PATTERNS OF PARTICIPATION IN WEST AFRICAN PERI-URBAN DAIRY MARKETS: ANALYSES OF CONSUMERS, RETAILERS, PROCESSORS, AND PRODUCERS IN MALI

By

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ABSTRACT

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The Malian dairy sector has the potential to play an important role in food security and economic development. However, less than 5% of Malian milk is marketed, dairy processing is largely dependent on powdered milk, and imports account for over 70% of household dairy consumption in Mali's capital, Bamako.

The objective of this research is to investigate the market failures behind this pattern, in order to identify opportunities for strengthening the competitiveness of the Malian dairy value chain. Three studies focus on key segments of this value chain, with a focus on peri-urban Bamako. The first study uses random parameters logit and latent class analysis of choice experiment data, to examine Malian consumer and retailer preferences for fresh milk as an ingredient in pasteurized milk, as well as for a number of quality-signaling attributes. The second study analyzes nine representative cases of artisanal, semi-industrial, and industrial dairy processors in Bamako, in order to understand the factors that drive a firm's choice to procure and use fresh milk, powdered milk, or some blend of both. The third study applies a double hurdle market participation model to a nationally-representative household dataset, to identify the barriers that constrain Malian milk producers from entering and supplying markets.

Among the key results, I find that most Malian consumers have a significant willingness-to-pay for dairy products that are manufactured from fresh milk, as opposed to powdered or blended milk. I also identify quality-signaling mechanisms that can help to address information asymmetry in consumer and retailer markets, and policy measures that could encourage fresh

milk supply in markets. Together, these measures should help the Malian dairy value chain to capture a greater share of growing dairy demand.

To my wife, Ruth,
who is beautiful in every way,
not least in her indelible love and support

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TABLE OF CONTENTS

LIST OF TABLES x

LIST OF FIGURES xi

CHAPTER ONE: INTRODUCTION 1
REFERENCES 4

CHAPTER TWO: ANALYSIS OF CONSUMER AND RETAILER PREFERENCES TOWARDS LOCAL MILK AND OTHER DAIRY PRODUCT ATTRIBUTES 6
2.1 Introduction 6
2.2 Theoretical framework and econometric modeling 10
2.3 Data and Survey 13
2.3.1 Sampling Strategy 13
2.3.2 Socio-demographic survey and sample characteristics 16
2.3.3 Choice experiment and dairy product attributes 21
2.4 Results and discussion 27
2.4.1 Results from the consumer random parameters logit models 27
2.4.2 Comparison of consumer and retailer preferences and WTP 33
2.4.3 Results from the latent class models 37
2.5 Conclusion 45
REFERENCES 50

CHAPTER THREE: ANALYSIS OF THE FACTORS MOTIVATING DAIRY PROCESSORS TO USE LOCAL OR IMPORTED MILK INPUTS IN THEIR OPERATIONS 55
3.1 Introduction 55
3.2 Conceptual Framework 57
3.2.1 Firm competitive advantage 57
3.2.2 Cost 59
3.2.3 Differentiation 60
3.3 Methods 62
3.3.1 Case study methods and case selection 62
3.3.2 Data collection and analysis 63
3.4 How do firms use fresh and powdered milk in their operations? 65
3.4.1 Fresh milk firms 67
3.4.2 Powdered milk firms 69
3.5 How does each milk input influence cost? 71
3.5.1 Purchase Price 71
3.5.2 Coordination costs 73
3.5.3 Other transaction costs 75
3.5.4 Other idiosyncratic costs 78
3.5.5 Summary of the relative costs 79
3.6 How does milk input choice influence differentiation? 80
3.6.1 Product types and sub-types 81

3.6.2 Enhancing or preserving product quality 83
3.6.3 Quality-signaling mechanisms 85
3.6.4 Packaging 91
3.7 Conclusion 94
REFERENCES 97

CHAPTER FOUR: ANALYSIS OF THE DETERMINANTS OF MILK PRODUCERS' PARTICIPATION IN OUTPUT MARKETS 101
4.1 Introduction 101
4.2 Conceptual framework 104
4.3 Materials and methods 106
4.3.1 Data sources 106
4.3.2 Econometric model and estimation 107
4.3.3 Variable definitions 109
4.4 Results and discussion 115
4.4.1 Descriptive statistics 115
4.4.2 Econometric results 117
4.5 Conclusion 123
APPENDIX 128
REFERENCES 126

CHAPTER FIVE: CONCLUSIONS 128

LIST OF TABLES

Table 1: Summary statistics of consumer sample……...19

Table 2: Summary statistics of retailer sample……20

Table 3: Pasteurized milk product attributes and levels in choice experiments……21

Table 4: Results from the consumers random parameters logit model……29

Table 5: Results from the retailers random parameters logit models……35

Table 6: Comparison of consumer and retailer WTP……36

Table 7: Results from latent class analysis of consumers……39

Table 8: Profiles of consumers from each latent class……40

Table 9: Results from latent class analysis of retailers……41

Table 10: Profiles of retailers from each latent class……42

Table 11: Overview of firms and dairy products……66

Table 12: Costs of fresh and powdered milk in Bamako……80

Table 13: Variable definition and summary statistics……110

Table 14: Distribution of milk sales across quintiles, weighted……115

Table 15: Summary statistics……116

Table 16: Cragg model results and average partial effects……119

Table 17: Robustness checks: alternative Tobit and Cragg model specifications……131

LIST OF FIGURES

Figure 1: Summary of dissertation research……...…….……2

Figure 2: Map of areas sampled in Bamako……...……...15

Figure 3: Example choice task for a consumer and retailer……..……27

Figure 4: Research framework and questions, based in Porter's comparative advantage…….59

Figure 5: Monthly volumes collected by peri-urban FENALAIT dairy cooperatives, 2012-16.....……..…….77

Figure 6: Per capita supply of domestic milk and dairy imports in Mali (L/per person) ……104

CHAPTER ONE: INTRODUCTION

The Malian dairy sector would appear to hold enormous growth potential. First, dairy consumption has been increasing over the past decades. Recent estimates of the income elasticity of dairy demand-1.1 and 1.3 in rural and urban areas, respectively- indicate that, as incomes rise, the consumption of milk is set to increase as a share of total food consumption (Zhou and Staatz, 2016). Second, Mali's livestock sector, which provides employment to about 85% of the population and has about six cows for every ten people in the population, has the potential to meet this demand (FAO, 2019; MSU, 2011). Additionally, there is some evidence suggesting that Sahelian West African consumers have a strong preference for local milk (or fresh milk), compared to imported dairy products (Lefèvre, 2014).

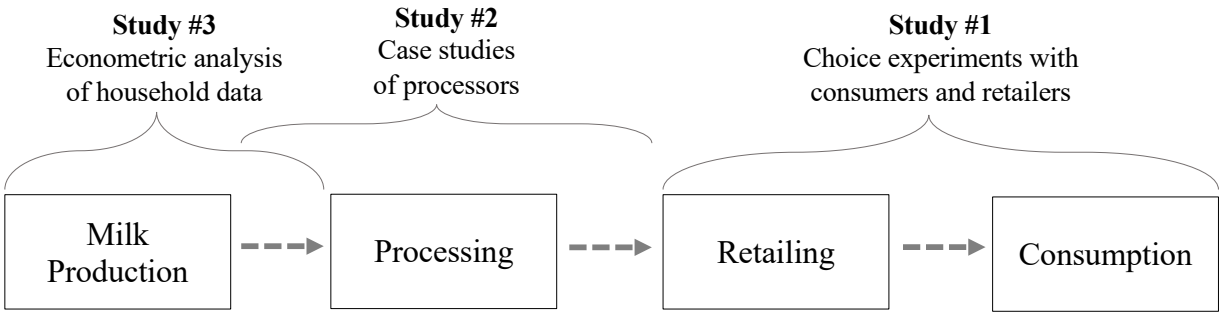
Although one might see these characteristics as a recipe for the rapid growth of Mali's domestic dairy sector over imports, what one observes is the opposite. Per capita availability of imports—especially powdered milk—is growing at the national level, while per capita availability of domestic milk is falling (authors' calculations from FAO, 2019). In Mali's capital, Bamako, imports have already captured the majority share of household dairy consumption (authors' calculations from World Bank, 2015).

This puzzling pattern is not unique to Mali. Two decades ago, Staal et al. (1997) documented similar features in East Africa, and identified them as the "tale-tell signs" of "dairying under large transaction costs." The objective of this dissertation research is to identify the key market failures that constrain the development of the Malian dairy value chain, and to propose policy options and value chain investments that can redress these challenges. To do this, I draw heavily from New Institutional Economics, which has been developed to explain and address market failures in their many forms (Kirsten et al., 2009). The classic definition of market failure refers

to a situation in which a free market fails to bring about a Pareto-efficient allocation of a good (e.g., raw milk or packaged pasteurized milk), such as when there exist unexploited trades between two parties that could make at least one party better off without making the other worse off (Besley, 1998).

This research focuses on market failures at key transactional points in the dairy value chain: between farmers and buyers in milk output markets, between processors and their value chain partners, and in the retailing of dairy products to consumers. Figure 1 visualizes these foci. I begin the analysis with the consumption and retailer segments, where demand is the primary driver for dairy value chain development (Reardon, 2015), then progressively move upstream.

Figure 1: Summary of dissertation research



In the first chapter, I use choice experiments to examine Malian retailer and consumer preferences for fresh milk as an ingredient in pasteurized milk, the most widely-consumed fluid dairy product in Mali, as well as for other novel product attributes. In doing so, I investigate information asymmetry as a source of market failure and also identify quality-signaling mechanisms that can help redress this problem. The second chapter turns to the processing segment of the Malian dairy value chain. I use case study methods to understand the factors that drive a dairy firm's choice to use fresh milk, powdered milk, or some blend of both, as an input

in the manufacturing of consumer dairy products. In the final analysis, I conduct econometric analysis of household data in order to identify the barriers that constrain Malian milk producers from entering and supplying output markets. In the final chapter, I synthesize the main findings from these three studies, and highlight the broad implications for policy and research.

Among the key results, I find that most Malian consumers have a significant willingness-to-pay for dairy products that are manufactured from fresh milk, as opposed to powdered or blended milk. I also identify quality-signaling mechanisms that can help to address information asymmetry in consumer and retailer markets, and policy measures that should encourage fresh milk supply in output markets. Together, these measures should help the Malian dairy value chain to capture a greater share of growing dairy demand.

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CHAPTER TWO: ANALYSIS OF CONSUMER AND RETAILER PREFERENCES TOWARDS LOCAL MILK AND OTHER DAIRY PRODUCT ATTRIBUTES

2.1 Introduction

Consumer demand for dairy in West Africa has been growing for several decades and is positively correlated with both income growth and urbanization (Hollinger and Staatz, 2015). For instance, from the late 1980s to mid-2000s, the share of household food expenditure on dairy increased by 50% and by 30% in urban and rural areas of Mali, respectively (Ibid.). The Malian capital, Bamako, consumes over one-fifth of the national dairy production that is marketed (83 of 376 million liters (L) per year), which is the equivalent of a per capita dairy consumption of 34 L per person per year (author's calculations from World Bank, 2015).[1]

The potential to meet this growing demand with domestic milk supply is high. Mali ranks 6th in total livestock holdings among African countries (FAO, 2017). The country's cattle holding is estimated at eleven million heads and the potential production of cow's milk is nearly 600,000 tons (Government of Mali, 2017). There is some evidence, although limited, that West African consumers have a preference for dairy products that are manufactured from local fresh milk rather than from imported powdered milk (2019; Hollinger and Staatz, 2015; Lefèvre, 2014).

Powdered milk accounts for about one third of dairy consumption in Mali as a whole (author's calculations from World Bank, 2015). This dependence is accented in urban areas, due to higher population densities and greater distances to agricultural production zones, combined with weak overall commercial infrastructure. In Bamako, household purchases of powdered milk account for 70% of volumes consumed in liquid milk equivalents (Ibid.). Fluid milk and yoghurts account for another 18% of consumption (author's calculations from World Bank,

[1] In this paper, I present dried milk products in Liquid Milk Equivalents (LME) using a conversion factor recommended by Meyer and Duteurtre (1998).

2015). Although Bamako-based companies manufacture most of these products, the most established local brands are mostly or entirely manufactured from powdered milk. Most fresh milk-based dairy products that are available in Bamako are manufactured by peri-urban dairy cooperatives or small artisanal processors. This dependence on powdered milk in urban processing and consumption—despite an overall preference for fresh milk—is a common pattern that has been documented elsewhere in Senegal (Lefèvre, 2014) and more generally across West Africa (Hollinger and Staatz, 2015).

One reason for this apparent market failure may be information asymmetry between the manufacturers and buyers of fresh milk-based dairy products. That is, it could be that consumers and retailers of dairy products demand certain credence or experience attributes that may or may not be available on the market, but are in any case difficult or costly for them to verify ex ante (Caswell and Mojduszka, 1996; Rosenman and Wilson, 1991). It could also be the case that certain value actors, such as processors or retailers, are unaware of consumer preferences for certain attributes and, therefore, do not offer them.

Two issues are relevant in developing contexts such as Mali, where food quality and labeling regulations are limited and/or weakly enforced. First, the ingredient composition of a dairy product is a quality attribute that is usually unobservable to consumers prior to the purchase or consumption. For example, Lefèvre (2014) estimates that Senegalese consumers are willing to pay 80% above average prices for a fresh milk-based dairy product; however, in urban markets this preference is not transmitted into an actual price premium, because many consumers do not know the ingredient composition of different brands and are also misled by ambiguous or deceitful labeling practices. Second, recent qualitative research conducted in several West African capitals found that consumers value local foods, but concerns over product safety and

other quality problems lead them to consume foreign brands instead (Hollinger and Staatz, 2015). Other studies conducted in Africa have showed that consumer dairy purchase decisions are influenced by perceptions of aflatoxin levels, unhygienic handling, color and smell, and fat content (Mtimet et al., 2015; Fadiga and Makokha, 2014).

The objectives of this paper are threefold. First, I examine Malian preferences for fresh milk as an ingredient in dairy products. Second, I investigate information asymmetry as a contributing factor to the market failure described above. Third, I analyze three quality-signaling mechanisms—ingredients listing, third-party certification, and enhanced packaging—that manufacturers of fresh milk-based products could be adopted to address information asymmetry. To accomplish this, I use discrete choice experiments to elicit buyer preferences, since quality certification, certain types of packaging, and the clear labeling of ingredients are dairy product attributes that are not yet offered in the Malian market. The study focuses on Mali's largest city and capital, Bamako, given its high dependence on powdered milk. Additionally, large urban markets such as Bamako account for a growing share of food expenditure in developing countries, and also represent the frontier of changing tastes and preferences in these contexts (Hollinger and Staatz, 2015).

A major contribution of this study is that I investigate the preferences of both consumers and retailers, the latter providing a critical link between the consumers and producers of local foods (Trivette, 2018). To do this, I conducted parallel choice experiments with both consumers and retailers, in the vein of the "stacked survey method" which allows for the statistical analysis of differences across value chain segments (Reardon et al., 2012, p. 32). To my knowledge, this is the first study to take this approach in a developing country context. Fernández-Polanco et al. (2013) used a similar approach to study retailer and consumer preferences for seafood products

in Europe. This study concludes that retailers understand well the preferences of consumers with respect to several product attributes, but that retailers overestimate the price-sensitivity of consumers. The study design builds on Fernández-Polanco et al. (2013), by allowing retailer respondents to make choices as firms (rather than as consumers), and by using a larger sample of retailers.

The approach allows me to probe more deeply into issues of information asymmetry and to provide more useful insights for the marketing of dairy products. Retailer value and procurement decision-making are partly driven by a retailer's knowledge of consumer preferences for product attributes (Skytte and Bove, 2004). If I find evidence that retailer preferences are aligned with those of consumers, then it suggests that retailers have adequate information about consumer preferences. Further, if retailer preferences manifest in positive willingness-to-pay (WTP) for product attributes, then it implies that other determinants of retailer value, such as considerations of cost and competition, are also satisfied for retailers to purchase that product. In this case, dairy processors can have greater confidence that those product attributes will be commercially successful, compared to only having evidence of consumer demand. Further, estimates of retailer WTP for product attributes—which factors in the marketing margins that retailers would expect to capture—should provide manufacturers with a more relevant price premium target, compared to consumer WTP.

Finally, because buyer preferences for dairy products are assumed to vary across individuals (Olynk and Ortega, 2013; Wolf et al., 2011; Olynk et al., 2010), I analyze the choice experiment data using models that account for preference heterogeneity. This analysis allows me to identify and characterize distinct consumer and retailer segments. This approach is useful for business

strategy and policy, because it enables them to target, and to tailor their approaches to, appropriate consumer groups along with the retailers that these consumers are likely to patronize.

In the next section, I present the theoretical and empirical framework that underlies the analysis of retailer and consumer preferences. In section three, I describe the data and choice experiment design. I discuss the results from the data analysis in section four, then conclude by highlighting implications for agribusiness strategy and government policy in section five. In this paper, "fluid milk" refers to milk in its liquid form, and includes raw, pasteurized, or sterilized (i.e. ultra-high temperature-processed) milk products that are made from fresh milk, reconstituted powdered milk, or some combination of the two. *Fresh milk* refers to fluid milk that is locally-sourced, i.e. produced in Mali. Mali does not produce any powdered or sterilized milk. *Pasteurized milk* refers specifically to fluid milk that has been pasteurized for sale as a consumer product. *Dairy* refers to any of these, plus any other product that is manufactured from a milk input.

2.2 Theoretical framework and econometric modeling

The theoretical framework of this research is grounded in random utility theory (Manski,1977; McFadden, 1974) and Lancaster (1966)'s consumer theory, which described product quality as a bundle of attributes (related to food safety, nutrition, packaging, processes, etc.) that together determine product performance (Caswell and Mojduszka, 1996).

As a flexible empirical method that conforms to these theories (Adamowicz et al., 1998), choice experiments closely simulate real-world purchasing decisions in which an individual must select one product alternative from a set of options. In most applications, the buyer is the final consumer of the product (e.g., Ortega et al., 2011). The literature has given little attention to

retailer preferences (one exception is Fernández-Polanco et al., 2013), although there is precedence for such an application given that researchers have adapted the approach to study other actors along livestock value chains, including farmers (e.g., Otieno et al., 2011) and traders (e.g., Ruto et al., 2008).

Consider a situation in which individual *i* faces *K* alternatives contained in ψ (the global set of alternatives), where each alternative *k* represents a bundle of product attributes $\boldsymbol{x}$. Subject to the choice set in situation *t*, the individual will select alternative $j \in \psi$ to maximize her utility U_{ijt}. Because of incomplete information and other errors, I model utility as a latent and unobservable random variable:

$$U_{ijt} = V(x_{ijt}) + \epsilon_{ijt}, \tag{1}$$

where $V(x_{ijt})$ is an observable deterministic utility component generated from the selected alternative, and ϵ_{ijt} is the random component of utility assumed to be independently and identically distributed across all individuals and choice situations. Individual *i* will choose product *j* if her utility derived from *j is* greater than or equal to her utility derived from the alternatives; formally $U_{ijt} \geq U_{ikt}\ \forall\ j \neq k$. Thus the probability of her choosing product *j* is given by:

$$Prob_{ijt} = Prob(V_{ijt} + \epsilon_{ijt} \geq V_{ikt} + \epsilon_{ikt};\ \forall k \in \psi,\ \forall k \neq j) \tag{2}$$

Assuming that the deterministic component of U_{ijt} is linear in parameters, I can specify individual *i*'s utility function as:

$$V_{ijt} = X'_{ijt}\beta + \epsilon_{ijt} \quad (3)$$

where X'_{ijt} is a vector of attributes for the *j*th alternative, β is a vector of taste parameters, and ϵ_{ijt} is the stochastic component which follows a Gumbel (extreme value Type I) distribution.

In a simple conditional logit (CL) models, individuals are assumed to have homogenous preferences. However, in reality, consumers preferences for food quality differ from one another. Therefore, I investigate preferences of dairy consumers using two approaches that account for preference heterogeneity.

The first approach is the random parameters logit (RPL) model, which relaxes limitations in the CL model by allowing preferences to vary randomly within a sample according to a specified distribution (McFadden and Train, 2000). The probability that individual *i* selects alternative *j* from the choice set ψ in situation *t* is:

$$P_{ijt} = \frac{\exp(V_{ijt})}{\sum_j \exp(V_{ijt})} f(\beta) d\beta \quad (4)$$

where β is a vector of random parameters with distribution $f(\cdot)$.

The second approach is the latent class (LC) model. This model segments individuals into a number of *C* latent classes across which preferences vary discreetly (Boxall and Adamowicz, 2002). In the LC model, $f(\beta)$ is discrete and takes on *C* distinct values. The probability that individual *i* selects alternative *j* from the choice set ψ in situation *t* is:

$$P_{ijt} = \sum_{c=1}^{C} \frac{\exp(\boldsymbol{x}_{ijt}\beta_c)}{\sum_j \exp(\boldsymbol{x}_{ijt}\beta_c)} R_{ic} \quad (5)$$

where $\boldsymbol{\beta_c}$ is the specific parameter for class *c*, and R_{ic} is the probability that individual *i* is a member of class *c*. I can model this probability of class membership as:

$$R_{is} = \frac{\exp(z_n\theta_s)}{\sum_r \exp(z_n\theta_r)} \quad (6)$$

where z_n is a set of observable characteristics that affect individual *i*'s class membership, and θ_s is the parameter vector for consumers in class *c*.

I use the RPL and LC models to analyze data collected through a choice experiment (see next section for a detailed discussion). For both models, the choice experiment data allows me to estimate parameters in preference-space. These estimated coefficients represent consumers' marginal utilities for different product attributes, while the ratio of any two coefficients represents the marginal rate of substitution of one attribute over the other; use of the price coefficient in the denominator yields willingness to pay. The specification of the RPL model can be reparametrized in WTP-space so that the model coefficients are themselves WTP estimates.[2]

2.3 Data and Survey

2.3.1 Sampling Strategy

I collected the data for this study in March 2018, by surveying 218 dairy consumers and 193 retailers located across Bamako, which has a population of approximately 2.5 million (World

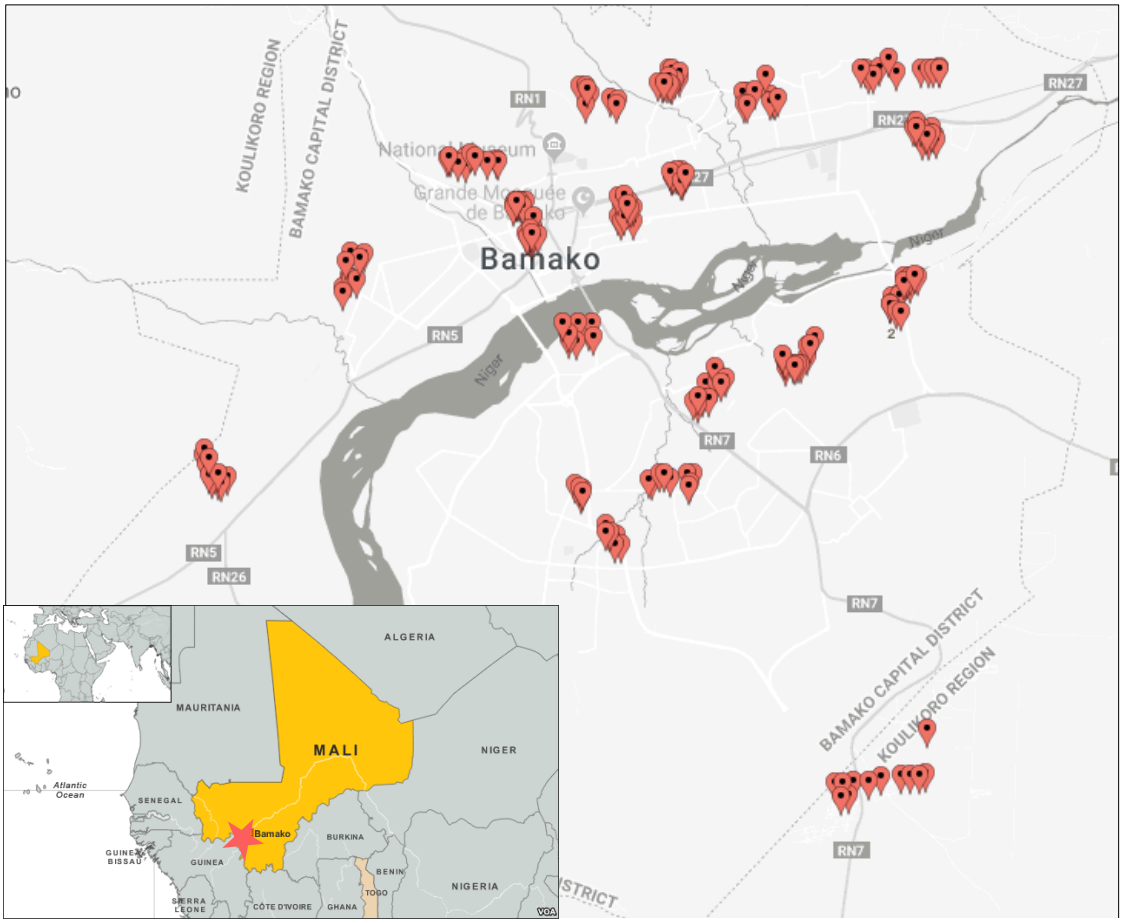
[2] For more details on models specified in WTP-space, see Train and Weeks (2005).

Bank, 2018). In order to obtain a sample that is representative of the Bamako population in terms of wealth, I used a stratified random sampling approach. In the first stage, I stratified the city by neighborhood wealth levels. Given that no official information exists on average household incomes by neighborhood, I classified each of Bamako's 61 neighborhoods into one of three wealth levels—low, medium, and high—based on research and field partners' knowledge of the neighborhoods in terms of housing conditions (e.g., access to electricity), infrastructure (e.g., whether roads are paved), and other socio-economic indicators (e.g., where expatriates reside). According to this classification, twenty-five neighborhoods (41%) are low-income, twenty-four (39%) are medium-income, and twelve (20%) are high-income. I randomly selected eight, seven, and four neighborhoods from each class, respectively, in order to have the same neighborhood weight in the sample as in the population. In the second stage, survey teams randomly sampled households within each selected neighborhood. Because censuses of these populations were not available, I developed a geographic random sampling approach aimed at capturing an appropriate cross-section of the neighborhood.

In each neighborhood, random and purposive sampling approaches to select retail outlets were used. Two types of small retail formats make up the vast majority of shops selling dairy and other food products in Bamako (Theriault et al., 2018). First, *boutiques* are small traditional shops that sell a limited selection of food items and non-food items (e.g., soaps, batteries) displayed behind a counter. Many are equipped with one or two refrigerators, which vary widely in quality and make available a limited selection of cold beverages and dairy products. Second, *alimentations* are small self-service grocery stores that mostly carry processed foods, including cold products, and are equipped with one cash register. Although most neighborhoods have at least a few *alimentation* shops, these formats are much less numerous than *boutiques* and are

typically located on main paved roads, rather than on the smaller residential dirt roads. One retailer survey team followed one of the two residential roads taken by the household survey teams, selecting every three retail shops that had at least one working refrigerator, a prerequisite for marketing pasteurized milk. The second retailer survey team purposively sampled *alimentations* located along the main road. Although Bamako has about half a dozen supermarkets, these were not sampled because of their small number and their unbalanced distribution throughout the city. Figure 2 presents the location of sampled households using their GIS coordinates. The clusters of map markers represent the sampled households in different neighborhoods. As this map shows, the randomly-selected neighborhoods are fairly well-distributed throughout the city.

Figure 2: Map of areas sampled in Bamako



2.3.2 Socio-demographic survey and sample characteristics

The surveys data had two parts: a questionnaire and a choice experiment, each tailored for either a consumer or retailer respondent. The survey teams conducted each consumer survey with the household member who was responsible for food purchasing decisions. In cases where this person was unavailable, the teams conducted the survey with the individual who was second-in-charge.[3] The teams conducted each retailer survey with the owner or manager of each shop (57% of the retailer sample) or, when he was unavailable, the agent on duty.[4] All questionnaires collected data on basic socio-demographic characteristics of the respondent and on knowledge, attitudes, and preferences regarding multiple dairy product quality issues. Additionally, the household survey included variables that might influence dairy preferences, including household composition and income; access to refrigeration, electricity, and a motor-vehicle; and dairy product transactions and consumption in the previous week. The retailer survey aimed at capturing basic information and variables influencing retailer value with respect to the procurement of dairy products, including: how retailers obtain information on consumer preferences and product attributes, customer characteristics, competitive positioning, and drivers of cost (Skytte and Bove, 2004).

Table 1 summarizes relevant characteristics of the consumer sample, disaggregated by neighborhood wealth level. Most respondents were females who had received at least some elementary school education. Almost 60% of the households are poor, based on the estimates of

[3] In about 75% of the households where the primary decision-maker was interviewed, this was a male or female household head. In about 70% of the households where the secondary decision-maker was interviewed, this was the female spouse of the household head. Thus, in most households, the household head was the primary decision-maker.

[4] Whenever neither individuals were available in households or shops, or else when they refused to participate, the survey team continued sampling using the same predesignated interval. In total, there were about seventy-five and sixty such cases for households and retailers, respectively.

per capita household income and the 2017 national poverty line of 178,000 FCFA (338 USD) per year (Government of Mali, 2018).[5] The data suggests that household assets, access to electricity, and expenditures for fresh milk and all dairy products are statistically different across neighborhood wealth levels, confirming the stratified sampling approach. Just over half of the households have access to both electricity and a refrigerator, with the worst and best access in poor and wealthy neighborhoods, respectively. Depending on the neighborhood type, households had spent an average total of 4,125 FCFA (7.84 USD) to 6,872 FCFA (13.06 USD) on dairy products during the previous week. Households allocated about a quarter of this expenditure to fluid milk, and about one-third to powdered milk. Approximately 70% of households had consumed fluid milk at least once in the previous week. Of these households, about half had consumed fresh milk in the previous week.

Table 2 presents characteristics of the retail shop sample, disaggregated by retailer type. On average, all shops are quite small, each with about two employees and one or two refrigerators. However, as expected, *boutiques* are smaller than *alimentations* in terms of number of employees and refrigerators, product variety, weekly volumes of fluid milk, and margins. On average, *boutiques* carry 2.7 distinct fluid milk products (i.e. different brands and/or sizes of pasteurized or sterilized milk) and procure 57 liters of fluid milk per week. In comparison, alimentations carry 4.6 different products and procure about 118 liters per week. The average marketing margin earned on fluid dairy products (i.e., the difference between the unit price at which retailers purchase and resell a product) is 16% for *boutiques* and 18% for *alimentations.* I did not find any statistically significant differences in the mean values of these variables when testing across neighborhood wealth levels. However, I do find that the average shop located in

[5] At the time of field work, the FCFA-to-USD conversion rate was .0019.

neighborhoods of intermediate wealth level experience power outages more frequently and of longer duration, compared to shops in poor or wealthy neighborhoods. Overall, retailers reported an average of five power outages in the previous week, with the average duration of the longest outage being almost two hours.

Table 1: Summary statistics of consumer sample

	Total (N=218)		Neighborhood wealth level							
			Poor (N=92)		Intermediate (N=81)		Wealthy (N=45)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Δ p-value	
Respondent characteristics										
Primary HH food purchases decisionmaker (yes/no)	0.31	0.46	0.35	0.48	0.31	0.46	0.22	0.42	0.49	
Female (yes/no)	0.78	0.41	0.76	0.43	0.79	0.41	0.81	0.40	0.89	
Education level attained (yes/no)										
None	0.16	0.36	0.16	0.37	0.16	0.37	0.13	0.34	0.96	
Elementary school or more	0.84	0.37	0.84	0.37	0.83	0.38	0.87	0.34	0.93	
Middle school or more	0.72	0.45	0.72	0.45	0.69	0.46	0.78	0.42	0.72	
Highschool or more	0.44	0.50	0.42	0.50	0.47	0.50	0.44	0.50	0.88	
University	0.34	0.47	0.30	0.46	0.40	0.49	0.31	0.47	0.55	
Household characteristics										
Below the poverty line (yes/no)	0.58	0.49	0.63	0.49	0.54	0.50	0.55	0.50	0.58	
Has access to electricity and refridgerator (yes/no)	0.54	0.50	0.43	0.50	0.60	0.49	0.64	0.48	0.06	*
Household dairy consumption in past week										
Total dairy expenditure (FCFA)	5,128.11	5,869.56	4,124.73	4,427.14	5,298.69	4,734.80	6,872.40	9,129.26	0.03	*
Expenditure share - all fluid milk (%)	0.26	0.27	0.25	0.30	0.26	0.24	0.27	0.26	0.90	
Expenditure share - powdered milk (%)	0.37	0.31	0.33	0.30	0.41	0.32	0.38	0.31	0.25	
Consumed any fluid milk (yes/no)	0.70	0.46	0.61	0.49	0.79	0.41	0.71	0.46	0.12	
Consumed fluid milk made from local milk (yes/no)	0.37	0.48	0.26	0.44	0.43	0.50	0.47	0.50	0.07	*

Note: ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively

Table 2: Summary statistics of retailer sample

	Total (N=193)		Retail format type: *Boutique* (N=144)		*Alimentation* (N=49)		Δ p-value	
	Mean	SD	Mean	SD	Mean	SD		
Respondent characteristics								
Manager or owner of shop (yes/no)	0.56	0.50	0.60	0.49	0.45	0.50	0.06	*
Education level attained (yes/no)								
None	0.13	0.34	0.16	0.37	0.04	0.20	0.03	**
Elementary school or more	0.85	0.35	0.83	0.37	0.92	0.28	0.15	
Middle school or more	0.76	0.43	0.75	0.43	0.80	0.41	0.52	
Highschool or more	0.61	0.49	0.60	0.49	0.63	0.49	0.72	
University	0.51	0.50	0.53	0.50	0.45	0.50	0.30	
Shop characteristics and cold chain								
No. employees (#)	2.02	1.13	1.77	0.87	2.75	1.45	0.00E+00	***
No. functioning refridgerators (#)	1.43	0.63	1.30	0.49	1.82	0.83	0.00E+00	***
No. power outages in previous week (#)	5.05	4.09	4.78	3.63	5.85	5.18	0.13	
Duration of longest power outage (minutes)	106.35	161.98	110.49	175.81	94.18	112.57	0.54	
Product availability and transactions								
No. distinct fluid milk products available - fluid milk (#)	3.18	1.65	2.69	1.40	4.61	1.50	0.00E+00	***
No. other distinct products available - other dairy (#)	5.17	3.66	3.76	2.25	9.31	3.87	0.00E+00	***
Volumes fluid milk procured in previous week (L)	70.47	71.21	56.70	57.30	118.34	92.20	0.00E+00	***
Mean marketing margin on fluid milk (% of consumer price)	0.16	0.03	0.16	0.02	0.18	0.04	0.00E+00	***

Note: ***, **, and * indicates $p<0.01$, $p<0.05$, *and* $p<0.1$, respectively.

2.3.3 Choice experiment and dairy product attributes

In addition to the questionnaire, each survey included a choice experiment that I tailored for either a consumer or retailer respondent. However, both experiments aimed at eliciting preferences regarding four pasteurized milk product attributes: 1) ingredients labeling, 2) third-party quality certification, 3) packaging, and 4) price. Table 3 summarizes the four dairy product attributes and the four levels for each.

Table 3: Pasteurized milk product attributes and levels in choice experiments

Attribute	**Attribute levels**
Ingredient composition claim	No claim (*status quo*) 100% reconstituted powdered milk Fresh milk mixed with powdered milk 100% fresh milk
Food safety certification	No certification (*status quo*) Certified by the Malian government Certified by a private third-party Double-certification by government and private third-party
Packaging	Tied transparent plastic sack (*status quo* for fresh milk) Sealed opaque plastic pouch Sealed transparent plastic bottle Sealed cardboard carton
Price (FCFA/.5L)	Consumers: 280, 370, 460, 550 Retailers: 240, 310, 380, 450

Note: The size of the hypothetical product was held constant at .5 L, which is a common size for packaged milk.

2.3.3.1 Ingredients Composition

The first product attribute is labeling that indicates the product's composition in terms of milk ingredients. Many Bamako retailers state that inquiries about the purity and origin of dairy products are the most frequent questions that they receive from customers. In this market, pasteurized milk comes in two forms (Ibid.). First, there are a few semi-industrial and industrial

processors that pasteurize milk that they reconstitute entirely from powdered milk or that is some blend of reconstituted and fresh milk. According to some of these processors, blending milk ingredients is a strategy that reduces input and transaction costs while preserving some of the taste of local milk that many consumers desire.

Second, there is a number of milk producer cooperatives and small artisan processors that pasteurize fresh milk that is sourced from peri-urban farms on the belief that many Bamako consumers prefer such purity to blended or powdered milk-based products. However, this is difficult to confirm from actual product data. Although most pasteurized milk products do provide some indication of ingredients, the location of this information on packaging varies across products. Terminology (i.e. indicating fresh or powdered milk) also varies across products, and in any case is always in French. This is a key observation, given high illiteracy rates in Mali and the presence of other packaging elements (e.g., icons of cows or the use of Bambara words) on powder milk-based products that could misinform buyers about the type and origin of the milk ingredients. For example, in the sample only 20% of retailers could correctly identify the ingredient composition of the most common brand of pasteurized milk. Lefèvre (2014) documented a similar situation in neighboring Senegal. She used stated and revealed choice data to confirm that urban consumers have strong preferences for fresh milk, while showing that misinformation regarding ingredient composition prevents them from actually allocating higher prices to these products.

To obtain a detailed assessment of consumers' and retailers' preferences for milk ingredient composition, and how they value information on composition, I include an ingredients label attribute in the experiment, with four levels: no ingredients label provided (*status quo*); a label indicating that the product is composed of 100% fresh milk; a label indicating that the product is

composed of 100% reconstituted powdered milk; or label indicating that the product is composed of a blend of fresh milk and reconstituted powdered milk. I expect findings consistent with Lefèvre (2014) – that consumers have the strongest preferences for products labeled with 100% fresh milk but that no labeling (which can give the false impression that a product is made from fresh milk) is preferred to labeling that indicates any powdered milk.

2.3.3.2 Quality certification

The second product attribute is a third-party quality certification that can assure retailers and consumers regarding the quality and safety of a product. Experts cite two categories of dairy food safety hazards—biological and chemical—that pose significant public health risks. Biological hazards include food-borne pathogens (e.g., *Salmonella*, brucellosis, and tuberculosis) and aflatoxins, as well as spoilage organisms and hygienic contamination that can affect reconstituted powdered milk as well as fresh milk (Kenny, 2013; Bonfoh et al. 2003; Hetzel et al., 2005). Chemical hazards include residues from antibiotics and other veterinary drugs, which enter milk when herds are improperly treated, farmers do not respect withholding periods between treatment and milking, or when handlers intentionally adulterate milk to forestall spoiling (Kenny, 2013).

The Malian government has already set up a system in which all food products must be certified by l'Agence Nationale de la Sécurité Sanitaire des Aliments (ANSSA) (Government of Mali, 2006). The ANSSA seal, which should be printed on product packaging, indicates to consumers that the product has met product-specific norms and standards that the Government has adapted from CODEX. However, few, if any, imported or domestic dairy products carried the seal at the time of fieldwork, due to high certification and compliance costs, combined with

historically weak enforcement by the government and limited recognition of the certification by Malian consumers.

In order to provide useful information on how consumers would value ANSSA certification if they were sensitized to its significance, I provided a short explanation to respondents, and included the ANSSA seal as one level of the quality certification attribute. The other attribute levels were: no certification (*status quo*), quality certification backed by a hypothetical private third party (e.g., a non-government organization or a private company), or double-certification (i.e. ANSSA seal plus another private certification).

The expectations regarding preferences for these attributes fall in line with similar research that has used experimental methods to investigate food quality certification. Focusing on Malian preferences for infant food quality, Masters and Sanogo (2002) found that Bamako consumers have a positive WTP for products that are backed by third-party quality certification. Other studies outside of Mali have used choice experiments to investigate the welfare gains associated with the certification of dairy products in particular. In Kenya, Mtimet et al. (2015) found large welfare effects for milk that is certified aflatoxin-free. Several studies considering different certification schemes in the U.S. context find welfare gains associated with most certification options (as opposed to none at all) but show that consumers prefer government to other industry of private certifying agencies (Olynk and Ortega, 2013; Wolf et al., 2011; Olynk et al., 2010).

2.3.3.3 Packaging

The third product attribute is packaging, which can create value for retailers and consumers by protecting product contents and improving convenience. Packaging quality can also potentially convey information about unobservable product attributes to buyers. Hollinger and

Staatz (2015) observed that improved product presentation, labeling, and packaging are key strategies for earning consumer acceptance of locally-processed products in West Africa. Recent research conducted in Bamako found that dairy processors use enhanced packaging features to differentiate their brands from those of rivals. For example, hedonic price analysis of retailer inventory data revealed that sterilized milk packaged in imported materials (e.g., cartons) earned a premium over locally-available materials (plastic pouches and bottles) (Theriault et al., 2018). In Senegal, analysis of choice-based conjoint data indicated that yoghurt consumers are willing to pay a price premium for individually-sized pouch packaging (possibly for its convenience value), and hedonic price analysis of product data revealed price premiums for cup packaging (versus simple pouch packaging) (Lefèvre, 2014). In Kenya, Mtimet et al. (2015) estimated positive WTP associated with plastic bottles and TetraPak packaging of fluid milk.

However, research also cautions that the welfare effects of different packaging types can be sensitive to consumer demographics and other factors. For example, Fadiga and Makokha (2014) found that fluid milk consumers living in Nairobi or belonging to middle or wealthy classes preferred sealed to unsealed packaging, while consumers who were poor or living in another city were indifferent. In Bamako, the value of packaging may also depend on the ingredient composition of the product. Many consumers identify fresh milk products by a particular form of packaging: hand-tied transparent plastic sacks. However, this packaging poorly protects product contents while its low cost potentially undercuts its value as an effective quality-signaling mechanism. Although factory-sealed plastic pouches and bottles are a common type of enhanced packaging for dairy products, many consumers associate this packaging with powdered milk-based products. Meanwhile, there are other types of packaging that local processors have not yet introduced. For example, cardboard cartons are recyclable and offer superior product protection

compared to plastic, but their use in Mali is currently limited to imported sterilized milk. In the choice experiment, I include four packaging attribute levels to explore preferences towards each of these four packaging types.

2.3.3.4 Price

Finally, I included price as a fourth product attribute to allow for the estimation of money-metric measures of WTP and in order to make welfare comparisons. For each experiment, I specified four price levels that were consistent with actual market prices and margins. Specifically, I selected consumer price levels that covered the full range of actual consumer prices for pasteurized milk in Bamako retail shops. The retailer price levels reflect a 14-18% margin on the consumer price levels. As a reference point, the second levels of consumer and retailer prices correspond roughly to the retail and wholesale unit prices of the most established and widely-distributed pasteurized milk product in Bamako, *Mali Lait* milk. This industrially-manufactured product has opaque plastic pouch packaging without certification and clear labeling of its ingredients; thus, it represents two the three *status quo* product attribute levels.

The choice tasks were designed following Street, Burgess, and Louviere (2005). The product attributes and corresponding levels were first used to develop an orthogonal fractional factorial design reducing the original attribute level combinations to 16. Following, the generators described by Street and Burgess (2007), were used to generate 16 choice tasks composed of two product alternatives and no purchase option (design D-efficiency of 94.49%). I designed the experiments using the Ngene software. Each choice experiment included sixteen choice-sets, each of these consisting of two hypothetical half-liter product alternatives with the above attributes and one opt-out option. To avoid respondent fatigue, the design was blocked in two so

that each respondent evaluated eight choice tasks.[6] To facilitate comprehension among choice experiment participants with varying levels of literacy, the survey teams presented illustrations of each choice to the participants. Figure 3 displays a sample choice task for a consumer and retailer, respectively.

Figure 3: Example choice task for a consumer and retailer

To reduce hypothetical bias in the choice experiment results, the survey teams delivered a cheap talk script to all participants (Lusk, 2003). The teams instructed consumer respondents to imagine themselves in an actual retail shopping scenario, while they instructed retailer respondents to imagine themselves purchasing merchandise from a supplier which they would resell in their shops.

2.4 Results and discussion

2.4.1 Results from the consumer random parameters logit models

I first fitted the consumer choice data with an RPL model, in order to analyze preferences and to test for heterogeneity within the sample.[7] I also estimated results in WTP-space. Both

[6] This yielded a statistical sample size of 1,744 observations for consumers and 1,640 observations for retailers, after taking into account a few respondents who did not complete all eight choice sets.
[7] In the RPL model, I keep price and opt-out as fixed, while assuming the other parameters to be random (Ubilava and Foster, 2009).

models Table 4 presents results from the RPL model. On average, consumers prefer some certification compared to no certification and any ingredient label compared to no label. Of the packaging attributes, they only have a preference for plastic bottle packaging in comparison to plastic sacks. The results in WTP-space are similar to those in preference-space, except that there is no significant WTP for any packaging attribute. These results, which represent mean effects for the entire consumer sample, are useful for providing an overall picture. However, the statistical significance of the standard deviation of every random variable in the RPL model supports the hypothesis of preference heterogeneity among consumers. In section 4.3 I will examine this heterogeneity more closely. Below, I explore the RPL results for each product attribute more closely.

Table 4: Results from the consumers random parameters logit model

	preference space			WTP space		
	Coeff.	Std. Error		Coeff.	Std. Error	
Parameter means						
Government certification	3.47	0.31	***	431.96	45.72	***
Private certification	0.92	0.30	***	103.53	37.94	***
Double-certification	3.95	0.33	***	505.04	51.02	***
Pouch packaging	-0.18	0.21		-30.91	25.51	
Bottle packaging	0.38	0.22	*	29.39	27.17	
Carton packaging	-0.13	0.20		-10.34	29.64	
100% powdered milk claim	1.13	0.28	***	138.44	36.88	***
100% fresh milk claim	2.27	0.27	***	280.21	35.83	***
Blended ingredients claim	1.11	0.29	***	146.73	38.35	***
Opt-out	-0.53	0.47		-676.23	371.80	*
Price	-0.01	1.05E-03	***	---	---	
Random parameter standard deviations						
Government certification	1.63	0.29	***	178.68	37.07	***
Private certification	1.99	0.33	***	237.62	45.30	***
Double-certification	1.54	0.29	***	200.51	38.53	***
Pouch packaging	0.83	0.36	**	101.26	51.81	*
Bottle packaging	1.17	0.27	***	159.97	27.89	***
Carton packaging	0.73	0.35	**	128.38	44.13	***
100% powdered milk claim	2.42	0.36	***	314.73	39.96	***
100% fresh milk claim	1.84	0.30	***	225.14	41.13	***
Blended ingredients claim	2.33	0.40	***	268.34	40.35	***
N	1720			1720		
d.f	20			20		
Log-Likelihood	1,213.14			1,209.35		
AIC/n	1.43			1.43		

Note: ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively.

The results in Table 4 confirm that, on average, consumers value the ingredient composition of 100% fresh milk more than either 100% reconstituted powdered milk or a blend thereof. This confirms other stated preference data that I collected: 92% of consumers in the sample said that they prefer pasteurized milk that is made purely from fresh milk while less than 1% prefer blended milk ingredients. The estimated WTP for fresh milk labeling versus no labeling is 280 FCFA (.53 USD) per half-liter, which is about 140 FCFA (.27 USD) more than the WTP for any labeling indicating powdered milk. This fresh milk-powdered milk price difference represents about one-third of the average price of the hypothetical products, and almost twenty percent of the price of the most popular pasteurized milk product sold on the Bamako market. In comparison, Lefèvre (2014) estimated a fresh milk-powdered milk price differential that amounted to about 80% of the average price in her choice-based conjoint experiment in the Dakar context.[8] In the results, the marginal utility and WTP for blended ingredients are almost the same as for 100% powdered milk. This challenges the belief that consumers view the practice of blending milk ingredients as a value-addition to using only powdered milk. On the contrary, the results indicate that the average Malian—when clearly informed about the ingredient composition of pasteurized milk—has a strong preference for pure fresh milk-based products.

Additionally, the results suggest that Malians are willing to pay for clear labeling in and of itself, regardless of the actual ingredient composition of a product. Because current packaging often does not provide clear labeling of ingredients, this result provides evidence of information asymmetry in the pasteurized milk consumer market. Yet, it is also somewhat surprising: in

[8] In Lefèvre (2014)'s analysis, 100% powdered milk was the sole alternative to 100% fresh milk and ranged between 225 FCFA and 325 FCFA for an unspecified package size. In this analysis, the lower bound of the confidence intervals for the fresh milk-powdered milk price difference amounted to 36% of the average price.

Lefèvre (2014)'s hedonic price analysis of market data, she found that "ambiguous" ingredients labeling actually earns a small price premium in the Dakar dairy market, possibly because it sometimes leads consumers to falsely believe that a given product is manufactured from fresh milk. In the absence of clear labeling, consumers should impose their own assumptions about a given product's ingredient composition. Even if this assumption reflects the least-desired composition of milk ingredients (e.g., 100% powdered milk), I should find no significant difference between preferences for no labeling and preferences for labeling indicating that particular ingredient composition. One possible explanation is that consumers are also concerned about the presence of non-dairy ingredients (e.g., preservatives) in pasteurized milk, and that participants in the choice experiment were mindful of this possibility when considering the hypothetical products with no labeling. It is also possible that the value of clear ingredients labeling goes beyond what it says about the product contents themselves, and that it also instills consumer trust in the brand.

Table 4 also shows that each certification variable has a positive and statistically significant influence on consumer utility, confirming that Malians are concerned about safety and demand more information on these attributes. Stated preference data from the survey indicates that consumers and retailers appear to be most concerned about quality issues originating in the processing and distribution stages of the value chain (i.e., unhygienic handling, inadequate pasteurization, adulteration of product with water spoilage due to a weak cold chain) and less concerned about issues originating at the farm-level (i.e., feed quality, aflatoxins, pesticide and antibodies residues).

The significant WTP coefficient for government certification suggests that consumers would pay a sizeable price premium—equal to about 100% of the average product price—for

pasteurized milk products that carried the ANSSA certification (compared to the *status quo* of no certification), if they were better-informed about the ANSSA seal. While the magnitude of this premium is striking, it is smaller in comparison to results from Mtimet et al. (2015)'s Kenya study, which estimated a WTP of almost 140% of the average product price for aflatoxin-free certification of fluid milk. I emphasize that better awareness of the ANSSA seal among Malian consumers is a critical condition for this WTP to be realized in actual markets. In the sample, only about 20% of consumers and retailers in the sample recognize the ANSSA seal on packaging, and just over 10% of the sample had some idea of the meaning.

Significant differences in WTP across certification types confirms that part of the value of certification is derived from who is verifying the claim (Olynk et al., 2013). In the results, consumer WTP for government certification is four times the WTP for private certification. Double certification provides only a little additive value compared to government certification alone. This pattern of greater consumer confidence in government certification (compared to private certification) resembles the preferences of U.S. dairy consumers as reported in several other choice experiment studies in this context (Olynk and Ortega, 2013; Wolf et al., 2011; Olynk et al., 2010). The consumer survey probed further into this question by asking respondents to rate their level of confidence in different verifiers on a four-point Likert scale ranging from one (no confidence at all) to four (complete confidence). Consumers gave the highest average rating (3.5) to government, an intermediate rating to a Malian consumer association (2.3), and the lowest rating (less than two) to a Malian industry association, or to a local or international company or non-government association. Overall, the relatively weak WTP for private certification may also explain why there is no alternative third-party certification option in Mali, especially when one considers the large costs of setting up and maintaining such systems.

Turning to packaging, the mean estimates of WTP suggest that consumers do not value any of the three types of enhanced packaging any more than they do plastic sacks. On one hand, this seems surprising, given that other choice experiments examining dairy preferences in Africa have found positive and statistically significant WTP for enhanced packaging features (Mtimet et al., 2015; Fadiga and Makokha, 2014; Lefèvre 2014). Additionally, when I asked consumer respondents to state their ideal type of packaging for pasteurized milk, the three most popular responses were plastic bottle (49% of respondents), carton (22%), and plastic pouch (8%). Only one respondent stated that plastic sack packaging was ideal. On the other hand, this result does seem to be consistent with qualitative accounts that many consumers in Bamako associate such traditional packaging with local fresh milk. It also seems consistent with consumer responses, when asked to rate the level of importance they accord to packaging as a source of information about a product. The average rating was only 1.9, on the basis of a four-point Likert scale ranging from one (not important) to four (very important). In the next sub-section, I will examine the variation of consumer preferences with respect to packaging, which will help shed some light on this puzzle.

2.4.2 Comparison of consumer and retailer preferences and WTP

In order to compare the preferences and marginal rates of substitution of consumers and retailers, I fitted the retailer choice data with the same RPL model used for consumers. Table 5 presents these results. Overall, the preferences and WTPs of the two groups are well-aligned, in terms of sign, significance, and ordering of the estimated coefficients. One exception is that for retailers the estimated coefficient on bottle packaging in preference space is not significant, while the corresponding estimate for consumers is statistically significant and positive at the

10% level of significance. This overall pattern of alignment suggests that retailers have good knowledge of consumer preferences with respect to the dairy product attributes in question. In their study of the Spanish seafood market, Fernández-Polanco et al. (2013) also found that retailer preferences towards several experience and credence attributes were well-aligned with customer preferences in terms of sign and significance, although the rank-order of marginal utility varied across actors.

To investigate this further, Table 6 compares the WTP estimates from the consumer and retailer RPL models. Paired t-test results show that, for almost every attribute, there are no statistically significant price differences between consumer and retailer WTP.[9] The one exception is the WTP coefficients for double certification, which have a difference that is statistically significant at the 10% level. At the same time, I note that for every attribute that has statistically significant coefficients in both datasets (i.e., all certification and ingredients composition variables except for private certification), the average retailer WTP is less than the average consumer WTP, depending on the attribute.[10] This is unsurprising, because I would expect a share of consumer price to be captured by retailers' marketing margins.[11] I conjecture that retailer WTP can be interpreted as the maximum procurement price that retailers are willing to pay for each attribute, which theoretically takes into account retailers' expectations about marketing costs, consumers' WTP, and competition-related considerations.

[9] In contrast, although Polanco et al. do not conduct a similar test between consumer and retailer WTP estimates, they conclude that retailer and consumer WTP diverge on the basis of statistically significant differences in some marginal utilities including that of price (on which the estimated WTP is based). They also acknowledge that one weakness of their analysis is large standards errors for retailers, due to a small sample size.

[10] Fernández-Polanco et al. (2013) report a similar pattern, although in their results retailer WTP was as much as 194% less than consumer WTP.

[11] However, I note that the percentage point differences in price shares that I examine here are not calculations of market shares.

Taken together, these results suggest that any information asymmetry in the pasteurized milk value chain regarding these attributes is not due to retailers' limited understanding of consumer preferences. On the contrary, Bamako retailers of dairy products appear to understand well what their customers desire and what they are willing to pay.

Table 5: Results from the retailers random parameters logit models

	RPL (preference space)			RPL (WTP space)		
	Coeff.	Std. Error		Coeff.	Std. Error	
Parameter means						
Government certification	2.21	0.23	***	330.54	52.03	***
Private certification	0.70	0.22	***	101.92	35.75	***
Double-certification	2.45	0.24	***	360.80	57.73	***
Pouch packaging	-0.04	0.18		-8.00	28.64	
Bottle packaging	0.08	0.18		4.64	28.11	
Carton packaging	-0.06	0.18		-8.28	29.21	
100% powdered milk claim	0.54	0.22	**	90.83	35.22	***
100% fresh milk claim	1.44	0.23	***	234.11	42.06	***
Blended ingredients claim	0.80	0.23	***	139.23	38.94	***
Opt-out	-1.38	0.40	***	-1,519.58	376.04	***
Price	-0.01	1.07E-03	***	---	---	
Random parameter standard deviations						
Government certification	1.33	0.28	***	178.38	47.33	***
Private certification	1.36	0.28	***	203.92	46.36	***
Double-certification	1.16	0.29	***	153.31	52.03	***
Pouch packaging	1.11	0.27	***	162.22	45.30	***
Bottle packaging	0.98	0.28	***	153.49	34.78	***
Carton packaging	1.02	0.30	***	169.52	48.61	***
100% powdered milk claim	1.83	0.28	***	271.59	46.07	***
100% fresh milk claim	1.57	0.24	***	266.72	51.90	***
Blended ingredients claim	1.40	0.32	***	197.66	50.18	***
N	1544				1544	
d.f.	21				21	
Log-Likelihood	-1,178.80				-1,261.28	
AIC/n	1.55				1.55	

Note: ***, **, and * indicates $p<0.01$, $p<0.05$, *and* $p<0.1$, respectively.

Table 6: Comparison of consumer and retailer WTP

	Consumers (N=218)			Retailers (N=193)				
Attribute	Mean WTP (FCFA/.5L)	SE		Mean WTP (FCFA/.5L)	SE		Difference	Δ p-value
Government certification	431.96	45.72	***	330.54	52.03	***	101.42	0.14
Private certification	103.53	37.94	***	101.92	35.75	***	1.61	0.98
Double-certification	505.04	51.02	***	360.80	57.73	***	144.24	0.06 *
Pouch packaging	-30.91	25.51		-8.00	28.64		-22.91	0.55
Bottle packaging	29.39	27.17		4.64	28.11		24.75	0.53
Carton packaging	-10.34	29.64		-8.28	29.21		-2.06	0.96
100% powdered milk claim	138.44	36.88	***	90.83	35.22	***	47.61	0.35
100% fresh milk claim	280.21	35.83	***	234.11	42.06	***	46.10	0.40
Blended ingredients claim	146.73	38.35	***	139.23	38.94	***	7.50	0.89

Note: ***, **, and * indicates $p<0.01$, $p<0.05$, *and* $p<0.1$, respectively.

2.4.3 Results from the latent class models

Given the statistical significance of the standard deviation estimates in the RPL models, I fitted the consumer and retailer datasets with LC models in order to further investigate preference heterogeneity among these actors. The comparative advantage of the LC model is that it facilitates the identification of market segments (i.e., different groups of consumers and retailers with similar underlying preference) via covariates in the class membership function. Because formal statistical tests are not available for identifying an optimal number of segments in a population, in empirical applications it is common to make this choice based on information criteria, such as the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and the Consistent Akaike Information Criterion (CAIC) (Pacifico and Yoo, 2013).[12] For the consumer and retailer models I identified three and two classes as optimal, respectively, based on these information criteria, while also ensuring that each class was large enough for statistical analysis and that each had a statistically significant price coefficient.

I also tried multiple combinations of potential class membership variables and ultimately selected a combination of variables that improved model fit and resulted in negative statistically significant price coefficients (as is consistent with conventional demand theory). For the consumer model, I included three covariates in the latent class membership model. The first two covariates are a dummy variable estimating whether or not the household is below the national poverty line and a continuous variable indicating the share of household members that under the age of fourteen. I expect households with higher incomes and more children to have stronger

[12] AIC, BIC, and CAIC are each estimators of the relative quality of a model. Each takes into account the model goodness of fit (measured by -2ln$L$ where L is the maximized sample log likelihood statistic) and the simplicity of the model (measure by some function of the number of parameters). The criteria differ only in how each measures the latter aspect, with BIC and CAIC penalizing models with extra parameters more heavily (i.e., by using penalty functions that increase in the number of choice makers) compared to AIC (Pacifico and Yoo, 2013).

preferences for product quality, while greater income should also positively influence WTP by reducing price sensitivity. The third covariate is household ownership of a motor vehicle, reflecting the hypothesis that access to a means of transportation affects fluid milk preference by improving household access to fresh milk, and perhaps. Additionally, consumers transporting milk by a motor-vehicle (e.g., by motorcycle, the most common means of transportation in Bamako) may have different preferences for packaging compared to others.

For retailers, I included one covariate, a dummy indicating whether the retail shop is a *boutique.* On one hand, because these shops have limited refrigerated shelf-space and tend to offer less variety than *alimentations,* I might expect these retailers to have weaker preferences for novel product attributes. However, Theriault et al. (2018) found that *boutiques* in Mali tend to offer a larger share of local dairy products compared to more modern formats, including *alimentations* and supermarkets, which tend to carry a higher share of imported products.

I present results from the consumer and retailer LC models in Tables 7 and 9, respectively, along with derived WTP estimates. Each probability reported at the top of these tables refers to the probability that a randomly-selected household or retailer belongs to that class. The estimated thetas, when statistically significant, indicate whether the class membership variable is positively or negatively correlated with membership in that class, compared to membership in class three (the base class in each model). In Tables 8 and 10, I also present descriptive statistics for each consumer and retailer class to allow for additional class profiling.

Table 7: Results from latent class analysis of consumers

	Class 1: Price-sensitive					Class 2: Fresh milk-focused					Class 3: Quality-conscious				
	Preference-space			WTP-space		Preference-space			WTP-space		Preference-space			WTP-space	
	Coeff.	SE		Coeff.	95% Confidence Intervals	Coeff.	SE		Coeff.	95% Confidence Intervals	Coeff.	SE		Coeff.	95% Confidence Intervals
Parameter means															
Government certification	2.94	2.36E-03	***	362.49	[60.08, 664.91]	-0.30	0.32		-107.26	[-346.04, 131.53]	3.11	0.28	***	980.78	[400.06, 1,561.50]
Private certification	-2.36	0.79		-291.43	[-1,241.59, 658.74]	0.49	0.29		175.16	[-65.66, 415.98]	1.70	0.30	***	534.82	[167.90, 901.74]
Double-certification	3.35	3.95	***	413.80	[77.81, 749.78]	-0.30	0.35		-107.13	[-376.14, 161.88]	3.60	0.33	***	1136.91	[452.77, 1,821.05]
Pouch packaging	-0.07	0.78		-8.30	[-185.18, 168.58]	0.43	0.29		154.73	[-79.62, 389.07]	-0.06	0.20		-18.58	[-138.14, 100.97]
Bottle packaging	-0.29	0.74		-36.05	[-182.18, 110.08]	0.32	0.31		114.95	[-115.91, 345.80]	0.58	0.25	**	183.28	[-24.75, 391.30]
Carton packaging	-0.68	0.65		-83.34	[-220.00, 53.33]	0.25	0.27		90.03	[-114.66, 294.72]	0.09	0.21		29.95	[-108.60, 168.49]
100% powdered milk claim	1.56	0.62	**	192.38	[-79.88, 464.64]	0.48	0.30		171.63	[-64.27, 407.52]	0.83	0.21	***	261.99	[48.07, 475.90]
100% fresh milk claim	2.89	0.85	***	356.88	[68.39, 645.36]	1.54	0.28	***	551.11	[76.66, 1,025.56]	1.38	0.23	***	435.68	[107.92, 763.44]
Blended ingredients claim	3.25	0.75	***	401.51	[60.83, 742.18]	0.45	0.32		159.37	[-105.40, 424.15]	0.84	0.25	***	266.10	[40.70, 491.50]
Opt-out	1.89	0.81		233.37	[-338.18, 804.92]	-0.51	0.56		-181.55	[-478.08, 114.98]	0.52	0.64		164.90	[305.62, 635.43]
Price	-0.01	1.90	***			-2.80E-03	1.11E-03	***			-3.17E-03	9.00E-04	***		
Class probability	0.17					0.21					0.63				
Thetas in class probability model															
HH owns motor-vehicle	0.57	0.83				-1.93	0.58	***							
Share of HH members who are <15 years	-2.09	1.40				3.42	1.40	**							
HH below international poverty line	0.10	0.48				-1.14	0.57	**							
N	5175														
No. of parameters	42														
Log-Likelihood	-1182.01														
AIC	2446.01														
BIC	2714.63														

Note: ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively.

Table 8: Profiles of consumers from each latent class

Variable	Total (N=218)		Class 1: Price-sensitive (N=32)		Class 2: Fresh milk-focused (N=36)		Class 3: Quality-conscious (N=148)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Δ p-value	
Househld access to, storage of, and consumption of milk (yes/no)										
Consumed any fluid milk in past week	0.70	0.46	0.75	0.44	0.58	0.50	0.72	0.45	0.40	
Purchased any dairy product from a traditional outlet in past week	0.18	0.24	0.24	0.25	0.16	0.25	0.17	0.23	0.24	
Purchased any dairy product from a boutique in past week	0.53	0.37	0.38	0.37	0.45	0.37	0.58	0.36	0.01	***
Purchased any dairy product from a modern outlet in past week	0.15	0.26	0.20	0.33	0.15	0.27	0.14	0.24	0.76	
Owns a vehicle	0.86	0.35	0.94	0.25	0.64	0.49	0.89	0.31	0.04	**
Owns a functioning refridgerator and has access to electricity	0.54	0.50	0.53	0.51	0.53	0.51	0.54	0.50	0.99	
Household composition										
Total household members+	12.59	9.39	10.09	7.68	11.22	6.61	13.47	10.17	0.12	
Share of household members that are under 14 years of age	0.32	0.17	0.26	0.16	0.37	0.17	0.32	0.17	0.02	**
Household includes an infant (< 2 years) (yes/no)	0.52	0.50	0.41	0.50	0.42	0.50	0.56	0.50	0.21	
Share of household members who are infants an infant (< 2 years)	0.06	0.07	0.50	0.51	0.44	0.50	0.62	0.49	0.42	
Household includes a pregnant or lactating mother (yes/no)	0.58	0.50	0.05	0.07	0.06	0.08	0.07	0.07	0.19	
Share of household members who are mothers	0.06	0.07	0.05	0.07	0.06	0.08	0.07	0.07	0.49	
Knowledge and preferences regarding dairy products (1/disagree - 5/strongly agree)										
Recognize and know meaning of ANSSA seal	1.40	0.89	1.59	1.04	1.14	0.49	1.43	0.93	0.26	
Food safety of imports is superior to Malian dairy products	2.85	1.65	3.28	1.55	2.51	1.63	2.86	1.66	0.19	
Environmental issues are key element in packaging preferences	1.55	0.99	1.63	1.07	1.39	0.84	1.58	1.02	0.71	
Closeability is key element in packaging preferences	3.20	1.08	3.25	1.08	2.61	1.29	3.35	0.96	0.02	**
Transparence is key element in packaging preferences	3.13	1.25	3.56	0.84	2.89	1.39	3.13	1.25	0.26	
Respondent characteristics										
Educational attainment of respondent (1/little none - 4/university)	2.35	1.45	2.25	1.46	1.97	1.54	2.46	1.42	0.24	
Respondent is primary household decisionmaker (vs secondary) purchases (yes/no)	1.69	0.46	1.50	0.51	1.63	0.49	1.75	0.44	0.07	*

Note: ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively.

Table 9: Results from latent class analysis of retailers

	Class 1: Fresh milk-focused					Class 2: Higher variety				
	Model results			Derived WTP		Model results			Derived WTP	
	Coeff.	SE		Coeff	95% Confidence Intervals	Coeff.	SE		Coeff	95% Confidence Intervals
Parameter means										
Government certification	1.56	0.16	***	877.34	[94.79, 1,659.89]	0.93	0.31	***	174.20	[29.08, 319.32]
Private certification	0.62	0.16	***	348.60	[-10.99, 708.19]	0.29	0.29		54.96	[-61.45, 171.37]
Double-certification	1.61	0.16	***	909.62	[78.09, 1741.15]	1.20	0.29	***	224.48	[65.98, 382.98]
Pouch packaging	0.15	0.14		85.68	[-92.47, 263.84]	-0.08	0.23		-14.90	[-98.18, 68.37]
Bottle packaging	0.31	0.16	*	173.18	[-66.01, 412.36]	-0.48	0.26	*	-89.89	[-175.86, -3.92]
Carton packaging	0.31	0.15	**	173.35	[-56.03, 402.73]	-0.33	0.24		-60.90	[-146.34, 24.53]
100% powdered milk claim	0.23	0.15		131.97	[-85.50, 349.44]	0.68	0.38	*	127.94	[-20.65, 276.53]
100% fresh milk claim	0.76	0.15	***	429.86	[-3.91, 863.64]	1.35	0.36	***	251.61	[71.24, 431.98]
Blended ingredients claim	0.31	0.17	*	176.44	[-58.49, 411.38]	1.34	0.29	***	249.40	[87.97, 410.82]
Opt-out	-2.38	0.50	***	-1343.26	[-2,346.45, -340.06]	-0.29	0.68		-54.73	[-285.97, 176.50]
Price	-1.77E-03	7.98E-04	**	---	---	-0.01	1.26E-03	***	---	---
Class probability	0.69					0.32				
Thetas in class probability model										
Retail outlet is a *boutique*	0.68	0.37	*							
N	4,632									
No. of parameters	39									
Log-Likelihood	-1162.19									
AIC/n	0.51									
BIC/n	0.55									

Note: ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively.

Table 10: Profiles of retailers from each latent class

Variable	Total (N=193)		Class 1: Fresh milk-focused (N=135)		Class 2: Higher variety (N=58)		Δ p-value	
	Mean	SD	Mean	SD	Mean	SD		
Retailer type, size, product availability								
Retailer is *boutique* format (yes/no)	0.75	0.44	0.79	0.41	0.64	0.48	0.02	**
Store is *alimentation* format (yes/no)	0.25	0.44	0.21	0.41	0.36	0.48	0.02	**
Total number of employees	2.02	1.13	2.02	1.12	2.00	1.15	0.90	
Total number of unique fluid milk products available	3.18	1.65	3.01	1.54	3.57	1.84	0.03	**
Total number of other unique dairy products available	5.17	3.66	4.90	3.68	5.79	3.55	0.12	
Volumes (L) of fluid milk purchased per week	70.47	71.21	68.01	68.50	76.33	77.66	0.48	
Concerned about milk quality issues (1/disagree - 5/strongly agree)								
Feed quality of dairy herd	0.24	0.43	0.24	0.43	0.22	0.42	0.76	
Aflatoxins	0.13	0.34	0.15	0.36	0.10	0.31	0.41	
Pesticide residues	0.27	0.44	0.30	0.46	0.21	0.41	0.20	
Pathogens associated with unvaccinated herds	0.35	0.48	0.32	0.47	0.43	0.50	0.13	
Antibiotic residues	0.23	0.42	0.22	0.42	0.26	0.44	0.58	
Pathogens associated with unhygienic milk handling	0.65	0.48	0.64	0.48	0.67	0.47	0.71	
Inadequate pasteurization	0.56	0.50	0.52	0.50	0.66	0.48	0.08	*
Quality deterioration due to weak cold chain	0.55	0.50	0.58	0.50	0.48	0.50	0.23	
Adulteration of product with water	0.66	0.48	0.61	0.49	0.76	0.43	0.05	*
Respondent characteristics								
Whether respondent is owner or manager	0.56	0.50	0.60	0.49	0.48	0.50	0.13	
Education level attained	2.78	1.48	2.84	1.50	2.66	1.46	0.28	

Note: ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively.

The largest "quality-conscious" consumer class (class three, representing 63% of consumers) appears to be the most conscious of dairy quality. It has the highest WTP for government certification and is the only class to significantly value private certification. It is also the only class with a statistically significant WTP for an enhanced type of packaging, i.e. factory-sealed plastic bottles. The class profiles (Table 9) highlight a factor that may be driving this distinct preference. I asked respondents to rate the ability to re-close product packaging as an important consideration when purchasing dairy products, on a Likert scale ranging from one (not at all important) to four (very important). Respondents in class three had the highest average rating (3.4), compared to classes one (3.2) and two (2.6). Finally, consumers in this class have positive WTP for any ingredients label, but value 100% fresh milk the most. They value blended ingredients about the same as 100% powdered milk.

Compared to class two (i.e., based on the class two membership covariates), households owning a motor vehicle are more likely to belong to this class, as are households that are below the poverty line. Although the pairing of these household characteristics may seem counterintuitive, they may be explained by the fact that poor households have a much larger number of household members (sixteen on average) compared to non-poor households (eight on average), which overall should increase the likelihood that the household includes at least one person who owns a vehicle. Households with larger shares of adult members are also more likely to belong to this class, compared to class two. Table 8 shows that these consumers are also the most-likely to have purchased a dairy product from a *boutique* in the previous week.

The second largest "fresh milk-focused" class (class two, representing 21% of consumers) is exclusively focused on the purity and freshness of product ingredients. Of all classes, it has the highest WTP for 100% fresh milk, and does not value any other ingredient composition nor any

other product attribute. Compared to class three, above the poverty line, households with larger shares of children, and households without a motor-vehicle are most likely to be in this consumer class. These households are also the least-likely to have purchased a dairy product from a *boutique* in the previous week.

The smallest "price-sensitive" consumer class (class one, representing 17% of consumers) is the most price-sensitive, as indicated by its relatively low price coefficient in preference-space. This class demands more quality and product information than the fresh milk-focused consumers. However, it values fewer attributes than quality-conscious consumers, i.e. it does not value certification that is not at least backed by the government and does not value any enhanced packaging. Additionally, WTP values are also generally smaller than those of the quality-conscious consumers. One exception is that, of all consumers, this class has the highest WTP for blended milk products, and even values this attribute more than 100% fresh milk products. Table 8 shows that these consumers have the lowest average share of children under fourteen in their households. These households also have the highest share of motor vehicle ownership and were the least likely to purchase a dairy product from a *boutique* in the previous week (but may have purchased from another outlet).

Turning now to the LC results for retailers (Tables 9 and 10), I identified two segments of retailers: "fresh milk-focused" retailers (representing 69% of retailers) and "higher variety" retailers (representing 32% of retailers. As its name suggests, the fresh milk-focused segment only has statistically significant preferences for labeling that indicates some inclusion of fresh milk (pure or blended), and has the largest WTP (at the 10% level) for pure fresh milk labeling. The negative and statistically significant marginal utility of opting out suggests that these retailers value the ability to offer a pasteurized milk product, as opposed to offering none. In

contrast, higher variety retailers have positive marginal utilities associated with any type of milk ingredients labeling and are willing to pay a smaller price differential for fresh milk labeling. Consistent with Theriault et al., (2018), results from the class membership model show that *boutique* shops are most likely to fall into the fresh milk focused segment. According to Table 10, about 80% of shops in this segment are *boutiques*, compared to 64% of higher variety retailers. Although this latter segment tends to offer more variety of fluid milk products, these are not necessarily local fresh milk-based products. The descriptive statistics in Table 10 suggest that retailer attitudes towards a couple quality issues may partially explain the differentiated preferences towards fresh milk. On average, higher variety retailers expressed greater concern over inadequate pasteurization and the illicit addition of water, two quality control problems that are commonly associated with informal fresh milk supply chains.

However, both segments have significant WTP for any certification entirely or partially backed by the government. Fresh milk-focused retailers have a much larger WTP for these attribute levels, and are also the only segment with a positive WTP for private certification. Fresh milk focused retailers have positive marginal utilities associated with bottle and carton packaging while higher variety retailers have negative marginal utility associated with bottle packaging; however, in each case the WTP is not statistically significant at the 10% level.

2.5 Conclusion

This study investigates information asymmetry as a potential problem that can help to explain the limited consumption of fresh milk in urban Mali, despite accounts that Malians largely prefer fresh milk to imported powdered milk. In a novel approach to using choice experiments to study an issue that has value chain-wide implications, I conducted parallel

discrete choice experiments on random samples of consumers and retailers in Bamako. Due to preference heterogeneity within these populations, I analyzed the data using random parameters logit and latent-class models and compared the results across samples. Five key findings emerge from this analysis, which have several implications for agribusiness strategy and government policy.

First, I find a positive and significant WTP for attributes that provide information on product ingredients, safety, and other dimensions of quality. Together, these results provide evidence of information asymmetry between the manufacturers and buyers of pasteurized milk products. This resonates broadly with Lefèvre (2014)'s study of the Dakar dairy market, and I echo that paper's recommendation for measures that improve information flows amongst consumers and other value chain actors.

One policy option is to require dairy manufactures to clearly indicate milk ingredients on product packaging using standardized wording or icons (to accommodate illiterate consumers). Manufacturers' compliance with such a regulation should cost them little; furthermore, the fact that consumers have a positive WTP for clearer ingredients labeling in and of itself (i.e., regardless of what milk ingredients the product actually contains) should operate as a positive incentive for compliance. The Malian government could develop other labeling regulations that more specifically aim at improving the competitiveness of fresh milk-based dairy products, although passing and enforcing such policies are likely to be more challenging. For example, the government could limit the use of certain words (e.g., local terms for milk), phrases (e.g., "made in Mali"), and imagery (e.g., images of cows in pastures) on powdered milk-based product packaging, which might mislead Malian consumers to believe that they are consuming locally-sourced fresh milk-based products (Lefèvre, 2014).

The second finding identifies another example of a policy enhancement that could improve information flows and reduce information asymmetry. I find that consumers have a specific preference for government certification of product quality, compared to private certification, and are willing to pay an important price premium for this assurance. This result suggests that dairy manufacturers can create value for their brands by improving product quality and adopting the existing government ANSSA certification, which is also required by law. However, several other conditions must be met in order for the ANSSA system to be effective. Among these, the Malian government must improve consumers' awareness of ANSSA certification, e.g., through public information campaigns and requiring more prominent placement of the ANSSA seal on packaging. Simultaneously, it must strengthen enforcement of corresponding regulations in the dairy market, e.g., through better monitoring and sanctioning for counterfeit certifications.

Third, I find that Bamako consumers are willing to pay a significant price premium for pasteurized milk that is made purely from fresh milk. Further, LC analysis indicates that nearly 85% of consumers prefer fresh milk most, compared to pure or blended powdered milk which these consumers value similarly. Given the current limited availability of fresh milk-based dairy products in Bamako, this finding points to an important market opportunity for fresh milk producers and processors. However, in order to successfully compete against imported powdered milk, the Malian fresh milk value chain must identify upgrades that reduce production and transaction costs while better differentiating their brands from those that are manufactured from powdered milk. The ingredients labeling and certification mechanisms that I analyze in this study are two options for improving differentiation.

The fourth finding pertains to another possible upgrade – enhanced packaging. However, the analysis showed that only one type of enhanced packaging (bottle packaging) is valued by just

one consumer segment (representing about 65% of consumers) who may especially appreciate their ability to reclose this packaging. Overall, consumers do not have strong preferences for upgrades from transparent plastic sack packaging. On one hand, this finding is surprising, given that other dairy consumer studies show that consumers derive value from higher-quality packaging. On the other hand, other research in Bamako shows that many consumers may view traditional packaging as a signaling mechanism for fresh milk-based products. I suggest that packaging preferences are especially dependent on particular packaging features and can vary widely across consumers, and I this as an important area for further research.

Fifth, the analysis of retailer data demonstrates that retailer preferences and WTP are well-aligned with those of consumers. These results suggest that retailers can be a useful source of information and, hence, a strategic distribution partner for upstream value chain actors wishing to better understand consumer preferences and demand. However, the LC analysis reveals significant segmentation among retailers, implying that pasteurized milk manufacturers should carefully select their distributors. For example, fresh milk products may obtain the greatest price premium among high-volume retailers that prioritize being able to offer a variety of dairy products. In contrast, many low-volume, low-variety retailers (representing about 30% of retailers) have zero WTP for fresh milk and any other product attributes. A third segment (representing another 40% of retailers) has positive WTP for each attribute, including packaging. Overall, these insights demonstrate the usefulness of complementing information on consumers with retailer analysis in a food market study. The paper illustrates the use of stacked choice experiments as one promising tool for this endeavor.

As with any stated preference method, there are some limitations that need to be considered. The hypothetical nature of choice experiments can potentially introduce a negative bias in

estimates of the marginal utility of price, and thus potentially overinflate WTP. Ideally, comparable future research should evaluate the results against results generated from other methods that mitigate hypothetical bias, i.e. analysis of actual market data (once available) or the use of incentive-compatible valuation methods. Additionally, one potential limitation of adapting choice experiments for retailers is that the design requires them to select a single product alternative, while in reality retailers may purchase multiple products at once in order to offer variety to their clients or to test out demand for new products. This could possibly introduce an upward bias on the marginal utilities estimated for retailers, which would lead to greater overestimates of retailer WTP. Taking these words of caution together, value chain managers and policy makers may wish to focus on the lower bound values of the WTP confidence intervals. Nonetheless, because the present study is the first of its kind to estimate WTP in the Malian dairy sector—as well as the first to compare retailer and consumers preferences using choice experiment methods in a developing market context—I expect that it will help to inform and benchmark future research in these areas.

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CHAPTER THREE: ANALYSIS OF THE FACTORS MOTIVATING DAIRY PROCESSORS TO USE LOCAL OR IMPORTED MILK INPUTS IN THEIR OPERATIONS

3.1 Introduction

In Bamako, nearly all dairy that is consumed by households has been, to some extent, processed and packaged. It follows that, if consumption of Malian milk is to increase, local processors must choose to use it more as an input in their products. However, most dairy processors in Mali—and especially the largest firms—favor the use of imported powdered milk over fresh milk.[13] Recent analyses have pointed to global trends that may further expand the processing and consumption of powdered milk in West Africa (Choplin, 2016; Orasmaa et al., 2016).[14] Clearly, competition from powdered milk is an important feature of West African dairy markets. From the perspective of the fresh milk stakeholders in these countries, the growth of these imports represent an existential threat to the local dairy sector (e.g., Baché, 2018, March 2; Livingstone, 2018, April 4).

Although there is a substantial economic literature focusing on African dairy development, studies have been surprisingly silent on the issue of import competition and, more importantly, how fresh milk value chains can strengthen their competitiveness against this threat. The objective of this study is to investigate this under-researched issue, by answering the following research question: What factors drive a dairy processing firm's choice to use local fresh milk,

[13] Because Mali does not manufacture powdered milk, all supply of powdered milk is imported. Also, in this paper I use the following nomenclature. "Fresh milk" refers to any fluid milk that is produced in Mali. "Dairy product" refers to any consumer product made from powdered and/or fresh milk inputs. "Local dairy product" refers to any dairy product that is manufactured in Mali, regardless of the type of milk input used. I also use the terms milk "inputs" and "ingredients" interchangeably. "Firm" refers to any dairy processor.

[14] Among these trends, European dairies have been making large investments in processing and distribution capacity in West Africa, including in Bamako, following the end of the European Union milk production quotas in 2015 and due to other factors in global milk markets (Choplin, 2016; Orasmaa et al., 2016).

powdered milk, or some blend of both, as an input in the manufacturing of consumer dairy products? I focus on competition between fresh and powdered milk as an input in dairy processing, because of the determining role that processor strategies play in the commercialization of these milk commodities.

To understand how and why processors select fresh or powdered milk, I draw on concepts from strategic management, industrial organization, and organizational economics. Specifically, I analyze how each of the two milk input types contributes to or detracts from a processor firm's competitive advantage, based on its influence on cost and on product differentiation (Porter, 1985). I employ case study methods and examine nine Bamako firms that use fresh milk and powdered milk to varying degrees in their operations, and which (together) are representative of the Bamako dairy processing industry.

From this analysis, I am able to identify several strategic factors on which fresh milk value chains and government policy can focus to promote the use of fresh milk by processor firms. This goal is of great importance to economic development, because increased competitiveness of domestic agricultural products should contribute to job and income growth while enhancing food and nutritional security in urban areas where access to dairy products can be limited (Theriault et al., 2018; Tschirley et al., 2015).

Additionally, this study responds to a longstanding need to apply industrial organization and agribusiness concepts to address challenges in developing agricultural markets (e.g., Bellemare and Bloem, 2018; Cook and Chaddad, 2000), particularly in the "hidden middle" segments of value chains (Reardon, 2015). These middle segments include wholesalers, transporters, and processors, who together account for a large share of added value and costs. For example, in dairy value chains, processors play the critical role of preserving liquid milk through

pasteurization of fermentation and converting it into numerous other products (Jaffee, 1995). Broadening analyses beyond the farming segment is also important because, in increasingly globalized food markets, value chains compete against other value chains (Boelhje, 1999).

In the next section, I define competitive advantage and its two domains—cost and differentiation—and relate these concepts to African dairy value chains. In Sections 3, I describe the case study methods that I use in this research. In Section 4, I describe the nine dairy processors representing the nine cases. In Section 5, I analyze the cases to answer two underlying questions: (1) How does each milk input influence cost? and (2) How does each input influence a firm's ability to differentiate? The answers to these questions, together, allow me to address the broader question: Why do dairy processor firms choose to use fresh or powdered milk, or some blend of both, in their operations? In the final section, I present implications for agribusiness strategy and policy, with the aim of improving the competitiveness of local dairy value chains in Mali.

3.2 Conceptual Framework

> *There are several techno-economic features of milk, milk production, and dairy processing which generate risks as well as opportunities for dairy producers and marketing enterprises and which might be expected to influence the industrial organization of dairy commodity systems in Africa* (Jaffee, 1995, p. 200).

3.2.1 Firm competitive advantage

In economic theory, a firm makes decisions in order to maximize its expected profit—or, under the principle of duality, to minimize costs—subject to constraints. However, the conventional neoclassical production model makes several strong assumptions, including the

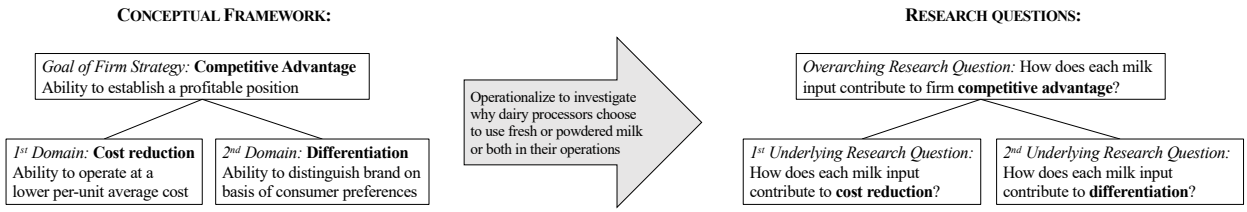
existence of perfect information, a complete set of markets, product homogeneity, competition between a large number of firms and buyers with ease of market entry and exit, and the absence of economies of scale (Kirsten et al., 2009). By relaxing these assumptions, organizational economics provide a framework for explaining the existence and behavior of different firms, as they seek to maximize profits and minimize costs in response to various market failures (Mahoney and Pandian, 1992).[15]

Drawing from this framework, as well as from concepts in industrial organization, strategic management theory redefines the firm's objective as the creation of competitive advantage, which is the ability of a firm to establish a profitable position in an industry, by differentiating its products from those of competitors in order to create value for its customers, while ensuring that firm costs do not exceed this value (Porter, 1985). Embedded within this definition are two domains that determine competitive advantage— cost and differentiation (Ibid.). The premise of this paper is that, by analyzing how a firm's choice of inputs influences these two domains, one can understand how different inputs contribute or detract from the firm's competitive advantage and, thus, identify the critical factors that shape firm preferences for the different inputs.

Figure two visualizes Porter (1985)'s conceptual framework and depicts its operationalization for investigating the strategic choices of dairy processors with respect to different milk inputs. I explain the concepts of cost and differentiation below, and further discuss the research questions in the following section.

[15] Organizational economics is the branch of economics that includes, among other theoretical frameworks, transaction cost theory and information economics. The shared premise in these frameworks—established by Coase (1937)—is that market failures explain not only the existence of firms, but also the strategic characteristics of firms including their size, scope, and internal organization (Mahoney and Pandian, 1992). A market failure occurs whenever a free market fails to bring about a Pareto-efficient allocation of a good or service, i.e. when there exist additional unexploited trades between two parties that could make at least one party better off without making the other worse off (Besley, 1998).

Figure 4: Research framework and questions, based in Porter's comparative advantage



3.2.2 Cost

The first domain of competitiveness is cost. For a dairy firm, costs are composed of the purchase price of milk and other inputs, the production costs associated with processing inputs into a consumer product (e.g., reconstitution, pasteurization and cooling, fermentation, packaging), the distribution costs for getting the product to the buyer (e.g., storage, transport, and promotional costs), and any associated transaction costs in these processes (e.g., gathering information on the buyer, assessing the product, contracting).[16]

Cost reduction contributes most to competitive advantage in the form of cost advantage, which is a firm's capability to operate at a lower per-unit average cost than its rivals, independent of scale (Waldman and Jensen, 2013; Porter, 1985). Cost advantage is rooted in superior (i.e., less costly) access to key resources such as a critical input, enhanced technology, financial capital, specialized human resources, or desirable production or distribution locations. It originates from imperfections in various capital, input, output, or labor markets, and arises when firms incur differently the transaction costs resulting from these market failures. Thus, identifying the sources of transaction costs are especially important to understanding competitive advantage.

[16] Transaction costs are the costs incurred by two parties in using a spot market prices to transaction a good (Coase, 1937). They include the *ex ante* costs of searching for and screening trade partners and negotiating an agreement; and the *ex post* costs of monitoring and enforcing the agreement, transferring ownership of the product, and any costs associated with adapting to disturbances (Staal et al, 1997).

Such imperfections are a common feature of developing agricultural markets, and dairy value chains are no exception (Jaffee, 1995). In fact, as the section epigraph suggests, milk has several fundamental attributes that generate significant transaction costs within the value chain. These include its high perishability and bulkiness, wide quality variability, the lumpy specialized assets required for production, and the seasonality of output (Ibid.). There is a broad literature describing the constraining presence of transaction costs in the supply and procurement of fresh milk in East Africa (e.g., Burke et al., 2015; Holloway et al., 2005; Holloway, 2004; Holloway et al., 2000), as well as in its processing (Jaffee, 1995). The major insight from these studies is that high transaction costs impede participation, efficiency, and supply in these markets. On the other hand, there is little documentation on the procurement and processing of powdered milk, and to what extent the costs associated with this milk input differ from those generated by fresh milk.

3.2.3 Differentiation

Differentiation refers to a firm's ability to distinguish its brand on the basis of consumer preferences for some perceived product attribute, services associated with products, or costs involved in switching from one product to another (Waldman and Jensen, 2013; Porter, 1985). As a domain of competitive advantage, differentiation allows a firm to sell more products at a given price, or to raise its price relative to the prices of its rivals while still retaining customers who prefer its products (Porter, 1985; Bain, 1956). Differentiation must be valuable to buyers and relatively rare on the market in order for it to lead to competitive advantage (Porter, 1985).

In addition to generating transaction costs, the techno-economic features of milk also create opportunities for differentiation (Jaffee, 1995). One potential basis for differentiation is the input composition of a dairy product. Some consumers may have a particular preference for dairy

products processed from fresh milk or, alternatively, from powdered milk, on the basis of taste, consistency, place of origin, or some other attribute that is associated with one milk type but not the other. For example, dairy firms might differentiate their products on the basis of consumers' preference for locally produced fresh milk instead of imported powdered milk as a product ingredient. Using choice experiment data collected in Bamako, Vroegindewey et al. (2019) showed that 85% of consumers have a distinct preference for 100% local fresh milk as the ingredient in pasteurized milk. Additional stated preference data suggests that similar preferences hold for other dairy products as well.

The choice of milk input might further affect competitive advantage through its influence on several other bases for differentiation. First, in general milk is amenable to processing into a very wide range of products and sub-product types. However, a firm's options for dairy product differentiation may depend on the input that is used.

Second, the taste, and safety of a dairy product depends on its chemical and biological quality, which can be highly variable and depends on an array of factors related to herd management as well as elements in processing, transport, and storage. Given the considerable differential in conditions between dairy farming in Mali and in other exporting countries, I would expect that dairy product quality is affected by the origin of its inputs.

Third, it is costly or impossible for consumers to directly observe many of these variations in quality, which creates information asymmetry between consumers and the other actors in the value chain. Consequently, to avoid problems of adverse selection, dairy processor firms must successfully differentiate their own products from other lower-quality products through quality-

signaling mechanisms, such as advertising, packaging, third-party certification, or an effective sales force (Rosenman and Wilson, 1991).[17]

3.3 Methods

3.3.1 Case study methods and case selection

A qualitative research methodology is appropriate for this study, because it seeks to answer several process-type questions about firm strategy that are outlined in Figure 4 (Maxwell, 2013). The objective of the research is to address the following question: *Why* do dairy processor firms choose to use fresh or powdered milk, or some blend of both, in their operations? Utilizing the concept of competitive advantage focuses the investigation on two underlying research questions. *How* does the use of each input influence cost? *How* does the use of each input influence differentiation? Qualitative methods are an effective tool for investigating such *why* and *how*-type questions, because they allow for thick description of processes, through the use of various types of data and methods (Yin, 2014).

More specifically, I adopt a qualitative *case study* approach because the phenomenon of interest—the milk input decision—is embedded within a context of multiple integrated systems – the procurement, production, distribution, and marketing activities of the firm – which, together, manifest and contribute to a firm's cost position and its basis for differentiation (Porter, 1985, p. 33). Thus, analysis of the milk input decision (i.e., its relationship with competitive advantage) cannot be abstracted from the variables of these broader systems. A case study approach is uniquely suited to cope with such complexity, in which the boundaries between the

[17] Information asymmetry exists in a transaction when one party has more information than the other. Adverse selection is a situation of information asymmetry in which buyers must rely on market prices alone as an imperfect indicator of quality. Akerlof (1970) showed that there will be a reduction in the average quality of marketed dairy products and buyers with a preference for higher quality will eventually exit the market.

"phenomenon and context are may not be clearly evident," and there are "many more variables of interest than data points" (Yin, 2014; pp. 16-17).

In the first step of case selection, I developed a preliminary list of processor firms operating in Bamako, based on secondary sources, informant interviews, and dairy product packaging that was gathered during preliminary fieldwork. I then refined this list of case candidates through initial interviews with the firms. In order to examine the relationship between the domains of competitive advantage and milk input decisions, I adopted a *multiple*-case study design in which the primary case selection criteria was to obtain a sample of firms that varied in the extent to which they use fresh versus powdered milk in their operations (Yin, 2014).

To ensure that the research is relevant to the entire Bamako dairy processing sector, the second case selection criteria was to obtain a sample that represented the range of dairy firms operating in Bamako, in terms of three variables. The first variable is product mix, or the variety of different types of dairy products that a firm produces. The second is scale, as indicated by a firm's annual dairy output, its number of employees, and its level of capitalization. The third variable is production technology, which I break down into three groups. I define an artisanal firm as one which completes all production and packaging steps by hand, a semi-industrial firm as one which has mechanized at one part of its production operations, and an industrial firm as one which has mechanized most of its operations.

3.3.2 Data collection and analysis

I collected the case study data during three waves from July 2017 to April 2018, to obtain a seasonal understanding of dairy production and marketing activities, to build rapport with each firm, and to facilitate a participatory process of data collection and validation. Field work

focused on several types and sources of data in order to obtain in-depth coverage of each case, and to facilitate data triangulation (Yin, 2014).

As mentioned above, one objective of the first wave of data collection was case selection. During this fieldwork, I collected preliminary information on most cases through relatively short interviews with the owner of each respective firm.[18] These interviews focused on obtaining a broad overview of firm history and activities, including information on the shares of milk ingredients that each firm used and each firm's product mix, production technology, and scale. The case information that I gathered from the initial interviews also provided a basis for deeper inquiry in the second wave of data collection.

During the second wave, I conducted in-depth semi-structured interviews with the owner and key personnel of each firm, as well as a short quantitative survey. These instruments focused on obtaining a more detailed understanding of how each firm used different types of milk inputs, and to explore how each input type influenced costs and differentiation in every area of firm activity (i.e., in procurement, production, distribution, and marketing). I also conducted semi-structured interviews with each firm's primary input supplier in order to gather additional data on procurement, and with a selection of buyers (i.e., the sellers, independent retailers, or wholesalers with whom the firm transacts directly) in order to gather additional data on marketing and distribution. I recorded interview data with audio recording interviews and hand-written notes, and also collected samples or photographs of packaging and other marketing artifacts (e.g., billboards, storefronts, electronic media) for each firm.

After the second wave of field work, I developed narratives of each case. These described in detail the strategic choices and processes associated with each area of firm activity and, as an

[18] In the case of the largest processor, the primary firm respondent was the assistant director of operations. For convenience, I will also refer to him as "owner."

analytical technique, began to organize the complexity of each case and set the stage for answering the research questions (Yin, 2014). I also summarized each case narrative into a short brief and shared it with the owner of each firm. During the final wave of field work, I invited each owner to correct any errors in the narratives and to provide any additional data or comments. In this way, the case narratives also served as a data validation tool and helped to generate a final layer of information.

Following the final wave of field work, I analyzed the case study data in three steps. First, I grouped each firm by its use of fresh milk versus powdered milk to understand how each input is used among the firms. Second, I identified the instances of cost reduction and differentiation within each group to understand the factors by which firms create competitive advantage. Finally, I analyzed the relationship between these factors and milk input choice. The results of each analysis are presented and discussed in the next three sections.

3.4 How do firms use fresh and powdered milk in their operations?

Table 11 presents summary information on each firm that I selected for the research, including the dairy products that the firms commercialize and whether each is made from fresh milk, powdered milk, or some combination thereof. The production technologies, scales, and different product types in the case studies (which I describe in the following sub-section) represent the entire range of domestically-manufactured packaged dairy products that are available in Bamako.[19]

[19] Ghee and butter are also manufactured in Bamako by some households and artisanal processors in Bamako. However, the level of commercialization of these products is very low, and no packaged version exists.

Table 11: Overview of firms and dairy products

Firm	Production Technology	Dairy Product Mix	Milk inputs: Primary input used (1st, 2nd)	Milk inputs: Share of total commercial volumes	Scale: Total commercial volumes (L/year)	Scale: Number of employees	Scale: Capitalization (FCFA)	Year Founded	Other products
100% VOLUMES FROM FRESH MILK									
FM1	Artisanal	Pasteurized milk	FM	70%	30,000	4	3 million	2010	
		Féné	FM	30%					
95% VOLUMES FROM FRESH MILK									
FM2	Artisanal	Pasteurized milk	FM	95%	92,000	5	3 million	2002	
		Drinking yoghurt	PM	5%					
FM3	Artisanal	Pasteurized milk	FM	70%	60,000	7	4 million	1995	
		Féné	FM	25%					
		Drinking yoghurt	PM, FM	< 5%					
		Dégué	PM	< 5%					
1% – 20% VOLUMES FROM FRESH MILK									
PM4	Artisanal	Dégué	PM	85%	225,000	16	6 million	2002	
		Pasteurized milk	FM	15%					
		Féné	FM	< 5%					
PM8	Semi-Industrial	Drinking yoghurt	PM, FM	65%	1,047,000	52	284 million	1996	Juice drinks
		Strained yoghurt	PM	15%					
		Dégué	PM	15%					
		Pasteurized milk	FM, PM	< 5%					
PM9	Industrial	Pasteurized milk	PM, FM	50%	12,000,000	125	1,500 million	1969	Juice drinks
		Drinking yoghurt	PM, FM	40%					
		Strained yoghurt	PM	10%					
		Soft cheese	FM, PM	< 5%					
		Fresh cream	FM, PM	< 5%					
0% VOLUMES FROM FRESH MILK									
PM5	Semi-Industrial	Pasteurized milk	PM	> 50%	33,000	70	57 million	2004 (2017)	Packaged Water
		Drinking yoghurt	PM	< 50%					
PM6	Semi-Industrial	Drinking yoghurt	PM	65%	26000	20	72 million	1999	
		Dégué	PM	35%					
PM7	Semi-Industrial	Drinking yoghurt	PM	90%	230,000	19	125 million	1993	
		Strained yoghurt	PM	10%					

Source: Authors, based on firm interviews and surveys. Dairy product mix only includes product types that the firm regularly manufactured at the time of the study. Volumes and shares are calculated from 2016 figures, except for PM4, PM5, and PM9 which are based on 2017 figures.
Capitalization refers to the reported value of all fixed investments. Year founded refers to the year in which the firm began dairy operations.

Based on the share of each firm's commercial volumes that is constituted by products manufactured from fresh milk, I classed the firms into one of four groups. One firm exclusively uses fresh milk for its volumes (100%), two firms mostly use fresh milk (for 95% of their volumes), three firms mostly use reconstituted powdered milk (for between 80% and 99% of their volumes), and two firms use 100% powdered milk. Interestingly, although many firms use some combination of fresh and powdered milk in their operations, all firms tend to depend heavily on one input or another with the dominant input accounting for 80% or more of volumes.

In this paper, I will refer to the three firms in the first two groups as "fresh milk firms," because they mostly or exclusively use fresh milk in their operations. I refer to the six firms in the last two groups as "powdered milk firms" for the same reason. In order to respect the anonymity of the case study participants, I also refer to each individual firm by a unique identifier composed of (i) "FM" or "PM" (to indicate whether it is a fresh milk firm or powdered milk firm, respectively), followed by (ii) a number that indicates its ordinal size relative to the other firms in the study.[20] I measure firm size by its level of capitalization, in terms of fixed investments. Among the case studies, firm capitalization tends to increase with the age of the firm, the number of employees, and the dairy volumes manufactured. I also note that the largest dairy firms in these cases (and in Bamako generally) mostly or exclusively use powdered milk for their operations.

3.4.1 Fresh milk firms

The three fresh milk firms (FM1-FM3) are the smallest among the case studies, each with four million FCFA or less in physical capital. FM1, which exclusively uses fresh milk, is the smallest

[20] For example, FM1 refers to the smallest firm among the case studies, which is a FM fresh milk, while PM9 refers to the largest firm, which is a powdered milk firm.

and sells about 30,000 L per year. The other two process up to about 90,000 L per year. All three firms are artisanal in their production technology, meaning that they complete all production and packaging steps by hand, utilizing rudimentary equipment (e.g., basins, cooking pots, and wood or charcoal stoves). Production takes place within the walled courtyard of the owner's residence or inside her house.

These firms use fresh milk for one or two products that make up the majority of their volumes. The primary product (making up 70% or more of commercial volumes for each firm) is pasteurized milk (*lait frais pasteurisé*), which firms manufacture by heating raw fresh milk to about 90 degrees Celsius. The second-most important product is *fɛ́né*, a traditional full-fat fermented milk that firms manufacture by leaving pasteurized milk to ferment at the ambient temperature, sometimes with a local culture.

The two larger firms in this group also have one or two additional yoghurt-based product that incudes powdered milk. Each of these yoghurt-based products makes up 5% or less of each firm's total volumes. Both firms manufacture drinking yoghurt (*yaourt à boire* or *yaourt brassé).*[21] FM2 makes this product entirely from powdered milk, while FM3 uses fresh milk as the base ingredient, and blends in some additional powdered milk. FM3 additionally manufactures a powdered milk-based *dégué*, a traditional product consisting of millet couscous mixed with a thick yoghurt. FM1 currently only manufactures pasteurized milk and *fɛ́né*; however, the owner has experimented with yoghurt in the past and wishes to begin regularly make this product in the near future.

Each of the fresh milk firms is a member of the Bamako Cooperative of Local Milk Resellers (CRLLB). In the 2000s, several artisanal firms (including the owners of FM2 and FM3)

[21] In Mali, the French word *lait caillé* ("soured milk") is sometimes also used colloquially to refer to either *fɛ́né* or drinking yoghurt.

collaborated with a local non-governmental organization (NGO) to create CRLLB. Its purpose was to build the capacity of processors of fresh milk-based products in Bamako, and to help coordinate their procurement of fresh milk. A broader goal was to develop a viable market channel in Bamako for eighteen peri-urban farmer cooperatives that are members of the National Federation of Malian Milk Producers (FENALAIT). In 2018, CRLLB had about 90 individual members (90% of whom are women), and delivered milk to about 160 artisanal firms throughout Bamako. Field work confirmed that the number of small firms selling fresh milk in Bamako greatly exceeds this amount, although CRLLB is the largest network of these actors.

3.4.2 Powdered milk firms

The other six firms in the case studies (PM4-PM8) use powdered milk for products that make up the majority, or all, of their volumes. Among these, one firm (PM4) is an artisanal firm. Like its fresh milk firm counterparts, this firm is also a member of CRLLB and manufactures a pasteurized milk and *féné* product using fresh milk. However, *dégué* accounts for 85% of its total commercial volumes (225,000 L per year), which greatly surpasses the output of the other artisanal firms.

Another four powdered milk firms (PM5-PM8) are semi-industrial: each has a dedicated factory and has mechanized at least the packaging process of its operations (and sometimes additional steps as well). These firms have a capitalization of about 60 million to 280 million FCFA, and commercialize up to one million L of dairy products per year. Informant interviews and secondary sources suggest that these four firms are among the largest semi-industrial dairy firms in Mali.

Among these semi-industrial firms, the product accounting for the most volumes is drinking yoghurt. Additionally, two firms (PM6 and PM8) manufacture *dégué* and two firms (PM7 and PM8) manufacture strained yoghurt (*yaourt étuvé*), which is less-viscous than drinking yoghurt. The smallest and largest semi-industrial firm (PM5 and PM8) also manufacture a pasteurized milk product. All of these products are made from powdered milk, with two exceptions. For its occasional production of pasteurized milk, PM8 uses fresh milk, powdered milk, or some blend of the two, depending on the availability of fresh milk (the preferred input) at that moment. When there is leftover fresh milk from pasteurized milk production, PM8 also blends this into the drinking yoghurt formula. Finally, firms PM5 and PM8 also commercialize a product line of packaged water and fruit juices, respectively.

The industrial firm PM9 has mostly mechanized facilities and is the oldest and largest dairy processor firm in Mali. It has a capitalization of 1,500 million FCFA and an output of about twelve million L per year. This firm manufactures its best-selling products, pasteurized milk and drinking yoghurt (together accounting for at least 75% of volumes) using a blend of reconstituted powdered milk and fresh milk. While the ratio of inputs varies, it is typically dominated by powdered milk. PM9's second most popular product by volume is strained yoghurt made entirely from powdered milk. Finally, the industrial firm also manufactures a fresh milk-based soft cheese (*fromage frais*) and fresh cream (*crème fraiche*) product manufactured from a blend of fresh milk (the base input) and powdered milk.

3.5 How does each milk input influence cost?

The case study data indicates that the costs of using one milk input instead of another can differ according to four elements: the purchase price of the input itself, the costs of coordinating input procurement in order to minimize transaction costs, any transaction costs that still remain after such coordination, and any idiosyncratic costs associated with processing and distribution. I assess the relative costs of using fresh or powdered milk by analyzing and comparing the cost elements of each input. I find that, for every element, firms face higher costs using fresh milk, implying that firms can reduce costs significantly by using powdered milk instead of fresh milk.

3.5.1 Purchase price

Each of the powdered milk firms cited the relatively high per-liter purchase price of fresh milk, compared to powdered milk, as a primary reason for its dependence on powdered milk. According to one dairy industry informant, among all of the factors influencing the use of fresh milk, its purchase price was the "brake" that constrained firms the most. Even fresh milk firms complained that the purchase price, in the context of intensifying competition, are increasingly squeezing their margins. PM9 stated that the purchase price negotiated with its suppliers is the primary factor determining fresh milk purchase volumes. This negotiated price has also been a perennial source of tension between the PM9 firm and its suppliers since its privatization in 1996. The real price has risen over time—from 200 FCFA per liter in 1996 to 400 FCFA in 2018—and a few facts suggest that it is a determinant of the fresh milk price throughout Bamako. First, PM9 is the single largest market channel for the largest peri-urban dairy

cooperatives, accounting for at least one quarter of the commercial volumes of these suppliers.[22] Second, PM9's purchasing terms were cited by all four artisanal firms, as a variable affecting their own transaction terms with suppliers. These firms reported purchasing fresh milk (usually pasteurized) at prices ranging between 400 and 425 FCFA/L in 2018, depending on the seller. Interviews suggest that this purchase price fluctuates little throughout the year, despite significant intra-seasonal variations in supply (discussed below).

Of issue, of course, is not merely the price of fresh milk but its relative position with respect to the price of powdered milk. In Mali, most powdered milk is imported from Europe, followed by New Zealand (FAOSTAT, 2018). According to Bamako powdered milk firms, and in contrast to fresh milk, the local powdered milk market is well integrated with international markets, due to the relatively low trade barriers in place for powdered milk and the high volumes that are imported. The per liter purchase price of these imports are cheaper in Bamako, compared to that of fresh milk, due to a combination of higher farm efficiencies and substantial policy support through the years (Choplin, 2016). Most powdered milk firms reported purchasing 25-kg sacks of whole powdered milk or filled powdered milk.[23]

An additional factor has been the market entry of filled powdered milk, in which dairy fat is substituted for a cheaper vegetable fat. Filled powdered milk imports began appearing on the Malian market around the year 2000 and surpassed the imports of whole powdered milk beginning around 2013 (FAOSTAT, 2018), due to the relative affordability of this high-fat milk ingredient option. Firms reported purchasing filled powdered milk in late 2017 at prices ranging

[22] According to the three largest dairy cooperatives supplying PM9, these cooperatives delivered 1,800 L to 3,500 L of milk daily to PM9 in 2016. It is difficult to pin down PM9's total daily procurement of fresh milk. According to company sources, it was procuring 10,000 to 15,000 per day during the 2017-2018 period; however, Corniaux (2014) reports that the daily average ranged between 2,000 L and 4,000 L.

[23] Whole powdered milk contains 100% milk fat. In contrast, manufacturers of filled powdered milk replace the milk fat with vegeß fats to maintain high fat contents ranging between 25% and 30%.

between 1,960 and 2,200 FCFA/kg, or 260 to 290 FCFA/L in liquid milk equivalents (LME).[24] Two artisanal firms, which purchase much smaller amounts of filled powdered milk packaged in consumer-sized packaging, reported slightly higher prices: 2,200 to 2,500 FCFA/kg (290 to 330 FCFA/L in LME) during the same period.

3.5.2 Coordination costs

In addition to the costs that are captured through purchase price, the case study data demonstrates that the procurement of fresh milk generates additional transaction costs associated with such challenges as finding suppliers, procuring the right quantities at the right time, and quality. Firms attempt to minimize these transaction costs through better coordination with suppliers. According to the two most experienced fresh milk firms, in the past two decades this has been greatly facilitated by several structural changes, including the expansion of cell phone coverage, increases in urban demand, and the diffusion of higher-yielding cow breeds alongside the development of dairy cooperatives.

However, coordination itself is also costly, both in terms of the fixed costs of setting up procurement arrangements and the daily costs of coordinating each individual transaction.

Broadly speaking, fresh milk firms and suppliers use several types of supply arrangements. First, each of the fresh milk firms procure inputs through relational contracting with individual dairy farmers, farmer cooperatives, or intermediary traders who work closely with farmers. PM8 uses a similar model for its occasional fresh milk purchases. Within these arrangements, firms coordinate carefully with suppliers on a daily basis, due to the perishability and bulk of fresh milk, limited cold storage capacity, and the tight production and distribution schedules that firms

[24] This price range is calculated from data from five of the six powdered milk firms, excluding the largest industrial processor for which this data was not accessible.

must keep. At minimum each day, fresh milk firms must call their suppliers to plan the next fresh milk delivery and must ensure that a capable agent is physically present to receive and inspect deliveries, to begin processing the milk, and to make any necessary adjustments for late deliveries or quantity or quality problems.

Second, all fresh milk firms also purchase a share of their volumes through the CRLLB supply cooperative, which collects 25 FCFA on every liter of fresh milk (or about 6% of the per-unit purchase price) to sustain its operations. This fee only represents a share of the daily coordination costs that firms incur for using this arrangement, given that firms must still coordinate with CRLLB (instead of directly with other suppliers) on a daily basis. Additionally, some CRLLB costs (e.g., salaries) are subsidized by external partners.

Third, the industrial firm (PM9) purchases fresh milk that is delivered to a collection center at its Bamako factory. Each week-day, it procures up to 10,0000 L from a select group of forty to sixty suppliers mostly made up of cooperatives and large farmers. Suppliers must deliver unpasteurized milk before one p.m., and are paid once a month. In 2018, the second-largest firm (PM8) was also in the final stages of constructing a collection center complex next to its factory, with the aim of increasing its fresh milk procurement capacity. Funded through a public-private partnership and set to begin operations in late 2018, the center will have 8,000 L in cooling tank capacity, a training center, and a retail point for animal feed and veterinary products.

In contrast to fresh milk, for which spot markets are not well developed in Bamako, powdered milk is retailed from virtually every food shop in the city. The relatively well-developed state of the powdered milk market reduces the *ex ante* transaction costs involved with searching out suppliers and negotiating prices, while mitigating some uncertainty around

availability. For this reason, the smallest firms (FM1-FM3, PM4-PM6) depend on the spot market to make weekly or biweekly purchases from a retailer or wholesaler.

There are several challenges, however, associated with sourcing powdered milk from spot markets. Powdered milk firms cited price volatility, quality uncertainty, and supply uncertainty.[25] In order to mitigate these problems associated with the spot market, the largest powdered milk firms (PM7-PM9) have developed two special procurement arrangements to better coordinate transactions. First, two semi-industrial firms (PM7, PM8) use ongoing relationships and repeated monthly transactions with reputed importers of high-quality powdered milk brands. These informal agreements provide some guarantees or incentives with respect to availability and/or price. However, these firms still maintain a second supplier as a backup. Second, the industrial firm (PM9) has partnerships with at least three foreign dairy companies, through which the firm imports and markets powdered milk and other products. This access, combined with the firm's strong financial and storage capacity, enables it to purchase large amounts of powdered when it is relatively favorable to do so and to maintain robust stocks. The company additionally purchases other brands of high-quality powdered milk.

3.5.3 Other transaction costs

Even with these procurement arrangements in place to coordinate daily fresh milk transactions, fresh milk firms identify two enduring problems that they must frequently manage,

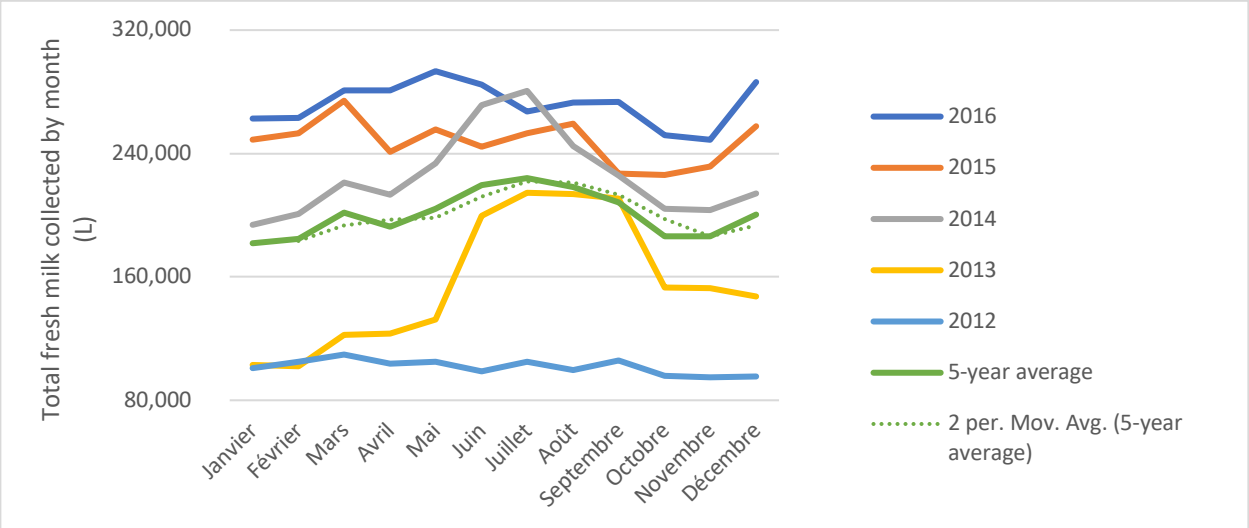
[25] Several firms and informants reported that powdered milk quality varies significantly across brands, does not always reflect the technical specifications printed on product packaging, and can even vary within the same brand. Informants report several potential reasons for this quality variability, including smuggling and informal trade, illicit repackaging, and counterfeit branding of powdered milk, combined with the fact that phytosanitary and food safety regulations are weakly enforced. A third problem is supply uncertainty. Most firms prefer a few select European brands that they trust, but which are not always available on the Malian market. According to firms, these problems can adversely affect the quality of their own manufactured products), result in stock-outs, or generate search costs.

which drive up the transaction costs of procuring fresh milk. The first problem is the uncertainty of milk supply interannually, across seasons, and even from day to day. Four of the powdered milk firms cited supply uncertainty, especially during the hot dry season of March to May, as a key challenge that drove and/or continually constrains them from using fresh milk. PM5 (the most recent entrant in the case studies) began its dairy operations in 2017 by sourcing fresh milk, but began during the hot dry season. Within a couple months, the firm made a complete switch to powdered milk. The owner cited the limited availability of fresh milk, in addition to its price and sensitivities in processing (see below), as the deciding factor. PM8 also stated that its choice of how much of each input to use in a given batch of pasteurized milk depends on the availability of fresh milk at that moment.

Fresh milk processors also underlined the problem of supply uncertainty. For example, the year-on-year changes in total volumes procured by CRLLB from 2012 to 2016 range between –29% and 24%. As an indication of seasonal variability, Figure 5 displays the volumes collected by the FENALAIT cooperatives in the years 2012 to 2016. While the mean trendline suggests that supply does tend to peak during the rainy seasons due to the availability of pasture for grazing (June-September,), this pattern is less pronounced in certain years (e.g., 2012, 2015, and 2016) and can fluctuate significantly from month to month. These broader dynamics translate into supply uncertainty for the CRLLB members and PM9 who source from the cooperatives. For example, CRLLB records in 2016 indicate that PM4 and FM1 received all of their ordered volumes only 35% and 55% of the time, respectively. To mitigate such uncertainty associated with any given supplier, FM3, FM2, and FM1, each maintained at least two additional suppliers from whom they regularly purchased throughout the week, as backup in the event that one of their orders was not fulfilled, or to supplement their input needs when they received large special

orders (e.g., for cultural ceremonies). In the words of the owner of FM2, "You cannot get what you want with only one or two suppliers."

Figure 5: Monthly volumes collected by peri-urban FENALAIT dairy cooperatives, 2012-16



Source: Author, based on FENALAIT (2017)

A second enduring problem in the procurement of fresh milk is quality uncertainty, particularly spoilage that leads to losses. The three largest powdered milk firms (PM7, PM8, and PM9) cited the quality of fresh milk as a challenge. Supply cooperatives and firms usually observe some minimal form of quality control, depending on their access to different testing instruments. PM9 and many supply cooperatives utilize a lactodensimeter (a tool for measuring milk density) and an alcohol test to assess deliveries of raw milk regarding density (e.g., to gauge whether it has been mixed with water or cream has been removed) and acidity (e.g., bacterial growth and spoilage), respectively. However, artisanal firms do not have access to these resources. Instead, they depend on any quality control procedures taken by their supplier, if any, and otherwise only apply organoleptic tests (based on sight, smell, and visual tests) when they receive deliveries (Ibid.). Under the above-described coordination mechanisms, a buyer typically

holds the right to reject milk *ex ante* if it is observably bad; however, the buyer must absorb the costs of losses or quality problems that are discovered *ex post.* For example, the owner of FM1 complained that, when deliveries are slow on hot days, milk can sour before it arrives at her door. She estimated that she rejects milk deliveries about twice per week. However, sometimes she is forced to work with milk that does not pass her test, because the alternative is no product until the following day. At other times (i.e., two or three times per month), it is only once she begins working with a batch of milk that she realizes that it was souring. Processing such milk into commercial products carries risks to her customers' health and, perhaps also, to her reputation. For example, one study found that Bamako schoolchildren who regularly consume pasteurized fresh milk were four times more likely to experience diarrhea and/or vomiting in a previous two-week period (Hetzel et al., 2004).

3.5.4 Other idiosyncratic costs

Even after procurement, the bulkiness and perishability of fresh milk make it more costly to store and process. Firms can store powdered milk in its dried form and reconstitute it into fluid milk only when they are ready to process. In contrast, firms must either process fresh milk immediately or else refrigerate it. For the semi-industrial and industrial firms—which handle large volumes—acquiring this capacity requires large lumpy investments. Indeed, four of these firms stated that one of the advantages of powdered milk is that it is "less delicate," "less difficult," or "easier to work with" than fresh milk. PM5 and PM6, both of which have a couple large refrigerators and use unrefrigerated delivery vehicles, stated that these resources were insufficient to process fresh milk. PM6 stated that switching from powdered to fresh milk would require new investments in a cold room, a gas pasteurizer (to heat large amounts of fresh milk

quickly), and refrigerated trucks. Maintaining this expanded cold chain capacity would generate additional electricity and fuel costs as well. The only powdered milk firms that do use some fresh milk (PM8 and PM9) already have such cold chain capacity.

3.5.5 Summary of the relative costs

Table 12 summarizes the relative costs for fresh and powdered milk, including the purchase prices, transaction costs in procurement, and other idiosyncratic challenges in processing and distribution for each commodity. This comparison indicates that, for every element, firms face significantly higher costs using fresh milk. Even the highest-reported price for powdered milk (purchased in consumer-sized packaging from retailers) is about 20% cheaper than fresh milk in LME terms. Although firms face some transaction costs due to the price, quality, and supply of powdered milk, the largest firms are able to successfully manage these issues through more coordinated relationships with milk importers. On the other hand, fresh milk firms face significant transaction costs related to uncertainty of quality and supply, even after putting in place costly procurement arrangements with suppliers. Additionally, the bulkiness and perishability of fresh milk make it difficult to handle in storage and distribution. Taken together, this analysis suggests that firms can reduce costs significantly by using powdered milk instead of fresh milk.

Table 12: Costs of fresh and powdered milk in Bamako

Milk input	Purchase price	Other costs
Fresh milk		
Raw milk, delivered by various suppliers to industrial firms	400 FCFA/L	Coordination and transaction costs in procurement: ・Frequent (daily) transactions ・Costly procurement arrangements used in every case (relational contracting, supply cooperative, maintaining collection center) ・High supply uncertainty (across years and seasons, and day-to-day) ・High quality uncertainty (spoilage, variations in composition and taste) Costs in processing: ・Requires large cold chain capacity and uncertainty prior to processing
Pasteurized milk, delivered by various suppliers to artisanal and semi-industrial firms	400 - 425 FCFA/L	
Powdered milk		
Filled or whole powdered milk, purchased from importers or other wholesalers by industrial and semi-industrial firms	1,960-2,200 FCFA/kg 260-290 FCFA/L (LME)	Coordination and transaction costs in procurement: ・Presence of spot markets, which some firms use. Others use procurement arrangements (relational contracting, partnerships). ・Price volatility ・Some related quality and supply uncertainty
Filled or whole powdered milk, purchased from retailers by artisanal firms	2,200-2,500 FCFA/kg 290-330 FCFA/L (LME)	

Source: Authors.

3.6 How does milk input choice influence differentiation?

The case study analysis revealed four general sources of differentiation among dairy firms operating in Bamako. First, firms physically differentiate their products by offering new product types, or more variety within a given product type. Second, they enhance or preserve some product quality attribute through key ingredient choices. Third, they use quality-signaling mechanisms to provide information on product attributes that are otherwise difficult or costly to observe. Fourth, firms offer unique packaging features. However, I find that fresh milk firms are less likely to exploit each of these sources of differentiation.

3.6.1 Product types and sub-types

One basic source of differentiation for all firms is to offer product types that are unique to others on the Bamako market. In Section 5, I presented the different product types that are currently available in Bamako. In recounting their beginnings, most firm owners stated that they launched their business on the back of one of these dairy products at a time that it was relatively rare on the market. For instance, PM9 was one of the first domestic firm to introduce packaged forms of several dairy products, including pasteurized milk and strained yoghurt. When all three of the largest semi-industrial firms (PM6-PM8) were launched in the mid-1990s nineties, they began with a similar flagship product, a drinking yoghurt, which at the time was uncommon in Bamako. Similarly, two artisanal firms (FM2, FM3) were among the first to begin regularly trading fresh milk in Bamako beginning in in the late 1990s. Almost simultaneously, these firms also diversified into *féné,* because of its simple conversion from fresh milk, and in order to offer some variety to customers.

Over time, new entrants increased the competition in these product markets. Many even closely mimicked the packaging, labeling, or brand-names of the market leaders. For example, the owner of PM8 recounted an incident in which a consumer became gravely ill from such an illicit product that mimicked her own brand. Increased competition drove some incumbent firms to offer entirely new products in order to continue differentiating their brands. PM9 introduced the first locally-manufactured soft cheese and fresh cream in the early 2000s. Around 2010, both PM8 and PM6 diversified into another product that was rare on the Bamako market—packaged *dégué*. PM5, the newest entrant among the cases, manufacturers what are now very common products (pasteurized milk and *drinking yoghurt*) but has invested in equipment and special packaging to offer a novel frozen dairy product based on powdered milk. In most cases, these

firms have continued to offer the older product types as they introduce newer ones, in order to offer variety to buyers and maintain market share.

Instead of introducing new product types, PM7 differentiated by creating variety within an existing product type. This firm, like PM8 and PM6, faced growing competition in the drinking yoghurt product category. However, it responded by increasing the flavor options from the standard three (strawberry, vanilla, and natural) to eleven, which represents the most variety within any dairy product type in Bamako. The firm selected this strategy based on a consumer study that it had conducted, which showed that Malians "have a curiosity for flavors." The owner explained that the objective was to allow each consumer to find the "flavor that was right for him or her."

The fact that a few product types (i.e., soft cheese, and fresh cream, pasteurized milk) are made mostly from fresh milk, and one product type (i.e., *féné*) is made exclusively from fresh milk, suggests that this input has some advantage over powdered milk in the production of certain product types. For example, PM9 stated that the unique taste of its soft cheese and fresh cream products "depend on fresh milk." The cultural familiarity that Malians have with pasteurized milk and *féné* may also play a role in preferences for fresh milk in these products. However, there is an implicit market standard that these products do not contain added sugar, flavoring, or other additive; thus, there may also be less scope for further differentiating these products, compared to powdered milk-based products.

Also, the physical characteristics of Malian fresh milk may limit its use in certain dairy products—namely, yoghurt products (i.e., drinking yoghurt, strained yoghurt, or dégué). One firm specializing in yoghurt (PM7) explained that the fresh milk that is available in Bamako has a lower fat and protein content than powdered milk. To compensate and obtain the same amount

of yoghurt product, this firm would have to use larger amounts of fresh milk which would effectively double milk input costs. Thus, almost all of the eight firms that manufacture any yoghurt product do so from powdered milk. One exception is FM3, which reinforces fresh milk with some powdered milk when making drinking yoghurt. Also, after the production of their fresh milk-based products, PM8 and PM9 mix any remaining fresh milk into their drinking yoghurt recipe in order to enhance the taste and consistency of this product. On one hand, there is some evidence that Bamako consumers prefer yoghurt products made from fresh milk. However, yoghurt products typically include other less costly ingredients (i.e., sugar, flavoring, starch, or millet) intended to enhance taste or consistency, which may compensate for any marginal utility that is lost from the exclusion of fresh milk.

3.6.2 Enhancing or preserving product quality

Within a given product type, all firms also seek to differentiate on the basis of some experiential or credence quality attribute, such as taste and consistency, shelf life, nutrition, or purity. For powdered milk-based drinks, success in quality differentiation partly depends on the careful selection of an appropriate powdered milk brand. This is aligned with Theriault et al. (2018), who found that "price premiums are paid for powdered milk manufactured in Europe and by a well-reputed multinational company, Nestlé." For example, although PM4 was not one of the first firms to offer *dégué* on the Malian market, according to the owner it has come to distinguish itself through careful attention to quality. The owner stated that she constantly seeks to improve her product formula by tasting and studying rival products, experimenting with her own product formula and presentation, and by upgrading to higher (and more expensive) grades of powdered milk. According to the owner, this strategy—combined with the owner's high

attentiveness to customer service—has grown the firm: it now employees seventeen people, and commercialized over 200,000 L per year. It has also driven its transition from processing mostly fresh milk to powdered milk, with *dégué* accounting for 80% of these volumes. As another example, PM7 uses a powdered milk brand that is enriched with vitamins and minerals, which is highlighted on product labeling and plays into the firm's mission to provide a nutritious food to children and elderly.

Other powdered milk firms seek quality differentiation based on the addition or omission of certain non-milk ingredients. In order to extend product shelf life, PM5 stated that it often adds the preservative sorbate to its pasteurized milk and drinking yoghurt products, adjusting the amount depending on whether the powdered milk brand already contains this additive. PM7 also stated that it is considering adding a preservative to its products. In contrast, PM9 claims to use a particular ferment that offers better product resilience than others. Two other semi-industrial firms, PM5 and PM6, have introduced a corn or soy starch to thicken their products. Although these imported starches are expensive and sometimes unavailable, the firms report that the powders thicken the consistency of yoghurt in a way that is appealing to consumers and which allows them to reduce the amount of powdered milk by 10% to 20%, thus reducing milk input costs. PM8 also considered using a starch, but ultimately decided against it because the owner was uncomfortable using such an additive, highlighting that the omission of an ingredient can also be a way to differentiate so long as consumers value product purity.

As noted above, fresh milk products rarely contain additional non-milk ingredients, thus limiting this differentiation opportunity. Instead, quality differentiation depends to a larger degree on the quality of the procured milk ingredient. However, again, fresh milk is vulnerable to several quality issues. The three largest powdered milk firms (PM7-PM9)—together representing

the most established domestic dairy brands in Bamako—all cited the quality of fresh milk as a key challenge. Overall, quality control and traceability of fresh milk is still at a very early stage in Mali. At best, firms are aware of which cooperative the milk is sourced from, but not which farm or animal. Further, firms do not have detailed or verified knowledge of herd conditions, including herd health, feed, and veterinary care.

For instance, all three of the fresh milk firms complained that CRLLB-sourced milk varied greatly in fat and other taste attributes, in comparison to milk from other supply channels. These firms and CRLLB suspected a number of possible causes, including the higher prevalence of mixed-breed dairy cows in among some cooperatives (which are popularly believed to provide milk that is less rich than the traditional breeds), feed quality, or a problem in the cooperative-level pasteurization equipment. Milk quality in Mali also varies by season. Although CRLLB and its milk cooperative partners have co-investigated quality complaints, including through a collection center inspection, they have been unable to identify the source of the problem. Other quality issues that are difficult to verify are even more deleterious to long term human health. For example, interviews with government technicians and value chain actors suggest that the proper use, documentation, and monitoring of veterinary drugs such as antibiotics and vaccines are not widely respected in the Bamako peri-urban production basin.

3.6.3 Quality-signaling mechanisms

Differentiation on the basis of experiential or credence quality attributes, on its own, is difficult for consumers to observe prior to the purchase and consumption of a product. Retailers, too, must be able to verify quality attributes that are important to the consumers they serve. In order to address this information asymmetry between processors and buyers, and to avoid a

situation of adverse selection, firms must couple such investments with attributes that provide information to retailers and consumers on quality attributes. In the Malian dairy sector, firms use several such quality-signaling mechanisms: sales representatives, product warranties, brand recognition, and third-party certification.

3.6.3.1 Sales representatives

All firms use sales representatives to provide product information to existing and potential clients. In the most direct model, all four artisanal firms interface directly with consumers through forward integration into retailing. According to fresh milk vendors, the two most frequent inquiries that they receive from customers are, "Is it real?" and "Where does it come from?" By maintaining their own retail points, firm owners or employees can provide personal assurance on these questions. Additionally, the owner of FM3 explained that Malians "have the mentality to go to the houses of sellers when they wish to purchase milk," especially when the sellers are reputed for having good quality, and because dairy products are traditionally consumed at night when markets are closed. Indeed, all four of the artisanal firms (FM1-FM3, PM4) make some sales from their homes, and two have sales windows that are connected to their household concession.[26]

As these artisanal firms have grown, they have acquired (through ownership or rental) retail points which they staff with family members or trusted employees. They are typically located in markets, near busy roads, or next to mosques in order to access high-traffic areas while offering convenience to customers who are commuting, shopping, or returning home from Friday prayers.

[26] Another advantage of maintaining a residential point of sale is that the owner can make sales throughout the day and evening without depending on an employee, while at the same time being present at home to receive milk deliveries, make and package products, and oversee any other domestic activities.

One owner stated that "it is not easy to have a retail point in Bamako that works." She explained that it had taken her years of searching and trying out new locations before she secured her external points of sale. CRLLB has provided some assistance to its members while attempting to standardize and scale up the direct retailing model. Since 2010, the cooperative has provided locally-fabricated retail kiosks to about 45 of its members. The kiosks are locally-constructed out of metal, wood, and glass, and include a sales window and signage. CRLLB has offered the kiosks (valued at about 800,000 FCFA) and new refrigerators (valued at about 450,000 FCFA) to its members on zero-interest credit.

In contrast, all semi-industrial and industrial firms outsource product distribution to external partners. Two artisanal firms (FM2, PM4) also make direct sales to retailers, which has become their primary market channel. In these cases, maintaining direct contact with consumers becomes more difficult and the relationship with the distributor becomes most important. Consequently, these firms employ commercial agents who make deliveries to their distribution partners, provide them with information, and monitor how products are stored and displayed. Individuals on motorcycles deliver products for the artisanal firms, while semi-industrial firms deploy two-person teams (a driver and sales agent) in delivery vehicles.

3.6.3.2 Warranties

As firm scale and distance to the end consumers increases, product warranties are another mechanism by which a firm provides product information and signals quality**.** All firms selling to retailers or other intermediary clients offer product warranties, in which they guarantee quality by replacing any defective products *ex post*. The conditions of warranties are usually vaguely defined, but at minimum include cases in which a client discovers a defect in the product that is

clearly attributable to the firm, such as faulty packaging or spoilage that the firm can trace to faults in the product process. Several firms extend their warranties to cover some share of losses that are clearly not their own fault, such as due to power cuts or even when the causes are unknown.

3.6.3.3 Brand recognition

Building brand recognition is another signaling mechanism used by the largest firms (PM7-PM9). These firms have developed brand recognition and reputation through time, scale, and/or mass communications. First, the largest firms are also the most experienced among the case studies, with the oldest having a market presence in Mali of over twenty years. Second, each firm has a substantial distribution network consisting of 500 retailers or more, and which reaches towns outside of Bamako. Third, each firm has invested in different forms of consumer advertising, which include branded trucks, websites, social media messaging, television and radio advertising, and billboard communications. As additional measures to develop brand recognition, PM7 has opened a yoghurt parlor in the national park and PM8 had used celebrity sponsorships and social media accounts to build brand recognition among youth.

In partnership with CRLLB, fresh milk firms have also attempted to build a collective brand to signal that products are made from high-quality fresh milk. Interviews and marketing materials suggest that the CRLLB brand represents at least three principles that depend largely on CRLLB's partnership with its FENALAIT suppliers and on a system of support, standards, and quality control set up within these organizations. The first principle is purity, i.e. that all CRLLB dairy products are made 100% from local milk. The second principle is food safety. CRLLB food safety standards (e.g., proper refrigeration and a clean retailing environment) are

checked weekly by marketing advisors who visit kiosks once a week. A third and related principle is traceability. Local milk is sourced from local farmers and through close relationships. Furthermore, firms have some degree of confidence that the production, collection, pasteurization, and transport of CRLLB milk is supported by an infrastructure of FENALAIT veterinary care, standards, and quality control. The cooperative's forty-five retail kiosks, placed throughout the city, play a role in building recognition for this brand. These kiosks are identically painted blue and white, with the cooperative name and tagline ("milk from our cows") written in Bambara in bold letters across the tops. On the sides are images of dairy farming and the phrase, "I love my local milk." CRLLB has also made available to its members branded product labels with similar colors, images and messages.

However, the effectiveness of the CRLLB brand faces several challenges. None of the interviewed members cited this common brand as a primary advantage to cooperative membership. Not all members have access to a kiosk, and others have additional unbranded retail points. Many members do not use branded labels because they are expensive for them to print and possibly also vulnerable to counterfeiting. CRLLB does not have the resources to advertise outside the kiosk signs. Feeble use of the CRLLB brand may also be due to weak implementation of its standards. First, many members sell products that are based on powdered milk alongside local milk products, sometimes in the CRLLB-branded kiosk. Second, traceability is weakened by the fact that firms source milk from outside CRLLB and the FENALAIT network. Firms often are not aware of the source of this milk, let alone the standards by which it was produced and handled.

3.6.3.4 Third-party certification

A final potential mechanism to signal product quality is through third-party quality certification. According to government regulation, all food firms must obtain for each of their products a certification that is issued by *l'Agence Nationale de la Sécurité Sanitaire des Aliments* (ANSSA) (Government of Mali, 2006). The ANSSA seal, which should be printed on product packaging, indicates to consumers that the product has met product-specific norms and standards that the Government has adapted from CODEX. However, few, if any, imported or domestic dairy products carried the seal at the time of fieldwork. Among the cases, only PM5 had obtained an ANSSA certification, and in this case for its water product.

One reason for this low certification compliance may be weak recognition of the seal by consumers and even retails. In a 2018 survey of Bamako consumers, only 20% of respondents recognized the ANSSA seal and most of these stated that they did not have a good idea of its meaning (Vroegindewey, 2019). Another reason for low compliance may be the complexity and costs of obtaining ANSSA certification. Among the required steps, a company must provide proof of necessary business registrations and tax payments, provide satisfactory results from lab tests of their products, and pass a factory inspection. PM5 estimated that obtaining certification for its water products took two years and cost about two million FCFA. Finally, low compliance might also be explained by the historically weak government enforcement of noncompliance. However, some of these trends could be changing: before its water carried the ANSSA seal, PM5 had been fined 250,000 FCFA by the Ministry of Commerce. To avoid similar sanctions and disruptions to its dairy and juice business, the firm was in the process of certifying these other product lines as well. Among the firm cases, at least two other powdered milk firms (PM7, PM9) had also initiated the certification application process.

3.6.4 Packaging

The use of distinct packaging features is the fourth source of differentiation in the Bamako dairy market. In the same context, Theriault et al. (2018) found price premiums to be associated with powdered milk products that were packaged in metal tins or cartons, as opposed to plastic pouches which could potentially be manufactured in Bamako. Packaging can potentially create value for retailers and consumers in three ways. First, packaging protects product contents from the external environmental, which can extend shelf-life and facilitate wider distribution. The fresh milk firms that primarily distribute through their own retail points (FM1, FM3) package all or most of their products by double-bagging them in thin transparent plastic bags that they hand-tie to close. The two larger artisanal firms (FM2, PM4), all of which distribute most of their volumes through independent retailers, have upgraded to use a thicker plastic bags that they heat-seal with a hot iron and, occasionally, locally-purchased plastic bottles. The powdered milk firms, all of which outsource their distribution to external partners, use even sturdier packaging: opaque plastic pouches (for drinking yoghurt and *dégué*), plastic bottles (for drinking yoghurt), or durable plastic cups (for strained yoghurt and *dégué*).

Second, packaging is another means of communicating information about quality. In addition to exposing products to more shocks and longer lead times between production and consumption, a longer marketing chain also increased the potential for information asymmetry between a firm and consumers. To mitigate this and avoid problems of adverse selection, expensive packaging can signal to consumers that quality contents are superior to products with less sophisticate packaging. Among the cases, five of the seven firms (all powdered milk firms) with longer marketing channels use packaging that they either custom-manufacture in their factories or

import directly. Package labeling can also explicitly convey information on product attributes. For example, PM7 packaging indicates that yoghurt is made with "enriched milk," a reference to the enrichment of the powdered milk they use.

Despite its low cost and the minimal protection that it provides, informants claimed that many consumers draw a strong cultural connection between the very familiar appearance of hand-tied plastic bag packaging and quality fresh milk. The bags themselves are locally manufactured and ubiquitously used by Malian vendors in traditional markets, and their transparence allows Malians to visually examine the milk contents (e.g., color and consistency, and any debris). The owner of FM3 explained that, traditionally, milk was sold out of calabashes, which allowed buyers to verify the quality *ex ante* by sight, smell, or taste.

Even when fresh milk firms upgrade to thicker plastic bags that are better suited for longer marketing chains, they maintain the transparency of their packaging. As distance between the firm and retail point of a product increases, labeling also becomes more important. One fresh milk firm does not even use labels for products sold from her home, because of the personal contact that she has with these consumers. Similar to their choice of packaging materials, fresh milk firms use simple labeling that evokes associations with traditional milk marketing. Most labels are locally-printed in monochromatic colors; feature icons of cows or traditional milk marketing; include a brand name that utilizes words from a local language and/or the personal name of the firm; and provide contact information on the firm.

For instance, FM2's label features a simple drawing of a Fulani woman selling milk from a bowl on her head, under the company name in Fulani, which translates as "milk from our cows." The owner, who is herself Fulani, explained that "everyone knows that it is the Peuhl who sell and know milk." To further underline (and help to protect) the product quality, "Fresh

pasteurized milk 90 degrees" and "conserve at 7 degrees" are printed vertically in large font up either side of the package. However, the owner of FM3 believed that there were limits on how much she should innovate on traditional packaging, because sophisticated packages have a "pharmaceutical" appearance that many Malians associate with the industrial processing of powdered milk. Indeed, all nicely-packaged yoghurts that are sold in Bamako are made from powdered milk.

Finally, packaging form and size can improve the convenience and affordability of a product, especially for consumers with limited resources for purchasing, storing, and consuming dairy products. Across the cases, the firms indicated/stated that their most popular packaging formats are those that are smallest. The per-liter consumer prices of PM9's pasteurized milk and drinking yoghurt are among the highest on the Bamako market. However, the firm packages these products in 200 ml pouches in order to offer a relatively low price-point to consumers. Consequently, this packaging has become the format preferred by wholesale distributors in Bamako and is an essential element for maximizing a brand's breadth of distribution. PM5, PM8, and the two other industrial dairies in Bamako have each introduced a similar packaging for their milk and drinking yoghurt products, and PM7 has purchased new packaging equipment to do the same. Additionally, pouches and plastic bottles are convenient for more viscous products (pasteurized milk, drinking yoghurt, *féné*) because consumers can drink from them directly, while plastic cups are preferred for products that are consumed by a spoon (e.g., strained yoghurt). Some firms also offer bottles and cups with re-closable tops as an additional enhancement.

3.7 Conclusion

This paper examines the competitiveness of local fresh milk—versus imported powdered milk—as an input for dairy processor firms in Bamako. To do this, I conduct case studies of nine dairy firms, analyzing the relationship between their use of each input and the creation of competitive advantage through cost advantage and/or product differentiation.

Regarding cost, I find that the use of fresh milk is more costly than use of powdered milk. The purchase price of fresh milk is at least 20% higher than the liquid equivalent of powdered milk. Additionally, in contrast to powdered milk for which spot markets already exist in Bamako, all firms that procure fresh milk must carefully coordinate their transactions with suppliers. Yet, even with special procurement arrangements in place, these firms still face transaction cost problems related to quality and supply uncertainty.

I also find four sources of differentiation that dairy firms use to distinguish their brands from competitors. First, firms offer unique products, such as a new type of yoghurt. Later, as rivals adopt similar products and competition increases, firms enhance the product or create variety by introducing new ingredients, such as flavors or additives. Second, within each product type firms seek to preserve or enhance quality. Third, firms adopt quality-signaling mechanisms to convince consumers that unobservable product attributes of their brand are superior to those of competitors. Mechanisms include the use of sales representatives, enhanced packaging and labeling, warranties, investments to improve brand recognition, and third-party certification. Finally, firms offer unique packaging features (e.g., different forms or materials) that create customer value by protecting contents, signaling quality, improving convenience, or increasing affordability.

However, I find that fresh milk firms face unique difficulties exploiting these differentiation opportunities, compared to firms of powdered milk. For example, these firms have adopted variations of three signaling mechanisms to communicate product information to consumers that have a preference for fresh milk, but each has significant disadvantages. One mechanism is to sell through small specialized retail points that are costly to scale up. Another is to use traditional packaging that poorly protects product contents and has limited appeal to many consumers. These firms also attempt to use collective branding that requires more coordination in order to work effectively.

In order to improve the competitiveness of local dairy value chains, milk farmers and processors should work with the Malian government to bring down the costs of procuring and processing fresh milk. Measures that improve milk producers' access to productive breeds, feed, and veterinary care should help to reduce the price of fresh milk, while improving quality and stabilizing supply. The government should also address problems in the business environment that drive up transaction costs in dairy procurement and marketing, especially the high costs of electricity, poor roads, and limited agricultural financing.

Even with these measures, it is unlikely that the costs of fresh milk will drop below those of powdered milk in the near term. The competitiveness of local dairy value chains, therefore, will also depend on their ability to stimulate and exploit demand for products made from fresh milk through differentiation. One possibility is the development and commercialization of products that are well-suited for local fresh milk and difficult to imitate using powdered milk. Because milk ingredient type is a product attribute that is difficult for consumers to observe, investments in more effective quality-signaling mechanisms will also be critical. One option is the development of innovative packaging that maintains traditional features while offering better

protection and convenience. Government can also strengthen the enforcement of an existing certification system—which, technically, has a special designation for local fresh milk—as a tool to help local value chains differentiate their products.

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CHAPTER FOUR: ANALYSIS OF THE DETERMINANTS OF MILK PRODUCERS' PARTICIPATION IN OUTPUT MARKETS

4.1 Introduction

Substantial growth in the market supply of Malian milk will be necessary to meet the rising demand for dairy products, while also improving the livelihoods of milk producers and strengthening the competitiveness of the Malian dairy sector against imports. The aim of this paper is to understand the barriers that constrain Malian milk producers from entering and supplying markets, and to identify policy measures that can boost such market participation.

The question of smallholder farm commercialization in Africa is an issue that has increasingly occupied the attention of policymakers, especially in recent years as liberalization of markets, globalization, and transformations in retailing and consumption are magnifying challenges and opportunities (Reardon and Timmer, 2012). As Barrett (2008, p. 300) summarizes, the theoretical benefits of market-oriented production and trade, relative to subsistence production for own consumption, are important, and include not only "the one-off, static welfare effects of trade according to comparative advantage" but also more rapid total factor productivity growth due to opportunities for larger-scale production and the increased interflow of ideas. Additionally, in the Malian context, a greater and more stable market supply of milk should have broad economic benefits, insofar as it strengthens the competitiveness of the local dairy value chain and contributes to greater availability and accessibility of diverse foods, perhaps especially in urban areas (Theriault et al., 2018).

However, a body of evidence has showed that transaction costs are a significant impediment to the participation of African farmers in various agricultural markets (Barrett, 2008). Transaction costs are *ex ante* costs that a household faces in searching for a market and

negotiating a transaction, and the *ex post* costs of monitoring and enforcing the terms of the transaction (North, 1990). Numerous market participation studies have focused on milk, because its perishability and other technical characteristics generate many transaction costs in its production, processing, and marketing (Jaffee, 1995). Most of these studies are from either Kenya (Burke et al., 2015; Olwande et al., 2015) or Ethiopia (Holloway et al., 2005; 2004; 2000). Their salient finding, consistent with findings from other African markets, is that household-specific variables (such as the level of education of a household's head) and geography-specific variables (especially access to milk buyers such as traders, cooperatives, and processors) strongly influence the probability and value of sales among milk producers, reflecting the pervasive impacts of transaction costs in milk markets (Barrett, 2008). These studies also confirm the importance of productivity-enhancing technologies and conditions, namely household ownership of crossbred dairy cows, access to extension, and favorable agricultural-ecological (or agro-ecological) conditions.

This study focuses on Mali because the milk market participation literature has largely overlooked West Africa and especially the Sahel region, which differs distinctively from the East African context in terms of policy history, market structure, and agricultural ecosystems. For example, the Kenyan dairy sector benefits from more favorable climactic conditions and, since 2002, has also enjoyed the protection of imports tariffs of up to 60% (Orasmaa et al., 2016). In contrast, the West African Economic and Monetary Union (UEMOA) has established a Common External Tariff (CET) schedule that taxes imported powdered milk at only 5%, and other products at up to 35% (UEMOA, n.d.).

To my knowledge, no other research has conducted econometric analysis of milk producer market participation in the Sahel region, and only one working paper has examined this issue in

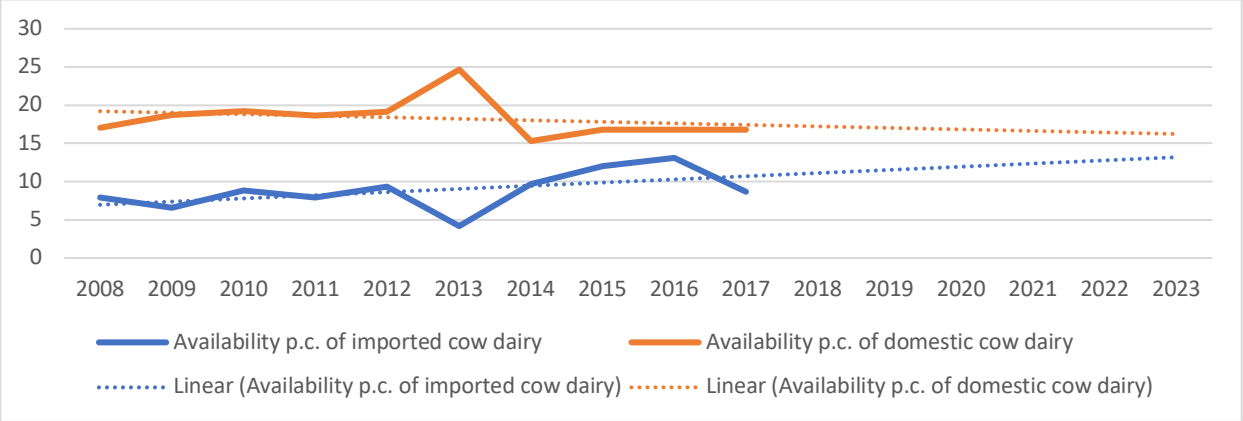
the broader West Africa region. Balagtas et al. (2007) use a Heckman selection model to study a limited sample of households in Ivory Coast. However, this paper defines milk market entry as household ownership of any cattle (versus household ownership of dairy cattle specifically or the production of milk) and uses a small nonrandom sample. This study uses a more precise definition of milk market participation, exploiting a randomly-sampled and nationally-representative household dataset, and by employing a rich set of control variables. Additionally, Mali has the third-largest cattle population in West Africa (after Nigeria and Niger) and a similar ranking in terms of annual milk production (FAO, 2019); thus, it provides an excellent case study for understanding commercial behaviors in the region's high-potential milk supply basins.

In West African countries, livestock plays a critical role in household incomes and the national economy. In Mali specifically, three-quarters of households own livestock of some kind, and in 2011 the livestock sector contributed to about eight percent of the national gross domestic product (FAO, 2017). Focusing on the dairy sub-sector, consumer demand in Mali and the region has been climbing steadily with income growth and urbanization (Zhou and Staatz, 2016). While this poses a huge opportunity to producers, regional supply has not been keeping apace. Zhou and Staatz (2016) estimate, even under conservative assumptions of future income growth, that by 2040 regional dairy supply will fall short of demand by a magnitude of five. Unless production growth increases, this deficit will have to be made up by a commensurate increase in imports, in order to avoid real price increases. Figure 6 provides a picture of this pattern for the case of Mali. It presents linear trends of the per capita supplies of domestic milk and imported dairy, based on the past decade of milk output and population growth.[27] Over time, domestic

[27] The large surge in domestic supply, followed by a drop, during the 2011-13 period might be explained by very good rain and pasture conditions in 2012 and, in contrast, poor agricultural and security conditions in 2013 (Government of Mali, 2013; 2012). The opposite inflection of imported milk supply during this same period suggests the substitutionary relationship that domestic and imported dairy supply have with one another.

supply has been decreasing while imports have been rising to meet the deficit. At the household level, low rates of market participation help to explain this pattern: although 20% of Malian households produce milk, only 3% market any volume milk during the year (authors' calculations from World Bank, 2015).

Figure 6: Per capita supply of domestic milk and dairy imports in Mali (L/per person)



Sources: Authors' calculations from Government of Mali (2007-2011; 2012; 2013; 2014-2016; 2017) and FAO (2019)

I investigate this household-level pattern in Mali. Section two presents the conceptual framework for understanding an agricultural household's participation in milk markets when transaction costs are present. Section three describes the data and empirical approach for applying this framework to the Malian context. In section four I present the results, then conclude by highlighting key findings and their policy implications for increasing milk supply in the Malian market.

4.2 Conceptual framework

Because the focus is understanding the supply behavior of milk producer households, the theoretical framework is the agricultural household model (Singh et al., 1986). If I could

reasonably assume that Malian producers had perfect access to markets for milk and all necessary inputs, then household milk supply boils down to a profit-maximization problem in which decision-making is guided only by exogenously-determined prices and conditioned on the given production technology. However, because Malian dairy producers face significant transaction costs in these markets, I must extend the model to account for market imperfections. Specifically, below I draw mainly from Barrett (2008)'s articulation of the non-separable agricultural household model.[28]

Assume that a household maximizes its utility over a bundle of commodities, subject to a budget constraint involving farm production, sales, and non-farm income; a production technology constraint; and a vector of unobservable "decision prices" (Key et al., 2000; p. 248). The decision prices for selling (or purchasing) a given commodity equals its observable local market price (P) minus (plus) the transaction costs that a household faces to participate in that market. The transaction costs themselves depend on household-specific characteristics (Z) and physical and institutional infrastructure (G), which together affect the search, information, transportation, and negotiation costs associated with carrying out a transaction. The transaction costs also depend on household-level productive assets (A), liquidity from non-farm income (W), and net sales (NS). The latter variable affects transaction costs when there is a fixed costs-component wherein the per-unit amount of total transaction costs drops as volumes increase and, consequently, there exists a threshold quantity below which market participation is infeasible (Barrett, 2008; Holloway et al., 2004). Net sales can also capture purchase arrangements in which buyers pay differentiated prices based on volumes in a given sales lot.

[28] Olwande et al. (2015) similarly drew from Barrett (2008)'s model in their analysis of farmer participation in milk (and other) commodity markets in Kenya.

The defining feature of this model is that, because household-specific variables determine transaction costs, the decision prices that producers face are likewise household-specific. Consequently, in a given milk market I expect to observe differentiated participation in markets across households.[29] For milk-producing household *i*, the market participation decision has two parts. The first is the decision to participate (or not) as a seller, denoted by *M* which equals one for market entry and zero otherwise. Second is the decision of sales volumes, denoted by the continuous variable *Q,* which is positive if and only if $M = 1$. I can express the reduced-form equation as:

$$Q_i = Q_i(M, P, Z, A, G, W, NS). \quad (1)$$

4.3 Materials and methods

4.3.1 Data sources

I apply the household market participation model to the Malian context by using data from the 2014 Mali Living Standards Measurement Study-Integrated Survey on Agriculture (LSMS), a 4,009 household cross-sectional survey that was implemented by the Planning and Statistics Unit of the Malian Ministry of Rural Development (CPS/SDR) and the World Bank (World Bank, 2015). The population-based survey has national coverage, with the exception of the northern region of Kidal which surveyors could not access due to insecurity at the time of data

[29] In addition to household-specific transaction costs, Barrett (2008)'s market participation model specifies a second layer of transaction costs that are commodity and geography-specific. Because I focus on participation in milk markets, it is not necessary to control for commodity type. The geography-specific nature of transaction costs arises because local markets "are differentially integrated into the global economy because of spatial differences in costs of commerce, in the degree of competition among market intermediaries, or both" (Barrett, 2008; p. 301). The incorporation of observed local market prices—which are determined by these factors—accounts for the geographically-differentiated nature of transaction costs.

collection. Government of Mali (2016) provides detailed information on the stratified random sampling approach of the LSMS survey.

The analysis is based on 717 households that reported owning a female cow. Of these milk producers, 126 households participated in milk markets as sellers. Data from the livestock modules of the LSMS were collected in a single round from December 2014 to February 2015 (Government of Mali 2016). Other modules cover household and community (i.e., enumeration area)-level characteristics, and were collected between July 2014 and February 2015.

4.3.2 Econometric model and estimation

The econometric model must account for the two-staged nature of market participation, as depicted in Eq. (1), as well as for the large share of nonparticipants in the dataset (i.e., households that produce, but do not sell, milk). Nonparticipation in markets results in a corner solution problem, in which the outcome variable (in this case, milk sales) is zero for a nontrivial number of observations but is continuous otherwise. Applying an ordinary least squares estimator on such a truncated dataset would result in biased and inconsistent estimates (Wooldridge, 2015).

The Tobit model (Tobin, 1958) represents one solution for addressing the corner solution problem (see Holloway et al. (2004; 2000) for different applications of the Tobit approach in the Ethiopian milk market). However, applying this model to the subsample of milk producers involves estimating simultaneously the determinants of the probability and magnitude of the market participation outcome. This imposes the restrictive constraint that the processes driving these two stages be the same, i.e., that the set of significant explanatory variables, and the

directions of their effects, be the same (Burke, 2009). Other studies have showed that this is an unreasonable assumption in the context of milk marketing (e.g., see Burke et al., 2015).

There are two commonly-used alternative models that more flexibly address the corner solution problem through a two-step procedure, but which also nest the Tobit model as a special case (Lin and Schmidt, 1984). One approach, the Heckman (1979) sample selection model, treats nonparticipants as unobserved data resulting from nonrandom sample selection (see Balagtas et al., (2007) for an application in Ivoirian milk markets). However, because the data is a random sample, and because the theoretical model views the outcomes of both stages (including nonparticipation outcomes) as the result of a household decision-making process, the Heckman model is not appropriate for the analysis.

The other approach is the Cragg (1971) two-tiered (or double-hurdle) model, which treats zeroes as observed outcomes and allows for two different processes to estimate different parameters for the probability and value of sales separately (see Olwande et al. (2015) and Burke et al. (2015) for application in the Kenyan milk market, and Holloway et al. (2005) for an application in Ethiopia). Because these features are better suited to the theoretical model and dataset, I adopt the Cragg model for the analysis.

Specifically, I estimate regressions of the following form:

$$\text{Stage 1:} \quad P(M_i = 1) = P(Q_i > 0) = \boldsymbol{X_i\alpha} + \varepsilon_i, \quad \text{and} \tag{2}$$

$$\text{Stage 2:} \quad Q_i = \boldsymbol{Z_i\beta} + \mu_i. \tag{3}$$

Eq. (2) defines the milk market entry decision for household *i,* where M_i takes on unity if the household makes any milk sales and zero otherwise. Eq. (3) defines the household's decision regarding its level of market participation, in terms of the quantity of milk sales. $\boldsymbol{X_i}$ and $\boldsymbol{Z_i}$ are the two vectors of explanatory variables, according to the theoretical model depicted in Eq. (1), and $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are the marginal effects of these vectors of explanatory variables, for the first and second stage, respectively. I estimate Eq. (2) using maximum likelihood estimation and a probit model. I can estimate Eq. (3) by fitting the data to either a truncated normal distribution or a lognormal distribution (Cragg, 1971). I assume that the errors in both equations are normally and independently distributed.

4.3.3 Variable definitions

Table 13 defines the dependent and explanatory variables that I select for the model. In addition to the theoretical model, the choice of variables is guided by a review of the other empirical studies investigating household participation in milk markets, and data availability from the LSMS survey. The first stage dependent variable is binary, taking on unity when a household reports any milk sales made in the previous year, and zero otherwise. The second stage dependent variable represents the liters of milk that each household sold in the previous year, which I calculate based on the number of months in the year that households reported milk offtake and the average milk quantities that they reported selling in each of these months.

Table 13: Variable definition and summary statistics

Variable	Definition
Dependent Variables	
Participation	HH made any volume of milk sales (Level of participation > 0) during 12-month survey period
Level of participation	Volume of milk (L/year) sold by HH during 12-month survey period
Household (HH)-specific explanatory variables	
No. local dairy cows	No. female cows (of local breed) raised by HH
No. foreign dairy cows	No. female cows (of mixed/exotic breed) raised by HH
% vaccinated	Share of HH cattle herd vaccinated in past 12 months (%)
% treated for parasites	Share of HH cattle herd treated for internal parasites (%)
% treated for ticks	Share of HH cattle herd treated for external parasites (%)
Water source	A pond or stream was a primary or secondary herd water source during dry season (dummy)
Oilseed cake	Oilseed cake was a primary or secondary source of herd nutrition in past 12 months (dummy)
Trough	Household owns a feed/drinking trough (dummy)
No. cell phones	Number of functioning cell phones owned by household
No. radios	Number of functioning radios owned by household
Transport	Household owns at least one means of transportation: bicycle, motorcycle, or car (dummy)
Ha. Land	Total hectares of land that is cultivable by HH
Log (nonfarm income, lagged)	Total annual non-farm income (1,000 FCFA/year) of HH during 12 mos. prior to survey period
Log (nonfarm income)	Total annual non-farm income (1,000 FCFA/year) of HH during 12 mos. during survey period
No. adult males	Number of household members who are adult males
No. adult female	Number of household members who are male and over the age of 18
No. children	Number of household members who are under the age of 18
HH head gender	HH head is male (dummy)
HH head Fulani	HH head reported Fulani ethnicity (dummy)
HH head yrs of edu.	Number of years of formal schooling completed by HH head
Location-specific explanatory variables	
Log (milk price)	Ave. (of two survey rounds) of local median price (FCFA/L) of packaged fluid milk
Urban	Community is located in an urban area (dummy)
No. collection centers	Number of collection centers inventoried at the *cercle* level
% electricity access	Share of households sampled in community that have access to electrical grid (%)
Dist. weekly market	Distance (km) to nearest periodic market
Dist. daily market	Distance (km) to nearest permanent market
Dist. training center	Distance (km) to nearest agricultural training center
Dist. financial institution	Distance (minutes) to nearest micro finance institute
Dist. motorable road	Distance (km) to nearest clay or paved road
Average temperature	Average annual temperature (multiplied by 10 °C) during 1960-1990 period
Annual rainfall	Total annual precipitation (mm) during 1960-1990 period
Semi-arid	Community is in semi-arid (vs arid or sub-humid) agro-ecological zone (dummy)
Arid	Community is in arid (vs semi-arid or sub-humid) agro-ecological zone (dummy)

Notes: N(sample) =718; N(market participants) = 127; HH refers to household

4.3.3.1 Household-specific explanatory variables

Household-level productive assets and production technology (represented by A in Eq. (1)) raise farm output and productivity, thereby increasing marketable surplus (NS) and reducing per-unit production and transaction costs. Thus, I expect that household access to such resources will positively influence market participation. The number of female cows raised by the household is clearly a critical asset for milk production, and I distinguish between local-breed cows and mixed (and foreign) breed cows to also capture the yield-enhancing benefits of the latter type.

To capture household management of dairy herd health and nutrition, I include variables measuring (separately) the shares of the total cattle herd in the past year that was vaccinated, treated for internal parasites, and treated for ticks and other external parasites. As a measure of herd access to water throughout the year, I include a dummy variable indicating whether a natural water source (e.g. pond or stream) was one of the primary water sources during the dry season. Two other dummies indicate access to resources that are associated with intensive milk production: use of an oilseed cake as a primary type of feed, and household ownership of feeding (or drinking) troughs. I also include household ownership of other assets that improve access to information and markets. Cell phones and radios could be a means for accessing information on markets, prices, and production practices. Ownership of a means of transportation should greatly reduce the time to market. Finally, I include the number of household adults and the number of farm hectares cultivated by the household, which may serve as important sources of labor and animal feed, respectively, in the context of imperfect factor markets. Similarly, in a context of imperfect credit markets, I also include estimates of the total nonfarm income earned during two periods: the past twelve months (i.e. concurrent to the milk production period examined), and the twelve to twenty-four months (i.e., preceding the milk production period examined).

Other household-level characteristics (Z) can influence market participation by influencing productivity, and/or by generating or attenuating transaction costs. Household characteristics are also determinants of milk consumption which, in the non-separable agricultural model, enters the market participation decision by constraining net surplus (NS). I attempt to capture gender effects by including a dummy variable for male or female household headship, and by

disaggregating the total household adults variable by male and female.[30] However, there is some ambiguity around the expected net effects of gender and household size. First, although women typically have more limited access to inputs and greater time and mobility constraints, compared to men, in traditional West African agricultural households they tend to be more involved with dairy herd maintenance, milking, intrahousehold milk distribution, and milk marketing (Salla, 2016). Second, although an increase in the number of household adults increases access to labor (as mentioned above), it may also increase household consumption of milk, thereby reducing net surplus, all other factors held constant. Increases in the number of household children, which increases milk demand without improving labor, should have a less ambiguous negative effect on market participation. Another household-level variable indicates whether the household head is *Fulani*, which is the largest pastoral ethnic group in Mali. I also include a continuous variable indicating the years of formal schooling completed by the household head, as a measure of his or her human capital, with the expectation that greater human capital has a positive effect on market participation.

4.3.3.2 Location-specific explanatory variables

Local market prices (P) are important determinants in a household's vector of decision prices. Price differences across markets, furthermore, reflect a second layer of location-specific transaction costs that are determined by market integration and concentration. I obtained prices from the LSMS community-level dataset, in which survey enumerators recorded three price observations (for each of a select number of consumer commodities) from the local market of

[30] In the sample, 61% of households reported that female cows were primarily managed by the household head. Another 27% reported collective management by multiple household members, which presumably includes partial management by the household head. Thus, focusing on the gender of this individual is appropriate.

each enumeration area and in both survey rounds.[31] Consumer prices should be a sufficient indicator of households' market incentives because milk supply chains in Mali are relatively short, and many households do sell their milk directly to consumers. To approximate the local output milk price faced by producer households, I took the median consumer prices of packaged fluid milk for each enumeration area, then averaged these medians from both survey rounds. Because households produce and market milk on a daily basis throughout the year, taking the average from two periods is appropriate. Also, for these reasons, estimating expected prices (instead of the use of realized prices) is less a concern for milk, compared to agricultural products associated with delayed production cycles. However, in an effort to capture longer-term expectations regarding milk demand and prices I include a dummy for whether the household is located in an urban area, versus a rural area.[32] Because urban areas contain large and growing consumer markets (Zhou and Staatz, 2016), this variable should encourage market participation. However, higher population densities place pressure on land that livestock might otherwise access for grazing or foraging; thus, I cannot predict the net effect of this variable.

Access to various physical and institutional infrastructure (G), can facilitate the adoption of productivity-enhancing technology and directly reduce the transaction costs to market participation. For example, milk collection centers provide a market outlet for local producers, and often facilitate access to other services and inputs such as veterinary care, vaccinations, and feed. I include a variable indicating the total number of centers at the *cercle*-level, which I expect

[31] Due to insecurity and other reasons, LSMS survey teams were unable to access 197 of 1,073 of the enumeration areas, which corresponds to about 15% of the sample of milk producers. I addressed missing community data (i.e., prices and infrastructure) by imputing median values from the next-largest geographic units.
[32] Following government census definitions (Government of Mali, 2012), the LSMS defines an enumeration area as urban if it both has at least 5,000 inhabitants and is administratively classified as an urban *commune*. In Mali, there are thirty-six urban communes and 667 rural communes.

to positively affect market participation.[33] Access to electricity enables such centers to run lights, cooling tanks, and refrigerators, while relying less on more costly gas generators. Electricity also enables retailers to store milk in refrigerators, which should increase milk demand from these intermediary buyers. Thus, I estimate the share of households in each community that reported having access to electricity and include this variable in the regressions.

To capture access to other various public goods, I include variables representing community distance to the associated infrastructure. I hypothesize that access to a weekly market, and especially to a permanent (i.e., daily) market, will positively affect market participation, as each should reduce the transaction costs that households incur to transport milk, search for buyers, and negotiate prices. Access to agricultural training centers should also positively affect market participation insofar as these improve access to extension agents and, thereby, encourage the adoption of productivity-enhancing technologies. Access to a financial institution might also positively affect market participation, by allowing producers to invest in lumpy assets (e.g., additional dairy cows). Household access to credit might smooth income during stressed periods, thereby stabilizing demand for milk while helping producers to avoid destocking as a negative coping mechanism. Access to a motorable road (defined here as a clay or paved road) should reduce transportation costs and overall access to markets and services. Finally, I control for location-specific climactic and agro-ecological conditions by including several variables that geo-reference rainfall and temperature data from secondary databases.

[33] This data comes from a *commune*-level government inventory that distinguishes between (but does not define) collection points, collection centers, and dairies. For simplicity, I refer to all of these, collectively, as "collection centers." In Mali, *cercle* and *commune* are the second and third administrative units in Mali, respectively. Among Mali's eight regions, there are forty-nine *cercles* and 703 communes.

4.4 Results and discussion

4.4.1 Descriptive statistics

In Table 14, I summarize the milk sales for each quintile of the weighted sample. The top twenty percent of household milk sellers account for eighty-five percent of all sales, while the bottom twenty percent account for only one percent. This distribution of sales is quite concentrated. For example, Olwande et al. (2015) calculated that the top quintile of milk sellers in Kenya accounted for 59% of sales in 2010.

Table 14: Distribution of milk sales across quintiles, weighted

	Quintiles, based on annual household milk sales				
	1st	2nd	3rd	4th	5th
Mean household sales (L/year)	144	256	437	1,147	12,926
Share of total sales	1%	1%	3%	9%	85%

Table 15 reports summary statistics of the explanatory variables for the LSMS sample, and also disaggregates these statistics between milk market participants and non-participants. The average size of the local breed herd is less than eight cows for the entire sample, but it is twenty-two cows among the sub-sample of market participants. For both the sample and market participants, ownership of mixed-bred dairy cows is very low. There are reports that farmer adoption of cross-bred cattle is increasing in peri-urban Bamako, through artificial insemination programs, direct breeding of local herds with cross-bred bulls, and the direct importation of breed stocks (Government of Mali, 2017). However, this adoption does not appear to be widespread in Mali as a whole.

Table 15: Summary statistics

	Sample (N=717)				Non-participants (N=591)	Participants (N=126)
Variable	Mean	Std. Dev.	Min	Max	Mean	Mean
Household (HH)-specific explanatory variables						
No. local dairy cows	8.73	15.57	0.00	208.00	5.93	21.89
No. foreign dairy cows	0.27	1.46	0.00	22.00	0.24	0.40
% vaccinated	0.54	0.43	0.00	1.00	0.51	0.68
% treated for parasites	0.38	0.44	0.00	1.00	0.37	0.41
% treated for ticks	0.24	0.39	0.00	1.00	0.23	0.30
Water source	0.41	0.49	0.00	1.00	0.38	0.56
Oilseed cake	0.14	0.35	0.00	1.00	0.12	0.22
Trough	0.15	0.35	0.00	1.00	0.12	0.26
No. cell phones	2.16	2.34	0.00	15.00	2.14	2.26
No. radios	1.21	1.27	0.00	8.00	1.24	1.08
Transport	0.67	0.47	0.00	1.00	0.68	0.61
Ha. land	12.88	26.77	0.00	239.45	12.30	15.60
Nonfarm income, lagged	7,038.26	8,479.96	0.00	84,888.00	7,333.85	5,651.84
Nonfarm income	24,335.98	167,358.40	0.00	3,116,750.00	25,483.99	18,951.23
No. adult males	2.91	2.00	0.00	15.00	2.95	2.75
No. adult female	3.25	2.35	0.00	22.00	3.32	2.90
No. children	7.64	5.77	0.00	47.00	7.81	6.83
HH head gender	0.98	0.14	0.00	1.00	0.98	0.96
HH head Fulani	0.20	0.40	0.00	1.00	0.15	0.44
HH head yrs of edu.	0.72	2.42	0.00	16.00	0.73	0.67
Location-specific explanatory variables						
Milk price	440.81	126.15	133.29	1,225.00	435.89	463.93
Urban	0.03	0.16	0.00	1.00	0.03	0.02
No. collection centers	1.76	2.30	0.00	12.00	1.72	1.96
% electricity access	0.03	0.14	0.00	1.00	0.03	0.05
Dist. weekly market	11.83	11.83	0.00	130.00	11.87	11.69
Dist. daily market	38.13	33.00	0.00	200.00	36.86	44.06
Dist. training center	30.48	31.92	0.00	240.00	29.73	33.96
Dist. financial institution	50.43	53.65	0.00	600.00	48.34	60.21
Dist. motorable road	21.15	22.77	0.00	185.00	20.89	22.39
Average temperature	275.97	7.34	261.00	300.00	276.19	274.93
Annual rainfall	715.95	293.23	78.00	1,299.00	708.81	749.45
Semi-arid	0.80	0.40	0.00	1.00	0.79	0.85
Arid	0.15	0.35	0.00	1.00	0.15	0.10

Notes: HH refers to household

Adoption of other productivity-enhancing technologies is also quite low. However, the average household land holding is almost 13 hectares. Average nonfarm household income was about 24 million FCFA during the year covered by the survey, and 7 million FCFA in the preceding year. The average household size is almost 14 people, with about half of that number made up of children under the age of sixteen. Household heads are almost always male, and on average have less than one year of formal education. Twenty percent of producer households have a Fulani household head, but this share jumps to forty-four percent among market participants.

Turning to location-specific characteristics, only three percent of producer households live in areas classified as urban, and about the same share has access to electricity. On the other hand, 80% of producers live in the semi-arid zone. On average, producer households live about twelve kilometers (km) from a weekly market, thirty-eight km from a daily market, thirty km from a training center, fifty km from a financial institution, and twenty-one km from a motorable road. Sixty-seven percent of households report owning some mechanical or motor-driven means of transportation for accessing these infrastructures and institutions, while the remainder would presumably walk or else use public, borrowed, or animal-powered transport. On average, households live in a *cercle* with 1.76 milk collection centers; however, due to the nature of this data it was not possible to estimate distances to a collection center.

4.4.2 Econometric results

Table 16 presents results from the two stages of the Cragg model. I estimated each using robust standard errors. In order to facilitate interpretation of the MLE results of the probit regression, which is nonlinear, I compute the average partial effects (APE) of each explanatory variable on the probability of market entry.[34] I first fitted the 2nd stage with a truncated normal distribution; however, it was not sufficiently smooth to obtain MLE convergence. In the final model, in order to smooth out the distribution of the 2nd stage dependent variable, I fitted the data with a lognormal distribution. The results of the 2nd stage regression are already interpretable as conditional average partial effects (CAPE), representing the APE of each explanatory variables on the quantity of milk sold, conditioned on market entry. Further, because the dependent variable in the second stage is in logarithmic form, the estimated coefficients represent

[34] I estimate standard errors and derive significance for the APE statistics (from the probit model) and CAPE statistics (from the lognormal model) via the delta method.

elasticities for explanatory variables that are also in logarithmic form (i.e., income and price) and semi-elasticities for all others.

Lastly, I estimated the unconditional APE (UAPE) in order to understand the net effect of each explanatory variable. The UAPE is dependent on both stages of the estimation and, thus, represents an overall effect across the entire population of milk producers. For these reasons, it is a helpful summary statistic and is especially useful for policy analysis.[35]

To test for robustness, I also fitted the data with two alternative models. The first was a Tobit model with the same explanatory variables as the original model. The second was a Cragg model that included regional dummies as explanatory variables. The results, displayed in Appendix A, show that the sign and significance of the parameters estimated in the original model are largely robust to these alternative specifications, with only a few minor differences.

[35] To obtain UAPE standard errors, I followed Burke (2009)'s bootstrapping method using 100 replications. However, to use this method I had to fit the data with a truncated lognormal distribution in the 2nd stage. A comparison of the 2nd stage coefficient estimates using lognormal and truncated lognormal shows that they are the same in significance and in value up to at least two decimal places.

Table 16: Cragg model results and average partial effects

	Probit (1st Stage)						Lognormal (2nd Stage)			Net effects		
	Regression Results			APE			Regression Results / Conditional APE			Unconditional APE		
	Coef.	Robust SE		Coef.	SE		Coef.	Robust SE		Coef.	SE	
Household (HH)-specific explanatory variables												
No. local dairy cows	0.032	0.009	***	0.006	0.001	***	0.020	0.005	***	0.040	0.013	***
No. cross-bred dairy cows	0.039	0.032		0.007	0.006		-0.010	0.060		0.043	0.081	
% vaccinated	0.370	0.161	**	0.068	0.029	**	-1.173	0.390	***	0.223	0.204	
% treated for parasites	-0.140	0.173		-0.026	0.032		0.724	0.353	**	-0.035	0.237	
% treated for ticks	0.230	0.171		0.042	0.032		1.005	0.497	**	0.440	0.258	*
Water source	0.352	0.132	**	0.065	0.024	**	0.073	0.253		0.421	0.168	***
Oilseed cake	0.325	0.167	*	0.060	0.031	*	-0.763	0.327	**	0.243	0.194	
Trough	0.366	0.152	**	0.067	0.028	**	0.099	0.328		0.439	0.215	**
No. cell phones	0.042	0.033		0.008	0.006		-0.019	0.078		0.046	0.049	
No. radios	-0.091	0.074		-0.017	0.014		-0.206	0.112	*	-0.142	0.095	
Transport	-0.222	0.161		-0.041	0.030		0.395	0.290		-0.190	0.217	
Ha. land	0.004	0.002	*	0.001	0.000	*	-0.002	0.003		0.004	0.003	
Log (nonfarm income, lagged)	-0.045	0.039		-0.008	0.007		-0.037	0.072		-0.058	0.059	
Log (nonfarm income)	-0.021	0.035		-0.004	0.006		-0.180	0.090	**	-0.056	0.051	
No. adult males	-0.013	0.050		-0.002	0.009		0.162	0.138		0.014	0.079	
No. adult female	-0.002	0.048		0.000	0.009		-0.079	0.133		-0.017	0.074	
No. children	-0.019	0.021		-0.004	0.004		0.051	0.045		-0.013	0.030	
HH head gender	-0.765	0.418	*	-0.141	0.077	*	-1.215	0.556	**	-1.099	0.546	**
HH head fulani	0.697	0.146	***	0.128	0.028	***	0.097	0.290		0.821	0.197	***
HH head yrs of edu.	-0.013	0.031		-0.002	0.006		0.031	0.057		-0.010	0.046	
Location-specific explanatory variables												
Log (milk price)	0.603	0.231	***	0.111	0.042	***	0.207	0.522		0.737	0.287	***
Urban	-0.179	0.465		-0.033	0.085		2.201	1.630		0.171	0.838	
No. collection centers	0.008	0.032		0.002	0.006		0.012	0.052		0.016	0.032	
% electricity access	0.462	0.542		0.085	0.098		1.633	1.299		0.819	0.594	
Dist. weekly market	-0.004	0.007		-0.001	0.001		0.003	0.011		-0.005	0.010	
Dist. daily market	0.005	0.002	*	0.001	0.000	*	0.002	0.004		0.006	0.003	**
Dist. training center	0.001	0.002		0.000	0.000		-0.001	0.004		0.000	0.003	
Dist. financial institution	0.001	0.001		0.000	0.000		0.001	0.001		0.001	0.002	
Dist. motorable road	0.000	0.003		0.000	0.001		0.009	0.007		0.002	0.004	
Average temperature	-0.018	0.013		-0.003	0.002		-0.031	0.029		-0.026	0.018	
Annual rainfall	0.001	0.000		0.000	0.000		-0.002	0.001	**	0.000	0.001	
Semi-arid	1.086	0.525	**	0.200	0.098	**	-0.213	0.639		1.210	0.984	
Arid	0.986	0.634		0.182	0.117		-1.073	1.018		0.940	1.072	
Constant	-0.783	4.192					17.472	8.724				
Pseudo R-squared	0.286						0.4694					
Observations	717						126					

Notes: Dependent variable of the probit model is 1 if household sold milk and 0 otherwise.

Dependent variable of truncated normal model is liters of milk sold. ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively

First, the overall pattern of results confirms the hypothesis that each stage of market participation is driven by a different process: the signs and significance of almost all explanatory variables vary across the two equations. The two variables that represent exceptions—the number of local breed female cows and the gender of the household head—are discussed further below. Thus, the data justifies the use of a two-stage model as opposed to a one-stage Tobit. I also conducted a formal specification test of the Tobit model against the Cragg model, using a post-estimation likelihood ration test (Lin and Schmidt, 1984), which confirmed that the Cragg model is the better fit.

The number of female cows of local breed is positive and statistically significant in both stages. Across both stages and for the entire population of milk producers, the UAPE estimate indicates that the acquisition of one additional local breed cow increases milk sales by an average of 4%. However, the number of foreign or cross-bred cows is not a significant variable in either stage. This is surprising, given that every other market participation study that includes a similar variable finds the estimated coefficient to be significant and larger than the effect of local breed cows (Olwande et al., 2015; Balagtas et al., 2007; Holloway et al. 2005; 2000). The result may be due to the overall low level of adoption of cross-bred cows in Mali: in the sample, only 8% of households own such a cow, and only half of these own more than one.

Herd vaccination rates, use of oilseed cakes in feed rations, and access to a trough, to land and to a year-round natural water source each have a positive and significant effect on the probability of market participation. However, none of these variables positively influence milk sales once households enter the market; further, oilseed cakes and vaccination have a negative effect on volumes sold. The herd share that is treated for ticks and the share that is treated for internal parasites each have a positive and significant effect on volumes sold. Of these

productivity-enhancing resources and technologies, three have a net-positive effect (i.e. significant and positive UAPE) across the entire sample of milk producers. A one percent increase in the herd share that is treated for ticks, dry season access to a natural water source, and ownership of a trough are each associated with increases in milk sales of 4%, 42%, and 44%, respectively.

Surprisingly, the number of radios and nonfarm income have a negative effect on volumes sold for households that have entered the milk market. It could be that milk sales are a less-preferred means of income-generation compared to other livelihoods (including nonfarm activities) that are more accessible to wealthier households, and that the number of radios partially captures this wealth effect. The usefulness of a radio or cell phone in facilitating access to market or production information depends on the availability of such information, which may in fact be limited in Mali. For example, the Malian government does not currently monitor, publish, or report the market prices of milk, as it does for other agricultural commodities.

Other household characteristics that influence market participation are the gender and ethnicity of the household head. In additional to the number of local breed cows, the gender of the household head is the only other variable to have a significant positive effect on both stages of market participation. Female-headed households are 14% more likely to participate in milk markets and are associated with a 122% increase in milk sales, compared to male-headed households.[36] Overall, the UAPE estimate indicates that such households are associated with a 110% increase in milk sales. Household heads that are of Fulani ethnicity are also 13% more likely to participate in milk markets, compared to others, and the UAPE estimate indicates that Fulani households are associated with an 82% increase in milk sales.

[36] In the sample of 717 producer households, fifteen households had a female head.

Increases in the number of male, female, or children household members do not significantly influence market participation. I expected some ambiguity with respect to the net effect of the number of household adults, since more adults potentially means more household demand for milk (thereby reducing net surplus) as well as more labor (thereby potentially increasing milk output). However, the insignificance of the coefficient for children is surprising, assuming that these individuals only factor into the consumption aspect of household decision-making.

A 1% increase in the price of packaged milk is associated with an 11% increase in the probability of market participation. Although price does not have a significant effect in the second stage, its net effect on all producers (the UPAE) is a .7% increase in sales for every 1% increase in price, *ceteris paribus*. Although being located in an urban zone and community electrification shares are only statistically significant in the second stage at the 18% and 21% levels of confidence, respectively, their estimated effects are quite significant.

Surprisingly, none of the variables capturing access to market institutions or infrastructure are significant, with the exception of distance to a daily market. However, its estimated coefficient on the probability of market participation is positive. The UAPE estimate is also positive and significant, suggesting that, as a household's distance to a daily market increases by each additional kilometer, its milk sales also increase by an average of .6%, other factors held constant. It could be that a primary motivation for producing milk is to meet household milk demand, in which case it is the unconsumed surplus that is marketed. Access to daily markets could allow such households to outsource their milk supply, obviating the need to produce it themselves. If milk marketing is a less preferred means of earning income, compared to other activities that suddenly become more feasible with the presence of daily markets, it would strengthen this line of reasoning. The muted effects of access to a training center or financial

institution might be explained by the low quality of services offered by these institutions (or their limited relevance to milk producers), even if they are nearby. I might understand the lack of significance of access to a weekly market in light of the fact that milk producers require a more regular market outlet to sell daily output. If a large share of milk is sold at farmgate or at the homes of neighbors, this would further mute the effects of better access to markets, milk collection centers, or motorable roads.

Finally, households located in the semiarid agro-ecological zone—as opposed to arid or sub-humid—are 20% more likely to participate in milk markets. This indicator primarily characterizes the water availability conditions—and, by extension, vegetative conditions—that best supports rainfed dairy cattle production, i.e. an annual length of growing period of 70-180 days (Sebastian, 2016). This zone covers most of the southern half of Mali, including all regions except Gao, Kidal, and Timbuktu.

4.5 Conclusion

Substantial growth in the market supply of Malian milk will be necessary to meet the rising demand for dairy products, while also improving the livelihoods of milk producers and strengthening the competitiveness of the Malian dairy sector against imports. In this study, I have utilized a nationally-representative household dataset to investigate the factors that can encourage such growth. Following other recent papers that have focused on East Africa, I use a double-hurdle econometric model, which allows me to examine separately the probability and the value of milk market participation. Because this is the first study of its kind to analyze milk marketing in a major milk producing countries of West Africa, I expect the results to provide fresh policy insights for this region. In particular, four key findings emerge.

First, despite the great yield-enhancing potential of mixed-bred dairy cattle, the adoption of this technology has been extremely limited in Mali. So much so, that the variability of mixed-bred cattle ownership in the dataset appears insufficient to allow me to estimate the marginal effects. However, taking the statistically significant UAPE for the number of local breed cows as a rough lower-bound estimate of the marginal effect of each additional mixed bred animal, I can conclude that the impacts on market participation should indeed be substantial. The Malian government should continue to increase producer access to mixed-bred cattle.

Second, improvements to the health and nutrition of dairy herds also have great potential to improve market participation through increased productivity. The findings indicate that pest and disease control, access to zero-grazing technologies (such as feeding troughs), and to year-round water sources are especially key. Although the particular measure for improved feed did not have a significant net effect across both stages of market participation, the significant and positive effect of being located in semi-arid zone, which partly reflects grazing conditions, points to the importance of herd nutrition. Improving the availability of high-quality feed will be especially critical with the dissemination of mixed-bred cattle, which have more complex nutritional needs compared to local breeds.

Third, gender has great influence on a household's participation in milk markets. Assuming that the household head plays a primary role in the management of milk production and use, female decision-makers market more than twice the volumes of males, other factors held constant. This result, combined with the reality that women currently face unequitable access to productive resources, suggests that milk commercialization policies could make substantial gains by focusing on female producers. However, other research conducted in Mali has cautioned that

women may get displaced milk value chains as they modernize (Schneider et al., 2007). Overall, this finding highlights the importance of mainstreaming gender into any milk-related policies.

Fourth, the results provide evidence that Malian milk producers are responsive to price incentives, despite the considerable asset specificity and transaction costs that are present in milk marketing. This suggests that macroeconomic policies, such as stronger import duties that increase the domestic price of fresh milk relative to that of imported substitutes, should have a positive pull on milk supply. This result also underlines the importance of market price information. The Malian government should prioritize the inclusion of milk prices in its regular market monitoring and information products.

APPENDIX

APPENDIX

Table 17: Robustness checks: alternative Tobit and Cragg model specifications

	Alternative model #1: Tobit			Alternative model #2: Cragg with regional dummies					
	Regression Results			Probit (1st Stage) Regression Results			Lognormal (2nd Stage) Regression Results		
	Coef.	Robust SE		Coef.	Robust SE		Coef.	Robust SE	
Household (HH)-specific explanatory variables									
No. local dairy cows	0.156	0.041	***	0.032	0.009	***	0.019	0.004	***
No. foreign dairy cows	0.211	0.177		0.032	0.033		-0.027	0.053	
% vaccinated	1.753	1.127		0.379	0.166	**	-1.118	0.335	***
% treated for parasites	-0.255	1.171		-0.101	0.175		0.681	0.303	**
% treated for ticks	1.964	1.154	*	0.235	0.176		0.979	0.417	**
Water source	2.155	0.927	**	0.388	0.137	***	-0.051	0.232	
Oilseed cake	2.389	1.113	**	0.326	0.172	*	-0.698	0.269	***
Trough	1.993	1.007	**	0.418	0.156	***	0.108	0.281	
No. cell phones	0.163	0.232		0.044	0.034		-0.006	0.068	
No. radios	-0.656	0.490		-0.090	0.075		-0.242	0.102	**
Transport	-1.151	1.110		-0.189	0.170		0.465	0.268	*
Ha. land	0.021	0.013		0.003	0.002		-0.002	0.004	
Nonfarm income, lagged	-0.322	0.270		-0.040	0.038		-0.028	0.062	
Nonfarm income	-0.379	0.247		-0.027	0.035		-0.163	0.075	**
No. adult males	0.164	0.364		-0.008	0.049		0.115	0.115	
No. adult females	-0.031	0.342		-0.017	0.048		-0.056	0.106	
No. children	-0.091	0.131		-0.019	0.021		0.050	0.034	
HH head sex	-5.418	2.837	*	-0.833	0.427	*	-1.383	0.490	***
HH head fulani	4.933	0.949	***	0.747	0.148	***	-0.052	0.289	
HH head yrs of edu.	-0.117	0.221		-0.013	0.032		0.048	0.048	
Location-specific explanatory variables									
Milk price	4.403	1.623	***	0.602	0.239	**	-0.141	0.486	
Urban	-0.972	3.279		-0.155	0.471		2.085	1.339	
No. collection centers	0.064	0.215		0.017	0.033		-0.012	0.038	
% electricity access	5.370	3.228	*	0.340	0.565		1.559	1.109	
Dist. weekly market	-0.019	0.044		-0.005	0.007		0.004	0.010	
Dist. daily market	0.030	0.013	**	0.005	0.002	**	0.002	0.003	
Dist. training center	-0.001	0.015		0.001	0.002		0.000	0.003	
Dist. financial institution	0.007	0.007		0.001	0.001		0.000	0.001	
Dist. motorable road	0.014	0.021		0.000	0.003		0.007	0.006	
Average temperature	-0.119	0.091		-0.030	0.016	*	-0.003	0.029	
Annual rainfall	0.003	0.003		0.000	0.001		-0.002	0.001	***
Semi-arid	5.732	3.055	*	1.157	0.524	**	0.115	0.675	
Arid	4.738	3.965		1.219	0.695	*	-0.742	0.936	
Constant	-3.753	28.639		2.600	4.842		11.349	8.549	
Kayes				0.343	0.450		0.150	0.470	
Koulikoro				-0.135	0.464		0.017	0.576	
Sikasso				0.051	0.497		0.813	0.843	
Segou				0.139	0.480		0.086	0.659	
Mopti				-0.093	0.428		0.753	0.544	
Pseudo R-squared	0.127			0.292					
Observations	717			717			126		

Notes: Dependent variable of the probit model is 1 if household sold milk and 0 otherwise. Dependent variable of truncated normal model is liters of milk sold. ***, **, and * indicates *p<0.01, p<0.05, and p<0.1*, respectively. In Alternative model #2, three regional dummies (Tombouctou, Bamako, and Gao) were omitted due to multicollinearity.

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CHAPTER FIVE: CONCLUSIONS

This research has identified and analyzed key challenges that have constrained supply and demand along the Malian dairy value chain, with a focus on the urban markets of Bamako. Five key findings emerge, along with several implications for improving the competitiveness of the dairy value chain through new investments and enhanced policies.

First, this research has provided evidence that end-buyers prefer fresh milk to imported powdered milk. Bamako consumers are willing to pay a price premium of about fifty-five cents per liter for pasteurized milk that is made purely from fresh milk (a premium of almost twenty percent on the current price of the most popular dairy product), as opposed to reconstituted powdered milk. Even after disaggregating consumers into three preference-based classes, each class still has a higher WTP for 100% fresh milk than for 100% powdered milk. Very similar results hold for retailers. Given the current limited availability of fresh milk-based dairy products in Bamako, these findings point to an important market opportunity for fresh milk producers and processors.

However, in order to realize this potential demand, the fresh milk value chain must better differentiate its products from those made from powdered milk. The second set of findings shed light on promising sources of differentiation. One general opportunity is to provide more information to consumers. The clear and consistent labeling of milk ingredients is one upgrade that manufacturers should make, and a business practice that government should more effectively regulate. There is also a significant WTP among consumers and retailers for quality certification. Government-backed certification appears to be the preference, conditioned on better government enforcement and consumer recognition of this system. However, about two-thirds of consumers and retailers also have a significant WTP for private certification. Future

research should seek to understand the dairy quality issues that consumers and retailers care about most, in order to identify the attributes that should be verified. Although enhanced packaging remains an important source of differentiation, consumers tend to associate "traditional" (and low-quality) packaging with "traditional" fresh milk-based products. Thus, there is very limited demand for certain forms of enhanced packaging, such as plastic pouches and cardboard cartons. Because enhanced packaging remains an important source of differentiation—not to mention potential implications for protecting contents and reducing environmental waste—future research should seek to identify packaging upgrading options that are still effective in signaling the fresh milk contents of a product.

The third finding highlights another means for value chain actors to improve information flows between themselves and consumers, by working more closely with retailers. Not only are retailers another conduit for providing product information to consumers, this research has showed that they also have accurate knowledge of consumer preferences and can thus provide such information to upstream value chain partners. In terms of geographic placement and total commercial volumes, *boutiques* and *alimentations* currently have the widest distribution throughout Bamako. However, it is mostly large powdered milk processors that partner with these retail shops, perhaps partly because these retailers source dairy products through wholesalers, which implies a requisite scale that most fresh milk processors cannot meet. Alternatively, many fresh milk processors retail directly, from their own homes or through owned kiosks. Despite any advantages of being able to directly interact with consumers, the informality and resource-intensiveness of these retail formats constrain the scalability of fresh milk distribution in Bamako. The peri-urban fresh milk value chain should explore investments

(e.g., in logistical and organizational capacity) that enable it to compete in more common retail formats, even while continuing to distribute through specialized formats.

Fourth, if the fresh milk value chain is to reach greater scale in distribution then it must also improve the supply of fresh milk from producers. Policy should improve access to technologies, practices, and resources that improve productivity and animal health, including access to mixed-bred dairy cattle, veterinary care, nutritious feed, zero-grazing technologies, and year-round water sources. Not only should policy seek to increase the total supply, but it should also seek to smooth supply throughout the year and improve quality, as these outcomes would substantially reduce the transaction costs in procuring fresh milk. Given that female decision-makers market more than twice the volumes of males, but face unequitable access to productive resources, mainstreaming gender consideration into dairy policy should be a government priority.

Finally, despite the presence of market imperfections, all three studies have underlined the important role of price throughout the Malian dairy value chain. Currently, processors are discouraged from procuring fresh milk instead of powdered milk, due to its higher purchase price and transaction costs. This research has highlighted three levers that could influence the decision prices faced by processors, in favor of fresh milk. First, through the adoption of quality signaling mechanisms (e.g., clear ingredients labeling), processors could capture price premiums that Bamako consumers appear willing to pay for fresh milk-based products. Second, government policy (i.e., raising tariffs in dairy imports) could increase the relative price of powdered milk with respect to fresh milk. Third, policy and value chain investments that improve cattle productivity and/or reduce the transaction costs of marketing milk should increase the market supply of fresh milk; holding other factors constant (including demand), this would reduce fresh milk prices. Additional research should estimate the costs of implementing these measures and

investments, and their expected welfare impacts on various actors of the dairy value chain, including consumers and smallholders.