

Strategic Market-Based Interventions and Price Volatility in The Dairy Sector: A Case of Kiambu County, Kenya

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ABSTRACT

Dairy farmers, particularly smallholders in Kenya, experience continuous price fluctuations which negatively impact on their income security, investment and production planning. The study focused on five strategic market-based interventions, namely forward contracting, price insurance, market intelligence systems, cooperative bargaining capacity and product diversification strategies, and their impact on price volatility of smallholder dairy farmers in Kiambu County, Kenya. The study utilized descriptive cross-sectional survey design with the theoretical framework of Price Theory, Risk Management Theory, Collective Action Theory and Market Information Theory. Structured questionnaires were filled out with smallholder dairy producers and cooperative officials, with 430 questionnaires sent out and 172 (40.0%) returned. The data was analysed, descriptive statistics, Pearson correlation, and multiple linear regression were used, respectively. The overall score of price stability was moderate to low (mean = 3.5, SD = 1.05), and the highest scores were given to farmers' forward contracting, market intelligence systems and cooperative bargaining capacity (mean = 4.5, 4.4, and 4.2 respectively). Multi-collinearity was checked using the diagnostic tests which yielded no value of VIF greater than 1.672. At the bivariate level, only market intelligence systems were found to have a statistically significant negative association with price volatility ($r = -.161$, $p = .036$); the other interventions had weak (and not statistically significant) negative associations. Overall, the regression model was not statistically significant ($F(5,165) = 1.056$, $p = .387$) and accounted for 3.1% of the variance in price volatility ($R^2 = .031$), and none of the five predictors was significant. The results indicate that market-based interventions are not enough to reduce farm price volatility, but the effect of structural, seasonal and institutional factors may be more important. Systemic measures, such as investment in market infrastructure, formal price stabilization policy and participatory insurance arrangements are recommended for the study, along with ongoing farmer-level capacity building.

KEYWORDS

price volatility; strategic market-based interventions; smallholder dairy farmers; forward contracting; cooperative bargaining; Kiambu County, Kenya

I. INTRODUCTION AND BACKGROUND TO THE STUDY

The dairy sector is among the most important in Kenya's agricultural sector and a vital source of food security and income for smallholder farmers (Kiplagat et al., 2024). Agriculture accounts for up to 33% of Kenya's gross domestic product (GDP) and supports the livelihoods of the majority of Kenyan rural households (more than three-quarters); Kenya produces more than 5.2 billion litres of milk per year, the majority of which comes from smallholder systems (Menjo, 2025). Nevertheless, the sector is subject to frequent

price volatility due to seasonality, market imperfections, limited infrastructure and inefficient institutional linkages. This instability reduces income predictability, lowers investment in improving production technologies and poses a threat to the smallholder dairy production system, especially in high production areas like Kiambu County.

Price volatility refers to the changes in agricultural prices over time, and is often measured by the standard deviation of farm-gate prices, the number of times prices change during a season, and the amount of income volatility that can be explained by the price changes (Chen et al., 2025; Mustafa et al., 2024). This volatility is aggravated by structural characteristics of dairy markets, which include limited storage and processing capacities, milk perishability, and an asymmetric thin market, and opens up opportunities for price manipulation by intermediaries on the dairy market (Muzaffar & Malik, 2024; Chen et al., 2022).

In most African dairy markets, such as in Kenya, the markets are poorly organised and the prevalence of informal price-stabilisation mechanisms leaves smallholders highly vulnerable to price risk (Dumont, 2022; Skevas, 2021). While the agro-climatic conditions are favourable for farming in Kiambu County, with high dairy production intensity (Wanjala, 2023), the dairy sector has several challenges including fragmentation of smallholder production, lack of processing and storage facilities and low power of farmers in bargaining (Mustafa et al., 2024) that necessitate localised interventions based on evidence. The study is based on the Market Based Price Stabilisation (MBPS) approach and focuses on the relationship between five strategic market-oriented interventions, dairy price volatility and generation of empirical evidence for policy and practice in Kiambu County, a descriptive cross-sectional design.

II. STATEMENT OF THE PROBLEM

There is an increasing interest in the development of Kenya's dairy value chain, yet the available literature is more focused on production-oriented interventions, including genetic selection, feed technologies, and agricultural extension services, and relatively less attention has been given to the coordinated market-based interventions such as cooperative bargaining, market intelligence systems, price insurance, and forward contracting (Cooper, 2021). This is an important missing point because market failures on the production side do not remedy market failures on the demand side, nor do they address the market power imbalances or information asymmetries that exist via the price formation mechanism. Furthermore, many of the price-stabilisation strategies that have been used in the dairy industry in developed countries have not always been adopted in the smallholder systems in Kiambu County because they tend to be specific to the context of strong farmer organisations, financial markets, and effective contract enforcement among other factors (Cooper, 2021; Coromina, 2022).

The evidence base is also weak due to the lack of studies that isolate the impacts of multi-intervention approaches, the reliance on cross-sectional designs which provide farmer perceptions of volatility but not actual price and income impacts, and the lack of evidence on the effects of integrated, multi-intervention approaches (Dumont, 2022; Kirui, 2022). Transaction costs, farmer bargaining power and access to market information are market aspects that are not fully analyzed. Therefore, there is a limited amount of empirical

evidence that exists regarding whether and how integrated market-oriented interventions can reduce milk price volatility and enhance income stability of smallholder dairy farmers in a setting like Kiambu County.

III. OBJECTIVE OF THE STUDY

The general objective of the study was to assess the effect of strategic market-based interventions on price volatility in the dairy sector of Kiambu County, Kenya. This objective was broken down into five specific objectives that were linked to five strategic interventions that enabled the ability to study the joint and independent effect of each of these interventions on price volatility: forward contracting arrangements, price insurance mechanisms, market intelligence systems, cooperative bargaining capacity, and product diversification strategies.

IV. RESEARCH HYPOTHESES

The study tested the following null hypotheses, derived from the specific objectives:

1. H_{01} : Forward contracting arrangements have no statistically significant effect on price volatility in the dairy sector of Kiambu County.
2. H_{02} : Price insurance mechanisms have no statistically significant effect on price volatility in the dairy sector of Kiambu County.
3. H_{03} : Market intelligence systems have no statistically significant effect on price volatility in the dairy sector of Kiambu County.
4. H_{04} : Cooperative bargaining capacity has no statistically significant effect on price volatility in the dairy sector of Kiambu County.
5. H_{05} : Product diversification strategies have no statistically significant effect on price volatility in the dairy sector of Kiambu County.strategies.

V. LITERATURE REVIEW

In the global context, factors such as climate variability, market integration, and value chain structural shortcomings have been associated with agricultural price volatility (Billah, 2023; Kiriimi et al., 2025). Formal risk-management instruments can meaningfully reduce income volatility: Formal risk management instruments that were found to reduce volatility in developed dairy markets include forward contracts on the U.S. and Swiss markets, which reduced volatility by about 35–48% compared to spot market participants, depending on the design of the contract, the base price mechanism and the length of the contract (Winston, 2021; Tambaou, 2024). Also, index-based price insurance schemes in developed and middle-income countries have proved to mitigate price risks faced by farmers, although they are also dependent on basis risk and poor correlation between payments and losses (Jensen et al., 2024).

At the regional (sub-Saharan Africa) level, evidence is more mixed. Contract-farming arrangements face weak enforcement, side-selling during the price hikes and default by buyers when prices drop and only around 42% of the schemes analyzed are considered to have high compliance (Singh et al., 2025). Informal verbal agreements are more prevalent

than formal contracts, but provide less price stability, as revealed by Kenyan-specific dairy research, while the contracted farmers in the central highlands of Kenya (CHK) also receive moderately higher and less volatile prices, but access to contracts is biased in favor of better-resourced farmers, posing equity concerns (Chuma et al., 2024; Muhia, 2024). While well-governed Kenyan dairy cooperatives have proven resilient to economic shocks by providing constant member services (Munene & Waweru, 2024), cooperative bargaining literature throughout the region has consistently pointed to free-rider problems, elite capture, and governance weaknesses as threats to the effectiveness of collective action.

At the local level in Kiambu County and similar smallholder-dominated markets, market intelligence systems such as mobile alerts on prices reveal a merging message: that information is effective at enhancing farmer bargaining power only when markets are competitive; in monopsonistic markets, information alone offers little benefit (Kariuki, 2025; Bergquist & Dinerstein, 2020). Product diversification into value-added dairy products (yoghurt, cheese and butter) is shown to be an effective strategy in reducing income-variance via portfolio effects, yet the realization of this strategy is limited by market access, technical capacity, investment and gender-specific constraints on women's control over diversified income (Rahman & Hye, 2021; Coromina, 2022).

Three gaps can be identified in this body of work. Most studies theoretically focus on intervention activities separately from one another, instead of looking at the combined effect of the interventions in an integrated dairy value chain (Mwangi, 2021). In the context of Kenya, much of the best evidence comes from more formalised dairy markets (such as the United States, Switzerland, India) that are structurally different from the smallholder-dominated, disorganised markets in Kenya. Descriptive designs have been widely used in Kenyan studies with little use of inferential statistical designs that could be used to compare the relative effect of multiple interventions at a time (Michels & Mußhoff, 2025). This study aims at filling these gaps through empirical and simultaneous testing of the impact of five strategic market-based interventions on price volatility of smallholder dairy farmers in Kiambu County.

VI. THEORETICAL FRAMEWORK

The study is anchored on the Market-Based Price Stabilisation perspective and reinforced by four complementary theories. Price Theory (Smith, 1776; Ricardo, 1817; Marshall, 1890) is a theory that shows how the interaction of the forces of supply and demand can cause farm-gate price fluctuations when there is imperfect information in the market for the smallholder system. Risk Management Theory (Knight, 1921; Markowitz, 1952) categorises forward contracting, price insurance, and product diversification as strategies used by risk averse individuals to reduce the variability of their expected income; but assumes that the financial and insurance markets are sufficiently developed to facilitate these and are somewhat lacking in the study setting. Collective Action Theory (Olson, 1965; Ostrom, extended) explains why dairy cooperatives have been formed to increase its bargaining power and decrease transaction costs, and admits that there are vulnerabilities like free-rider and elite-capture. This work relies on the ideas of Market Information Theory (Akerlof, 1970; Spence and Stiglitz) that explains the information asymmetry which puts farmers at risk from price manipulation by intermediaries, and therefore the study's approach to market intelligence systems. These theories help explain how the five strategic interventions are expected to affect dairy price volatility, individually and collectively.

VII. CONCEPTUAL FRAMEWORK

The conceptual framework (Figure 1) treats price volatility as the dependent variable, with five independent variables that influence it (Forward contracting arrangements, Price insurance mechanisms, Market intelligence systems, Cooperative bargaining capacity, Product diversification strategies), with farmer characteristics, farm characteristics and market characteristics fixed.

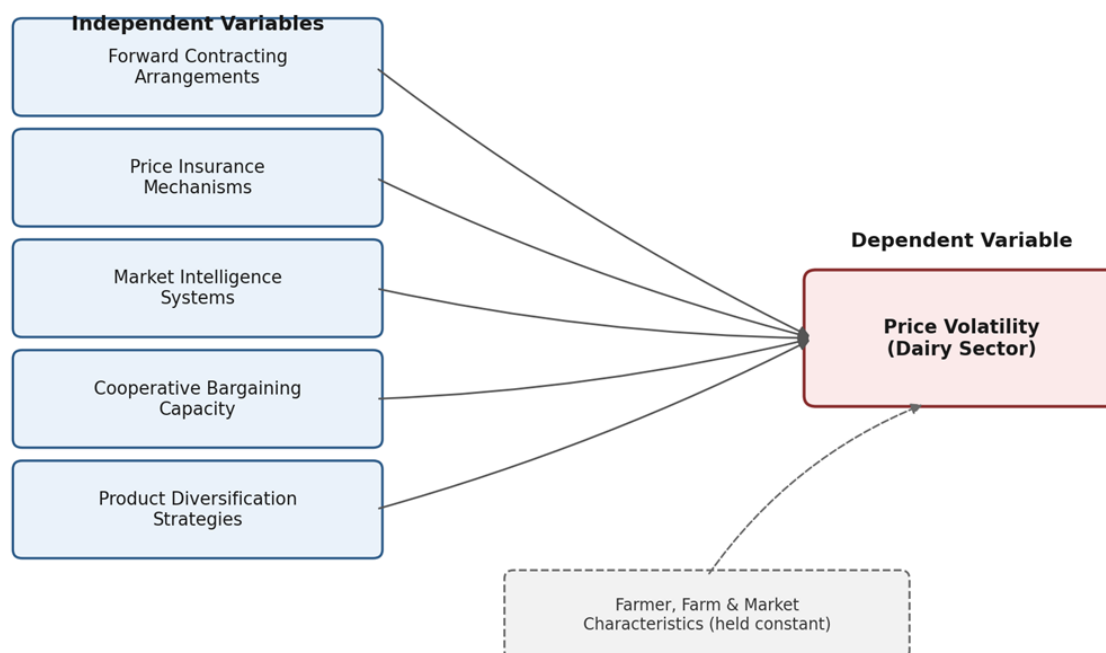


Figure 1: Conceptual Framework Linking Strategic Market-Based Interventions to Dairy Price Volatility

VIII. RESEARCH DESIGN AND METHODS

The study adopted a descriptive cross-sectional survey design, appropriate for describing existing patterns and associations among market-based interventions and price volatility without manipulating variables. The target population included the smallholder dairy farmers who are about 15,000 in total in Kiambu with valid contact details, 20 dairy cooperatives, 11 licensed processors and 8 relevant NGOs/institutions. The finite population sample size formula of Yamane (1967) was used with a 10% non-response error to determine the sample size for the farmer with 5% precision, which amounted to 430 farmers and all the 20 farmer cooperatives were included by census. Multi-stage sampling technique was used, where the sub-counties were stratified by dairy production intensity as well as market access, cooperatives were sampled proportionately to the number of members they had, and the individual farmers were sampled in a systematic manner from the lists of the cooperatives and the village list, with key informants (processors, government, NGOs) being purposively selected.

Primary data were collected using structured questionnaires for farmers and cooperative officials, and a semi-structured interview guide for key informants, administered in English and Kiswahili following pilot testing (with roughly 30 farmers, 5 cooperative officials, and 5

key informants) that yielded Cronbach's alpha values of 0.74–0.88, indicating satisfactory internal-consistency reliability. Content validity was established by the interaction of experts and supervisors. A total of 172 (40.0%) questionnaires were returned and were suitable for analysis. Data were analysed in SPSS version 26 using descriptive statistics, diagnostic tests (normality, multi-collinearity via VIF/tolerance), Pearson correlation, and multiple linear regression, specified as:

$$\text{Price Volatility} = \beta_0 + \beta_1(\text{Forward Contracting}) + \beta_2(\text{Price Insurance}) + \beta_3(\text{Cooperative Bargaining}) + \beta_4(\text{Market Intelligence}) + \beta_5(\text{Product Diversification}) + \varepsilon$$

As a cross sectional design, the results of regression analysis are interpreted as associations, not causality. The study complied with the ethical standards required, such as institutional approval, informed consent, voluntary participation, confidentiality, and anonymised reporting.

IX. FINDINGS AND RECOMMENDATIONS

A. Findings

The descriptive analysis revealed that the highest scores of adoption were obtained by the respondents for forward contracting, with a mean score of 4.5 and a standard deviation of 0.82; market intelligence systems had a mean score of 4.4 and a standard deviation of 0.80; cooperative bargaining capacity had a mean score of 4.2 and a standard deviation of 0.88; and price insurance and product diversification each had a mean score of 4.3 with high standard deviations of 0.43 and 0.88, respectively. Price stability was rated as moderate to low (mean = 3.5, SD = 1.05) and price changes were reported as having a significant impact on household budgets (mean = 4.1, SD = 0.98). There was no evidence of multicollinearity as there were no VIF values above 1.5.

None of the other interventions were statistically significant, with market intelligence systems being the only one showing a negative relationship with price volatility ($r = -.161$, $p = .036$). Forward contracting ($r = -.140$, $p = .068$), cooperative bargaining capacity ($r = -.130$, $p = .091$), product diversification ($r = -.105$, $p = .172$), and price insurance ($r = -.056$, $p = .469$) were also not significant. The regression model was weak overall ($R = .176$, $R^2 = .031$, Adjusted $R^2 = .002$) and not statistically significant, $F(5, 165) = 1.056$, $p = .387$, explaining only 3.1% of the variance in price volatility. The data for the multivariate model revealed no statistical significance for any of the five predictors: market intelligence systems ($B = -.125$, $p = .297$), but the significance of the bivariate model was not maintained after the other interventions were controlled suggesting this intervention may have a similar effect as cooperative bargaining and other interventions that were correlated. Thus, all the five null hypotheses (H_{01} to H_{05}) were accepted.

These non-significant results are not considered a null result to be rejected, but rather a finding of substantive significance. There are three possible explanations: (i) farm-level interventions may be insufficient to offset market-level volatility, market fluctuations in supply availability, processors' power, and macroeconomic conditions; (ii) the achieved sample ($n = 172$, 40% response rate) may have lacked statistical power to detect small effect sizes; and (iii) both independent and dependent variables were measured as

perceptions using perceptual Likert-scale items, which could have underestimated the relationships that would be more apparent in objective transaction-level price data.

B. Recommendations

Policy: County and national governments should invest in dairy price-monitoring units that disseminate farm-gate price bulletins via SMS, strengthen the legal enforceability of forward-contracting arrangements, expand access to affordable, subsidised agricultural price insurance, and invest in market infrastructure; storage, processing, and transport, to address the structural roots of volatility.

Practice: Farmers should be encouraged to enter well-governed, transparent cooperatives, and provide targeted training on market-based risk management tools; improve access to market information, both in terms of time and quality, via digital platforms and extension services, and promote product diversification as a complementary and not a substitute income-stabilisation strategy.

Institutions: Government agencies, NGOs and development partners should enhance value chain coordination and linkage between farmers, processors and markets, strengthen cooperative governance and accountability, and provide extension/financial-advisory services to support farmers to manage market risk.

Future study: Future studies should include objective, longitudinal price-panel data in addition to macro-structural and policy data, larger and purposively selected samples to capture small-sized effects, and comparative and cross-regional designs to assess whether these findings are generalizable.

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