 CFA F/kg), monthly aggregate flour demand of 70 tons per month implies a derived demand for maize grain equal to only one-quarter the existing level of urban consumption. For whole-grain flour (130 CFA F/kg post-devaluation), monthly

² To account for processing losses, dehulled flour consumption must be inflated by one third to arrive at the derived demand for maize grain. Thus 10.1 kg/ae/year in grain equivalent terms represents dehulled flour consumption of 7.2 kg/ae/year. For whole-grain flour, processing losses are negligible.

³ Although the monthly aggregate demand for maize flours is compared to existing maize grain consumption on an annual basis for convenience, the seasonality of potential demand for maize flour is unknown. This depends on the underlying causes of seasonality in the demand for maize grain, and the pricing behavior adopted by maize processors and retailers.

aggregate demand of 490 tons per month is still, at 9.7 kg/ae/year, slightly higher than existing levels of maize grain consumption. The reduction in quantities of flour demanded as a result of devaluation is primarily attributable to increased processing costs. In the medium term, these estimates could prove to be conservative because they do not take account of the intended increase in urban incomes in response to economic opportunities made possible by devaluation, or increases in the cost of processing under household supervision (e.g., as a result of increased charges at custom plate mills). Estimated aggregate demands for maize flours using contingent valuation responses are consistent with existing levels of maize procurement and household costs of flour preparation. Results from probit and Tobit models with the same independent variables are also highly consistent.

9.2.4 Devaluation and the profitability of maize cultivation

Fertilizer prices increased by 40% following devaluation. Partial budget analysis was used to assess the impact of devaluation on the profitability of intensive maize cultivation for three types of maize cultivation and three marketing scenarios. The increase in fertilizer prices results in a marked decrease in the profitability of intensive maize. Unless there is either an increase in the price of maize, or an increase in the productivity of fertilizer use, or a reduction in price risk through contracts, or some combination of such changes, farmers are likely to opt for more extensive cropping patterns or crop management practices. While an increase in maize prices would help to restore profitability, it would also make it considerably more difficult for maize-led development of the urban market for

processed coarse grains to occur. It is therefore important to identify potential sources of increased productivity (discussed further in section 9.4).

9.3 Methodological issues and needed research

This section deals with research questions of more general interest. Research questions specific to maize in Mali or to IER's commodity subsector economics program are discussed in subsequent sections.

For a given commodity subsector study, researchers face difficult trade-offs between the amount of resources devoted to different stages in a subsector, the number of issues at any one level and the depth with which they are studied. For example, urban household consumption systems are as complex as farming systems, and large multidisciplinary teams can spend years studying them. Over time, there is a parallel trade-off between the number of commodities studied, and the depth with which any one subsector is studied. In the longer run, there is a further trade-off between more and/or more detailed subsector studies and studies that seek to synthesize the implications of the results from individual subsector studies for overall food system development. Thus, the methodological challenge is to determine the trade-off between accuracy and cost of alternative methods. With the exception of the literature on sampling methods, information about these trade-offs is, in general, very limited.⁴ Both the contingent valuation and conventional consumption survey components of this study generate such questions.

⁴ This lack of information raises questions about the incentive structure facing researchers in developed countries where most research is undertaken, but that question is beyond the scope of this dissertation.

Researchers are increasingly making use of contingent valuation methods to predict the consequences of changes in policy and/or institutions (Rubey, 1993, Mukumbu and Jayne, 1994). Limited dependent variable models will frequently be used to analyze the data generated. An important empirical question that needs to be answered is what are the implications of the violation of the assumed error distribution and variance? For example, heteroskedasticity may be a likely occurrence when asking consumers or producers to predict how they will behave in alternative scenarios that increasingly depart from their present frame of reference. While heteroskedastic models can easily be computed, search costs for the correct form of heteroskedasticity and derivation of the partial effects and expected values will be very time consuming. Furthermore, the predictions may not necessarily change greatly. What are the implications of ignoring violations of the underlying assumptions concerning the distribution of the error term for the magnitude of the prediction error?

A related issue is the trade-off between cost and error in the degree of disaggregation into population sub-groups. The derivation of expected values and partial effects is very labor intensive when there are many potential target groups of interest.⁵ The problem can be overcome by using a matrix programming language such as GAUSS, but many researchers will not have the time to invest in becoming proficient in the use of this kind of specialized research tool. Are there rules of thumb that can be developed for approximating values for different groups rather than explicitly deriving values for each?

⁵ For example, the derivation of aggregate demand schedules in chapter 7 required 24 linked spreadsheets (6 population sub-groups times 2 flour types times 2 income levels), each with 8 blocks of coefficients (one for each price level) to calculate partial effects and expected demands.

While economists have tended to use contingent valuation or hedonic pricing models in private goods markets, the business schools and industry have used mainly conjoint analysis. From the literature, there does not appear to have been any cross-fertilization between these two disciplinary branches. What are the costs and benefits of the information generated by these techniques in relation to different policy questions? Under what circumstances is one to be preferred over another? This is an important methodological issue to pursue given policymakers' needs for timely and reliable information.

Turning to the subject of detailed household consumption studies, while these are demonstrably rich in the information that can be generated, they are extremely costly to undertake. This is particularly true in regard to data management and analytical resources.⁶ Even the simplified version undertaken for the current study came close to overwhelming the relatively generous (by African NARS standards) resources available, crowded out analysis of important questions at other stages of the subsector, seriously reduced time for interaction with private sector and donor clients, caused tardy report submission, and did little to improve the quality of interaction among team members. There has to be a way to keep the elephant, even a baby elephant, out of the row-boat. What would be the consequences for accuracy if households were interviewed once a month instead of once a week, using one-month recall for bulk cereal purchases and one-week recall for small purchases? What would be the consequences if households were interviewed once every three months instead of once a week, using the same recall pattern? What

⁶ For example, the SPSS program to compute the proportion of dishes prepared from flour and grits at different mealtimes for each type of coarse grain is 75 pages long.

would be the effect if daily condiment expenditures, a relatively easy figure to obtain, were used instead of estimates of total expenditure? If reasonably accurate results can be obtained, the marginal benefits from allocating resources to more timely analysis and reporting of data, and more interaction with clients, would be high.

In regard to the debate over substitutability between rice and coarse grains in the Sahel, an important dimension has received little attention. Economists have focussed almost exclusively on relative grain prices and, more recently, complementary processing and preparation costs (Dibley et al., 1994). But this is to look only at the denominator of the neoclassical equilibrium condition (see chapter 2, p. 21). Little effort has been made to understand the nature of preferences for rice and coarse grains. Why is rice so widely consumed at mid-day and coarse grains in the evening? Is it because the rice and coarse-grain-based dishes give greater satisfaction at particular times of day (e.g., because rice is more filling and coarse-grain-based dishes more digestible), or does the relative cost of preparing them change with the time of day (e.g., because the opportunity cost of women's time is higher at noon than at dinner)? Another way to phrase the question is to ask whether the lack of substitutability is a reflection of highly convex indifference curves (and if so, what attributes are generating that form, and can they be manipulated to improve substitutability?) or are rice and coarse grains instead complements so that an increase in the consumption of one increases the marginal satisfaction of the other? In seeking to understand the relationship between cereal attributes and preferences, the results of this study suggest that it

is important to distinguish between different coarse grain types and not lump them together.

An important dimension of household consumption that this study has ignored is the restaurant sector. Reardon et al. (1988) report that a high proportion of total rice expenditures for low income households in Ouagadougou is on prepared rice purchased from street vendors. Reardon (1993) further argues that street vendors are influential in promoting innovation in household consumption habits.

Incorporating the restaurant sector appeared less important when estimating the potential demand for maize flour, since flour is already widely used by households. Information on prepared food expenditures was sought as part of the survey of total household expenditures, including the dish purchased. Consumption of prepared food outside the household is a sensitive issue, however, since it could be construed as a criticism of what is prepared at home as well as revealing the extent of an individual earnings. Thus, information obtained from household heads is unlikely to be an accurate reflection of aggregate household expenditures on prepared food.

Since the baby elephant did climb aboard this row-boat, there are numerous ways in which the analyses could be extended. Subject to the assumption of strong separability between cereal and non-cereal expenditures, a rough approximation of cross-price elasticities could be attempted. However, given the limitation of the data (incomplete time-series for non-food expenditures, lack of price data for non-cereal food expenditures), and the large number of studies that have already been undertaken at different times using different methods (bemoaned by Kite, 1993), it is not clear how valuable the additional information would be.

Furthermore, the assumption of strong separability between cereal and non-cereal expenditures is contradictory to the finding that sauce cost varies with the choice of cereal (chapter 6). This assumption also contradicts the maintained hypothesis (chapter 2) that the demand for cereals is derived from the demand for dishes.

A unique aspect of the consumption data collected is the detail on dishes prepared, processing methods and costs, and complementary condiment expenditures. A cereal demand system could be formulated to estimate the derived demand for different cereals at different mealtimes from the demand for dishes. The cross-price elasticities of demand between rice and coarse grains for specific meals would be more informative than standard cross-price elasticities of demand. Examples of hypotheses that could be tested on the basis of meal and dish analyses presented in chapter 6 are 1) that sorghum and maize have a greater cross-price elasticity of substitution for rice at breakfast than at lunch or dinner, and 2) sorghum and maize have a greater cross-price elasticity of substitution for rice than millet at any meal. The analysis would require an assumption of strong separability between food and non-food expenditures, which is more credible than an assumption of strong separability between cereal and non-cereal food expenditures.

9.4 Implications for development of the maize subsector and maize research priorities in Mali

This section focusses on the implications of the study's results for future development of the maize subsector in Mali, and for maize research priorities.

9.4.1 Implications for development of the maize subsector in Mali

Development opportunities for the maize subsector are discussed at two levels: 1) opportunities to promote maize processing, and 2) opportunities to increase farm-level productivity. Opportunities to reduce marketing costs are not explicitly addressed, although possibilities to improve coordination between farm-level supply and potential processors are.

9.4.1.1 Opportunities to promote maize processing

Despite devaluation of the CFA franc, the present (albeit modest) level of potential urban demand for maize flour is adequate to initiate private-sector involvement in coarse grain processing activities if facilitative actions are taken by the PRMC and GRM. It is important to seize this opportunity to launch the process of transformation of the urban coarse grain distribution system. Structural changes in the broader urban economy over time will lead to an increasing demand for a range of coarse-grain products with different amounts of processing services embodied rather than just unprocessed grain. For example, household demand for dehulled millet, dehulled sorghum, and maize flour and grits are all positively related to the proportion of women in the household with a cash-earning primary activity. This proportion will increase over time as more women participate in economic activity and household size declines. Similarly, the demand for dehulled maize, dehulled millet, maize grits and maize flour (dehulled) are all positively related to income. In the long run, the recent devaluation will lead to increased real incomes if the policy succeeds in its objective of stimulating productivity growth.

An efficient coarse grain processing industry will facilitate this broader process of economic development, while an underdeveloped one will hinder it. Because development of the coarse grain processing industry and that of the broader urban economy are synergistic, the rate of transformation will depend on how quickly the cost of processing services relative to the opportunity cost of labor in urban households can be brought down through technical innovation to reduce processing costs and losses, and organizational innovation to capture economies of scale.

Aside from the opportunity to improve the efficiency of coarse grain dehulling services (Sanogo et al., 1993; Holtzman et al., 1991), there are three potential market development strategies for maize flour. Each has advantages and each has obstacles that need to be overcome. Option 1 is first to promote refined maize flour to build consumer confidence and then introduce whole-grain flour as a low-cost competitor. Option 2 is to forget about refined flour and promote whole meal flour, possibly with subsidies in connection with an urban food aid distribution program. Option 3 would be to promote both flours simultaneously without direct (i.e. production cost) subsidies. Given the complementarity between dehulled and whole-grain flour in regard to markets niches and economic linkage effects, option 3 is preferred.

The promotion of dehulled maize flour has three advantages and one major obstacle to overcome. The first advantage is that the Grands Moulins du Mali (GMM) already has a state-of-the-art maize mill installed. Since the investment is a sunk cost, and many overhead costs are joint with wheat and paddy processing, GMM has a rationale to price the product at below average total cost in the short

run to obtain at least some return on the investment. Furthermore, GMM management is becoming more responsive to opportunities for innovation as milling margins on wheat are progressively squeezed by the removal of tariffs on flour imports and coordinated donor selling of commodity-aid wheat. Second, GMM has stated that it would be willing to purchase maize from farmers on a forward contract basis if the PRMC would be willing to finance a maize flour promotion campaign. Farmers repeatedly stated that the lack of a guaranteed price was their principal reason for not purchasing fertilizer for maize production. Since improved returns for cereal growers are a major objective of the PRMC, there would be solid justification for using PRMC funds to promote maize flour marketing if linked to maize procurement contracts from maize grower associations. Third, there are other industrial needs for maize products that are currently being met through imported products (e.g., starch for glue, batteries and conserves; grits for brewing) that could be supplied locally once GMM's maize production line was up and running.

The main constraint is that the volume of demand at estimated post-devaluation retail prices may too small to make it worthwhile. One possible way to overcome this problem would be to incorporate maize flour with wheat flour intended for baking bread. For example, a mix of 95% wheat and 5% maize flours would generate a requirement of 1500 tons of maize flour per year, based on pre-devaluation demand for wheat flour. If the technical and financial feasibility of maize flour incorporation with wheat flour can be confirmed, the next step would be to undertake a test of consumer acceptability. In view of the acrimonious history of relations between GMM and the bakers, it would be useful to have some outside

encouragement and supervision of such a test (e.g., by the PRMC) to ensure that it is undertaken and evaluated in good faith.

An additional policy measure required is to rescind VAT on processed maize products. This tax only applies to GMM since it is not enforced upon the informal sector. It currently generates no revenue, and its continued existence is inconsistent with previous legislation that rescinded VAT on rice dehulling to promote consumption of domestically produced paddy.

The promotion of whole grain maize flour has two key advantages. First, it would involve small-scale processors immediately rather than after a delay. Second, consumers need and are receptive to lower-cost products as a result of the fall in real incomes following devaluation. Even the lower post-devaluation level of demand of 490 tons per month is sufficient to keep up to 20 hammer mills in business. Nevertheless, this strategy also has disadvantages that must be overcome. First, there may be strong consumer resistance, at least initially, to purchasing flour from retailers unless it is in sealed packages. Such packaging would drive up the cost significantly, undermining the very basis on which the product could compete - cheapness.⁷ Second, whole-grain flour has a relatively short shelf life. It can become rancid in as little as three weeks. Unless a very rapid and effective distribution system is established, the product could quickly lose credibility with consumers. Third, owners and/or operators of coarse-grain processing equipment currently have very little experience in combining processing and product marketing operations (vertical integration).

⁷ Assuming a 10 CFA F/kg cost of packaging, demand would fall by nearly half to 260 tons per month.

The difficulties associated with the promotion of a whole-grain flour processing and distribution could be overcome through innovative forms of organization. For example, rapid low-cost distribution might be achieved by networks of women retailers residing in the densely populated suburbs ("quartiers populaires"). Through their detailed knowledge of households in their locality, such retailers could establish a regular clientele. Knowing their clients personally, and being in a position to verify the quality of flour supplied to them and distribute it quickly, they could avoid the need for costly disposable packaging and deliver the product in re-usable containers instead. Such an approach would create badly needed part-time informal-sector employment opportunities for women, as well as providing households with a low-cost ready-to-use coarse grain product.

Several options exist for supplying retailers with whole-grain flour on a regular basis. These include 1) an existing GIE such as SAMA, 2) an urban wholesaler or group of wholesalers who combine a hammer mill with dehulling equipment, 3) women could purchase grain themselves and have it milled at a hammer mill installed alongside an existing custom plate mill, or 4) women retailers could form their own GIE for processing flour. Option 2 is particularly promising since urban wholesalers are well-placed to procure maize of appropriate quality (soft endosperm, white) on a regular basis from their rural counterparts. Furthermore, fixed costs could be reduced in the early stages as the dehuller and hammer mill could be run alternately by a single electric motor.

A promotion campaign is even more necessary for whole-grain flour than for dehulled flour. Consumer awareness of the product will facilitate rapid distribution and reduce the risk of rancidity. Furthermore, consumers need to be made aware

that the discoloration of whole-grain flour is due to the presence of bran, not impurities, and that whole-grain flour has nutritional advantages over refined flour.

The third option is the most ambitious, seeking to capture the advantages of options 1 and 2. Option 3 has the advantage that the costs of a promotional campaign would not necessarily be significantly higher for two types of flour than for one, and could be designed to target the flours to different market segments. The results of the survey suggest that dehulled flour can be most effectively promoted in higher income suburbs, and dehulled flour in low income suburbs. Smaller households and households where women have cash-earning activities will generally be more receptive to promotional efforts. Military households in Bamako and nearby Kati represent a key opportunity to establish a regular source of demand at an early stage in market development.⁸ Institutional sources of demand, such as school feeding programs, could also be used as a vehicle to promote maize flour consumption. If option 3 is chosen, whole-grain flour cannot be promoted using subsidies without undercutting GMM, however, since whole-grain flour is only weakly self-targeting.

Promotion of maize flour should be accompanied by technical backstopping for maize processors. For both types of flour it will be necessary to monitor flour storage quality at different times of year. For potential hammer mill operators, there is a need to identify mills that can provide sufficiently fine flour without having to

⁸ To maximize the long-run effectiveness of any promotion campaign it is important to develop a better understanding of the reasons for higher demand for maize flour among military households. Is this because household heads are frequently absent for long periods of time so that military households' demand patterns are similar to those of female-headed households? Or did military households simply become more familiar with maize during the period when OPAM supplied cereals to the military prior to cereal market liberalization?

manually sieve the product as carried out for the second large-scale consumption test (e.g., from machinery suppliers in Zimbabwe where maize is milled primarily for human consumption). Hammer mill operators also require organizational support from a specialized microenterprise development unit. In addition to facilitating the establishment of whole-grain flour processing and distribution networks, assistance will be needed to secure a year-round supply of maize grain of appropriate quality from urban wholesalers or farmer associations.

9.4.1.2 Opportunities to increase farm-level productivity

There are two related technological themes for improving maize productivity and reducing unit costs of production at farm level: fertilizer use efficiency and varietal adoption. As a result of devaluation of the CFA franc in January 1994, fertilizer prices in the CMDT zone will increase by 40% on average in the coming season. Yet, because of aggregate cereal self-sufficiency in 1993, maize prices did not increase significantly between 1993 and 1994. If farmers are to have an incentive to use fertilizer it is essential to improve the financial return to fertilizer use. This can be accomplished by an increase in yield response to fertilizer use and/or a reduction in fertilizer cost. Potential avenues for a reduction in the cost of fertilizer that could be explored through on-farm agronomic trials include:

- urea top dressing only for maize grown after cotton instead of the present universal recommendation of basal application of complete-formula fertilizer at planting as well as urea top dressing;⁹
- investigation of the marginal rate of return to moderate as opposed to full recommended fertilizer doses, the former shown to be much higher in similar agro-climatic conditions in Senegal (Posner and Crawford, 1992);
- investigation of the financial returns to less expensive basal fertilizer sources (i.e. binary or single-nutrient sources as opposed to the complete-formula fertilizers currently recommended).

An important potential source of improved yield response to fertilizer is the use of hybrid maize varieties. The current policy of not producing and distributing hybrid maize seed on the grounds that it is too costly, which has never been subject to a careful financial analysis, should be urgently reviewed. If hybrid varieties can produce a better return to the farmers' investment including the higher cost of seed, they should be promoted. Since an important component of the additional cost of hybrid seed compared to open-pollinated varieties is labor, the relative cost of hybrid seed to fertilizer will be lower following devaluation. A careful study of the costs and returns to hybrid varieties under farmers' management with different fertilizer regimes and cropping systems is an urgent agronomic research theme.

Farm-level surveys conducted by IER in collaboration with the CMDT suggest that adoption rates for existing improved varieties could be significantly increased

⁹ The application of a 100 kg/ha urea (46% N) top dressing only for maize grown after cotton was recommended prior to the implementation of a guaranteed price of 55 CFA F/kg in 1980. In 1980, and without financial analysis, the recommendation was changed to 200 kg/ha complete-formula fertilizer at planting, followed by 100 kg/ha urea top dressing at first weeding, and has not been revised to reflect the radically changed market circumstances.

by an extension policy that tailors varietal promotion to farmer needs and circumstances. In trying to encourage intensification of rainfed cereal production, the CMDT promoted only long-duration varieties with high yield potential in the high-rainfall areas. Nevertheless, a significant proportion of farm families are food deficit due to low levels of mechanization and the absence of a cash crop. Their first need is for early maturing varieties, even if the yield is lower than could be obtained with long duration varieties. Similarly, farmers who intercrop maize with late millet to take advantage of the longer rainy season in the southern part of the CMDT zone are interested in early-maturing maize varieties. Improved early-maturing varieties of maize are available but, due in part to CMDT's policy of distributing mainly long-duration varieties in high rainfall areas, are not yet widely accessible to farmers in the southern part of the CMDT zone.

Complementary innovations to reduce financial risk will also facilitate fertilizer adoption at farm level. In the course of informal interviews conducted during the ex-post impact assessment study and the rapid maize subsector appraisal, farmers repeatedly stated that the lack of a guaranteed price was the principal reason for not purchasing fertilizer for maize production.¹⁰ GMM has stated that it would be willing to purchase maize from farmers on a forward contract basis if the PRMC would be willing to finance a maize flour promotion campaign. Since improved returns for cereal growers is a major objective of the PRMC, there would be solid justification for using PRMC funds to promote maize flour marketing if linked to maize procurement contracts from maize grower associations.

¹⁰ These interviews took place prior to devaluation of the CFA franc. While increases in fertilizer prices are certainly a major disincentive to fertilizer use, removal or reduction in the uncertainty concerning output prices is a valid objective to pursue since it would serve to mitigate the effect of fertilizer price increases.

9.4.2 Implications for maize research priorities

An important potential contribution of commodity subsector studies undertaken by NARS is to inform research priority-setting within and between commodities. We do not imply that this should be the major focus of the research of commodity subsector study teams, nor that their contribution should necessarily carry more weight than the views of other stakeholders in the research system. However, assessment of the longer-term prospects for development of a particular subsector will inevitably generate information useful to the design of, and allocation of resources to, agricultural research programs. We first look at the focus of research effort within the maize subsector, and then at implications for other commodities.

The maize program is of appropriate size but needs to be more focussed geographically, and with greater integration between on-station and on-farm research. In justifying this conclusion, we briefly review the past and then look at the future.

Boughton and Henry de Frahan (1994) report that during the 1970's an average 0.73 full time equivalent (FTE) person years went into maize research, all for on-station varietal selection. During the 1980's, this rose to an average of 6 FTEs per year (including research-extension liaison personnel in the development agencies), 70% for sole maize research (evenly split between on-farm and on-station) and 30% for intercropped maize research (90% on-farm). During the 1970's the program was arguably too small to be effective. During the 1980's the program achieved a critical mass of researchers, and effectively dealt with the maize streak virus problem through close collaboration between research and

development agencies, and between different research disciplines. Intercropping research activities were by contrast geographically and organizationally diffuse, suffered from poor coordination, and were inconclusive. The contrasting experiences of intercropping research and action to combat maize streak virus provide an important clue as to how to improve program effectiveness in the future.

As of June 1994, the maize program has 5.35 FTEs (1.5 agronomists, 1 breeder, 1 pathologist, 1 entomologist and 1 weed scientist). All but 1 FTE are based at Sotuba, a location agro-climatically representative of the northern half of the CMDT zone. At present, the Sikasso farming systems team is also devoting approximately 2 FTEs to on-farm maize research (1 agronomist and 1 economist). The total of 7.35 FTEs represents 2.5% of total research personnel, 3.3% after excluding those on long-term training or in full-time administration.

Expansion of the varietal improvement component from a testing program to a breeding program is not justified. Maredia (1993) estimates that, for wheat in developing countries, a threshold annual production level of 150,000 tons is necessary for a varietal testing program to achieve an IRR in excess of 12%. For a breeding program to be more profitable than just testing varieties from elsewhere (e.g., CIMMYT), the threshold is 780,000 tons.¹¹ Even after haggling over differences between maize and wheat, maize production in Mali, which peaked in 1986 at 232,000 tons, will remain significantly less than 780,000 tons per annum for many years to come. The varietal evaluation component of the maize program

¹¹ Based on a scientific personnel requirement of 1 FTE for a testing program and 3 FTEs for a breeding program at a cost of (1992) US \$35,000 per FTE per year.

has proved extremely effective at borrowing material from outside and there is no reason to think that this strategy will not continue to bear fruit in the future.

The effectiveness of the varietal improvement component of the program could be sharpened in three ways. First, as the geographical focus of future area expansion, the southern part of the CMDT zone, should be given more emphasis in regard to screening efforts. Second, parallel on-farm testing of improved varieties should be undertaken by the farming systems program in southern Mali for both sole and intercropped maize systems. The recent reorganization of IER into regional centers with both on-station and farming systems research activities could greatly facilitate this collaboration. However, to serve the high potential area where future expansion of maize production is likely to occur more effectively, the main location of the maize program should be moved from the Sotuba regional center to the Sikasso regional center. Third, in view of the increased cost of fertilizer, more attention should be given to a careful evaluation of the economic feasibility of hybrids, and on-station and on-farm research on fertilizer application levels should be conservative. Approximately 2 research FTEs, one each on-station and on-farm, could undertake such a program.

Aside from continued varietal selection, the single most important challenge facing the maize research program is to re-establish the profitability of fertilizer use. Without the use of added fertility amendments, maize is no less land-degrading than millet or sorghum. A number of avenues for reducing the cost and/or increasing yield response to fertilizer have been enumerated above. A critical organizational innovation is that the research again be carried out in parallel on-station (to measure agronomic response and soil fertility effects of alternative treatments accurately)

and on-farm (to assess economic feasibility and risk under farmers' management accurately). Again, this work should be focussed in the southern part of the CMDT zone where yield potential is highest. Fertility research should be conducted for both sole and intercropped maize research. Approximately 2 research FTE's would be required to undertake the on-farm and on-station programs. In view of the weed challenge in the high potential southern part of the CMDT zone, and the interaction between weed control and fertilizer use, both fertilizer agronomy and weed science disciplines need to be represented on the team.

In view of the importance of assessing the economic feasibility of alternative varietal and fertilizer treatments in both sole and intercropped systems, the availability of an economist to the maize program is crucial. There is also a need to assess the marketing difficulties faced by farmers in the southern part of the CMDT zone due to poor transport infrastructure, and the extent to which different technology-development strategies are appropriate for farm households with different resource endowments (in particular for food-insecure households). The maize program could absorb 1 FTE economist in order to undertake marketing and food security research in the high potential zone in addition to economic analysis of on-farm and on-station trials.

In addition to core disciplines of varietal selection, agronomy and economics, limited contributions (up to 0.25 FTEs) from support services in soil science, pathology, and entomology would be required. Entomology inputs may need to expand to 1 FTE if increased storage pest problems are encountered as a result of expanded production or migration of the Large Grain Borer (*Prostephanus truncatus*) from neighboring countries.

There is no indication that industrial maize processing requirements show strong varietal specificity. For whole grain maize flour, a soft-endosperm white variety such as Tuxpeno would be preferred. This variety is readily identified by its flat shape and indented outer face. Farmers prefer it as a commercial variety because it is high yielding but difficult to process manually. For refined flour, a medium-textured grain of either color would be suitable. Separation of grain lots by variety would marginally improve flour yield¹², and hence provides a further motive for GMM to enter into forward contracts with farmers that specify the variety to be grown. However, there is no need to select varieties specifically for their mechanical processing characteristics. The difficulty of manual processing (dehulling and milling) can vary considerably from one variety to another (DRSPR, 1994) and should, along with culinary tests, become an integral part of varietal evaluation in collaboration with the food technology laboratory and rural households. Up to 0.5 food technology FTEs could be absorbed by this component, depending of the extent of work with rural households.

If PRMC and GOM decide to adopt facilitative measures in support of maize processing, then additional research input from a food technologist and social scientist would be advisable. The role of the food technologist would be twofold: 1) to develop instructions for use in promotional materials on how to prepare principal dishes (bouillie, toh, couscous), focussing on differences in technique between dry and moist flour;¹³ 2) monitoring the cooking and storage quality of processed flours and diagnosis of the cause of any problems that emerge. The

¹² Christian Mestres, personal communication.

¹³ In Bamako, housewives are used to flour milled in custom plate mills. Water is added to dehulled grain prior to milling to produce a finer flour.

social scientist would monitor sales to different population sub-groups and recommend improvements in marketing and promotional strategies. In view of the short-term nature of this activity, personnel could be provided from a local consulting firm or micro-enterprise support project rather than from IER.

Taking account of the need for limited additional inputs from supporting scientific personnel such as plant pathologists and soil scientists, the near to medium-term priorities described above imply a program of similar size to that prevailing during the 1980s, but with sharper geographic and agronomic focus on production opportunities (area expansion in the high potential southern part of the CMDT zone) and constraints (high fertilizer costs), and closer collaboration between on-station and on-farm activities. This could be accomplished more effectively if the principal location of the maize program were moved from Sotuba to the Sikasso regional center. In terms of disciplinary mix, up to one full-time economist and one half-time food technologist need to be available to the program. It is not clear that the program needs full-time input from a pathologist and an entomologist at present, although the situation could change if there were a resurgence of maize streak virus or an outbreak of storage pests.

9.4.3 Implications for research on other cereal subsectors

In regard to other foodgrain subsectors two main points emerge. First, rice dominates cereal calorie supply to the population of Bamako. Yet the rice subsector in Mali is undergoing traumatic changes as a result of devaluation and the withdrawal of the state from rice processing and marketing, and credit and input delivery. This coincides with a period of political tension following the 1991 coup,

attempted coups in 1991 and 1992, and sharp increases in the cost of living following devaluation in 1994. A breakdown in the supply of rice to the capital's population would clearly result in serious social distress and political instability. Careful monitoring of the subsector activity, focussed on private sector decision makers' intentions, is a top priority in the short run. In the medium to longer term there are numerous issues that need to be investigated to increase productivity in the rice subsector, close the gap remaining between domestic consumption and production, and drive down costs of rice delivered to the urban consumer. These have been enumerated for the irrigated rice subsector at the Commodity Subsector Economics Program design workshop (IER, 1994), but need to be augmented for rainfed rice production systems.

For millet and sorghum, there exists a window of opportunity to increase the efficiency of mechanical dehulling services through improvements in technology and changes in market organization. The introduction of abrasive disk dehullers at wholesaler level would reduce processing losses, reduce distribution costs, and permit more efficient use of by-products by livestock rearers. Since sorghum varieties vary considerably in their dehulling characteristics, growth in demand for dehulled products would eventually lead to a price premium for varieties with appropriate criteria (harder textured and without red discoloration of the outer layer of endosperm). This in turn would encourage adoption of improved varieties with these characteristics (e.g. some of the Malisor series of improved sorghums).

9.5 Implications for IER's commodity subsector economics program

Although addressed primarily to IER's commodity subsector economics program, the conclusions drawn in this chapter are broadly applicable to African NARS seeking to take account of market opportunities and constraints in the design of agricultural research programs.

9.5.1 Methodological implications

The flexibility of the commodity subsector approach means that the depth and focus of studies can be adjusted to a wide range of personnel and financial resources. For any study, the initial subsector appraisal is a critical first step. It will have the following objectives: 1) to bring together existing information about the nature and functioning of the commodity subsector; 2) to bring together different subsector participants and make that information available to them; 3) to identify constraints and potential solutions at different stages of the subsector; and 4) to identify and define the role of different subsector participants (including researchers) in overcoming identified problems.

For small NARS, or for less important commodities, the initial appraisal may be the only subsector research activity for a given commodity. Large NARS may consider using initial appraisal methods extensively as a means to set priorities for long-term subsector development programs. For either situation, high priority should be attached during the initial subsector appraisal to the identification of innovations that can be implemented (or at least initiated) rapidly (e.g., repeal of redundant fiscal or regulatory legislation, supplying information needs of subsector participants).

Where problems or issues are identified that require more in-depth study, great care must be given to the amount of quantitative data collected (Tefft et al., 1990). Large-scale formal data collection efforts such as consumption, cost-of-production, or market information studies may best be confided to specialized projects or units (e.g. Mali's Market Information System or the national statistical agency). In many cases, less quantitative and/or less frequent data collection will be adequate for the pragmatic objectives in view.

Of critical importance to the payoff to commodity subsector programs is a system to monitor the implementation of recommendations. For both innovations that can be implemented rapidly and for longer term activities (such as setting up cooperative marketing programs, testing of improved technology, or in-depth research activities), a monitoring system must be designed that identifies and tracks intermediate and final outcomes against expected progress, and circulates information in a timely way to interested parties. Like any research activity, commodity subsector programs will need to demonstrate their economic impact.

9.5.2 Organizational implications

Critical to success of a commodity subsector economics program is the identification and involvement of "stakeholders" in the private sector (e.g., farmers, traders, consumers, bankers) and the public sector (e.g, the research organization and its donors, extension agencies, and other government or non-government organizations). An important role for a commodity subsector research program will be to help build and motivate coalitions, or networks (Juska and Busch, not dated), that can integrate the actions of different participants.

The type and degree of involvement of each stakeholder will vary over time. Representatives of relevant technical research programs and the farming systems research programs must participate (i.e. a human resource investment "stake" must be taken) in the initial subsector appraisal and identification of available innovations and/or necessary in-depth studies. Researchers and representatives of the private sector and government or non-government extension agencies should agree about the need for, and approach to, in-depth research on constraints or problems identified during the initial assessment (including the time required to achieve intermediate and final objectives). Representatives of the private sector and government or non-government extension agencies must participate, and in many cases take a lead role, in the design and implementation of action programs to test and/or implement potential solutions to identified constraints.

A key step is to strengthen linkages between agricultural research and planning and policy units within ministries of agriculture, planning and finance. The optimal set of technologies needed ten to fifteen years hence depends on complementary investments in physical, financial and communications infrastructure. For example, the decision as to whether or not to invest in a domestic fertilizer industry could have a profound effect on which kind of crop research strategy to pursue. Similarly, a decision to devote a major proportion of investment resources to the development of irrigated perimeters as a hedge against drought would have important implications for the allocation of research resources between rainfed and irrigated cropping systems. Thus, in terms of the allocation of resources between different commodity areas, the allocation of resources to different types of problems within a commodity group, and even in the approach

taken to a specific problem (e.g., farm-level pest management for cocoa), decisions taken by NARS need to be consistent with those taken by the public and the private sector to promote specific economic development paths. One method for achieving this is to set up joint task forces for key commodity subsectors that include representatives from the private sector, planning units and agricultural research.

The establishment of effective linkages between NARS and private and public sector clients will require investment in human capital. If NARS are to contribute to, and interpret the implications of, policy and institutional innovation they will require additional types of skill. To support linkages with the broader public sector, for example, NARS will need to include some macro and marketing economists on their staffs as well as farming systems economists. Similarly, in their interaction with private sector clients, social scientists will need to be able to grasp and respond to a broad range of financial and legal concerns (e.g., contractual design). Often, mutual suspicion will need to be overcome to build collaborative relationships between researchers and the private sector.

Regional organizations such as INSAH and SACCAR have important roles to play in building capacity, helping to strengthen organizational linkages, and providing analytical support. Regional organizations can provide a constructive forum for building consensus on the need for, and exchanging experiences concerning, the establishment of effective linkages between research and policy units (e.g., CILSS, 1994). Regional organizations also have a comparative advantage in providing certain types of analyses that affect the region as a whole, such as analysis of economic trends or comparative analyses of structural adjustment processes in several countries within a region.

Finally, effective external linkages will be of little value unless there are equally effective linkages within the NARS itself. For example, monitoring the impact of liberalization of livestock feed markets will involve both marketing and farming systems dimensions. Research on these impacts will need to be designed and implemented jointly. Similarly, because of significant changes in the demand for technology as a result of devaluation, there will need to be more effective linkages between technology development and technology testing activities than have been the norm hitherto. Again, joint task forces organized around particular commodities can provide a means to bring together thematic researchers, farming systems research, and marketing economists in order to develop commodity research strategies.

9.6 Conclusion

The development of an agricultural policy and technology design process that brings together different private and public sector actors, and different groups of scientists within the NARS, cannot be achieved by a cookbook method. A commodity subsector approach can provide a framework for organizing analysis of food system problems in such a way as to promote dialogue between different groups of participants, each of which has a contribution to make to solving those problems. A commodity subsector approach can improve the potential payoff to investments in agricultural research by identifying ways of driving down costs throughout the subsector by a combination of appropriately sequenced technological, institutional and policy innovations that better match the supply of agricultural technology to market demand over time. The Institut d'Economie Rurale

has included subsector studies in its strategic plan to ensure that its efforts are relevant to the needs, circumstances and opportunities of clients at all stages from farm-level production to final consumer. The maize subsector study was the first in this series, and contributes to both a methodological foundation for future studies and directly useable results to enhance the performance of Mali's cereal subsectors.

APPENDICES

APPENDIX 1

APPENDIX 1: Maize Recommendation Domain Partial Budgets

Table A1.1: CMDT 1: North Intensive (pre-1980, urea top dressing only)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1500	45	67500
Improved millet/sorghum yield	800	45	36000
Incremental Gross Benefit			31500
Seed	15	90	1350
Seed dressing	0.025	450	11.25
Compound fertilizer (cotton)	0	62.5	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	100	55	5500
Labor	0	750	0
Incremental Cost			6861
Incremental Net Benefit			24639

Table A1.2: CMDT 1: North Intensive (1980-1985, compound fertilizer and urea)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	2000	55	11000
Improved millet/sorghum yield	900	55	49500
Incremental Gross Benefit			60500
Seed	15	110	1650
Seed dressing	0.025	800	20
Compound fertilizer (cotton)	100	105	10500
Compound fertilizer (cereal)	0	120	0
Urea top dressing	150	103	15450
Labor	0	750	0
Incremental Cost			27620
Incremental Net Benefit			32880

Table A1.3: CMDT 1: North Intensive (1980-1985, half fertilizer dose)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1750	40	70000
Improved millet/sorghum yield	900	55	49500
Incremental Gross Benefit			20500
Seed	15	80	1200
Seed dressing	0.025	1040	26
Compound fertilizer (cotton)	0	140	0
Compound fertilizer (cereal)	50	120	6000
Urea top dressing	75	130	9750
Labor	0	750	0
Incremental Cost			16976
Incremental Net Benefit			3524

Table A1.4: CMDT 2: North Semi-Intensive (1980-1985)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1400	55	77000
Improved millet/sorghum yield	900	55	49500
Incremental Gross Benefit			27500
Seed	15	110	1650
Seed dressing	0.025	800	20
Compound fertilizer (cotton)	0	105	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	0	103	0
Labor	0	750	0
Incremental Cost			1670
Incremental Net Benefit			25830

Table A1.5: CMDT 2: North Semi-Intensive (1986 onwards)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1500	40	60000
Improved millet/sorghum yield	900	55	49500
Incremental Gross Benefit			10500
Seed	15	80	1200
Seed dressing	0.025	1040	26
Compound fertilizer (cotton)	0	140	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	0	130	0
Labor	0	750	0
Incremental Cost			1226
Incremental Net Benefit			9274

Table A1.6: CMDT 3: South Intensive (pre-1980: urea top dressing only)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	2000	45	90000
Improved millet/sorghum yield	1000	45	45000
Incremental Gross Benefit			45000
Seed	15	90	1350
Seed dressing	0.025	450	11.25
Compound fertilizer (cotton)	0	62.5	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	100	55	5500
Labor	0	750	0
Incremental Cost			6861
Incremental Net Benefit			38139

Table A1.7: CMDT 3: South Intensive (1980-1985, compound fertilizer and urea)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	2500	55	137500
Improved millet/sorghum yield	1100	55	60500
Incremental Gross Benefit			77000
Seed	15	110	1650
Seed dressing	0.025	800	20
Compound fertilizer (cotton)	100	105	10500
Compound fertilizer (cereal)	0	120	0
Urea top dressing	150	103	15450
Labor	0	750	0
Incremental Cost			27620
Incremental Net Benefit			49380

Table A1.8: CMDT 3: South Intensive (1980-1985 half fertilizer dose)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	2250	40	90000
Improved millet/sorghum yield	1100	55	60500
Incremental Gross Benefit			29500
Seed	15	80	1200
Seed dressing	0.025	1040	26
Compound fertilizer (cotton)	0	140	0
Compound fertilizer (cereal)	50	120	6000
Urea top dressing	75	130	9750
Labor	0	750	0
Incremental Cost			16976
Incremental Net Benefit			12524

Table A1.9: CMDT 4: South Intensive intercropped (1980-1985)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1500	40	60000
Improved cereal intercrop yield	750	55	41250
Improved millet/sorghum yield	1100	55	60500
Incremental Gross Benefit			40750
Seed	15	80	1200
Seed dressing	0.025	1040	26
Compound fertilizer (cotton)	0	140	0
Compound fertilizer (cereal)	50	120	6000
Urea top dressing	75	130	9750
Labor	0	750	0
Incremental Cost			16976
Incremental Net Benefit			23774

Table A1.10: CMDT 5: South Semi-Intensive (1980-1985)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1750	55	96250
Improved millet/sorghum yield	1100	55	60500
Incremental Gross Benefit			35750
Seed	15	110	1650
Seed dressing	0.025	800	20
Compound fertilizer (cotton)	0	105	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	0	103	0
Labor	0	750	0
Incremental Cost			1670
Incremental Net Benefit			34080

Table A1.11: CMDT 5: South Semi-Intensive (1980-1985)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1750	40	70000
Improved millet/sorghum yield	1100	55	60500
Incremental Gross Benefit			9500
Seed	15	80	1200
Seed dressing	0.025	1040	26
Compound fertilizer (cotton)	0	140	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	0	130	0
Labor	0	750	0
Incremental Cost			1226
Incremental Net Benefit			8274

Table A1.12: CMDT 6: South Semi-intensive intercropped (1980-1986)

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1250	40	50000
Improved cereal intercrop yield	500	55	27500
Improved millet/sorghum yield	1100	55	60500
Incremental Gross Benefit			17000
Seed	15	80	1200
Seed dressing	0.025	1040	26
Compound fertilizer (cotton)	0	140	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	0	130	0
Labor	0	750	0
Incremental Cost			1226
Incremental Net Benefit			15774

Table A1.13: OHV 1: Intensive

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1750	45	78750
Improved millet/sorghum yield	900	45	40500
Incremental Gross Benefit			38250
Seed	15	90	1350
Seed dressing	0.025	450	11.25
Compound fertilizer (cotton)	50	62.5	3125
Compound fertilizer (cereal)	0	120	0
Urea top dressing	50	55	2750
Labor	0	500	0
Incremental Cost			7236
Incremental Net Benefit			31014

Table A1.14: OHV 2: Semi-intensive

Input/output	Quantity (kg/ha)	Price (CFA/kg)	Value (CFA/ha)
Improved maize yield	1500	45	67500
Improved millet/sorghum yield	900	45	40500
Incremental Gross Benefit			27000
Seed	15	90	1350
Seed dressing	0.025	450	11.25
Compound fertilizer (cotton)	0	62.5	0
Compound fertilizer (cereal)	0	120	0
Urea top dressing	0	55	0
Labor	0	500	0
Incremental Cost			1361
Incremental Net Benefit			25639

APPENDIX 2

APPENDIX 2: Maize Subsector Study Research Planning Matrix

COMPOSANTE	SOUS-COMPOSANTE	QUESTIONS GENERALES	QUESTIONS SPECIFIQUES (hypothèses à tester)	DONNEES NECESSAIRES	SOURCE	TYPE D'ANALYSES
CONSUMMATION ET TRANSFORMATION	Humidité (laborel) Maïs grain	Prix du maïs dans le système alimentaire	*Niveau et variation saisonnière de consommation	Consommation totale par capita - par mois - par région/caractéristique socio-culturelle - par niveau de consommation - par niveau de revenu	ENSI Enquête formelle UA Suivi UA IER	
		Contraintes à l'augmentation de la consommation du maïs	*Coûts de transformation et de préparation élevés par rapport aux autres céréales	Budget de préparation - prix de la main d'œuvre - coût du décorçage manuel et coût d'opportunité - pertes de décorçage - prix du moulin au moulin - prix du moulin manuel - pertes de mouture - temps de cuisson par type de farine (couscous, semoula, mochi, fofio, nyanya kiki) - quantité de combustible de chauffe consommé - coût d'opportunité du combustible - poids du produit cuit par rapport au produit de base	Suivi UA (sous-échantillon) Enquête formelle UA ATI (ec)	Budgets d'exploitation par type de transformation et analyse de sensibilité Budget partiel de préparation par pilt et type de transformation
			*Incidence peu favorable du centre de décision	Structure de prise de décision pour l'achat des céréales et services de transformation	Enquête formelle UA Suivi UA	Indice d'instabilité des prix absolus et relatifs
			*Instabilité du niveau du prix relatif en grains	Prix mensuel à la consommation	SIMOPAM	Analyses descriptives des contraintes d'utilisation du maïs
			*Pénibilité du travail	Opinions des ménagères	Enquête formelle UA	Analyses des marges entre types et qualités de produits
			*Marques d'équipement adéquat pour la transformation	Recensement types et caractéristiques des équipements utilisés dans les quartiers	Enquête formelle UA	Analyses descriptives/factorielles des caractéristiques des consommateurs par type de produit
			*Qualités non-conformes au goût des consommateurs	Inventaire des qualités vendues sur les marchés au cours de l'année Inventaire des qualités achetées par les consommateurs - type de produit - couleur - fractionnement - conditionnement	SIM	
					Enquête formelle UA Suivi UA	

DONNÉES NÉCESSAIRES		SOURCE	TYPE D'ANALYSES

COMPOSANTE	SOUS-COMPOSANTE	QUESTIONS GENERALES	QUESTIONS SPECIFIQUES (Hypothèses à tester)	DONNEES NECESSAIRES	SOURCE	TYPE D'ANALYSES
CONSUMMATION ET TRANSFORMATION	Humaine (urbaine) Maïs grain		• Faible connaissance des consommateurs du maïs	Fréquence de consommation des plats à base de maïs Appréciations des ménagées en matière de préparation des plats à base de maïs Appréciations des consommateurs par rapport aux différents types du maïs	Enquête formelle Suivi UA	Analyses descriptives
			• Préjugés défavorables pour certains types de maïs	Quantités et qualités transigées sur les marchés au cours de l'année	Suivi UA	Analyses descriptives
		Possibilités pour lever ces contraintes	• Disponibilité faible et irrégulière • Stabilisation de l'offre du maïs en grains • Disponibilité des services de transformation • Disponibilité de produits transformés - conditionnement		SIM	
	Humaine (urbaine) Maïs frais				Simulation de la demande	
					Analyses technologie alimentaire Modèles probit/Tobit	
		Niveau de consommation et préférences des consommateurs	• Caractéristiques de la demande en maïs frais	Prix et quantités transigées sur les marchés de Bamako - en état frais - en état grillée Qualités exigées par les consommateurs Origines et systèmes de production du maïs frais livré à Bamako au cours de la saison Circuits de commercialisation Contraintes de production et commercialisation	Suivi marchés de débarquement Suivi vendeuses Enquêtes informelles Suivi marchés de débarquement et Enquêtes informelles	Analyses graphiques prix et Quantités au cours de la saison Analyses des marges de commercialisation Analyse descriptive Analyse descriptive Analyse descriptive

COMPOSANTE	SOUS-COMPOSANTE	QUESTIONS GENERALES	QUESTIONS SPECIFIQUES (Hypothèses à tester)	DONNEES NECESSAIRES	SOURCE	TYPE D'ANALYSES
CONSUMMATION ET TRANSFORMATION (suite)	Animale (aviculture)	Quelles sont les synergies potentielles entre les filières maïs et avicole	* Quelle est la demande pour le maïs de la filière avicole et quelle est sa tendance	Recensement des exploitations avicoles, leurs tailles et date d'établissement	Reconnaissance rapide des aviculteurs	Analyse descriptive
			* Quelles sont les contraintes de la filière avicole, y compris approvisionnement en maïs	Part du maïs dans la ration alimentaire et évolution au cours de l'année	Reconnaissance rapide Suivi aviculteurs	Estimation des courbes de demande et simulation
			* Quelles sont les possibilités de contrats entre éleveurs et producteurs du maïs, et avec quels modalités de financement	Système d'approvisionnement en composantes de la ration alimentaire et contraintes	Reconnaissance rapide des aviculteurs	Analyse descriptive
			* Quelle est la consommation actuelle du maïs et sa tendance	Maladies et mesures phytohygiéniques: contraintes de santé avicole	Reconnaissance rapide des aviculteurs	Analyse descriptive
	Animale (autre)	Tendances dans la consommation du maïs dans la ration bétail	Tendances dans la consommation actuelle du maïs et sa tendance	Modalités de contrat qui conviennent aux participants	Discussions entre aviculteurs, producteurs du maïs et le CMDT	Budgets d'exploitation et analyse des flux de trésorerie
				Flux de trésorerie des aviculteurs	Suivi aviculteurs	Analyse descriptive
	Industrielle	Les différentes formes d'utilisation du maïs dans l'industrie	* Quelle est la consommation actuelle du maïs et ses perspectives	Quantités des différents types d'aliments consommés et pourcentage du maïs dans la ration	Reconnaissance rapide Sources secondaires	Analyse descriptive
				Tendances dans la production et commercialisation d'aliments	Reconnaissance rapide Sources secondaires	Analyse descriptive
				Recensement des entreprises qui utilisent le maïs et quantités consommées	Reconnaissance rapide Sources secondaires	Analyse descriptive

COMPOSANTE	SOUS-COMPOSANTE	QUESTIONS GENERALES	QUESTIONS SPECIFIQUES (Hypothèses à tester)	DONNEES NECESSAIRES	SOURCE	TYPE D'ANALYSES
COMMERCIALISATION	FONCTIONS PHYSIQUES					
	Transport	Conditions et stratégies de transport	* Frais de transport	Quantités transportées par axe de commercialisation Frais de transport Frais de location véhicule	Reconnaissance rapide Enquête approfondie au niveau des commerçants	Budget d'exploitation pour les commerçants
	Stockage	Types et conditions de stockage	* Avantages et inconvénients des différents types de stockage	Inventaire des types de stockage Durée/pertes de stockage	Enquête approfondie auprès des producteurs et commerçants	Analyse comparative des types de stockage
	Opérations d'achat et de vente	Mode d'organisation des producteurs (collectif et individu)	* Stratégies de mise en marché des producteurs pour accroître leur marge bénéficiaire	Surplus vendable Quantités vendues et prix par période	Reconnaissance rapide Enquête approfondie auprès des producteurs	Analyse descriptive des stratégies de vente
		Mode d'organisation des commerçants	* Stratégies de mise en marché des commerçants pour accroître leur marge bénéficiaire	Réseau de relations entre catégories de commerçants Marges de commercialisation	Reconnaissance rapide Enquête approfondie auprès des commerçants	Analyse descriptive des stratégies de vente Analyse des marges
	FONCTIONS DE COORDINATION				SIM MSU/CESA	Analyse de la structure du marché Elaboration et analyses des comptes de filière
	Financement	Modes de financement et contraintes	* Avantages comparatifs des différents modes de financement	Inventaire des crédits effectués -conditions de remboursement -taux d'intérêt -montants accordés	BCEAO	Analyse descriptive
	Partage des risques	Modes de gestion des risques	Stratégies et mise en oeuvre	Inventaire des différents types de contrats formels et informels	Enquête auprès des commerçants	Analyse descriptive
	Information	Mode de circulation de l'information	Acteurs et canaux	Types d'information Sources Moyens de communication	Enquête auprès des commerçants	Analyse descriptive

COMPOSANTE	SOUS-COMPOSANTE	QUESTIONS GENERALES	QUESTIONS SPECIFIQUES (Hypothèses à tester)	DONNEES NECESSAIRES	SOURCE	TYPE D'ANALYSES
PRODUCTION	Maïs grain	Place de maïs dans le bilan céréalier national	* Niveau et variation inter-année de la production du maïs par rapport aux autres céréales	Production totale céréalière - par an - par céréale - par région - par capita	DNA/DNSI ODRs (CMDT, OHV, ODIMU)	Analyse des tendances
		Place de maïs dans les systèmes de production au Sud-Mali	* Superficie de maïs par rapport aux autres céréales dans les systèmes de production au Sud-Mali	Superficie cultivée pour chaque céréale - par unité de production - par actif - par région - selon le niveau de mécanisation	Enquête Permanente CMDT	Analyse descriptive du sous-système céréalier des systèmes de production
		Possibilités d'augmenter la productivité (réduire le coût unitaire de production) du maïs au Sud-Mali	* Quels sont les pratiques culturales utilisées pour le maïs	Pratiques culturales - rotation - préparation du sol - entretien - fertilisation	Enquête Permanente CMDT (fiche parcellaire)	Analyse descriptive des techniques de production du maïs
			* Quels sont les taux et contraintes d'adoption des variétés améliorées au niveau paysan	Superficie cultivée par variété et par région	Enquête sur l'adoption des variétés en zone CMDT	Analyse descriptive des taux d'adoption par variété et par région
				Appréciation des caractéristiques des variétés		Analyse factorielle/cluster des caractéristiques et taux d'adoption
			* Quels sont les coûts de production du maïs par rapport aux autres céréales sèches	Quantités et prix des intrants par céréale Temps des travaux culturaux par céréale	DRSP/Sikasso	Budgets partiels par céréale et par région Analyse de sensibilité pour le coût d'opportunité du maïs d'oeuvre
			* Quels sont les écarts de productivité au niveau paysan	Pratiques culturales Rendements Situation agro-écologique - sols - pluviométrie	CMDT Recherche-Développement Démonstrations sur la fertilisation du maïs	Régression/analyse factorielle des rendements du maïs par rapport aux techniques culturales adoptées

APPENDIX 3

APPENDIX 3: Milling costs for GMM and SAMA (selected scenarios)

Table A3.1A: Hammer mill and dehuller (SAMA) scenario 1 (CFA F/ton)

Scenario	Volume (tons/year)	200.0		
	Dehulling	YES		
	Milling yield	75%		
	Pre-devaluation			
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg	
Cost of one ton maize	40000	50000	60000	
Financial charges	1075	1344	1613	
Transport	10000	10000	10000	
Handling	1000	1000	1000	
Fumigation	<u>200</u>	<u>200</u>	<u>200</u>	
Delivered cost of grain	52275	62544	72813	
Cleaning losses (3%)	<u>53892</u>	<u>64478</u>	<u>75064</u>	
Fixed cost of mill/motor	1575	1575	1575	
Fixed cost of dehuller/motor	2675	2675	2675	
Building rent	1500	1500	1500	
Electricity	4800	4800	4800	
Spare parts	3000	3000	3000	
Labor	2000	2000	2000	
Value of by-products	<u>-6250</u>	<u>-6250</u>	<u>-6250</u>	
Processing costs (CFA/ton)	9300	9300	9300	
Processed cost of grain	63192	73778	84364	
Flour yield	0.75	0.75	0.75	
Processed cost of flour	84256	98371	112486	
Packaging	5000	5000	5000	
Handling	<u>1000</u>	<u>1000</u>	<u>1000</u>	
Cost ex-depot	90256	104371	118486	
Margin (15%)	<u>13538</u>	<u>15656</u>	<u>17773</u>	
Wholesale price ex-depot	103794	120026	136259	
Distribution	5000	5000	5000	
Retail mark up (15%)	<u>16319</u>	<u>18754</u>	<u>21189</u>	
Retail price per ton	125113	143780	162448	
Retail price per 50 kg bag	6256	7189	8122	
Retail price per kg	125	144	162	

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 10 tons
- 3) Financial charges 21.5% per annum for 45 days
- 4) By-products valued at 25 CFA F/kg wholesale price ex-factory
- 5) Mill cost 750,000 CFA F, 10 year life, 15% interest
- 6) Dehuller cost 1,650,000 CFA F, 10 year life, 15% interest
- 7) Electric motor cost 350,000 CFA F, 5 year life, 15% interest

Table A3.1B: Hammer mill (SAMA) scenario 2 (CFA F/ton)

Scenario	Volume (tons/year)	300.0	
	Dehulling	NO	
	Milling yield	98%	
	Pre-devaluation		
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg
Cost of one ton maize	40000	50000	60000
Financial charges	1075	1344	1613
Transport	10000	10000	10000
Handling	1000	1000	1000
Fumigation	<u>200</u>	<u>200</u>	<u>200</u>
 Delivered cost of grain	 52275	 62544	 72813
Cleaning losses (3%)	<u>53892</u>	<u>64478</u>	<u>75064</u>
 Fixed cost of mill/motor	 1050	 1050	 1050
Fixed cost of dehuller/motor	0	0	0
Building rent	800	800	800
Electricity	2400	2400	2400
Spare parts	1500	1500	1500
Labor	1000	1000	1000
Value of by-products	<u>0</u>	<u>0</u>	<u>0</u>
 Processing costs (CFA/ton)	 6750	 6750	 6750
Processed cost of grain	60642	71228	81814
Flour yield	0.98	0.98	0.98
Processed cost of flour	61879	72682	83484
Packaging	5000	5000	5000
Handling	<u>1000</u>	<u>1000</u>	<u>1000</u>
 Cost ex-depot	 67879	 78682	 89484
Margin (15%)	<u>8485</u>	<u>9835</u>	<u>11186</u>
 Wholesale price ex-depot	 76364	 88517	 100670
Distribution	8200	8200	8200
Retail mark up (15%)	<u>10571</u>	<u>12090</u>	<u>13609</u>
 Retail price per ton	 95135	 108807	 122478
Retail price per 50 kg bag	4757	5440	6124
Retail price per kg	95	109	122

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 10 tons
- 3) Financial charges 21.5% per annum for 45 days
- 4) Mill cost 750,000 CFA F, 10 year life, 15% interest
- 5) Electric motor cost 350,000 CFA F, 5 year life, 15% interest

Table A3.1C: Hammer mill and dehuller (SAMA) scenario 3 (CFA F/ton)

Scenario	Volume (tons/year)	100.0	
	Dehulling	YES	
	Milling yield	75%	
	Post-devaluation		
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg
Cost one ton maize	40000	50000	60000
Financial charges	1075	1344	1613
Transport	16400	16400	16400
Handling	1000	1000	1000
Fumigation	<u>200</u>	<u>200</u>	<u>200</u>
Delivered cost of grain	58675	68944	79213
Cleaning losses (3%)	<u>60490</u>	<u>71076</u>	<u>81662</u>
Fixed cost of mill/motor	5670	5670	5670
Fixed cost of dehuller/motor	9630	9630	9630
Building rent	3792	3792	3792
Electricity	6067	6067	6067
Spare parts	4920	4920	4920
Labor	2000	2000	2000
Value of by-products	<u>-7500</u>	<u>-7500</u>	<u>-7500</u>
Processing costs (CFA/ton)	24579	24579	24579
Processed cost of grain	85069	95655	106242
Flour yield	0.75	0.75	0.75
Processed cost of flour	113425	127540	141655
Packaging	8200	8200	8200
Handling	<u>1000</u>	<u>1000</u>	<u>1000</u>
Cost ex-depot	122625	136740	150855
Margin (15%)	<u>18394</u>	<u>20511</u>	<u>22628</u>
Wholesale price ex-depot	141019	157251	173484
Distribution	8200	8200	8200
Retail mark up (15%)	<u>22383</u>	<u>24818</u>	<u>27253</u>
Retail price per ton	171602	190269	208936
Retail price per 50kg bag	8580	9513	10447
Retail price per kg	172	190	209

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 10 tons
- 3) Financial charges 21.5% per annum for 45 days
- 4) By-products valued at 30 CFA F/kg wholesale price ex-factory
- 5) Mill cost 1,350,000 CFA F, 10 year life, 15% interest
- 6) Dehuller cost 2,970,000 CFA F, 10 year life, 15% interest
- 7) Electric motor cost 630,000 CFA F, 5 year life, 15% interest
- 8) Devaluation 80% pass through, rent 33% imported component, electric 32%, spares 80%, transport and distribution 80%, sacks 80%

Table A3.1D: Hammer mill (SAMA) scenario 4 (CFA F/ton)

Scenario	Volume (tons/year)	200.0	
	Dehulling	NO	
	Milling yield	98%	
	Post-devaluation		
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg
Cost of one ton maize	40000	50000	60000
Financial charges	1075	1344	1613
Transport	16400	16400	16400
Handling	1000	1000	1000
Fumigation	<u>200</u>	<u>200</u>	<u>200</u>
 Delivered cost of grain	 58675	 68944	 79213
Cleaning losses (3%)	60490	71076	81662
 Fixed cost of mill/motor	 2835	 2835	 2835
Fixed cost of dehuller/motor	0	0	0
Building rent	1517	1517	1517
Electricity	3034	3034	3034
Spare parts	2460	2460	2460
Labor	2000	2000	2000
Value of by-products	<u>0</u>	<u>0</u>	<u>0</u>
 Processing costs (CFA/ton)	 11845	 11845	 11845
Processed cost of grain	72335	82921	93508
Flour yield	0.98	0.98	0.98
Processed cost of flour	73811	84614	95416
Packaging	8200	8200	8200
Handling	<u>1000</u>	<u>1000</u>	<u>1000</u>
 Cost ex-depot	 83011	 93814	 104616
Margin (15%)	<u>10376</u>	<u>11727</u>	<u>13077</u>
 Wholesale price ex-depot	 93388	 105540	 117693
Distribution	8200	8200	8200
Retail mark up (15%)	<u>12698</u>	<u>14218</u>	<u>15737</u>
 Retail price per ton	 114286	 127958	 141630
Retail price per 50kg bag	5714	6398	7081
Retail price per kg	114	128	142

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 10 tons
- 3) Financial charges 21.5% per annum for 45 days
- 4) Mill cost 1,350,000 CFA F, 5 year life, 15% interest
- 5) Electric motor cost 630,000 CFA F, 5 year life, 15% interest

Table A3.2A: Grands Moulins du Mali (GMM) scenario 1 (CFA F/ton)

Scenario	Value added tax	0.0		
	Overhead costs	0		
	Packaging	5 kg		
	Milling yield	75%		
	Pre-devaluation			
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg	
Cost of one ton maize	40000	50000	60000	
Financial charges	2150	2688	3225	
Transport	10000	10000	10000	
Handling	230	230	230	
Fumigation	<u>200</u>	<u>200</u>	<u>200</u>	
Delivered cost of grain	52580	63118	73655	
Cleaning losses (3%)	54206	65070	75933	
Overhead costs	0	0	0	
Depreciation	4076	4076	4076	
Variable costs	3907	3907	3907	
Value of by-products	<u>-3992</u>	<u>-3992</u>	<u>-3992</u>	
Processed cost of grain	58197	69061	79924	
Flour yield	0.75	0.75	0.75	
Processed cost of flour	77596	92081	106565	
Packaging	10000	10000	10000	
Technical Assistance	1500	1500	1500	
Handling and transport	<u>3011</u>	<u>3011</u>	<u>3011</u>	
Cost delivered Bamako	92107	106592	121076	
Margin (10%)	<u>9211</u>	<u>10659</u>	<u>12108</u>	
Wholesale price ex-depot	101318	117251	133184	
Value added tax (10%)	<u>0</u>	<u>0</u>	<u>0</u>	
Wholesale price	101318	117251	133184	
Distribution	5000	5000	5000	
Retail mark up (15%)	<u>15948</u>	<u>17588</u>	<u>19978</u>	
Retail price per ton	122266	139839	158162	
Retail price per 50 kg bag	611	699	791	
Retail price per kg	122	140	158	

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 30 tons
- 3) Financial charges 21.5% per annum for 90 days
- 4) By-products valued at 16 CFA F/kg wholesale price ex-factory

Table A3.2B: Grands Moulins du Mali (GMM) scenario 2 (CFA F/ton)

Scenario	Value added tax	0.0		
	Overhead costs	0		
	Packaging	5 kg		
	Milling yield	80%		
	Pre-devaluation			
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg	
Cost of one ton maize	40000	50000	60000	
Financial charges	2150	2688	3225	
Transport	10000	10000	10000	
Handling	230	230	230	
Fumigation	<u>200</u>	<u>200</u>	<u>200</u>	
Delivered cost of grain	52580	63118	73655	
Cleaning losses (3%)	54206	65070	75933	
Overhead costs	8668	8668	8668	
Depreciation	4076	4076	4076	
Variable costs	3907	3907	3907	
Value of by-products	<u>-3992</u>	<u>-3992</u>	<u>-3992</u>	
Processed cost of grain	66865	77729	88592	
Flour yield	0.80	0.80	0.80	
Processed cost of flour	83581	97161	110740	
Packaging	3335	3335	3335	
Technical Assistance	1500	1500	1500	
Handling and transport	<u>3011</u>	<u>3011</u>	<u>3011</u>	
Cost delivered Bamako	91427	105007	118586	
Margin (10%)	<u>9143</u>	<u>10501</u>	<u>11859</u>	
Wholesale price ex-depot	100570	115507	130445	
Value added tax (10%)	<u>0</u>	<u>0</u>	<u>0</u>	
Wholesale price	100570	115507	130445	
Distribution	5000	5000	5000	
Retail mark up (15%)	<u>15836</u>	<u>17326</u>	<u>19567</u>	
Retail price per ton	121406	137834	155011	
Retail price per 50 kg bag	6070	6892	7751	
Retail price per kg	121	138	155	

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 30 tons
- 3) Financial charges 21.5% per annum for 90 days
- 4) By-products valued at 16 CFA F/kg wholesale price ex-factory

Table A3.2C: Grands Moulins du Mali (GMM) scenario 3 (CFA F/ton)

Scenario	Value added tax	0.1	
	Overhead costs	1	
	Packaging	5 kg	
	Milling yield	80%	
	Post-devaluation		
Purchase price of maize	40 CFA F/kg	50 CFA F/kg	60 CFA F/kg
Cost of one ton maize	40000	50000	60000
Financial charges	2150	2688	3225
Transport	16400	16400	16400
Handling	253	253	253
Fumigation	<u>344</u>	<u>344</u>	<u>344</u>
Delivered cost of grain	59147	69685	80222
Cleaning losses (3%)	60976	71840	82703
Overhead costs	12135	12135	12135
Depreciation	6685	6685	6685
Variable costs	5470	5470	5470
Value of by-products	<u>-5309</u>	<u>-5309</u>	<u>-5309</u>
Processed cost of grain	79957	90820	101683
Flour yield	0.80	0.80	0.80
Processed cost of flour	99946	113525	127104
Packaging	16400	16400	16400
Technical Assistance	2700	2700	2700
Handling and transport	<u>4697</u>	<u>4697</u>	<u>4697</u>
Cost delivered Bamako	123743	137322	150901
Margin (10%)	<u>12374</u>	<u>13732</u>	<u>15090</u>
Wholesale price ex-depot	136117	151054	165992
Value added tax (10%)	<u>13612</u>	<u>15105</u>	<u>16599</u>
Wholesale price	149729	166160	182591
Distribution	8200	8200	8200
Retail mark up (15%)	<u>23689</u>	<u>24924</u>	<u>27389</u>
Retail price per ton	181618	199284	218179
Retail price per 50 kg bag	908	996	1091
Retail price per kg	182	199	218

Notes:

- 1) Maize grain purchase price includes costs of sacks
- 2) Maize grain purchase price for lots of approx 30 tons
- 3) Financial charges 21.5% per annum for 90 days
- 4) By-products valued at 21.3 CFA F/kg wholesale price ex-factory
- 5) Devaluation pass through 80%
- 6) Transport, depreciation, and packaging import component 80%
- 7) Technical assistance import component 100%
- 8) Overhead and variable cost import component 50%
- 9) Domestic labor costs up 10% in line with public sector pay increase

APPENDIX 4

APPENDIX 4: Conditional Price Elasticities of Demand for Maize Flours

Table A4.1 Conditional Price Elasticities of Demand for Dehulled Maize Flours

DEHULLED FLOUR PRE-DEVALUATION								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
CIVILIAN								
Lower Y	-1.56	-1.55	-1.49	-1.41	-1.29	-1.19	-1.06	-0.92
Middle Y	-1.61	-1.59	-1.53	-1.44	-1.31	-1.19	-1.06	-0.91
Upper Y	-1.62	-1.60	-1.54	-1.45	-1.31	-1.19	-1.06	-0.91
MEAN	-1.60	-1.58	-1.52	-1.43	-1.30	-1.19	-1.06	-0.91
MILITARY								
Lower Y	-2.18	-2.22	-2.08	-1.91	-1.67	-1.49	-1.28	-1.07
Middle Y	-2.35	-2.35	-2.16	-1.93	-1.64	-1.42	-1.20	-0.99
Upper Y	-2.11	-2.15	-2.04	-1.89	-1.68	-1.53	-1.31	-1.10
MEAN	-2.21	-2.24	-2.09	-1.91	-1.66	-1.48	-1.26	-1.05
DEHULLED FLOUR POST-DEVALUATION								
CIVILIAN								
Lower Y	-1.53	-1.52	-1.47	-1.39	-1.28	-1.18	-1.06	-0.93
Middle Y	-1.57	-1.56	-1.50	-1.42	-1.30	-1.19	-1.06	-0.92
Upper Y	-1.57	-1.56	-1.50	-1.42	-1.30	-1.19	-1.06	-0.92
MEAN	-1.56	-1.54	-1.49	-1.41	-1.29	-1.19	-1.06	-0.92
MILITARY								
Lower Y	-2.04	-2.09	-1.99	-1.86	-1.67	-1.51	-1.33	-1.13
Middle Y	-2.11	-2.15	-2.04	-1.89	-1.68	-1.50	-1.31	-1.10
Upper Y	NA	-2.24	-2.10	-1.92	-1.67	-1.48	-1.27	-1.06
MEAN	NA	-2.16	-2.04	-1.89	-1.67	-1.50	-1.30	-1.10

Notes:

- 1) A meaningful estimate cannot be obtained for the high income military group at 175 CFA F/kg.

Table A4.2: Conditional Price Elasticities of Demand for Whole Grain Maize Flours

WHOLE GRAIN FLOUR PRE-DEVALUATION								
GROUP	PRICE (CFA F/kg)							
	175	150	130	115	100	90	80	70
CIVILIAN								
Lower Y	-1.47	-1.46	-1.42	-1.35	-1.25	-1.16	-1.05	-0.93
Middle Y	-1.46	-1.45	-1.41	-1.34	-1.25	-1.16	-1.05	-0.93
Upper Y	-1.35	-1.34	-1.30	-1.25	-1.17	-1.10	-1.02	-0.91
MEAN	-1.43	-1.42	-1.37	-1.32	-1.22	-1.14	-1.04	-0.92
MILITARY								
Lower Y	-2.21	-2.24	-2.10	-1.92	-1.67	-1.48	-1.27	-1.06
Middle Y	-2.31	-2.32	-2.14	-1.93	-1.65	-1.44	-1.22	-1.01
Upper Y	-1.96	-2.02	-1.94	-1.82	-1.65	-1.51	-1.34	-1.15
MEAN	-2.16	-2.19	-2.06	-1.89	-1.66	-1.48	-1.28	-1.07
WHOLE GRAIN FLOUR POST-DEVALUATION								
CIVILIAN								
Lower Y	-1.48	-1.47	-1.42	-1.36	-1.26	-1.17	-1.06	-0.93
Middle Y	-1.49	-1.47	-1.43	-1.36	-1.26	-1.17	-1.06	-0.93
Upper Y	-1.41	-1.40	-1.36	-1.30	-1.21	-1.14	-1.04	-0.93
MEAN	-1.46	-1.45	-1.40	-1.34	-1.24	-1.16	-1.05	-0.93
MILITARY								
Lower Y	-2.11	-2.15	-2.04	-1.89	-1.68	-1.50	-1.31	-1.10
Middle Y	-2.14	-2.18	-2.06	-1.90	-1.68	-1.50	-1.30	-1.09
Upper Y	-2.17	-2.20	-2.08	-1.91	-1.68	-1.49	-1.29	-1.08
MEAN	-2.14	-2.18	-2.06	-1.90	-1.68	-1.50	-1.30	-1.09

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