Journal of Entrepreneurship & Project Management

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ISSN: 2616-8464

Stratford Peer Reviewed Journals and Book Publishing
Journal of Entrepreneurship & Project Management
Volume 7||Issue 2||Page 64-77||May||2023|
Email: info@stratfordjournals.org ISSN: 2616-8464

Entrepreneurial Production Technology and Growth of Smallholder Dairy Enterprises in Kenya

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***How to cite this article*: Munyua, P. M., Gathenya, J.W., Kyalo T.N. (2023). Entrepreneurial Production Technology and Growth of Smallholder Dairy Enterprises in Kenya. *Journal of Entrepreneurship & Project Management*, 7(2), 64 - 77. https://doi.org/10.53819/81018102t2136**

Abstract

This study investigated influence of entrepreneurial production technology on growth of smallholder dairy enterprises in Kenya. The enterprises continuous respond to increasing demand for dairy products in the market from rising global populations. Dairy industry has introduced technologies, and adoption has increased productivity. In an attempt to gain and retain competitive advantage in the market, amidst environmental challenges, some related to climate change, enterprises have adopted entrepreneurial production technology. This study proposed that growth of smallholder dairy enterprises depends on the adoption of these technologies. The hypothesis was tested using a field survey on the actual technologies adopted by smallholders and extent of the adoption. Open and closed ended questionnaires were administered to a study sample of 395 smallholder dairy farmers, proportionately drawn from among active members, currently supplying milk to Githunguri, Wakulima and Nyala dairy cooperative societies in Kiambu, Nyeri, Nyandarua and Laikipia counties in high potential Central Kenya. The study established a significant positive influence of entrepreneurial production technology on growth of smallholder dairy enterprises in Kenya, supporting the idea that growth of smallholder dairy enterprises in Kenya is positively correlated to the extent of adoption of entrepreneurial production technologies in breeding, feeds production and feeding, and in waste handling. The results imply that smallholder dairy enterprises are poised to achieve greater growth when they adopt more entrepreneurial production technologies for breeding dairy cattle, feeds production and feeding and in handling waste from their dairy farms

Key Words: *Entrepreneurship; Entrepreneurial Production Technology; Enterprise Growth*

1.0 Introduction

Adoption of technologies in dairy sector is a common approach for enhancing production and enterprise performance (Nhamo & Chikoye, 2017). Technologies are generally believed to provide an opportunity for developing competitive advantages to the firm and industry in general (Pachava, 2018). In the dairy sector, technologies are used for a variety of reasons ranging from improvement of breeds, feeds production, feeding, and waste management among others (Singh et al., 2018). Technologies, such as precision farming and robotics herald significant transformative changes across the three stages of the dairy production cycle of breeding, feeding and milking (Henchion *et al*., 2022). Nonetheless, technology does not always create positive benefits. The green revolution, a case in point, was a technological breakthrough with great success in increasing food production, however, it led to environmental problems of soil salinity, water pollution and nutrient depletion, becoming counterproductive on the overall enterprise performance (Shilomboleni, 2020). To achieve positive effects, it is important for the technology to demonstrate high level of novelty and sustainability. Technology adoption must therefore be leveraged on its entrepreneurial capabilities to create positive impacts on the enterprise (Rose & Chivers, 2018).

Presuming that entrepreneurial production technologies positively reflect on the primary farming activities for milk production, recent studies in Kenya have focused on what technology and how these technologies influences milk production (Mugabe, 2019; Wairimu, 2021). While entrepreneurial production technologies enhance farm productivity, technologies do not work in isolation neither do they work singularly with the extent of adoption of the entrepreneurial production technologies being the biggest influencer of enterprise performance (Brutus & Chiyem, 2018). The implication is that dairy enterprises choosing to prioritize the use of entrepreneurial production technologies must invest heavily on a wide array of these technologies over a long period of time in order to generate high levels of enterprise performance.

1.1 Statement of the problem

Adoption of technology in dairy industry notwithstanding, studies reveal limited empirical evidence on the integration of entrepreneurial production technologies in smallholder dairy enterprises in Kenya (Kosgei et al., 2020). Further, effects of these technologies on enterprise growth of smallholder dairy enterprises has not been fully explored. Given the pivotal role of entrepreneurial production technology in dairy production and lack of research highlighting their effects on enterprise growth, there is a need for research that examines the relationship between adoption of entrepreneurial production technologies and growth of smallholder dairy enterprises in Kenya.

1.2 Objectives of the study

The study investigated the influence of entrepreneurial production technologies in breeding, feeds production and feeding; and waste handling management on growth of the enterprises. Growth was measured as composite of change in productivity, change in return on investment (ROI), change in return on equity (ROE) and change in employment. The growth indicators were measured over a five-year period between 2018 and 2022 and the annual change differences averaged for the 5 years to establish an index for growth.

2.0 Literature Review

Smallholder dairy farmers are the force driving dairy farming into the important and vibrant sector, that it has become in Kenya today. They account for 80% of the country milk production and 50% of marketed dairy output in the country (Rademaker et al, 2016 & Auma et al, 2018). However, smallholders are victim of inefficiencies in dairy value chain, threatening the sustainability and competitiveness of the industry. The inefficiencies centre round limited access to inputs, services and markets, heightening production costs, restricting households to a low- input-low-output vicious cycle (Berem et al., 2015).

They face low productivity from constraints of poor cattle breeds, inadequate feeds, diseases, poor access to credit facilities and poor access to output markets (Richards et al., 2016). Possession of good dairy cattle breeds improves smallholders' efficiency and resilience in milk production. Breeding technologies like artificial insemination (AI), have introduced farmers to further benefits from technologies like multiple ovulations, embryo transfer and use of sexed semen which accelerate genetic gains. This notwithstanding, smallholders face challenges identifying the exact time when cows are ready for service, leading to improper timing of insemination and low conception and low reproductive performance (Abebe & Alemayehu, 2021). Birth weight, growth rates, mature weights and milk production are individual genetic factors. Breeding accumulates and conserves success and achievements from multiple generations (Hutu et al., 2020).

Smallholders provision of an adequate all-time supply of quality feeds is key for sustaining increased dairy productivity and profitable dairy farms. Most smallholders, however, rely on rain fed forage and fodder, as the main source of nutrition for dairy cows. Therefore, introducing fodder production and conservation technology of high yielding, drought tolerant fodders with high nutrient content, reduces susceptibility to effects of climate change is expected to increase milk yield from dairy cows (Wilamune et al., 2021) and reduce feeding costs (Castaff & Muller, 2018). Proper feeding improves nutrition and keeps cattle healthy, improving milk production and reproduction performance (Jaregui, 2016), impacting on age of calving of heifers, conception rates and calving intervals.

Waste in the form of dung, urine, feed leftovers, beddings, plastic, glass and jute containers and drug bottles are generated from dairy farms daily, and partly contribute to 4% of greenhouse gases (FAO, 2018) causing pollution, foul smell and attracting flies. Broadly waste is either organic (biodegradable) or inorganic (which present opportunity for recycling or reuse). The way dairy farmers handle and utilize waste from their farms is important for farm and environmental sustainability (Waterton et al., 2018). Adoption of modern technology in waste management provides opportunity for the waste to be converted into useful products like manure and gas fuel. Old practices of disposal of farm waste need updated with modern techniques (Singh et al., 2018).

Though smallholders face challenges adopting specific practises, and thereby fail to achieve full potential in productivity, use of smart technologies is higher in advanced economies (Pauschinger & Klauser, 2022, Ngoteya et al, 2020) with increased productivity. There is limited evidence on integration of entrepreneurial production technologies in smallholder dairy enterprises and the extent of their use. This study sought to establish the influence of the entrepreneurial production technologies on the growth of smallholder dairy enterprises in Kenya.

2.1 Theory and Hypothesis

The study is anchored on Schumpeter's innovative theory of entrepreneurship. This theory was propounded by Schumpeter (1947), and according to him innovation can be leveraged in launch of a new product or an upgraded version of an existing product, application of new methods of production, launch of new market, acquisition of new sources of new materials and leveraging of new industry structure such as disruption of monopoly.

The theory takes an entrepreneur basically as an innovator and an innovator is one who introduces new combinations and creates change. According to this theory, innovations of the entrepreneurs, the drivers of market systems as they seek profit, change the way people interact with the world, cause a disequilibrium in the economy as they break the routine circular flow resulting in the rapid economic development of any country. The innovative entrepreneur and his enterprise function to serve as impulses for motion in the market economy to satisfy market needs and the needs of the system level. The entrepreneur takes calculated economic risks to maximize profit, expand business activities and grow the firm while bearing the state of uncertainty caused by the possibility of failure.

Technological innovation is an essential driver of competitiveness and is at the centre of economic change causing gales of creative destruction, incessantly transforming industry and economic structure from within. Schumpeters divided the innovation process into the dimensions of invention, innovation, diffusion and imitation. Of these, the diffusion and imitation phase have the greatest influence on the state of the economy. The implementation of the powerful new ideas relies upon the strong characters of entrepreneurs and their influence.

Technological innovation presents an opportunity to the smallholder dairy enterprises to adapt technology that increases milk production, increases production efficiency, converts waste into useful input, better business processes, enter new markets, form new organizations and adopt a new combination of production factors. In today's dynamic business world, it is vital for enterprises to gain and maintain a competitive advantage through innovation. In this study therefore, the adoption of dairy production technologies leads to better farm performance and growth. High-end technological innovation gives a competitive advantage to the firm and industry on a global level (Pachava, 2018). This theory therefore forms a foundation on the influence of entrepreneurial production technology on the growth of smallholder dairy enterprises in Kenya.

Stratford Peer Reviewed Journals and Book Publishing
Journal of Entrepreneurship & Project Management
Volume 7||Issue 2||Page 64-77||May||2023|
Email: info@stratfordjournals.org ISSN: 2616-8464

Null Hypothesis: There is no influence of entrepreneurial production technology on growth of smallholder dairy enterprises in Kenya

2.2 Conceptual Framework

Entrepreneurial Production Technology **Enterprise Growth**

3.0 Methodology

The study adopted a descriptive research design to establish the influence of entrepreneurial production technologies on growth of smallholder dairy enterprises in Kenya. The target population comprised 29,300 active smallholder dairy farmers currently selling their milk to Wakulima cooperative society in Nyeri county, Githunguri dairy cooperative in Kiambu county and Nyala Dairy Cooperative Society, whose members traverse Laikipia, Nyandarua counties and parts of Nyeri county.

Yamane (1967) formulae was used to determine the study sample size of 395 respondents. The study used probability proportional sampling method to select the sample of 395 from the sampling frames, the list of active members of the three dairy cooperative societies. The proportionate sample had 229 respondents from Githunguri dairy, 85 respondents from Wakulima dairy and 81 respondents from Nyala dairy. Simple random sampling was used to draw the representative samples from each cooperative society.

A survey tool was used to collect data over a four-week period in the months of February and March 2023. The questionnaire consisted of a 5-point Likert scale, closed and open-ended questions that collected data from the respondents

3.1 Data analysis

Data was cleaned and summarized using descriptive statistics of mean, median, mode, frequencies, distribution and standard deviation. Qualitative data was classified, coded and analyzed as quantitative data. Quantitative data was analyzed using IBM statistical package for social sciences (SPSS) Version 25 and presented using tables, charts, and graphs. Data was subjected to diagnostic tests of normality, multicollinearity, outliers, homoscedasticity, kurtosis and skewness. Inferential statistics was used to determine relationship and test hypothesis.

4.0 Key results and findings

The study achieved 97.8% response rate and Cronbach's Alpha of 0.609 for construct reliability. The study revealed that majority of the respondent (52%) were males and 48% were females. This is in line with findings by Wairimu et al. (2022), which established that males formed majority (76.2%) of dairy farmers in Mukurwe-ini, Nakuru and Sotik regions of Kenya. Therefore, the findings imply that males have greater chances of participating in dairy production. This brings to the fore findings by Wilkes et al. (2020), which indicated that milk yield tend to be higher for male dairy farmers as they are more likely to adopt zero grazing and intensive feeding programs. Men are also mostly to engage in formal milk marketing unlike women who prefer to sell to informal markets, even when the household is a cooperative member. Thus, increasing women's ownership of cattle may not directly increase either milk yields or women's involvement in milk sales. A factor which may further inhibit participation of women in the sector as milk sells is related to control of dairy income and investment at the household level.

Thirty-two percent were aged between 51-60 years; 31.6% between 41 and 50 years; 20.2% above 60 years; 14.8% between 31 and 40 years and 1.3% below 30 years. This showed that most dairy farmers in Kenya are fairly old. This supports research findings by Kosgei et al. (2020) which established that the youngest and the oldest small-holder dairy farmer in Mosop Sub County in Nandi County were aged 25 and 90 years respectively, with a mean age of 49 years. This would have implications on the extent of adoption of entrepreneurial production technology as younger farmers are comparatively typically less risk-averse and are more willing to try new technologies than older farmers (Udimal at al., 2017).

Majority (41.3%) of the respondents had secondary education as the highest academic qualification while 31.1% had primary education, 16.3% college, 6.1% university degrees and 5.1% had no formal education. The findings are in line with a study by Wairimu et al. (2022), which indicated that on dairy farmers in Kenya have on average 10.47 years of formal education. Meaning, that majority had secondary education level. Education plays an important role in adoption of new technologies and it is believed to improve the willingness of the household head to embrace new ideas and innovations (Kosgei, 2020).

Majority (32.1%) had between 11 and 20-years' experience in dairy production; 29.3% had less than 10 years; 23.5% between 21 and 30 years; 7.4% between 31 and 40 years; and 7.7% above 40 years. This corroborates the findings that majority of the farmers were aged 51 years and above. Thus, it implies that they have sufficient knowledge on dairy farming, a factor which would affect extent of technology adoption based on past experiences. Study by Okello et al. (2021) established that mean dairy farming experience of 19 years, findings in support of the current study.

On adoption of high yielding breeds, the study showed that the most preferred breed was Friesian. Majority (70.7%) started their dairy farming with Friesian breed. This number has grown to 94.1%. This is followed by Ayrshire where only 13% of the farmers started with the breed. This has dropped to 10.7%. The adoption of Guernsey, Jersey, Crosses, local breeds and others is less than 10% percent for both time periods. This concur with findings by Kosgei et al. (2020) that the main dairy breeds that are kept in Kenya are Friesians, Ayrshires and

Crosses. The Friesian breed is the highest milk producer among dairy breeds, thus is preference is mostly linked to milk production and subsequent sales.

The mean calving age of heifers was 26.32 months with a standard deviation of 4.921 while the mean calving interval for cows was 17.59 months with a standard deviation of 9.148. This implies when a heifer enters production and also when a cow returns to production. A study by Wanjala and Njehia (2014) showed that the mean calving interval was 14.77 months with a range of 12-36, while mean age at first calving was 28.16 months with a range of 24-38 months. This shows that an increase in the mean calving interval for cows while the age at first parturition remaining fairly unchanged.

On adoption of breeding technologies, majority of the smallholders (51%) responded that an average of 2 inseminations were done in their cows before a conception occurred. Repeat inseminations impact on costs of production and production time. Regarding breeding challenges majority of the respondents cited low conception (41.5%) as their biggest challenge, followed by high cost (23.3%) and heat detection (10.0%). A study by Lawrence et al. (2015), indicated that mostly farmers (87%) using AI in Kenya cited the problem of repeat breeding, a factor deemed as the main limitation of an efficient and profitable reproductive management of the dairy farm (Khair, et al., 2018).

On adoption of feeding technologies, majority of the respondents (64.42%) indicated they relied on forage grown on their farms to feed their livestock while 35.6% indicated they relied on bought feeds. that dairy meal was the most used (34.6%), followed by maize germ (29.4%), then pollard (17.4%) followed by bran (13.1%). Other feeds fed in smaller amounts include boosters, brewer grains, screened chicken droppings, cotton seed cake, fish meal, machicha (brewers waste), mineral salts, molasses, pellets, stock meal, sorghum and sunflower (fed to lactating cows only). This finding corroborates findings by Wanjala and Njehia (2014), which indicated that 98% of the farms used Napier grass as the main fodder.

In enhancing feed efficiency, smallholders had adapted the following technology; chopping feeds (77.3%), fodder conservation (45.1%), feeding total mixed rations (TMR) (32.7%) and established new fodder (31.6%). Other technologies were use of urea molasses mineral block (UMMB)-(2%), treating feeds with molasses and bio-vet (0.8%), treat fodder with yeast (0.8%), treat dry forage with urea solution (0.5%), mix feed with brewers' waste and fencing of free range (0.3% each). All smallholders (100%) feed their dairy cattle on grasses. Those feeding herbaceous legumes were (12%), silage (19.6%) crop residues (15.6%), and tree legumes were 0.5%. This contradicts earlier assertion by Wanjala and Njehia (2014), that smallholder dairy farmers do not invest in quality feeds and feeding programs. A pointer to an improvement on the feeding practices with the objective on ehnhancing production and general farm performance.

On the fate and beneficial use of the waste, majority (55.5%) used farm waste for manure preparation while 11.1% recycled wastes, 8.7% prepared composts, 8.0% slurry, 7.2% sell, 5.2% biogas, and 3.3% recycle. Those who burn or dispose in pit latrine were 0.7% and 0.4% respectively. The findings are aligned to assertion by Kusiluka et al. (2012) that majority of livestock farmers heaped the wastes near the animal sheds without treatment before disposal, with majority spreading wastes as manure on crop farms (62.1%), some burning (10.6%), and others (24%) dispose wastes on any available open space.

Analysis revealed that 68% of the respondents agreed that they adopt entrepreneurial production technologies while 22% somehow agreed. Delving further, breeding technologies had an adoption of 73%, feeds production and feeding technologies had an adoption of 65%, while waste handling technologies had an adoption of 65%. This showed a high level of adoption of entrepreneurial production technology among the farmers and fails to support the assumption that younger farmers are comparatively typically less risk-averse and are more willing to try new technologies than older farmers (Udimal at al., 2017). This implies that the entrepreneurial adoption was driven by the benefits of technology rather than the age. Meaning, farmers well informed about technology benefits would most readily adopt.

Table 1: Adoption of Entrepreneurial Production Technologies

Constructs	Indicators	SDA	DA	SHA	A	SA	Mean	SDV
Breeding Technologies	Heifers produce more milk than mothers	1%	3%	13%	29%	55%	4.4	0.9
	Farm has reduced calving intervals	5%	16%	20%	34%	26%	3.6	1.1
	Cost of AI is affordable	2%	9%	15%	26%	47%	4.1	1.1
	Sub Total	**3%**	**9%**	**16%**	**30%**	**43%**	**4.0**	**1.0**
Feeds production and feeding ttechnologies	New fodder variety are high yielding	0%	3%	25%	20%	19%	3.6	1.3
	Feed conservation reduce feed cost	0%	12%	23%	30%	22%	3.0	1.2
	Feed mixing increases yield	0%	2%	6%	11%	26%	4.3	1.0
	Sub Total	**0%**	**9%**	**27%**	**31%**	**34%**	**3.6**	**1.2**
Waste handling Technologies	Waste may be overwhelming	0%	14%	23%	21%	24%	3.1	1.3
	Waste management is expensive	0%	6%	11%	13%	34%	3.9	1.2
	Most farmers cannot afford	0%	7%	11%	12%	27%	3.9	1.3
	Sub Total	**0%**	**13%**	**22%**	**23%**	**42%**	**3.6**	**1.3**
Entrepreneurial Production Technologies	**Aggregate Score**	**1%**	**10%**	**22%**	**28%**	**40%**	**3.8**	**1.2**

A regression equation was estimated using Stata with enterprise growth as dependent variable and entrepreneurial production technology as the key predictor. The study met the assumption of normality (Skewness Z-value =-0.537; Kurtosis Z-value =-0.266); Homoscedasticity (Cameron and Travedi's decomposition of information matrix (IM) test, $\chi^2(14, N = 392) = 14.04, p = .4467$); Autocorrelation (*D-W test*= 1.516) and Multi-collinearity (*VIF*=1.516). The study established a significant positive influence of entrepreneurial production technology on growth of smallholder dairy enterprises in Kenya. Findings in Table 2 further shows that

https://doi.org/10.53819/81018102t2136

entrepreneurial production technologies explained 19.59% variance in enterprise growth (Adjusted R^2=0.1959, F (1, 390) = 94.69, p<0.01). In support of the alternative hypothesis, the study found that entrepreneurial production technology significantly predicted enterprise growth (β = .028, t (390) = 9.81, p < 0.01). These findings support the general hypothesis that aadoption of technologies in dairy sector enhancees production and enterprise performance (Nhamo & Chikoye, 2017).

Table 2: Entrepreneurial Production Technologies

Source	SS	df	MS		Number of obs	=	392
Model	.099547192	1	.099547192		F (1, 390)	=	94.69
Residual	.403252805	390	.001033982		Prob > F	=	0.0000
Total	.502799997	391	.001285933		R-squared	=	0.1980
					Adj R-squared	=	0.1959
					Root MSE	=	0.03216

Growth	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
EPT	.0277476	.0028279	9.81	0	0.0221877	0.0333074
_cons	.0804949	.0107019	7.52	0	0.0594543	0.1015355

The entrepreneurial production technology adoption score was higher in Laikipia (*M* =3.96, *SD* = 0.388) compared to Kiambu (*M* =3.7, *SD* = 0.60), Nyeri (*M* =3.6, *SD* = 0.53), and Nyandarua (*M* =3.5, *SD* = 0.55).

Table 3: Comparing Means

	N	Mean	Std. Deviation	Std. Error
Kiambu	229	3.762433	.6077210	.0401593
Nyeri	86	3.644375	.5300959	.0571617
Laikipia	45	3.967372	.3889585	.0579825
Nyandarua	32	3.523003	.5579319	.0986293
Total	392	3.740514	.5746846	.0290260

Welch and Brown-Forsythe tests was used to test whether there was a significant difference between the means. These tests are recommended instead of the ANOVA test, which relies on F-statistic to determine whether the means are significantly different. This is because if the difference between the sample sizes is too large, this can affect homogeneity of variance assumption tested by Levene's test. The results show that entrepreneurial production technologies scores revealed a statistically significant difference between at least two counties, Welch's F (3, 101.351) = 7.452, p < .001; Brown-Forsythe's F (3, 169.226) = 5.973, p = .001.

Table 4: Robust Tests of Equality of Means

	Statistic[a]	df1	df2	Sig.
Welch	7.452	3	101.351	.000
Brown-Forsythe	5.973	3	169.226	.001

a. Asymptotically F distributed.

Post hoc comparisons, using the Games-Howell post hoc procedure, were conducted to determine which pairs of county's mean scores differed significantly. These results show a

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Journal of Entrepreneurship & Project Management
Volume 7||Issue 2||Page 64-77||May||2023|
Email: info@stratfordjournals.org ISSN: 2616-8464

significant difference between score for Kiambu and Laikipia (p=0.023); Nyeri and Laikipia (p=0.001); Laikipia and Nyandarua (p=0.02)

Table 5: Games-Howell Post Hoc

(I) County	(J) County	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kiambu	Nyeri	.1180581	.0698587	.332	-.063159	.299275
	Laikipia	-.2049388*	.0705319	.023	-.389485	-.020393
	Nyandarua	.2394298	.1064919	.127	-.045439	.524298
Nyeri	Kiambu	-.1180581	.0698587	.332	-.299275	.063159
	Laikipia	-.3229969*	.0814213	.001	-.535265	-.110729
	Nyandarua	.1213718	.1139965	.712	-.180974	.423718
Laikipia	Kiambu	.2049388*	.0705319	.023	.020393	.389485
	Nyeri	.3229969*	.0814213	.001	.110729	.535265
	Nyandarua	.4443687*	.1144103	.002	.140669	.748069
Nyandarua	Kiambu	-.2394298	.1064919	.127	-.524298	.045439
	Nyeri	-.1213718	.1139965	.712	-.423718	.180974
	Laikipia	-.4443687*	.1144103	.002	-.748069	-.140669

*. The mean difference is significant at the 0.05 level.

5.0 Conclusion

This study contributes to the research on entrepreneurial production technologies in the dairy sector. Prior work mainly focused on what technology and how it influences milk production (Mugabe, 2019; Wairimu, 2021) without creating a link to enterprise growth. The study examined the influence of entrepreneurial production technologies (for breeding, feed production and feeding, and waste handling technologies) on enterprise growth (Productivity, ROI, ROE and Employment) of smallholder dairy enterprises in Kenya and in doing so, empirically linked the depended and predictor variables.

The study findings are consistent with research suggesting that adoption of entrepreneurial production technologies directly affect growth of smallholder enterprises (Brutus & Chiyem, 2018; Mugabe, 2019; Wairimu, 2021). While much of the research on this topic has been productivity outputs, this study was conducted in the context of actual smallholder dairy farms

https://doi.org/10.53819/81018102t2136

that made use of entrepreneurial production technologies in an attempt to enhance their competitive advantage and enterprise growth.

6.0 Managerial implications

The study finding suggest that practitioners should expect greater enterprise growth when entrepreneurial production technologies are applied. Practitioners in the dairy sector investing in entrepreneurial technologies should ensure that breeding technologies, feeds production and feeding technologies and waste handling technologies are collectively incorporated to create a more positive effect.

7.0 Limitations and future research

The results of this study should be viewed in light of the following limitations. First, the study was conducted in only 4 counties in Kenya. Although, these are predominantly high milk producing counties in Kenya, the findings can be cited with caution. The study also focused only on four variables of enterprise growth (productivity, ROI, ROE and Employment). Thus, future research should consider expanding the growth measurement scope to include other measures such as market share and product development. The study also used a Likert scale to measure level of adoption. Thus, optional choice models may provide more information for corroborating the current findings.

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