SMALLHOLDER MARKET PARTICIPATION AND WELFARE EFFECTS: EVIDENCE FROM THE KENYA DAIRY SECTOR

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ABSTRACT

The combination of increasing demand for food and improving food system market integration suggests that great opportunities may exist for a supply-side response amongst rural smallholder farmers, especially in Sub Saharan Africa, with its large gaps between existing and potential crop yields. With limited evidence, it is unclear how smallholders participate or if they benefit from participation in these new market opportunities. In this paper, these questions are examined in the context of dairy production and sales in Kenya. Analysis of welfare household asset dynamics highlights a strong association between high milk sales levels and improved welfare, but the causal direction is not evident. Qualitative findings suggest that more capable farmers with higher capacity to manage risks and make costly investments are the ones that are able to achieve and maintain high production and sales levels.

BIOGRAPHICAL SKETCH

Michael Mulford completed his undergraduate training in Engineering Science and Mechanics in 1998 (B.S.), graduating Summa Cum Laude from Virginia Polytechnic Institute and State University. Afterwards, he volunteered for two years (1999, 2000) working with students at the University of Zambia in Lusaka. From 2001-2005, Michael served as Disaster Response Program Officer with World Relief. During this time he received training (Health Emergencies in Large Populations course) from the Center for International Emergency, Disaster and Refugee Studies (CIEDRS) at Johns Hopkins Bloomberg School of Public Health. This was followed by work with Food for the Hungry, as Food Security Coordinator (2005-2007). Between 2007-2011, Michael served in the Democratic Republic of the Congo, first as Food for the Hungry's Program Director for South Kivu and Maniema Provinces (2007-2008) and subsequently as Country Director (2008-2011).

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Introduction

The rise of modern food systems in developing countries brings promise of new opportunities to address challenges of food insecurity and chronic poverty. Of particular interest are agricultural value chains (AVCs) that link production with processing, storage, marketing, distribution and consumption of agricultural products. Food systems modernization is a relatively new phenomenon particularly in Sub Saharan Africa (SSA), where many questions remain about the impact of these improvements in market integration on poverty and the environment. For policy makers interested in stimulating rural economic growth or reducing poverty in SSA, an important area of research concerns the degree to which smallholder farmers participate in and/or benefit from these new market opportunities.

Swelling populations, urbanization and income growth have all contributed to a rising demand for food across SSA. The fastest growing region in the world, SSA's population has more than tripled over the past 50 years, and is projected to grow to nearly 2 billion by 2025 (UN, 2011). The percentage of people living in urban areas increased from 11 to 36 percent since 1950, and is expected to reach 57 percent by 2050 (UN, 2012). On average, SSA countries weathered the global recession much better than other regions, with average 5.7 percent annual economic growth since 2004 (International Monetary Fund, 2012). In spite of this general trend of macroeconomic growth, food purchases still make up a dominant share of the average household budget, due in part to rising world food prices.

On the supply side, most SSA countries rely heavily on domestic production to meet their food needs. As a rich literature has described, investment in improved agricultural technologies holds the potential of unlocking the unique role of agriculture to drive pro-poor growth and economic development (Haggblade, Hammer, & Hazell, 1991; Johnston & Mellor, 1961). Until recently, policy makers have largely neglected the agricultural sector. This lack of investment and other factors have contributed to persistently low crop yields and limited use of improved technologies. For example, in contrast with its large arable land endowments, SSA currently accounts for less than 3% of global fertilizer use (FAO, 2008).

Food systems across the SSA region have been heavily influenced by government policies over the years. In the 1940-70s, governments sought to control food systems through mechanisms such as food price stabilization or parastatal marketing and monopsony pricing (Pinstrup-Andersen & Watson, 2011). This was followed by a radical shift, with the 'structural adjustment' programs of the 1980-90s that sought to dismantle these structures and liberalize markets - removing production subsidies and reducing tariff barriers. While these macro-level strategies often bypassed smallholder farmers, the focus has more recently shifted to micro-level and institutional policies (Barrett et al., 2011) that take smallholder farmer constraints into consideration. One example is Malawi's recent attempt to improve smallholder access to agricultural inputs through significant nationwide subsidy programs.

In spite of growing demand for agricultural products and some improved market conditions, smallholder farmers may be excluded from these opportunities for a number of reasons. Relatively low population densities and poor infrastructure in and across many SSA countries isolate smallholder farmers from markets and increase transaction costs for input and output markets, especially for those within land-locked countries (Sachs & Warner, 1997). In addition to physical remoteness, other factors, such as the behavior of marketing agents may be as or more important dimensions of market access

(Chamberlin & Jayne, 2013). Even where markets exist, biophysical constraints such as poor agro-climatic conditions or plot-level soil infertility can lead farmers to rationally opt out of yield-enhancing input markets (Marenya & Barrett, 2009).

Other idiosyncratic factors such as household labor constraints, education and experience, along with nonfinancial returns to adoption or technological externalities may also limit the uptake and continued adoption of improved agricultural technologies (Foster & Rosenzweig, 2010; Moser & Barrett, 2006). Limited access to credit or insurance can also be a significant constraint with the high risks and high stakes in food production typified by rain-fed agriculture. Smallholder farmers tend to be net buyers, and the inability to manage price and yield shocks and their compound effects can even lead to autarkic strategies (Barrett, 1996). Risk exposure related to insecure land or other property rights may also reduce the likelihood of smallholders participating in AVCs (Barrett et al., 2011).

The dynamic interactions of these and other exclusionary mechanisms with smallholder behaviors are likely influential in both causing and sustaining low-level production equilibriums and persistent poverty. Often referred to as poverty traps, these can be defined as 'any self-reinforcing mechanism which causes poverty to persist' (Azariadis & Stachurski, 2004). Selecting appropriate policies to spur on rural economic growth or reduce poverty hinges on correct identification of the structural causes that underpin these poverty traps, where they exist. While a fast-growing literature has sought to empirically identify their existence in different settings, more research is needed to better understand the underlying mechanisms and their dynamic interactions with farmer behaviors and the broader food systems (Barrett & Carter, 2013). For example, while there are early signs of improving market integration in SSA, it is unclear how smallholders participate or if they benefit from participating in new AVC opportunities (Gómez, Barrett, Buck, &

Groote, 2011). Smallholder access to AVCs is often limited, and the handful of empirical studies on the welfare effects of participation provides examples of both gains and losses to smallholder farmers (Barrett et al., 2011).

Contribution of research

Empirical studies examining welfare effects of modern AVC participation by smallholders have primarily used cross-sectional or short panels focused on flow-based welfare measures (Barrett et al., 2011). One contribution of this paper is the application of an asset-based approach (Michelson, 2013) to gain more insight into the welfare dynamics of smallholder farmers in relation to their participation in agricultural value chains over time. In particular, this paper will focus on the dynamic and growing dairy sector in Kenya using household panel survey data. A unique characteristic of dairy production in this setting is that milk supply comes predominantly from smallholder farmers in both informal and formal markets. While not suggesting any causal linkages, one goal of this research is to identify key farmer characteristics or behaviors associated with higher dynamic welfare paths and equilibrium by examining smallholder milk sale participation levels and patterns together with household welfare dynamics.

Background

In many countries around the world, economic growth has often coincided with diminishing rates of poverty (Ravallion, 2001). While country specific data is limited, the strong economic growth that has broadly characterized SSA economies over the past decade appears to also correspond with declining poverty rates. For the handful of SSA countries with national survey data, the percentage of people living under $1.25 per day has dropped from an average of 56% between 1981-2001 to 48% in 2008 (World Bank, 2013). In Kenya, the most recent national study suggests that poverty could be on a downward trend, falling from 57% in 1997 (1997 Welfare Monitoring Survey) to 46% in 2006 (Kenya Integrated Household Budget Survey, 2007).

Aggregate trends often conceal local disparities and within country variation of these measures is also important to distinguish and analyze. For example, an estimated two-thirds of the world's poor live in rural areas (Pinstrup-Andersen, Pandya-Lorch, & Rosegrant, 2001). In Kenya, rural poverty rates were 49% compared with 34% for urban areas in 2005/06. Several studies using rural household panel data in Kenya find that welfare levels have remained relatively static over the past decade (Radeny, Van den Berg, & Schipper, 2012). Looking at income, Suri et al. (2009) found that less than 1% of households transitioned from the bottom (or top) quintile to the highest (or lowest) quintile over the period 1997–2007, while 32% of households oscillated in and out of poverty over this time.

Working with the Stages-of-Progress approach, Kristjanson et al. (2012) found that 68% of households in their sample remained in the same poverty category between 1990-2005. Using an asset-based measure of welfare Burke et al. (2007) found that 57% of households in their sample remained at the same relative poverty level between 2004-07. Less than 6% of household moved between the top and bottom tercile. During the same period, 22% of households made small movements out of poverty, while 21% experienced some decline in welfare.

Using a first difference approach, Burke et al. (2007) found that entering the milk market and/or the livestock sales market were the only positive and statistically significant factors associated with those experiencing growing wealth over this period. These activities were also highly correlated with the probability of being non-poor, based on probit model analysis and controlling for factors exogenous to the household, such as geography and infrastructure. A brief overview of the recent history of dairy production and sales in Kenya sheds some light on the overall dynamics and trends that potentially contributed to these results.

Kenya Dairy

With an estimated annual per capita milk consumption of 145 liters, Kenya's milk demand is five times higher than neighboring East African countries. Dairy products also make up the largest share of food expenditure in Kenyan household budgets (Argwings-Kodhek, M'mboyi, Muyanga, & Gamba, 2005; Kaitibie, Omore, Rich, & Kristjanson, 2010). Amongst Eastern and Southern Africa countries, Kenya is also the largest producer, with over 70% of the region's dairy cattle (Muriuki, Mwangi, & Thorpe, 2001). Milk is supplied predominantly from an estimated 1.8 million smallholder dairy farmers (Smallholder Dairy Project, 2006).

A wide range of production systems often correspond spatially to differences in biophysical characteristics and population densities. For example, in lower-elevation areas with smaller population densities, free-grazing systems with indigenous or cross-bred cattle are more common. Typical herd sizes in this extensive system can reach up to 10 cattle or more (McDermott, Staal, Freeman, Herrero, & Van de Steeg, 2010). More intensified mixed farming systems are found in areas above 1,200 meters, where two rainy seasons prevail and can support year-round feed-production systems (Place et al., 2009).

High population density in these areas keeps farm sizes small, with average holdings of 0.9 – 2.0 hectares per household (Kibaara, Ariga, Olwande, & Jayne, 2008; Steven Staal & Nicholson, 1997). As a result, dairy systems are often characterized by stall-fed or semi-zero grazing, with average herd sizes between 1-5 cows. There is a much larger incidence of improved cattle breeds (cross-bred and/or exotic European cattle breeds) and more investment in animal feed, supplements and animal health. In these mixed farming systems, farmers commonly use manure as fertilizer for crop production and often grow animal fodder crops such as napier grass.

Family members are the main source of labor in dairy production. When employed[1] hired labor makes up a third of the labor contribution on average (Yamano, Otsuka, Place, & Kijima, 2005) for an estimated 365,000 farm level, dairy-related jobs (Baltenweck, Yamano, & Staal, 2011). From the first wave of household survey data used in this study, the total hours of labor are more or less the same across the different systems (grazing, semi-zero, and zero-grazing). A notable distinction is that zero-grazing systems require more physical and knowledge-based labor activities. While the reported labor allocation for these activities appear balanced between men and women, other sources cite underlying gender biases that generally prevent women from owning or making decisions about care or sale of the animals (Niamir-Fuller, 1994).

Milk marketing and sales patterns have been significantly influenced by Kenyan government policies over the years. In the early 1990s, the dairy sector was liberalized and this marked the end of state-managed, Kenya Cooperative Creameries' (KCC) monopoly on milk processing and urban milk sales. Since then, more than thirty private processors entered the market, with three processors – Brookside Dairy Limited, New KCC and Githunguri Dairy Farmers Cooperative and Processors - accounting for over 80% of the formal market (Wambugu, Kirimi, & Opiyo, 2011). The largest of these, Brookside Dairy Limited, has a capacity to process 800,000 liters per day, and sources its

[1] 50-70% of all smallholder dairy farmers employ full-time labor
[2] Less than 2 percent of their milk is supplied by commercial dairy farmers (4,000-5,000 liters/day/farm).

milk from more than 185,000 smallholder farmers[2]. The liberalization also removed a raw milk sales ban that led to the rapid growth in small-scale milk trading, estimated to make up 86% of milk sales (Omore, Muriuki, Kenyanjui, Owango, & Staal, 1999).

Tension between private-sector processors and informal traders culminated in the ‘milk wars’ of 2003 with media campaigns that sought to influence public opinion and policy with regard to health concerns around informal milk sales (Amos Omore & Baker, 2007). Actors[3] advocating for mechanisms to bridge the informal milk market regulatory gap contested this campaign and provided evidence to counter the unsubstantiated health concerns. Policy changes in 2004 provided official recognition for small scale milk vendors, leading to further growth in milk sales and benefits for small-scale producers, traders and consumers alike (Kaitibie et al., 2010).

Related trends during this period include increasing household investment in improved dairy practices and rising productivity levels. Kibaara et al. (2008) observed a 28% increase in the number of improved dairy cows (cross or pure bred) and an increase of households growing fodder from 16% in 1997 to 53% in 2007. Baltenweck et al. (2011) show that agro-climatic factors are among the most significant influences on (non)adoption of improved dairy practices over time. This is illustrated by Kibaara et al. (2008), where the proportion of households growing fodder in the better suited central and western highlands increased from 40% to 94% and 19% to 92%, respectively during the same period. Over the past 15 years, the overall impact of fodder shrub adoption by farmers in the Kenyan highlands is estimated to be between US$19.7 to $29.6 million in terms of additional net income from milk sales (Place et al., 2009). National annual milk

[2] Less than 2 percent of their milk is supplied by commercial dairy farmers (4,000-5,000 liters/day/farm).
[3] Smallholder Dairy Project (SDP) and its civil society organization partners, Institute of Policy Analysis and Research (IPAR), ActionAid Kenya, Intermediate Technology Development Group (ITDG) East Africa and Strengthening Informal Sector Training and Enterprises (SITE)

productivity rates increased from 1,164 liters/cow to 1,371 liters/cow between 1997-2007, with the highest rates found in the central highlands (1,991 liters/cow).

Notwithstanding this recent productivity growth, Kenya's yields remain below international standards, compared with average yields between 2,500 and 3,500 liters/cow in South Africa and Argentina (Technoserve, 2008), and 9,500 liters/cow in the United States. Evidence shows that genetic improvement and improved feed regimes can lead to gains of 60% to 300% in milk productivity (McDermott et al., 2010). In terms of animal genetics, the Kenyan government heavily subsidized AI services and supplied veterinary services and medicines at nominal charges in the post-independence years (Ngigi, 2004). While expensive, this strategy resulted in widespread adoption of improved cattle breeds. Starting in 1988, the government gradually withdrew these subsidies and services. Where available, existing AI services usually offer semen from bulls that have not been appropriately selected, have high delivery charges and achieve low conception rates (McDermott et al., 2010).

A second constraint to improving productivity is the scarcity and low quality of feed resources. Concentrates are often expensive or not regularly available, and low quality crop residues make up the bulk of feed resources. This, in turn, leads to cyclical production patters that are heavily dependent on rainfall, and related crop and fodder production. Crop breeding to improve digestibility and palatability of staple crop residues is seen as one option for partially overcoming this constraint (McDermott et al., 2010). High-protein feed legumes offer another less expensive alternative to concentrates. Place et al. (2009) found a smaller, but still significant productivity ratio of .66, or an additional .66 kg of milk per 1 kg of shrubs as compared to a productivity ratio of 1.36 for concentrate.

Rural mixed-farming households derive multiple benefits from dairy, including nutritional benefits from own consumption and crop productivity benefits from manure. One to two-thirds of households sell their milk, and in the most productive highland zones, the household income share of milk sales can range between 20-50% (Yamano et al., 2005). Unlike other agriculture-related income sources, this revenue can be obtained on a daily (through informal sales) or monthly basis (through sales to co-ops or directly to private processors). Livestock are also an important source of wealth and asset storage, providing savings or insurance mechanisms for rural smallholder farmers.

Multiple milk sales options are often available to these farmers, each with its own advantages and disadvantages. A non-price related advantage of selling via the informal market is the ability to receive immediate cash as opposed to an end-of-month payment. Comparatively, co-operatives and private processors provide demand and price stability via contract mechanisms. These co-operatives or milk aggregators often also provide 'check-off' services, whereby farmers can purchase inputs or dairy-related services on credit. Seasonal price fluctuations are often one of the factors that often cause famers to move between formal and informal markets.

The Kenya dairy sector has benefited from the interest and support of a number of donor-funded, multi-year interventions seeking to improve the productivity, marketing and policy environment for smallholder dairy farmers. These interventions include: the UK Department for International Development (DFID) funded Smallholder Dairy Project, jointly implemented by the Ministry of Livestock Development (MoLD), the Kenya Agricultural Research Institute (KARI) and the International Livestock Research Institute (ILRI); the USAID (United States Agency for International Development) funded Kenya Dairy Sector Competitiveness Program (KDSCP) implemented by Land O'Lakes, Inc.; IFAD funded Smallholder Dairy Commercialization Program (SDCP) implemented by the Ministry of Livestock Development; Bill and Melinda Gates Foundation funded East African Dairy Development (EADD) Program, implemented by the Heifer Project International, TechnoServe and ILRI; and, the Kenya Dairy Project (KDP) funded by private donors and implemented by Technoserve and other partners (Land O'Lakes, 2008).

Data and Descriptive Statistics

Data from a household panel survey (2000, 2004, 2007) conducted in western and central Kenya form the basis for this research. The western and central provinces (Central, Nairobi area, Nyanza, Rift Valley and Western) are home to over two thirds of Kenya's population, primarily clustered around the agriculturally productive highlands and western areas around Lake Victoria. The agro-ecological zones most favorable for dairy production are located within these provinces. In an effort to characterize smallholder dairy systems, a collaborative team from the Ministry of Livestock Development & Fisheries, the Kenya Agricultural Research Institute (KARI), and the International Livestock Research Institute (ILRI) collected the first round of data between 1998 and 2000.

Within the western and central regions, prospective study districts were grouped according to agro-ecological production potential (high or medium) and market access (high, medium, or low). Two sub-locations were chosen from within one or two districts that combined the different groupings (agro-ecological and market access). Sample sizes were weighted by household estimates extrapolated from the 1989 census figures. Households were selected according to a random sampling procedure using transects between randomly selected landmarks in each sample community (Staal & Baltenweck, 2002). The survey collected a wide variety of data on household assets, land use, livestock inventory and management practices, and the use of livestock and extension services.

In 2004, 894 of the initial 2,966 ILRI-selected households were surveyed in two waves. The National Graduate Institute for Policy Studies (GRIPS) conducted these surveys in collaboration with Tegemeo Institute of Egerton University, the World Agroforestry Centre (ICRAF), and ILRI. This research was part of a multi-country project called the Research on Poverty, Environment, and Agricultural Technology (RePEAT), with similar surveys conducted in Ethiopia and Uganda. Ninety-nine sub-locations were randomly selected from the ILRI survey, and 10 previously-surveyed households were randomly selected within each sub-location. The two waves were conducted in February and October 2004, asking respondents about the previous six months (August 2003 - January 2004 & February 2004 – July 2004). Due to budget constraints, the number of sub-locations was reduced to 76 for a 2007 wave, and 725 out of the targeted 777 households in the 76 sub-locations were re-interviewed (6.7% attrition rate).

Table 1 provides a description of some of the selected household variables, along with summary statistics for both the 2004 and 2007 surveys. Average household-level daily milk sales were calculated from survey data on morning and evening milk sales in high and low-sale milk periods. The household reported number of months of high, low or no milk sales were combined with data on morning and evening milk sale amounts for these periods to estimate annual milk sale levels. For ease of comparison, these are reported in average daily milk sales levels per household, and grouped into the following categories: high milk sales (>20 l/day/hh), medium milk sales (10-20 l/day/hh), low milk sales (>0 –

10 l/day/hh), and no milk sales. Table 2 provides the means of the data for households within each of these categories for both the 2004[4] and 2007 survey periods.

[4] Data from the two 6-month surveys was combined to establish the annual estimates for 2004

		2004		2007	
Variable	Description	Mean	Stand. Dev.	Mean	Stand. Dev.
Education, years	Number of years of education of the head of household	6.74	4.73	6.89	4.68
HS Education, %	Percentage of household heads with a high school education equivalent	24%	6%	24%	4%
Owned land, ha	Hectares of land owned (both titled and owned but not titled land)	4.46	6.97	4.65	7.16
Local Cows	Number of local cows owned	0.42	1.84	0.36	1.21
Improved Cows	Number of improved cows owned	1.01	1.47	0.94	1.23
AI, 1,000 KES	Total annual expenditure on AI services, 1,000 Kenyan Shillings	25%	92%	27%	77%
Concentrates %	Percentage of farmers feeding any dairy feed concentrates	31%	23%		
Feed 1,000 KES	Total annual expenditure on concentrate, 1,000 Kenyan Shillings			3	6.92
Growing napier, %	Percentage of farmers growing napier grass	30%	51%	45%	50%
Tick, 1,000 KES	Total annual expenditure on tick services, 1,000 Kenyan Shillings	1.01	1.51	0.91	3.22
Health, 1,000 KES	Total annual expenditure on health services, 1,000 Kenyan Shillings	0.98	1.67	0.73	1.11
Productivity, l/c/d	Milk productivity, liters per cow per day	5.87	7.18	6.44	7.37

Table 1. Variable description and summary household statistics

Year	2004				2007			
Milk sales category	None	Low	Med	High	None	Low	Med	High
N	320	271	81	45	298	251	95	74
Education, years	6.37	6.74	6.95	8.93	6.71	6.75	6.85	8.09
HS Education, %	23%	21%	25%	49%	26%	21%	20%	32%
Owned land, ha	4.03	4.54	4.79	6.43	4.29	4.39	5.74	5.55
Local Cows	0.43	0.58	0.02	0.02	0.47	0.38	0.17	0.09
Improved Cows	0.27	1.17	1.98	3.58	0.21	0.98	1.82	2.62
AI, 1,000 KES	0.04	0.19	0.40	1.89	0.04	0.21	0.42	1.19
Concentrates, %	8%	39%	65%	76%				
Concentrates, 1,000 KES					0.38	2.10	6.09	12.62
Growing napier, %	23%	29%	36%	72%	31%	51%	57%	66%
Tick, 1,000 KES	0.45	1.21	1.57	2.77	0.42	1.16	1.07	1.83
Health, 1,000 KES	0.43	1.14	1.42	3.14	0.38	0.77	1.03	1.64
Productivity, l/c/d	0.51	7.18	15.33	19.05	0.71	6.82	13.93	18.65

Table 2. Summary household statistics across different milk sales categories and years

From Table 2, the ownership and the number of improved dairy cows corresponds strongly with increasing average daily milk sales. In 2004, 92% of households in the low sales category had between 0-2 improved cows; 91% of medium sales households had 1-3 improved cows, and 89% of high sales households had three or more improved cows. The difference in hectares of owned land is only statistically significantly different between households in the high sale category and the no milk sale category for 2004. Staal and Baltenweck (2002) find a low association between land size and use of improved dairy practices that leads them to conclude that dairy production 'appears to be an enterprise open for even those with very small landholdings.' Later, Baltenweck et al. (2011) provide a caveat that larger land-holdings may be associated with households that are able to continuously adopt improved dairy practices over time.

In terms of feeding characteristics, 76 and 72 percent of households in the high sales category fed concentrate and grew napier grass, respectively, in 2004. This compares to 29 and 39 percent, respectively, in the low sales category for the same period. In 2007, Table 2 lists the average amount spent on purchased feed (concentrates, salt, etc.) over the year in Kenyan shillings (1,000 KES). It is clear that households in the higher sale categories have invested more in feed and the difference in means are statistically significant. Similar patterns can be observed for the amount spent on AI, tick control, or health services (veterinary, medicine, vaccine, or advisory services) for each of these categories (listed in terms of 1,000 Kenyan shillings).

As expected, the use of higher-grade dairy cows, together with improved dairy practices and other factors also corresponds with higher per-cow productivity estimates. These productivity rates were calculated by dividing the total average daily milk production amounts by the number of cows that produced any milk during this period per household.

The distribution of estimated productivity rates for each of the different sales categories is displayed in Figure 1.

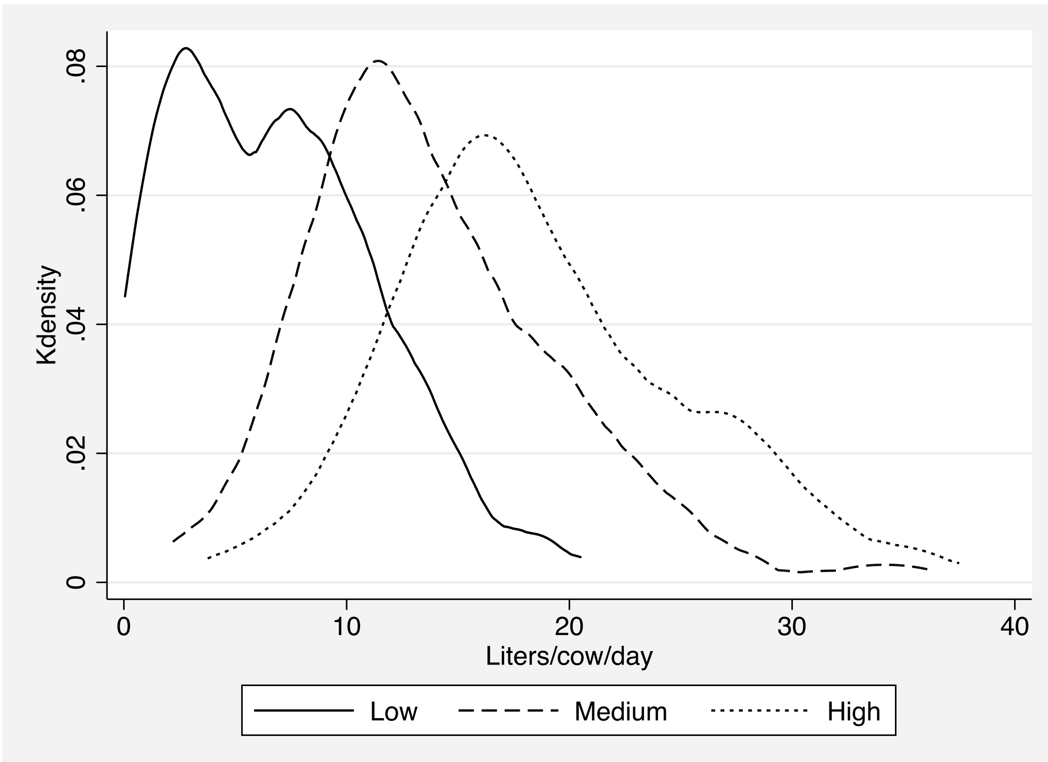

Figure 1. Productivity rate (Liters/cow/day) distributions for each of the different sales categories (low, medium and high) in 2007

Lastly, it is interesting to note from these summary statistics that the average number of years of education of the household head is nearly identical for all of the categories apart from the high sales category. The difference between the average for the high sales category and nearly all of the other categories is statistically significant for both 2004 and 2007. As a further comparison, the percentage of household heads that have completed twelve years of education is listed.

Methods

Quantitative data analysis was performed using the aforementioned panel data, including asset-based welfare dynamics analysis. Findings were compared with results from similar panel studies performed in rural Kenya during the same period. Structured and semi-structured interviews with private large-scale dairy processors, co-operatives or hub-level LLCs, service providers such as agro-vets, research institutes, NGOs, donors, and individual dairy farmers took place during the first half of 2013 in Nairobi, Eldoret and rural locations in Western Kenya. These qualitative findings were used to complement the quantitative analysis, and provide a more nuanced and comprehensive picture of the observed choices and production and marketing behaviors of smallholder farmers in this context.

Household level milk sales data was used to investigate marketing patterns and correlations with asset-based welfare dynamics of smallholder dairy producers over time. As described earlier, a growing number of milk-marketing channels often offer producers a variety of options for selling their milk. Farmers may choose to sell milk to individuals, small-scale traders, local retail outlets, co-operatives, or private processors. At any given time, producers may sell through multiple market outlets. In this data for example, we find that producers may sell morning milk to a private processor or co-op, and evening milk to individuals. The principal buyer for household milk sales also varies significantly across seasons, as well as between years in this data.

Welfare dynamic analysis

As a snapshot of the percentage of people living below an identified poverty line, national poverty rates are a static measure of poverty derived from cross-sectional household surveys. Panel data, in which individual households are tracked over time, provide the possibility of observing who is consistently poor or non-poor, and which households transition between these categories over time. For households that transition either into or out of poverty, it is difficult to discern whether this was merely a temporary jump due to an unlucky or lucky event, or a transition based on changes in the fundamental characteristics of the household. For this reason, Carter and Barrett (2006) propose a household asset, stock-based approach to complement traditional flow-based measures of expenditure and income in attempting to better understand poverty dynamics.

There are both theoretical and practical advantages to using asset-based approaches over money-metric measures in welfare analysis. The ownership or level of assets provides a good indication not only of a household's current welfare, but also of future expected welfare. In this sense, one can partially distinguish the underlying structural elements of household welfare from the more stochastic dimensions of income. From a practical perspective, it is often more difficult to obtain reliable income or expenditure data from household surveys as compared to information on assets. Income or expenditure recall questions are more susceptible to measurement error, seasonality, unreliable reportage, and framing bias. Intertemporal comparisons of money-metric welfare measures are also limited by the precision of deflators and weaknesses of consumer price indices (Kanbur & Grootaert, 1994). One challenge with the asset-based approach is the question of how to compare a wide variety of potential household assets.

A household asset index provides one way of combining different household stocks with unrelated units into a single measure for comparison across households. Different methods are often used to reduce this multidimensionality of a household's asset portfolio, and Michelson, Muñiz, and DeRosa, (2013) provides a comparison of the effects of choosing one asset index over another. Perhaps not surprisingly, they find that while estimations of poverty rates and transitions are largely consistent across indices, some of the welfare analysis results clearly depend on the choice and construction of the asset index (Michelson et al., 2013).

One of the potentially more transparent methods is the factor analysis approach introduced by Sahn and Stifel (2000) to capture a latent 'wealth' variable common to most assets. Based on an underlying linear relationship assumption, the factor analysis defines this latent factor as a weighted sum of individual assets. For the purposes of this research, selected assets include physical assets (land, livestock, TV, radio, etc.) and one element related to human capital (years of education of the household head).

Similar to Barrett et al. (2006), data was pooled across sample periods in order to compute factor weights consistent across periods, with period-specific dummy variables accounting for temporal changes. Household and period specific asset indices were computed from the resulting factor weights and used to analyze welfare dynamics in this unitless asset space. A two-period representation of asset dynamics can then be visualized by plotting the household-specific asset index levels on the vertical axis against their time-lagged values on the horizontal axis.

Allowing for the possibility of non-linear asset accumulation patterns requires more flexible functional forms than standard linear regression methods. One approach is to model the auto-regressive asset relationship non-parametrically. There are many non-parametric options including local polynomial regression, nearest-neighbor smoothing, and penalized spline regressions. Local polynomial regression uses weighted averages of observations that fall within a specified range around each point. Locally weighted scatterplot smoothing (LOESS) uses weighted least squares on subsets defined from a nearest-neighbor algorithm. Penalized spline regressions select the optimal degree of smoothing from the data using restricted maximum likelihood. As each of these methods have pre-programmed functions in statistical software packages, it is possible to compare and test the robustness of the results across different non-parametric regression options.

Neoclassical economic theory, that assumes decreasing marginal returns to scale, predicts that poorer households, countries, etc. will eventually converge to their richer counterparts over time. Empirical evidence instead suggests “divergence, big time” (Pritchett, 1997), and a rich literature based on micro-level longitudinal data demonstrates the existence of persistent, low-level dynamic equilibrium, or poverty traps. These can result from locally increasing returns to scale caused by exclusionary mechanisms that prevent poor households from engaging in more profitable income generating opportunities, or due to the nature of the underlying income generating process itself and related minimum investment levels (Carter & Barrett, 2006).

There are many challenges to the empirical identification of these multiple or single equilibrium poverty traps. This is in part due to the fact that different exclusionary mechanisms can simultaneously be at play at different scales, and can lead to the coexistence of multiple single equilibrium, or multiple equilibrium within a single economy. As a result, some households may face a single non-poor equilibrium outcome, some a single poor equilibrium outcome, and others multiple equilibria, with outcomes dependent on initial endowments and periodic shocks (Barrett & Carter, 2013). Barrett and Carter highlight a number of other empirical identification issues, and alternatively recommend an indirect approach of testing for behaviors that would only be rational in the presence of one or more poverty trap mechanisms. Following this caution, the welfare analysis presented here will draw strongly from the asset-based approach, but stop short of attempting to fully identify dynamic equilibrium and their underlying causal mechanisms.

Results

Average household daily milk sales volumes were regressed on the variables described in Table 1 for both 2004 and 2007 and the results are presented in Table 3 below. One additional variable for years of experience with dairy farming was added, but the coefficient was not significant in any of the regressions. As expected, the number of improved cows owned, and the amount invested in feed concentrates and artificial insemination are strongly correlated with milk sales volumes in both 2004 and 2007. The coefficient on concentrate feeding is associated with a dummy variable for households in 2004 providing any concentrate, and for the amount of Kenyan shillings (1,000 KES) invested in concentrate feed for 2007. These findings correspond with previous research in this area and qualitative information gleaned from key stakeholders in Kenya dairy in January 2013[5].

Columns three and four of Table 3 display regression results with district-level dummy variables included. Some of the largest, significant coefficients are associated with districts that are both in favorable climatic zones and relatively close to Nairobi markets (Nyandura, Kiambu and Nakuru). The original variable coefficients remain consistent, with the number of improved cows, concentrate feed, and AI investments remaining strongly correlated with average daily milk sales for both years. It is also interesting that growing napier grass or expenditures on health have no statistically significant correlation with the average daily milk sales for either year.

[5] Including Isabelle Baltenweck (ILRI), Mary Munene (Land O'Lakes), David Heath (Brookside Dairy)

Years	Average Daily Milk Sales 2004	2007	Average Daily Milk Sales 2004	2007
Improved Cows	2.35***	4.30***	2.42***	3.96***
Local Cows	-0.027	0.27	0.13	0.56*
Owned land	-0.024	-0.066	-0.041	-0.075
Growing napier	-0.21	0.14	0.26	0.96
Feeding concentrate	2.92***	0.53***	2.39***	0.52***
AI	4.82***	3.59***	4.60***	3.56***
Tick	0.62	-0.44***	0.66*	-0.43***
Health	0.29	0.61	0.18	0.47
Dairy Experience	0.011	-0.0089	0.0048	-0.012
Education, years	0.086*	-0.0018	0.11**	0.0011
Districts				
kisii			0	0
nyamira			0.24	0.57
rachuonyo			2.30***	2.14**
vihiga			1.83**	0.83
bungoma			2.37**	1.83*
kakamega			2.01***	2.41***
nakuru			4.34***	5.15***
narok			0.91	1.51
nandi			-0.43	3.59**
kirinyaga			1.61*	2.21**
muranga			1.17	1.77*
maragua			1.59	2.16*
kiambu			4.60***	3.88***
nyandarua			6.34***	6.42***
Constant	-0.60	0.56	-3.17***	-2.27**
Observations	717	718	717	717
R-squared	0.607	0.625	0.644	0.646

Table 3. Average household-level daily milk sales regression results

Welfare dynamics results

In Table 4, the variables, variable descriptions and factor analysis results are listed. The negative factors corresponding with ownership of local breed varieties of various livestock, as compared to the positive factors related to ownership of improved varieties is in line with the qualitative results about improved breed ownership and underlying wealth characteristics.

Variable	Factor	Variable Description
tractor	0.216	Number of tractors owned
trailer	0.201	Number of trailers owned
vehicle	0.407	Number of vehicles owned
cart	0.180	Number of carts owned
donkey	0.064	Number of donkeys owned
wheelbarrow	0.465	Number of wheelbarrows owned
borehole	0.354	Number of boreholes owned
cutter	0.292	Number of cutters owned
spraypump	0.591	Number of spray pumps owned
dieselpump	0.246	Number of diesel pumps owned
watertank	0.453	Number of water tanks owned
motorcycle	0.146	Number of motorcycles owned
bicycle	0.226	Number of bicycles owned
radio	0.332	Number of radios owned
carbattery	0.477	Number of car batteries owned
tv	0.613	Number of TVs owned
mobile	0.494	Number of mobile phones owned
solar	0.386	Number of solar panels owned
churn	0.459	Number of milking churns owned
landT2	-0.237	Dummy variable for landholding <= 2 hectares
landT5	0.041	Dummy variable for landholding > 2 and <= 5 hectares
landT55	0.236	Dummy variable for landholding > 5 hectares
cow_l	-0.454	Dummy variable for owning local cow(s)
cow_i	0.662	Dummy variable for owning improved cow(s)
bull_l	-0.262	Dummy variable for owning local bull(s)
bull_i	0.299	Dummy variable for owning improved bull(s)
ybull_l	-0.250	Dummy variable for owning local young bull(s)
ybull_i	0.339	Dummy variable for owning improved young bull(s)
heif_l	-0.335	Dummy variable for owning local heifer(s)
heif_i	0.432	Dummy variable for owning improved heifer(s)
calf_l	-0.414	Dummy variable for owning local calf(s)
calf_i	0.565	Dummy variable for owning improved calf(s)
goat_l	-0.185	Dummy variable for owning local goat(s)
goat_i	0.080	Dummy variable for owning improved goat(s)
sheep	0.273	Dummy variable for owning sheep
chicken12	-0.176	Dummy variable for owning 12 or fewer chickens
chicken13	0.233	Dummy variable for owning more than 12 chickens
eduhead6	-0.091	Dummy variable for household head having finished lower primary school
eduhead12	0.324	Dummy variable for household head completing secondary school
y2004	-0.062	Dummy variable for period-specific weighting - 2004
y2007	0.062	Dummy variable for period-specific weighting - 2007

Table 4. Factor analysis results

Figure 2 plots the household-specific asset index on the vertical axis against its time-lagged value on the horizontal axis (2007 & 2004). The pattern of scatter around the 45°

line suggests a low level of asset mobility which is consistent with the overall economic stasis found by other rural poverty studies over this same period.

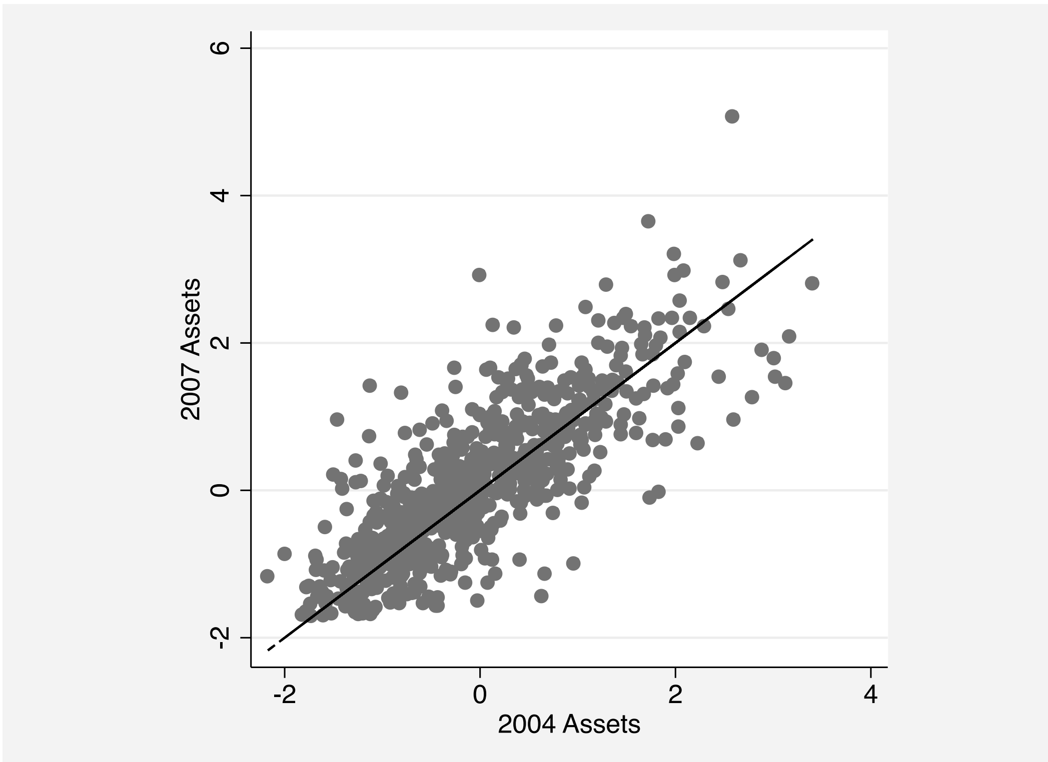

Figure 2. Scatterplot of asset index against lagged asset index (2007 & 2004).

In our case, the results are generally similar. As an example, Figure 3 plots the LOESS and penalized spline curves for household assets between 2007 and 2004. Dynamic equilibrium are hypothesized to exist where the curve crosses the 45 degree line, with the possibility of stable and unstable equilibrium under multiple equilibrium conditions. When plotted with the 95 degree confidence intervals, a large portion of these curves are not statistically different from the 45 degree line. These results are similar to the random walk type findings of Nashold (2012), where in expectation, households will remain at their current welfare level over time. This general observation remained consistent across a number of dimensions, including tests for geographic location, household composition, access to credit, etc. and implies that there is no expected escape from poverty for the poor.

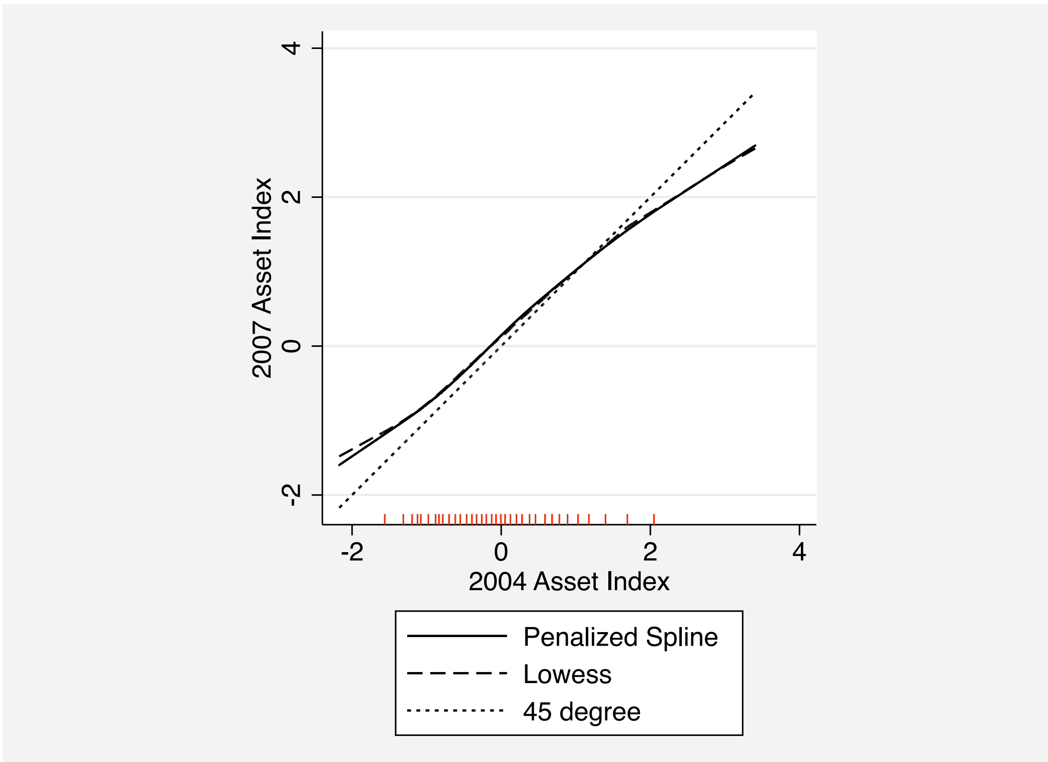

Figure 3. Penalized Spline and LOESS non-parametric comparison.

Figure 4 retains the LOESS plot for all of the data, and compares this with the penalized spline non-parametric regression of the asset / lagged assets for households who were in the low, medium and high sales levels respectively in 2007. The low sales non-parametric curve closely follows the 45 degree line and suggests a pattern of economic stasis similar to the overall population. The medium sales non-parametric regression curve suggests a possible single dynamic equilibrium, but when compared with different non-parametric regression methods, the confidence intervals often overlap with the overall population non-parametric regression curve. The only case with significant deviation from this pattern is the high sales non-parametric curve. This appears to suggest a single high-level equilibrium is possible for households that are involved in high levels of milk sales.

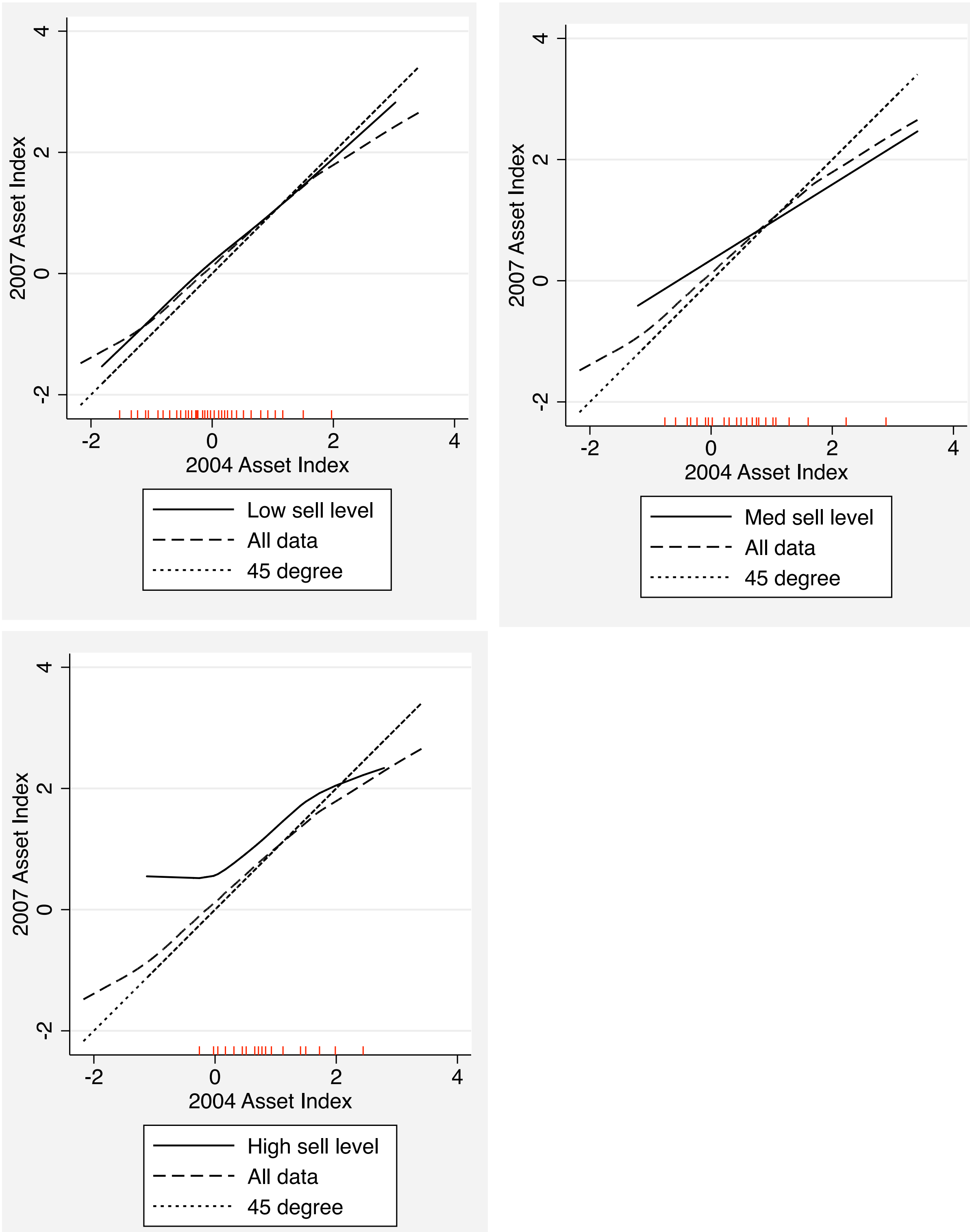

Figure 4. Non-parametric regression comparisons using penalized splines for low, medium and high sales households in 2007.

Following the Post-Election Violence (PEV) in 2007/2008, an additional survey wave was conducted with 295 households in Rift Valley and Nyanza Provinces. This subsample was selected based on the perception of which areas were more affected by PEV-related events. The only district that was fully re-sampled was Nakuru, one of high-potential districts nearby to Nairobi. While this is a limited comparison group, the asset-based information was used to compare 138 of the 144 households surveyed in Nakuru in 2007. Similar to the analysis above, data from the different sales categories (low, medium and high) were compared with the overall data in this dynamic two-period visualization for 2009 and 2007. In Figure 5, the non-parametric regression for the high sales data points to a higher dynamic equilibrium for households in this category, while the other sales categories resemble the lower dynamic equilibrium of the overall data.

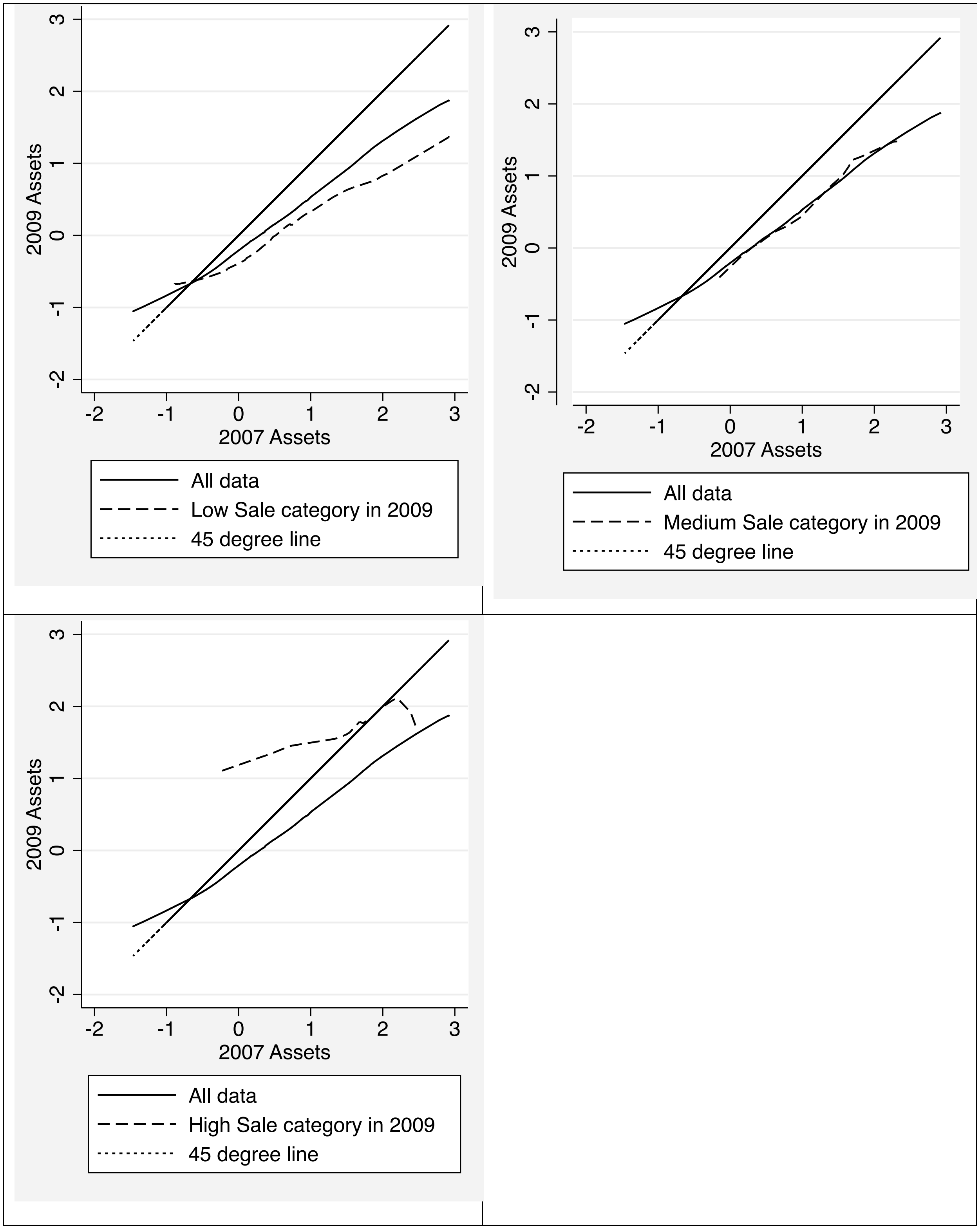

Figure 5. Non-parametric regression comparisons using penalized splines for low, medium and high sales households in 2009 in Nakuru district.

Qualitative findings

A common response to the question of why a household is involved in dairy production is: "…because my father, my grandfather, and his father before him have always kept cows." As in many other societies, there are strong traditions associated with the ownership of cattle, including dairy cows, in Kenya. The societal pressure to continue with family and cultural traditions is often cited as a reason that farmers are reluctant to take up improved dairy practices. For example, there is a strong symbolic status and value of cattle associated with marriage engagement negotiations between two families. While an improved dairy production strategy may be to limit herd size and invest more in genetic improvements and feeding of fewer cows, this could be difficult for families that are anticipating multiple dowry payment transactions on behalf of their sons. For families receiving cattle dowry payments, it would be deemed culturally inappropriate to later cull or sell these particular cattle in order to invest in fewer, improved breed cows.

In rural areas that are underserved by formal or informal savings or insurance mechanisms, cattle often play an important savings/insurance role, as one of the largest fungible assets that families own. Households may sell one or more cows to support large, unexpected expenses, such as medical costs for sick family members or funeral expenses for deaths in the family. In discussions with the managing director of Tanykina, a dairy collection hub in Western Kenya serving over 4,000 active members, he mentioned that periodic family-member illness was one of the biggest constraints limiting the growth and productivity of their individual members. In response, they established a health insurance plan, where members could receive services and medicines at pre-approved health facilities, from designated local clinics, up to the general referral hospital in Eldoret.

Other large expenses that lead households to sell their cows include land acquisition or school fees. One farmer in Busege, in Western Kenya, explained that he sold his three cows to resolve a land dispute and pay for his children's school fees. Herd accumulation, followed by complete divesture may also be considered a strategic household investment plan over certain periods. For example, an older couple reflected that the sale of all their cows to pay for their children's education was the main reason their children were able to succeed in their professional careers. Their children later contributed to the construction of a new brick home with metal roofing for them, and they were now able to get back into dairy farming again. On a related point, ILRI staff mentioned that they observed a high incidence of retirees adopting the more labor and capital-intensive improved dairy production practices. With significantly reduced household expenses and the support of a pension in some cases, these households often have both the time and resources necessary to make consistent investments in improving and maintaining productive dairy cows.

In addition to cultural and asset-related improved dairy production and marketing constraints, one of the challenges for smallholder crop and dairy farmers is the diversity of livelihood activities at the farm level. In the previously mentioned example, retirees often have the luxury of focusing more attention and resources on the management and investments associated with improved dairy production. By contrast, many farmers are managing staple, cash (tea, coffee, cotton, horticulture) and fodder crop production simultaneously with small livestock (goats, sheep, chickens, etc.) and dairy production. Food insecurity, and particularly the dimension of food access in rural zones with inconsistent or poorly functioning markets, can drive farmers to over-allocate land and other factors of production to staple crops in a quasi-autarkic strategy to meet the household's own food needs. Omamo (1998a, 1998b) uses evidence from Western Kenya to make a similar point when comparing household's decisions in staple and cash crop production. Under these conditions, dairy production becomes one of many livelihood activities, with farmers unable to devote the time or resources to meet the more intensive demands of increasing and maintaining higher productivity and production levels.

As mentioned in the background section and illustrated in the quantitative results, there is strong evidence that improving animal genetics and providing improved feed can dramatically increase productivity rates. Market liberalization policies and gradual infrastructure improvements have also generally contributed to improved marketing opportunities for smallholder dairy farmers. However, to operate at the high average sales levels of 20 liters of milk sales per day, farmers must have knowledge, skill and capacity to manage dairy as a business. Operating at this level of milk production and sales is a complex endeavor, with a number of context-specific challenges described below.

The most recommended strategy for increasing production is improving the animal genetics. A common way for farmers to access improved breeds is by steadily improving the pedigree of their herd through investment in AI services. Improved genetics enable famers to achieve better conversion rates (feed to milk ratio) and significantly increase yields.

A long list of challenges quickly surface when talking with farmers and AI service providers about AI services. First, farmers often do not have records to show the breed and specific genetics of their current animal(s). Without this information, the AI service provider is left to guess about the most appropriate animal genetics to provide. This can result in either no breed improvement - by giving near-identical genetics rather than crossing the animal genes - or in some cases, an ‘over-breeding’ that results in the death of the cow and/or calf during delivery (due to excessive calf size).

When it comes to AI services, another consideration for farmers is the relatively high costs, together with variable conception rates. In many cases, AI service providers cover a very wide geographic area. Delays in responding to service request calls often result in missing the relatively narrow optimal insemination period. With relatively minimal to no competition for these services in many areas, farmers do not have much choice when they lose confidence in the quality or effectiveness of their current AI provider. In this case, farmers typically revert to the traditional practice of borrowing or paying a nominal fee for the bull services from a nearby neighbor. Bull services can range from 200-300 KSH, as compared with 1,200-1,500 KSH per attempt for AI services. Challenges with the timing and/or quality of the AI service provision may result in a farmer making multiple attempts with AI before achieving a successful conception.

In terms of farmer's preference for female offspring, sexed semen (~3,000 KSH) is sometimes available but rarely used. In the case of male calves, farmers often sell them immediately (~3,500 KSH) rather than investing in feed and animal care which would in most cases not be recovered in higher sales prices. The other option for obtaining improved breed cows is to purchase them directly. Most farmers do not have access to the required capital (80,000 – 90,000 KSH) either through personal savings or credit facilities. In addition, access to these improved breed markets may be limited, with a high market demand being driven in part by neighboring Rwanda's national 'one cow per household' policy.

Where access to credit for purchasing improved breed cows exists, the related loan premiums and terms may be cost-prohibitive due to the underlying issue of risk associated with improved or exotic breeds in particular. Unlike in the US, UK or Australia, dairy farmers in Kenya face a wide range of potential diseases or animal illnesses including East Coast Fever, Foot and Mouth, and Milk Fever. These can either reduce the productivity of the animal during the sickness and recovery period, or lead to animal deaths. As improved breeds are generally more susceptible to diseases, animal health services become a much more critical element in preventing animal morbidity and mortality. Similar to some of the availability and access constraints of AI services, farmers also complained about the variable quality and difficulty in accessing veterinary services. From discussions with farmers, it seems that the importance of preventative measures (vaccinations, tick control, etc.) are appreciated, but inconsistently applied, either due to liquidity constraints or access to reliable services or treatments.

Improved breed cows also require a complementary investment in improved feeds (dairy meal concentrates) to achieve the desired productivity levels. Farmers thus face a decision to remain with local or slightly improved breeds that are generally resistant to diseases and relatively easy to maintain, versus investing in a more costly, risky venture that has implicit regular animal health and improved feeding requirements. Any lapse in these complementary investments can quickly lead to reduced productivity rates and/or animal death.

Most farmers employ a feed strategy that can include purchased dairy meal concentrates, mineral salts, grown or purchased napier grass, more nutritious fodder (calliandra), crop residues, and pasture or tethered road-side grazing. Access to good quality dairy meal is a challenge both from a cost perspective and physical distance to agro-vet shops with consistent supply. Additionally, commercially available concentrates are not differentiated based on particular animal dietary needs. Both Brookside and ILRI staff mentioned cases of farmers creating their own concentrates based on perceptions of the dietary needs of their cows, but the majority of farmers purchase the standard dairy meal. Other issues include feed conservation, with limited knowledge or practice of improved storage techniques, and Maize Lethal Necrosis (MLN). Maize is both the principal staple crop in these zones as well as the base for a majority of silage, and thus there are serious concerns over recent reports of MLN cases in Western Kenya.

In areas that periodically struggle with food insecurity, poor market access, and access to credit, it is also challenging for farmers to turn maize into silage and forgo immediate revenue from maize harvest sales, or the benefit of storing maize as a household safeguard against future price spikes or unavailability on local markets. Even if farmers make these costly feed investments, there is a possibility that they may not be recovered due to seasonal milk price fluctuations. Good rains during the rainy season can lead to extended high-production periods that drive down milk prices, in turn eroding farmers profits and causing them to sell at a loss. As an aside, one of the largest commercial processors, Brookside, is installing a $7B KSH milk powdering plant that is intended to provide a partial solution to the seasonal milk surpluses. This plant will increase their processing capacity from 800,000 to 1.8M liters of milk per day and enable Brookside to buy up any excess milk supply in high production months and in turn provide price stabilization to national milk markets.

On the marketing side, there are many logistical and coordination challenges to aggregating milk from large numbers of rural smallholder farmers. Poor rural road networks lead to high transaction costs, and heavy rains periodically cut off access to certain areas, leaving farmers with limited or no options for selling their milk. There are also coordination challenges around milk collection in the formal sector. Large milk processors typically purchase a majority of their milk from co-operatives or milk hubs that collect milk from their individual members and store at central cooling plants. While these co-ops and hubs often provide many services for their members, there is also a long history of mismanagement or theft, leading to the bankruptcy and collapse of many of these institutions. Accounting and financial management procedures and systems can be outpaced by rapid growth, with managers tempted to skim off a portion the significant daily revenues. Without strong board accountability, this may even be done in a 'legitimate' way with managers awarding themselves large salaries and related benefits.

In a system based on large numbers of geographically disparate, small suppliers, there is also an inherent difficulty in quality differentiation. Some basic quality tests can be performed at the point of collection, but more advance quality tests are typically conducted when the milk arrives at the cooling facility. At this point, a milk container may contain milk from 5-10 farmers. Given existing aggregation methods, the smallest unit of differentiation for quality purposes is thus groupings of 5+ households. This also assumes a high level of organization and control at the collection and transportation of the milk to the cooling plants. All of this contributes to challenges from a policy perspective of certifying quality standards, and a market perspective of price differentiation based on milk quality.

As described above, dairy production, especially intensification systems that revolve around improved breeds, high-quality and consistent feeding regimes, and careful attention to animal health and preventative care, is an especially complex optimization problem in this context. In addition, farmers do not control all of the factors of production, and rainfall inconsistencies, droughts or serious frosts can all have significant effects on animal health and productivity. High-level dairy production based on improved or exotic breeds faces a number of specific production and price risks, with intertemporal variation of both input costs and milk sales prices. In the absence of appropriate financial risk management mechanisms, it is often better-off farmers with other income sources who are able to take the risks, and make costly investments in improved dairy practices.

Operating at these higher production and sales levels also requires a relatively high degree of technical knowledge and business savvy.

These characteristics were all evident in broadly categorizing farmers that operated at the higher productivity and sales levels during this qualitative data collection. In some cases, it appeared that high-level dairy production was almost done as a hobby or something to signal prestige and personal capability. On the other side, there were many stories of farmers, armed with information on improved practices, that began investing in AI, improved feed, and other elements, only to later become discouraged and abandon some or all of these practices when they recognized that they were operating at a loss. Others tried, but were unable to maintain these practices due to their associated regular costs. Most farmers cited the need to pay school fees, or medical bills as the main reason that they did not continue with these investments that they knew were critical for maintaining higher production levels.

Lastly, related to gender, recent focus group sessions and experience from ILRI staff highlight that while women are often responsible for the majority of the dairy production activities, the overall decisions surrounding cow management and milk sales profits are the domain of the male household head. Under these circumstances, women lack a strong incentive or ability to invest in the additional labor and costs associated with improved dairy management practices. In the EADD program, there were instances where woman and men from the same household were given individual accounts at the project-supported milk hub, and the women were thus able to have direct control over some of milk sales profits. According to focus group discussions, this was greatly appreciated by the women, who in turn had a higher incentive to invest in improved dairy production practices.

Conclusions

In this paper, the first question was what characterizes smallholder farmers who participate in agricultural value chains or new market opportunities in the Kenya diary sector. The results affirmed other evidence that investments in animal genetics (improved breed cows and AI services) and improved animal feed are strongly associated with higher per-cow productivity rates. These factors also corresponded with higher levels of individual farmer milk sales in this data. The results highlight the importance of geographic advantage in the Kenyan context, where high-productivity, high-sales farmers are most commonly found in the more productive agricultural zones closer to urban centers.

The data is also consistent with findings elsewhere which suggest that land ownership levels are not a primary constraint to engage in milk production and sales. Interestingly, after improved breed cows, AI services, and concentrate feeds; other improved dairy production practices were generally not statistically significant in relating to milk sales levels. One of the notable differences between farmers in the high milk sales category and all other categories was the years of education of the household head. This could also be seen with higher rates of secondary education qualifications for those in this category. This corresponds with other studies which find no significant effect of primary school education, but a large and significant effect of having more than a primary school education on the probability of being non-poor and upwardly mobile over time in Kenya during this period (Mathenge & Tschirley, 2007; Suri et al., 2009).

A second general question for this research was the degree to which smallholder farmers benefited from participation in agricultural value chains or improved market opportunities in Kenyan dairy markets. While causal attribution of welfare levels or benefits derived from this participation was not possible, an asset-based welfare analysis approach was used to look at patterns and welfare dynamics corresponding to varying levels of milk sales volumes. Similar to several other studies done in rural Kenya over this period, the welfare analysis revealed a general picture of economic stasis, where in expectation, households remain at their current welfare level over time. A notable distinction was the category of households that sold 20 liters of milk or more per day on average. Households at this high sales level also appeared to have a higher dynamic equilibrium path in asset and lagged-asset space.

It is likely that both observable and unobservable factors that enabled these households to achieve high milk sales levels were also influential in success in other welfare increasing areas. Qualitative findings suggest it was indeed the very characteristics, capabilities, initial asset levels, social networks, etc. that enabled these farmers to successfully sell high milk volumes as well as succeeding in other areas. Consistent resources outside of dairy, combined with fewer expenses or household obligations, and the ability to manage risk were especially important characteristics of these farmers. The complexity of high milk production operations and sales in this context also implied that a certain minimum combination of education and business savvy was probably necessary to succeed in this area.

An unexpected pattern from other studies looking at smallholder adoption of new technologies and market participation is that there is often a highly variable participation and non-participation, or adoption and non-adoption cycles of improved production techniques over time. This pattern is also evident in the quantitative data and qualitative findings of this research. Households moved in and out of the different sales categories over the select periods captured in the panel data, and farmers often described adopting certain improved practices but then being unable to maintain these due to a household shock (medical expenses, funeral, land dispute, poor harvest, etc.), or any number of factors in the production and marketing of their milk. It seemed that a certain wealth level was necessary to buffer against these shocks and continue with the costly routine investments necessary to maintain high levels of milk production and sales.

As may be the case with smallholder participation in other agricultural value chains, it appeared that a set of underlying idiosyncratic characteristics and capabilities, together with sufficient initial wealth levels were essential in both obtaining and maintaining high sales levels and relatively higher welfare dynamics. As such, no clear single policy solution seems evident to address a potentially exogenous factor constraining the participation of smallholder farmers in dairy production and sales. Certainly, other important policy objectives of reducing food insecurity – especially dimensions of food access – continue to be relevant in reducing poverty in this context. As overall net-buyers of food, improved food access will also mean that smallholder farmers can reduce possible over-investment in household food production, and engage in more optimal on- and off-farm livelihood strategies. It is also important to emphasize the high risks associated with improved dairy farming strategies in this context. Policies, commercial insurance products, etc. that enable farmers to better manage this risk will also be critical to sustained smallholder participation and benefit from these market opportunities.

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