Staff Paper

Analyzing the Impact of Structural Adjustment on Commodity Subsectors: Currency Devaluation and the Maize Subsector in Mali

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ABSTRACT

Structural adjustment programs (SAPs) are intended to help increase productivity and income growth over the long run. Technological and institutional innovation are necessary if increases in productivity growth are to be sustained. This paper applies a subsector framework to the analysis of the effect of currency devaluation on the demand for agricultural production and processing technologies 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 framework is relevant to National Agricultural Research Systems (NARS) in Africa as a means to better understand the needs of, and strengthen linkages with, private and public sector research users.

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1. INTRODUCTION

Since the early 1980s, Structural Adjustment Programs (SAPs) have been introduced widely in Africa to increase economic growth through greater reliance on market-based economic systems.[1] As part of a broader process of economic development, sustained increases in productivity growth within the agricultural sector will require technological and institutional innovation. In West Africa, the recent devaluation of the CFA franc has changed market opportunities, constraints, and the needs for technological and institutional innovation in the agricultural sector in a particularly dramatic way. The region's National Agricultural Research Systems (NARS) are therefore one among a number of public sector organizations that need to be able to analyze the implications of devaluation to develop effective strategies to facilitate structural change in the economy.[2]

The purposes of this paper are threefold: 1) to present a conceptual framework for integrating commodity subsector and farming systems perspectives; 2) to illustrate how the framework can be applied to the analysis of the impact of SAPs on the demand for technological and institutional innovation; and 3) highlight linkages between NARS and public and private sector research users that need to be strengthened to respond effectively to major policy changes such as devaluation. The paper is organized as follows. The next section presents the conceptual framework. Section 3 briefly explains the rationale and objectives of devaluation of the CFA franc, and highlights the role of West Africa's NARS for the long-term success of this policy change. Sections 4 and 5 apply the framework: first to an analysis of the historical impact of SAPs on the development of the maize subsector in Mali, and then to a preliminary analysis of the implications of devaluation for future innovation. The paper concludes by reviewing critical issues related to the successful incorporation of a commodity subsector perspective within NARS.

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[1] This paper seeks neither to evaluate or defend SAPs. Rather, given their pervasive influence on African economies, it presents an approach to the analysis of their implications for the design of more effective development strategies.

[2] NARS directors have recognized the need for agricultural research systems to contribute to the formulation and evaluation of SAPs (CILSS, 1994).

2. CONCEPTUAL FRAMEWORK

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 Bernsten, 1992).[3] Both farming and marketing systems are components (or sub-systems) of the food system.

A simple but effective tool for organizing analysis of a food system is a matrix of agricultural products and functions (Shaffer, 1973; Holtzman, 1986). In Figure 1, 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). The rows of the matrix represent individual stages or functions in the production and transformation of commodities. In a market economy, the food system is driven by effective demand from domestic and international consumers. Effective demand can be thought of as a gravitational force that pulls raw material through the different stages of a subsector, engaging resources to add value (and hence also cost) to the product.

Interdependencies, or system interactions, are common to both vertical and horizontal dimensions of the food system. 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 by providing soil fertility and animal traction services (Savadogo et al., 1994). In the vertical dimension, transport costs to urban centers play a key role in determining the profitability of different crop and livestock enterprises. 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 for draft animals in Mali. The effect of interdependencies between stages in a subsector on the profitability of different types of technical innovations depends in part on what mechanisms for coordination are available. For example, the establishment of a farmer cooperative (an institutional innovation) to invest in processing facilities could provide a means to overcome high transport and storage costs associated with bulky and/or perishable commodities. Possibilities for technical innovation are thus not independent of the possibilities for institutional innovation, and they should be considered jointly.

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[3] We consider fiber crops and trees to be integral to a food system. For example, cotton has had a major impact on cereal production in the Sahel by facilitating investment in animal traction and fertilizer. In the humid tropics, trees are essential to the preservation of biological capital for sustainable food crop production.

Figure 1. FOOD SYSTEMS MATRIX

PRODUCTION / DISTRIBUTION FUNCTIONS	**COMMODITY SUBSECTORS**
	Millet Sorghum Maize Rice Cotton Livestock... Off-farm
Input Distribution **Extension** **Farm-level production** **Processing** **Storage** **Transport** **Exchange, transactions** **Finance** **Coordination functions** - **Prices** - **Quality control** - **Regulations** - **Property rights** - **Contracts** - **Risk management** **Consumption**	▲ **Subsector Approach** (vertical arrow, top to bottom) ▼ **Farming Systems Approach** <--->

Source: Adapted from Ndoye and Newman (1984).

Historically, agricultural research has tended to focus on a single stage (often farm-level production) for a single commodity (Staatz and Bernsten, 1992). Interactions with other stages in the commodity subsector, or other commodities at the same stage, were frequently overlooked. Farming systems researchers have consistently 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 <u>farmer</u> 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. An increasing proportion of inputs are obtained off-farm, and an increasing proportion of farm-level products and services are sold or exchanged.[4] The benefits from technological innovation at farm

[4] Some 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 Bernsten, 1992).

level will increasingly depend on the extent to which it responds to evolving off-farm client preferences for different product characteristics (e.g., taste, appearance, ease of processing, seasonal availability, lot size) as reflected in market prices.

In this context, a commodity subsector perspective broadens the scope for productivity gains. As Staatz and Bernsten (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 with a marketable surplus, 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 on farm gate prices if any.[5] In the case of export crops such as cotton and groundnuts, driving down unit costs at multiple stages may be the only way to maintain profitability of the subsector 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 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 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.

With this conceptual framework in mind we can now turn to the implications of devaluation, as one element in a set of policy changes over time that constitute a SAP, for the kinds of technological and institutional innovation that will be appropriate for research users.

3. RATIONALE AND OBJECTIVES OF DEVALUATION

On January 12, 1994, the exchange rate between the CFA franc and the French franc (FF) dropped in half, from 1 FF = 50 CFA F to 1 FF = 100 CFA F. The devaluation marked the first change in the parity rate between the two currencies since 1948. If fully passed on to consumers, the devaluation would double the price of imported goods, exported goods and domestically produced

[5] This result is dependent on a competitive marketing system. In single-channel vertically integrated systems such as cotton in West Africa the allocation of the gains from a reduction in marketing costs is a policy decision.

goods that substitute for imports (what economists call tradable goods) relative to the price of goods that aren't internationally traded (non-tradables) in the countries of the CFA zone. The devaluation was a dramatic event, but is part of a much longer process of structural change in the Francophone West African economies (Staatz, 1994). The overvaluation of the CFA Franc resulted from structural changes in these countries' economies over the past 30 years. Consequently, a change in the nominal exchange rate by itself isn't a solution to the structural problems that led to currency overvaluation in the first place.

The basic arguments for devaluation are well-known. When a country's domestic costs of production rise more quickly than those of its trading partners (for example, due to stagnant technology), the country's goods become more expensive. If the exchange rate (the rate at which domestic resources are exchanged for foreign resources) doesn't adjust to bring back relative prices between the two countries to their old level, imports to the "overvalued" country become artificially cheap, encouraging their consumption. Exports become less competitive in foreign markets. The results are a balance-of-payments deficit (which has to be covered by foreign currency reserves, borrowing, or foreign aid), and an increase in the income of those who produce non-tradable goods relative to those who produce tradables. The process feeds on itself as entrepreneurs substitute artificially cheap imported technologies in place of more labor-intensive local technologies, and migrants are attracted to urban areas because of higher income-earning opportunities and, in some cases, cheaper imported food.

The argument for devaluation is that changing the nominal exchange rate will increase incentives for domestic production of tradable goods (exportable goods and import-substitutes), and discourage domestic consumption of those goods. This process leads to re-establishment of external balance in foreign trade and greater intersectoral balance in the domestic economy. External account balance will, in turn, permit a lowering of the high real interest rates that helped to choke off economic growth in the recent past. However, unless complementary monetary, fiscal, and sectoral policies aimed at stimulating productivity growth in the economy are implemented, the domestic currency is likely to become overvalued again.

Because agriculture is an important tradable goods sector, sustained growth in agricultural productivity is crucial to achieving the objectives of the devaluation policy initiative. An exhaustive treatment of potential constraints to domestic agricultural supply response to devaluation is beyond the scope of this paper.[6] Nevertheless, the technology available to farmers, processors and other economic agents will be a crucial factor affecting their ability to respond. A key question is whether the available technology is adaptable to the new set of relative prices or whether it is heavily dependent on imported inputs that have increased in price following devaluation. A corollary question is whether there exist complementary institutional innovations that can promote productivity (e.g., rural assembly of grain by farmer cooperatives to reduce transport costs) or reduce risk (e.g., contracts to improve coordination of supply and demand).

Before attempting to answer these questions, we first examine the interaction between SAPs, coordination mechanisms and farm-level technology adoption in the past.

4. ANALYSIS OF THE HISTORICAL IMPACT OF SAPs: MAIZE PROMOTION IN SOUTHERN MALI 1975 - 1990

The historical development of maize in southern Mali illustrates the potential impact of institutional and policy innovations on technology adoption at the farm level, as well as the interdependence between different commodity subsectors. Maize is a relatively minor crop in Mali, representing about 5-10% of the total cereal area of the country and about 10-15% of cereal production. At a 7% rate of growth of output, however, it is the most rapidly growing cereal subsector. 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.

The promotion of intensive maize production in the early 1970s was undertaken by the Compagnie Malienne pour le Développement des Textiles (CMDT) in a context of chronic food deficits.[7] Initially promoted among farmers using small tractors, the program was quickly expanded to include farmers using animal traction. The rapid rate of adoption from 1979 through 1985, when the area planted to improved maize varieties in the CMDT zone increased from under 10,000 ha to nearly 50,000 ha, can be attributed to both institutional and technological innovations (Figure 2).

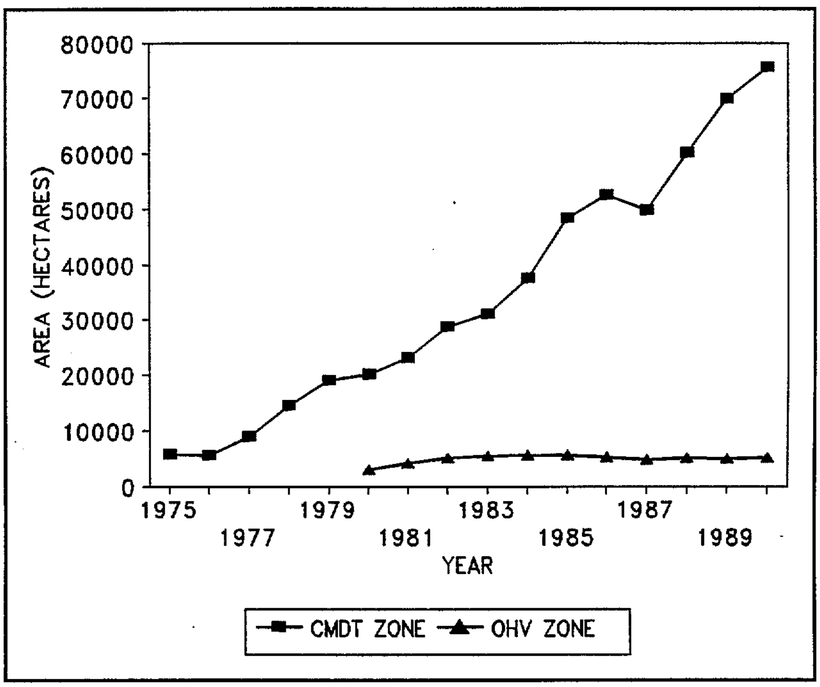
The key institutional innovation was the application to maize of the same integrated approach to technology delivery that was already successfully in use for cotton. The CMDT ensured that all

[6] See Staatz et al., 1994, for a more complete treatment.

[7] The terms "improved" and "intensive" are used synonymously here, reflecting the use of the term "maïs amélioré" in CMDT annual reports, and refer to the use of improved varieties, management practices and chemical fertilizer.

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. This approach was made possible by a policy innovation that from 1981 gave rural development agencies such as the CMDT the right to purchase of cereals at a guaranteed price on behalf of the national grain board (OPAM). The guaranteed price facilitated credit repayment by farmers for production inputs, and the resale price to OPAM included a margin that partially defrayed the CMDT's marketing costs.

FIGURE 2: ADOPTION OF IMPROVED MAIZE IN THE CMDT AND OHV ZONES



Source: CMDT and OHV Annual Reports

The rapid adoption of maize technology was also facilitated by the prior development of the cotton subsector in southern Mali. Since the late 1950s, the CMDT's predecessor (the CFDT) had been introducing mechanization as part of its program to expand cotton production. Over the period 1975 - 1990 the number of oxen and related equipment trebled, paid for by farmers out of their cotton profits. Mechanization is crucial to farmers' capacity to adopt intensive maize because of the need to plow and weed frequently in a timely manner. Not surprisingly, the area of improved maize is highly correlated with mechanization levels over the period 1975-90 (Boughton and Témé, 1992).

An additional contribution of the cotton subsector to maize technology adoption 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 permits lower cash outlays for farmers.

The joint impact on farm-level adoption of a coordinated subsector interacting with farming systems characterized by a high level of mechanization linked to a profitable cash crop can be clearly demonstrated by comparison of adoption in the CMDT zone with adoption in the adjacent Opération Haute Vallée (OHV) zone. The OHV did not put an integrated maize technology development program in place, and farming systems have considerably lower levels of mechanization. Consequently, the adoption curve for intensive maize was almost flat (Figure 2).

Although dramatically effective in terms of adoption rates, the integrated approach to maize production and marketing implemented by CMDT was not financially sustainable. Accumulated cereal trading losses on the part of the national grain board (of which only a small proportion was maize) resulted in a default on payments due to the CMDT for maize procured from farmers. The CMDT in turn was obliged to cease purchases. With the removal of guaranteed prices for maize in 1986 (accompanied by the withdrawal of credit for maize inputs), farmers were exposed to lower and unstable market prices.

While the combination of a highly coordinated subsector and mechanized farming systems had a dramatic effect on the increase in <u>area</u> under improved maize, the withdrawal of marketing services and guaranteed prices after 1986 primarily affected farmers' choice of <u>production techniques</u>. Although the area of improved maize quickly resumed its growth trajectory, farmers radically altered their choice of technology and degree of interaction with the market by the following measures:

(i) reduction in fertilization levels and substitution of manure for chemical fertilizer.

(ii) substitution of early maturing varieties tolerant of low soil fertility conditions for medium or long-duration varieties with high fertilization requirements.

(iii) rapid shift from sole cropping back to the traditional practice of maize-millet intercropping. This system is more tolerant of lower soil fertility and drought. It also earns a higher gross margin because under liberalized markets millet now sells at a higher price than does maize.

(iv) changes in marketing strategy. If the early maize harvest is good, and if the prospects for the millet/sorghum also look good, farmers will sell their old millet and sorghum stocks on the market while prices are still high and eat the new maize crop instead.

In the face of erratic maize prices, and without a line of credit to purchase fertilizer, farmers effectively chose those technology options that enabled them to insulate themselves from the uncertainties of the market.

The key lesson from this historical experience is that the technical input packages adopted by farmers, and thus the productivity of farming, is greatly influenced by the cost and reliability of input and product delivery and distribution systems.

5. PRELIMINARY ANALYSIS OF THE IMPACT OF DEVALUATION ON THE DEMAND FOR INNOVATION IN THE MAIZE SUBSECTOR

The focus of this analysis is limited to strategic leverage points for long-term development of the maize subsector. Section 5.1 provides a descriptive analysis of the maize subsector today and constraints to future development. Based on this analysis, section 5.2 identifies key leverage points important to the expansion of demand and supply through the market over time: urban processing and farm-level production. Sections 5.3 and 5.4 examine the implications of devaluation on demand for technological and related institutional innovations.

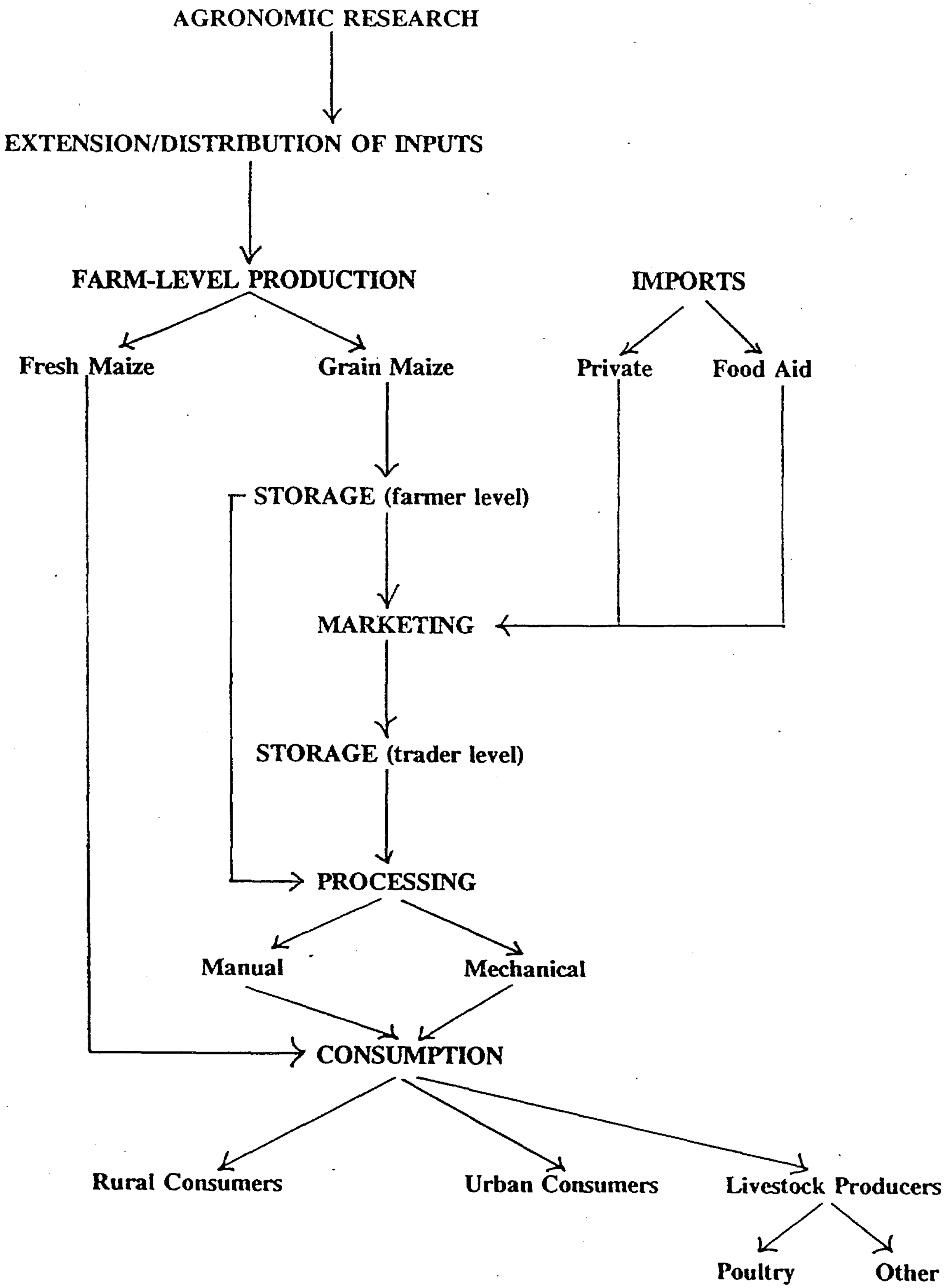
5.1 Overview of the maize subsector

Figure 3 provides a schematic representation of the maize subsector in Mali. Since the farm-level production and upstream stages have been discussed already in the context of the historical impact of SAPs, we focus our attention on the downstream stages.[8]

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. **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. The quantity of maize is not only small relative to millet and sorghum but also highly variable. 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).

[8] An activity or function that is boldfaced in the text refers to a stage in the maize subsector diagram (Figure 3). This descriptive analysis is based on a rapid reconnaissance of the maize subsector carried out during the period February to April 1992, with support from INSAH/PRISAS (IER, 1992).

FIGURE 3: THE MAIZE SUBSECTOR IN MALI



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.

The **marketing** of grain maize takes place through the same network of rural collectors and wholesalers, transporters, and urban wholesalers and retailers as millet and sorghum. Traders report that the volume of maize is small relative to millet and sorghum, and that most maize marketed beyond rural markets goes to the capital city, Bamako.[9] Farmers report that a high proportion of maize is consumed on-farm not just because it is available during the hungry season, but also because millet and sorghum command a higher price than maize in local markets. Furthermore, if either the previous year or this year's 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. The combination of a small share for maize in total cereal production, high variability in amount produced, and high variability in rural consumption requirements, all contribute to a very thin market.

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 among traders.[10] 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.

Processing represents a constraint to more widespread maize consumption, particularly in urban areas. The processing of coarse grains involves four stages: 1) threshing to remove grains form 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

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[9] Dioné (1987) analyzed cereal sales for 189 farm households in the CMDT and OHV zones for the 1985/86 crop season. He found that maize accounted for 7.3% of all cereal sales (compared to 66.1% for sorghum and 27% for millet). Maize sales represented less than 5% of total maize production.

[10] 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.

stages cleaning activities will be 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 earnings (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. Urban mill operators also charge slightly more for processing maize than millet or sorghum because it is harder. The availability of pre-processed products such as flour that could avoid the additional time, cash and transactions costs associated with maize processing is very limited.

Human consumption of grain maize is mainly in the same form as millet and sorghum, i.e. tô (a thick porridge made from flour and usually consumed in the evening), seri (a porridge made from maize grits), bouïllie (a thin porridge consumed at breakfast or supper), or couscous. Despite similarities with millet and sorghum, the consumption of maize in grain form rather than fresh is a relatively recent phenomenon. Many Malians first consumed maize as food aid during the famines of the early 1970s and early 1980s, and hence associate the cereal with very negative experiences. In Bamako, a detailed one-year survey in 1992/93 reported only 8kg of maize per adult equivalent compared to 22kg for millet, 55kg for sorghum and 107kg for rice (Boughton, 1994). Lack of familiarity with the cereal is reinforced by the fact that good quality maize grain is difficult to find on Bamako markets after February or March. In contrast to urban consumers in other African countries, Bamako consumers prefer yellow maize in order to make seri.

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

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. The failure to communicate consumer preferences to through the different stages of the subsector is also a reflection of the relatively small volumes moving through the market.

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

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. Unfortunately, all these products require maize to be de-germed prior to milling, for which no small-scale equipment exists. Grands Moulins du Mali, an industrial scale plant which undertakes wheat milling and rice dehulling, also has a maize processing line that could produce de-germed maize products if the volume of demand was high enough.

In sum, an initial appraisal of the subsector reveals many characteristics associated with a thin market. 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.

5.2 Potential development strategies to overcome the thin market dilemma

The development of the maize subsector 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 stable, profitable margin for farmers and merchants. Improvements in net margins could be achieved by a reduction in marketing costs (which might come about through vertical integration by farmers organizations into the marketing of cereals), and/or by a reduction in unit costs of production. 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 ensure their access to specific quantities and qualities of grain maize at planting time.

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 relevant to the choice of agricultural research strategy. Varietal selection criteria and degree of crop intensification could be quite different for maize grown as a cash crop for industrial processing than for maize as a farm household staple.

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. It is therefore important to assess how devaluation of the CFA franc is likely to affect alternative development options for the maize subsector.

5.3 The impact of devaluation on opportunities for expanding urban demand for maize through the development of maize processing

From a pre-devaluation perspective the principal market for potential maize surpluses in the medium term, given limited industrial and livestock demands for maize feed, appears to be the rapidly growing urban population, in particular Bamako, the capital city (population approx 1 million). The growth in urban demand for grain maize will depend in large part on the relative cost of preparing meals from maize compared to other cereals. This will depend in turn on relative prices of maize and other cereals, and the extent to which higher costs for processing maize can be reduced. Since the cost of processed maize-based products will be sensitive to the cost of maize grain, it is also necessary to explore possibilities for reducing farm-level costs of maize production.

A formal survey of 640 Bamako households revealed that consumers want to buy dehulled grains and/or flour in order to make traditional coarse grain-based dishes more easily (Témé and Boughton, 1993). IER researchers focussed on estimating the potential demand for pre-processed maize flour through household tests of flour samples prepared by a hammer mill. Opportunities for improving the efficiency of dehulling services were also evaluated (Sanogo et al., 1993).

Figure 4 presents estimated aggregate monthly demand for dehulled and whole-grain flour at different prices before and after devaluation. The demand curves are estimated using contingent valuation responses from men and women belonging to 110 households, a sub-sample of a representative sample of 640 households surveyed for their cereal procurement, processing and consumption behavior (Témé and Boughton, 1992). Each participating household prepared the main coarse-grain based dishes from samples of the dehulled and whole-grain maize flours, and were then asked how frequently they would prepare these dishes at different prices for maize flour, holding the price of other cereals constant. A Tobit maximum likelihood estimation procedure was used to generate demand curves from the household responses.

Devaluation affects quantity demanded in two ways. First, it affects consumer real incomes. In the short run, increases in the prices of imported consumption goods result in a reduction in incomes. In the long run, devaluation is intended to bring about an increase in real incomes. Second, it increases processing costs and therefore retail prices. Given relatively low income- and relatively high price-elasticity of demand for maize flour, the increase in processing costs has a more significant effect on aggregate demand than the short run reduction in real incomes.

Prior to devaluation, on the basis of estimated retail prices of 150 CFA F/kg for dehulled and 115 CFA F/kg for whole-grain flour, projected demand in Bamako 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.[12] For whole-grain flour, this is approximately equal to current levels of maize grain consumption. This analysis assumes that relative prices of rice and coarse grains remain unchanged or, equivalently, that the cross-price elasticity of demand is zero. Thus, the estimates of the impact of devaluation may err on the pessimistic side. 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 absolutely and relative to coarse grains in the medium term, since price increases for imported inputs such as fertilizer and fuel will inflate domestic costs of rice production, and the price of imported rice to meet any shortfall has now doubled in CIF terms.

Given the sensitivity of maize flour demand to retail prices, and the lack of any obvious increase in substitutability with rice,[13] devaluation has reduced the potential for urban demand for

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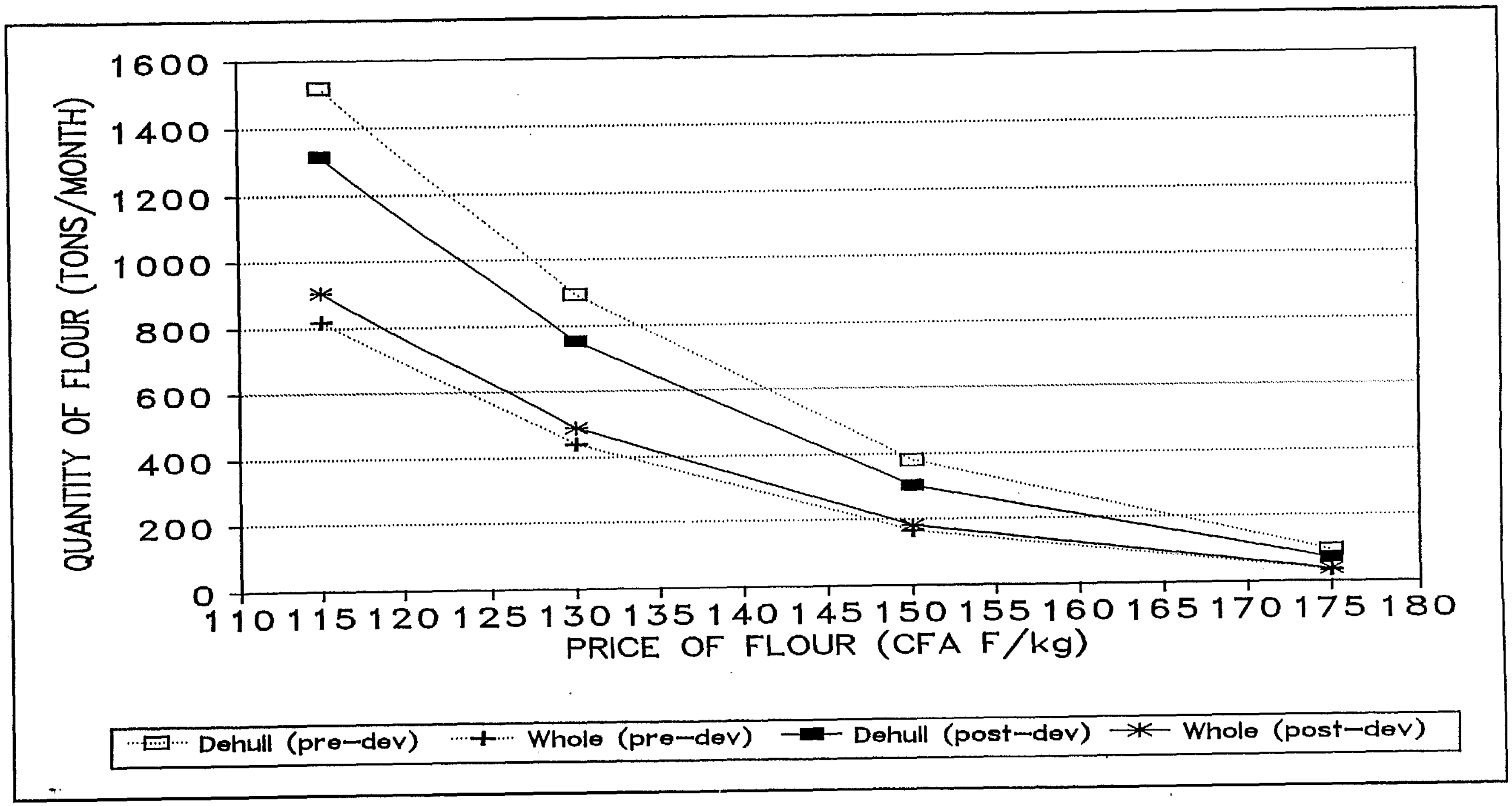
[12] Retail prices are estimated on the basis of grain purchase price, transportation, processing costs and losses (adjusted for the value of by-products), and retail distribution costs. Post-devaluation retail prices reflect an 80% increase in the price of tradable components of the cost structure. Processing losses of 25% are assumed for dehulled flour, 3% for whole grain flour.

[13] Most consumption studies have found low cross-price elasticities of demand between rice and coarse grains (Reardon, 1993). Because the prices of other cereals were held constant for different prices of maize flour in the consumer tests, we cannot formally compute a cross-price elasticity of demand between maize flours and rice. However, analysis of the meals at which consumers intend to prepare maize flour reveals a heavy emphasis on breakfast and dinner, meals typically prepared from coarse grains. There was little demand for maize flour for meals at which rice is typically prepared, especially the noon meal.

Figure 4: 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.

maize flour to lead an expansion of the maize subsector in short run given existing processing technology. Furthermore, the high price elasticity of demand for flour is unlikely to motivate processors to enter into fixed-price contracts for grain since, if the price of grain on spot markets is significantly below the contract price, they would find it difficult to sell flour at a profit.[14] Nevertheless, the differential impact of devaluation on the demand for different types of maize flour reveals that whole grain flour is a more appropriate product than dehulled flour for urban consumers. Indeed, whereas the demand for dehulled flour shifts to the left as a result of the short run decrease in real incomes, the demand curve for whole grain flour shifts to the right. This increased willingness of consumers to trade quality for price is consistent with maize flour demand in countries undergoing structural adjustment in Eastern and Southern Africa (Rubey, 1993; Mukumbu and Jayne 1994).

In contrast to household demand for processed maize products, industrial and livestock feed demand for maize may expand significantly as a result of devaluation. Imported maize grits for brewing, and imported starch for glue, batteries, and tomato paste will all have doubled in terms of their CIF price. Both types of product can be produced simultaneously by Grands Moulins du Mali. Increased livestock feed demand could come from both the domestic dairy subsector (because of the increased price of imported milk powder), the domestic egg subsector (higher cost of eggs imported from Senegal and Ivory Coast due to higher input and transport costs), and external livestock feed demand (e.g., Senegal). The strength of demand growth for maize for livestock feed will depend on government willingness to liberalize the livestock feed market, and the ability of different livestock subsectors to adjust to increases in the cost of inputs such as vaccines. Nevertheless, future expansion of demand for maize is likely to be more broadly based as a result of devaluation.

5.4 The impact of devaluation on opportunities for farm-level technological innovation

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

[14] Although hammer mill operators are unlikely to find fixed-price contracts attractive, they would have an incentive to pay a small premium for soft-endosperm varieties since they result in a finer flour.

additional costs. The issue is important to examine for two reasons. First, the recent 50% devaluation of the CFA franc has resulted in a 40% increase in the cost of imported fertilizer that may in turn lead to reductions in the already small volume of maize coming to market. 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).

Boughton (1994) used partial budget analysis to estimate the impact of devaluation on the profitability of intensive maize for three types of maize production and three marketing scenarios. The three types of maize crop production considered in his analysis are 1) sole crop maize production in the northern part of the CMDT zone; 2) sole crop maize production in the southern part of the CMDT zone; and 3) intercropped maize in the southern part of the CMDT zone. In each case the profitability of intensive maize is compared to the most likely alternative use of the land and labor resources before and after devaluation. For pre-harvest sole crop scenarios, maize with fertilizer is compared to maize without fertilizer. 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.

The three marketing scenarios considered are 1) net buyer pre-harvest; 2) net seller pre-harvest; and 3) net seller post-harvest. Table 1 presents the average cereal prices used in the analysis, based on weekly data collected by the Market Information System (SIM/OPAM) for the four growing seasons between April 1989 and January 1993.

TABLE 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 (standard deviations in parentheses).
2. The three months August - October are classified as pre-harvest, and the three months December - February are classified as post-harvest.

For net buyers, maize is valued at the average pre-harvest price of maize in the respective zone plus transport costs of 5 CFA F/kg. For net sellers pre-harvest, maize is valued at the pre-harvest price of sorghum, less transport costs and an additional processing charge for maize consumed in the household in place of sorghum of 2.5 CFA F/kg. For net sellers post-harvest, cereals are valued at post-harvest prices in the respective zone less transport costs. In contrast to fertilizer prices, which increased 40% following devaluation, coarse grain prices have not increased significantly. The possibility that they might rise in subsequent years is considered through sensitivity analysis. Table 2 presents value cost ratios (VCRs) for the profitability of fertilizer use on maize in the CMDT zone before and after devaluation. VCRs greater than 1 imply positive incremental net benefits from fertilizer use, VCRs less than one imply negative net benefits. A VCR of 2.0, equivalent to a marginal rate of return of 100% in the present analysis, is considered necessary for widespread adoption of a farm-level technology.[15] 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.[16] For only one scenario, sole crop maize net buyers in the southern part of the CMDT zone (Table 2 B), does the VCR exceed the adoption threshold. For other scenarios, with the exception of intercropped maize 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.[17] For sole crop maize in the northern part of the CMDT zone (Table 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

[15] 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.

[16] 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.

[17] Post-devaluation prices are based on retail prices announced by the CMDT for the 1994 crop season, plus 10% short-term finance charges.

TABLE 2A: VCRs FOR INVESTMENT IN SOLE CROP MAIZE (WITH FERTILIZER) VERSUS SORGHUM (NO FERTILIZER) IN THE NORTHERN PART OF THE CMDT ZONE

SCENARIO	NET BUYER PRE-HARVEST	NET SELLER PRE-HARVEST	NET SELLER POST-HARVEST
PRE-DEVALUATION	1.65	1.68	1.7
POST-DEVALUATION			
No change in cereal price	1.19	1.21	1.26
Cereal price up 20%	1.43	1.45	1.51

TABLE 2B: VCRs FOR INVESTMENT IN SOLE CROP MAIZE (WITH FERTILIZER) VERSUS SORGHUM (NO FERTILIZER) IN THE SOUTHERN PART OF THE CMDT ZONE

SCENARIO	NET BUYER PRE-HARVEST	NET SELLER PRE-HARVEST	NET SELLER POST-HARVEST
PRE-DEVALUATION	2.17	1.82	1.86
POST-DEVALUATION			
No change in cereal price	1.57	1.31	1.37
Cereal price up 20%	1.89	1.58	1.65

TABLE 2C: VCRs FOR INVESTMENT IN INTERCROPPED MAIZE WITH VERSUS WITHOUT FERTILIZER IN THE SOUTHERN PART OF THE CMDT ZONE

SCENARIO	NET BUYER PRE-HARVEST	NET SELLER PRE-HARVEST	NET SELLER POST-HARVEST
PRE-DEVALUATION	1.79	1.61	1.2
POST-DEVALUATION			
No change in cereal price	1.30	1.17	0.89
Cereal price up 20%	1.55	1.40	1.07

Source: Adapted from Boughton (1994).

CMDT (Table 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 the south (Table 2 C) 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.[18] 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.

A 20% price increase (such as might result from expanded export opportunities) restores incremental net benefits to levels slightly higher than those before devaluation, but leaves VCRs still too feeble to expect widespread adoption.

In conclusion, the increase in fertilizer prices will result in a significant 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.

A detailed discussion of opportunities to improve the profitability of fertility amendments is beyond the scope of this paper. In brief, this requires 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. There are three options for reducing the cost of fertility amendments in response to increases in the cost of chemical fertilizer: (i) use more economical doses of chemical fertilizer; (ii) use less expensive formulations of chemical fertilizer; and (iii) substitution of organic fertilizer for chemical fertilizer. Opportunities to increase the productivity of fertilizer can be sought through aggressive marketing of existing improved varieties, and possibly the use of hybrid varieties (Boughton, 1994).

[18] Only 22% of the potentially cultivable area in Bougouni was under cultivation in 1989/90, compared to 66% in Koutiala (Goïta, 1993).

6. SUMMARY AND IMPLICATIONS FOR AGRICULTURAL RESEARCH

This paper has analyzed the implications of devaluation for the demand for technological and institutional innovations for maize in Mali using a commodity subsector perspective. At both the farm and processing stages there has been a shift in demand toward technologies that make more efficient use of imported inputs. At the processing level, the analysis reveals a shift in favor of technologies with lower processing losses (i.e., whole grain as opposed to refined flour), that many observers would have dismissed as too radical given traditional consumer taste preferences. At the farm level, alternative strategies for intensification with a lower level of dependence on costly imported chemical fertilizers must be developed in order to avoid an expansion soil mining crop production practices. New forms of coordination, such as contracts between farmers and processors, feed manufacturers or exporters, could facilitate and expand the scope for technological innovation.

Devaluation has significantly changed the constraints and opportunities for many commodities, not just maize. A practical question is how to apply a commodity subsector perspective systematically as part of an agricultural policy and technology design process?

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 problem 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 vehicle 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 staff 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 has 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.

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. Nevertheless, 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.

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