In Search of the Determinants of Dairy Production in an Emerging Market: A Panel Data Approach

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Abstract

In view of the growing importance of the dairy sector, especially for the livelihood of the rural population and the increasing demand for milk by the Indian population, higher yield of milk animals and milk availability have become the focal point of attention. This study aims to identify the determinants of dairy production in India by examining the relationship of crossbreed and buffalo populations with the quantity of milk production across different Indian states. Fifteen major Indian states were included in this study and relevant secondary data from 2001 to 2019 was taken for analysis. The sources of statistical data are BAHS (GOI), Statistical abstract, NDDB website, etc. Coarse cereal, fodder crops, grazing land, artificial insemination and veterinary services have an influence on the total milk production of the Indian states, and the significance of these impacts were tested by pooled OLS regression analysis. Crossbreed cows, indigenous cows, buffalo and goat populations were tested with the Spearman's rho correlation test, and these variables were also found to have a positive correlation with the quantity of total milk production (TMP). The study was further extended to compare the population strength of the crossbreed and buffalo, their growth rate and ultimately the status of average milk production across the major Indian states during the period 2001 to 2019. Uttar Pradesh, Rajasthan, Gujarat, Punjab and Andhra Pradesh were found to have healthy production of milk. However, Bihar and Rajasthan were found as promising states. States like Orissa, Kerala, Uttarakhand and West Bengal were found to have certain points of concern.

Key words: *Dairy production; Emerging market; Panel Data; Coarse cereal; Artificial Insemination; Veterinary institution; Cross-breed cow*

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Introduction

Dairy farming in India is an important source of livelihood for rural societies comprising small, marginal and landless farmers. The dairy sector contributes to 9 percent of the GDP, employing 8 percent of the labour force. India has been transformed from a milk deficient country into the world's largest milk producer (from 55.6 million tonnes in 1990-91 to 187.7 million tonnes in 2018–19) (BAHS, 2020). Although the growth of milk production in India was steady for more than 20 years, progress in yield, *i.e.*, as the productivity of milk animals and growth of milk production, did not occur at the same pace in all the states. In this context, the importance of feed and fodder, and the implications of artificial insemination and veterinary service have been the subjects of debate.

During the last three decades, the dairy sector, especially the cattle and buffalo sector, has undergone a major transformation through genetic improvement resulting in a high yielding variety of crossbred cows and buffaloes (Sreenivas, 2013). Crossbreeding is an efficient short-term livestock improvement process. Improvement is possible in a single generation, though even then, cross-breeding effort is limited (McDowell et al., 1996). Limitation happens due to a lack of strategy and policy (Rege, 1998), the gap in understanding the levels of exotic inheritance for specific production arrangement (Kahi, 2002), improper assessment of socioeconomic factors and cultural values of livestock in different production environments leading to improper breeding objectives (Chagunda, 2002), small herd sizes having limitation in terms of breeding stock for cross-breeding purpose and in some cases even due to unknown exotic blood levels (Galukande et al., 2013). Although, India possesses a good number of high yielding breeds, still only 20-25 percent of the milk animal population belongs to a high yielding variety (Sreenivas, 2013). Apart from veterinary services, such as artificial insemination, vaccination, castration, and deworming are a few options that help to contain epidemics in milk animals and facilitate the growth of milk production (Yadav et al., 2014).

On the other hand, the growth and overall nourishment of milk animals depend largely on fodder from arable land, forests, pastures and grazing lands supported by crop residues of paddy, jowar, bajra, maize, etc. in the form of straw or bhusa (Shah et al., 2011). From the livelihood perspective, feed and fodder costs are significant, accounting for more than 70 percent of livestock rearing costs (Devendra and Leng 2011; Makkar, 2016). Locally available feed sources have been stated as the principal factor behind animal productivity. It has also been suggested that green fodder significantly aids in boosting health, productivity and reproductive efficiency. This is a suitable substitute to replace costlier feed ingredients (Mohini et al., 2007). The inclusion of green fodder in the ratio of the dairy animal diet reduces the requirement of concentrate feeding, thus, it enabling higher profits (Hossain et al., 2017). Green fodder rationing also helps in environmental sustainability through reductions of methane emission by 5 to 10 percent (Prusti et al., 2014).

Over time, our food basket composition has changed due to rapid urbanization, increase in disposable income, changing lifestyle and increasing health consciousness (Kumar et al., 2007). Milk and milk products have been essential components in our food basket, though milk production and per capita availability of milk vary among the states in India (Kumar et al., 2014). This has led to an interest in exploring the core reasons behind the variation of milk production among the major Indian States.

Materials and Methods

Collection of data and variables

In the present study, fifteen major Indian states (Gujarat, Karnataka, Uttar Pradesh, Uttarakhand, Punjab, Rajasthan, Orissa, West Bengal, Maharastra, Andhra Pradesh, Tamilnadu, Kerala, Bihar, Madhya Pradesh and Haryana) were included. These states together have a significant contribution (more than 80 percent of total milk production) to the total milk production of India. The sourcing period of annual data was considered from 2001 to 2019. Basic data with regard to milk animal population and milk production was taken from the 2020 Basic Animal Husbandry Statistics Report. The variables examined in this study are outlined in Table 1, and were examined for visible differences, if any, to determine the possible reasons for any disparity of development.

Empirical Model

To meet the research study objective, the study examined the different states of India over the years 2000/01 to 2018/19 to assess the response of total milk production with respect to variation in the variables: Coarse Cereals (CC), Fodder Crops (FC), Grazing Land (GL) Number of Veterinary Institutions (VI) and Artificial Insemination (AI). The analysis was based on the model by Gujarati (2012):

$$\ln TMP_{i,t} = \alpha_i + \beta_1 \ln(CC)_{it} + \beta_2 \ln(FC)_{i,t} + \beta_3 \ln(GL) + \beta_4 \ln(AI)_{i,t} + \beta_5 (VI)_{i,t} + \varepsilon_{i,t}$$

All symbols have their identification of variables in respective to Table 1. All variables were converted into their respective natural logarithm form except (VI), as this indicates the absolute number of veterinary institutes. The subscript "i, t" of each variable stands for state 'I' at time't'.

Table 1. Description, Symbols and Source of Data Variables

Variables in study	Symbol	Description	Sources (Accessed in September 2020)
Total milk production	TMP	Annual milk production in each state (in tonnes)	Basic Animal Husbandry and Statistics, Department of Animal Husbandry, Dairying. Govt. of India
Coarse Cereals	CC	In tonnes	Directorate of Economics and Statistics. Dept. of Agriculture, Cooperation and Farmers' Welfare.
Fodder Crops	FC	Irrigated area (hectares) available on an annual basis	Directorate of Economics and Statistics. Dept. of Agriculture, Cooperation and Farmers' Welfare.
Grazing land	GL	Grazing land for feeding	Directorate of Economics and Statistics. Dept. of Agriculture, Cooperation and Farmers' Welfare.
Veterinary Institution	VI	No. of operational vet service units	Basic Animal Husbandry and Statistics, Department of Animal Husbandry, Dairying. Govt. of India
Artificial Insemination	AI	Total inseminations per year for each state	National Dairy Development Board website

Further, the coefficients βi, (i=1, 2, 3, and so on) correspond to the elasticity of total milk production with respect to the five independent variables taken into consideration in this study.

While observing the influence of core factors on milk production, the authors further examined the relationship of crossbreed cows and buffalos with the quantity of milk production. In view of the low number of crossbreeds and buffalos in India in comparison to other developed countries of the dairy sector, the study was extended to determine the impact of crossbreed and buffalo populations on milk production across these states.

Results and Discussion

As a prerequisite of panel data analysis, the authors conducted LLC (2002) and IPS (2003) tests to detect the order of all selected variables to overcome the problem of spurious regression. Subsequently, this study considered the panel data analysis techniques to ensure the robustness of the obtained results. The study estimation consisted of the pooled ordinary least squares (OLS) technique (Freeman, 2003; Golder et al., 2013). Though it was assumed that this was likely to generate a biased result by not considering the state-wise effects and endogeneity of the independent variables, the purpose of this study was to examine the direction of the impact of independent variables, and not the strength of their relationships (Bass and Wittink 1975; Vuko and Čular, 2014). The results of the pooled OLS are given in Table 2, which shows that the coefficient estimates and the sign (positive) are in the expected direction. The results of the pooled OLS regression clearly showed that Artificial Insemination (AI), Veterinary Institution (VI), Coarse Cereals (CC), Fodder Crops (FC) and Grazing land (GL) have a positive and significant impact on the total milk production in the different states of India (Table 2).

The effectiveness of Artificial insemination (AI) has been proven in several studies. AI was found to be more effective than natural selection by Lima et. al. (2010). The findings regarding fodder ratio were also positive, as it was found to increase milk production by 1.5 litres/ day (Vinothraj et al., 2019). The impact of improved veterinary services on milk productivity was observed through the study of Uddin et al. (2010).

To examine the relationship between the number of crossbred cows and buffalos with the production of milk in that particular state of India, the Spearman's rho rank correlation test was performed. The results showed that there was a positive significant correlation between the number of crossbred cows,

Table 2. Pooled OLS regression analysis results

Dependent Variable- lnTMP			
Independent variables	Coefficient	t-Statistic	Significant Values
lnCC	0.1909	4.522	0.000
lnFC	0.1818	11.936	0.000
lnGL	0.1129	5.575	0.000
lnAI	0.2672	9.003	0.000
VI	0.2295	3.7566	0.000

R square value 0.8438

indigenous cows, buffaloes and goats with the quantity of the total milk production (TMP) in the states of India (Table 3). The contribution of cross-breeds to the increase in milk production in Kerala state was previously mentioned (Chacko, 2005). It was also reflected through the recommendation of the

Table 3. Spearman's rho Correlation Coefficient between

	Number of crossbreed cows	Number of indigenous cows	Number of buffalos	Goats
Total Milk Production	0.319	0.357	0.837	0.392
Significance value	0.000	0.000	0.000	0.000

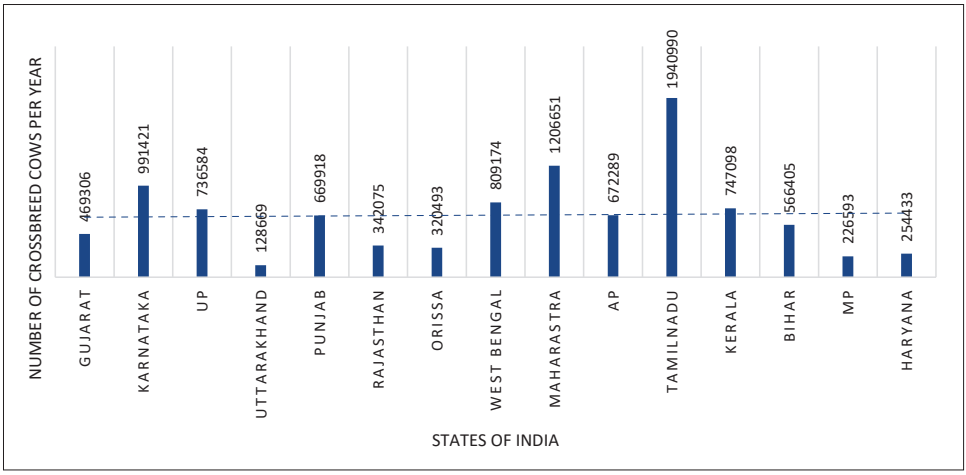

Figure 1. Average cross-breed cows population (numbers/year) in 15 states of India

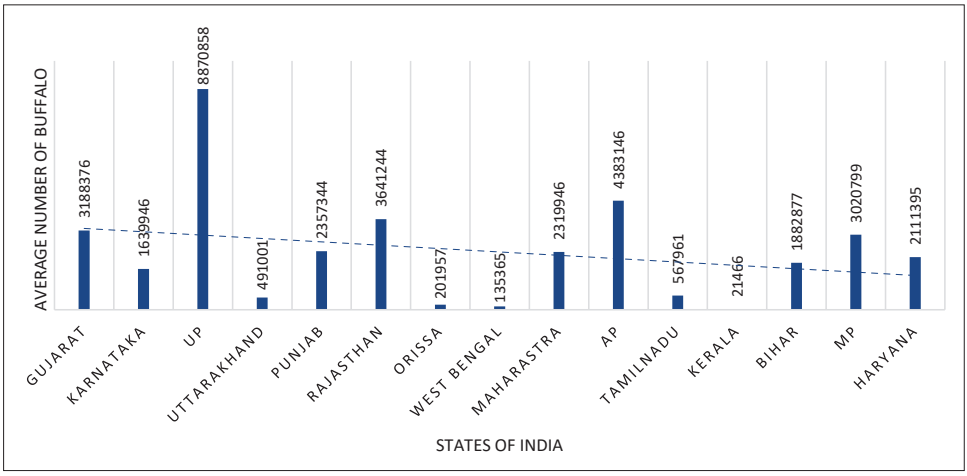

Figure 2. Average Buffalo population (numbers/year) in 15 states of India

National Commission on Agriculture (NCA) in 1974 to adopt a cross-breeding strategy for increasing milk production in India (NCA, 1976).

State-wise average Crossbreed Cows and Buffalo population

Subsequent to the findings of the relationship between the crossbreed and buffalo population with total milk production, crossbreed and buffalo populations of those states and their growth rate were examined to anticipate future trends.

Tamilnadu was the leading state in the cross-breed population followed by Maharastra and Karnataka. Madhya Pradesh (MP) and Uttarakhand had very small cross breed populations (Figure 1 and 2).

In the case of the buffalo population, Uttar Pradesh (UP) had a substantially larger population than other states, followed by Andhra Pradesh (AP), Rajasthan and Gujarat. West Bengal,

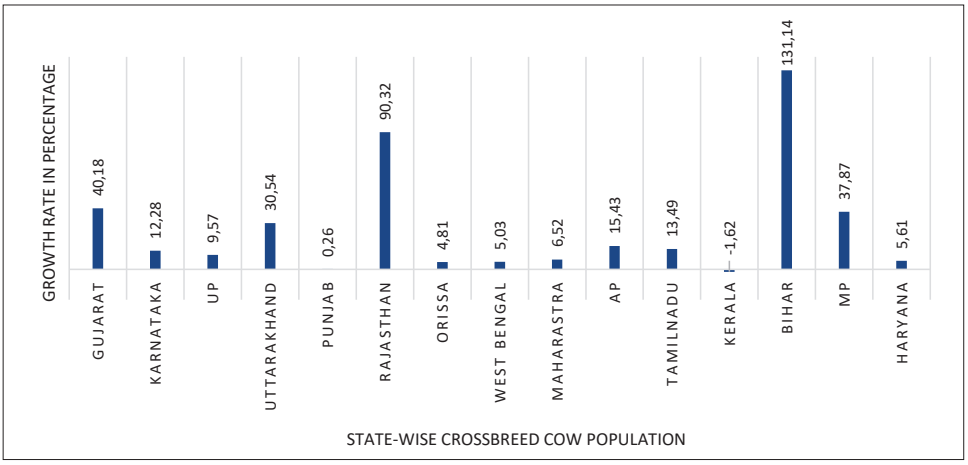

Figure 3. Growth Rate of Cross Breed Cow Population during 2001 to 2009

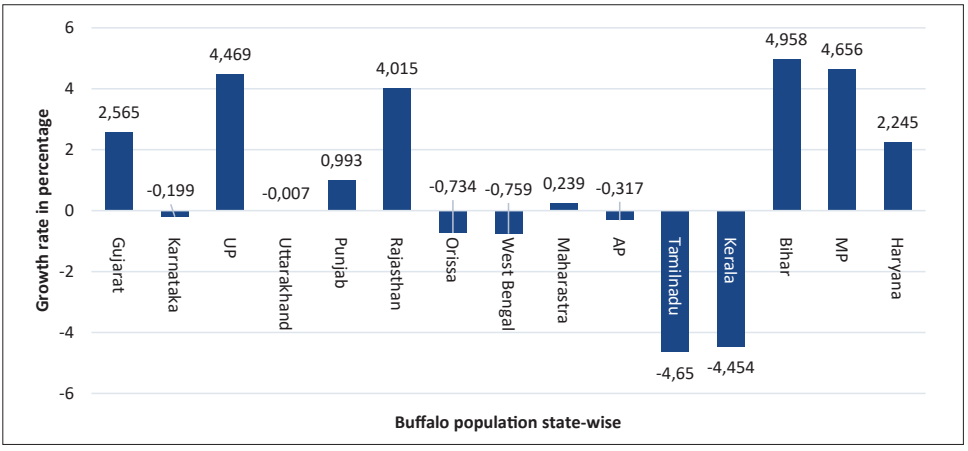

Figure 4. Growth rate of Buffalo population in 15 states of India

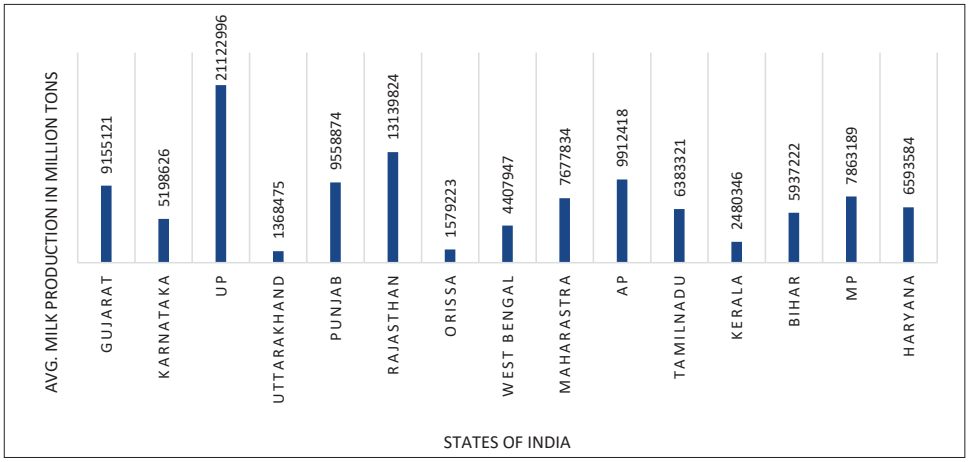

Figure 5. Average milk production during 2001 to 2019

Kerala, Orissa, Tamil-Nadu and Uttarakhand had very small buffalo populations.

Growth rate of cross-breed cows and buffalo populations

After a comparison of population strength, the population growth rate was considered for the study, as this can direct the growth of milk production due to the higher milk production potential of crossbreed and buffalo.

In spite of having a moderate crossbreed population, Rajasthan and Bihar were found to have a healthy growth rate in comparison with the remaining states of India (Figure 3 and 4).

Bihar was found to lead the growth rate of buffalo population followed by Madhya Pradesh (MP), Uttar Pradesh and Rajasthan. Tamil-Nadu, Kerala, Karnataka, Uttarakhand, West Bengal, Orissa and Andhra Pradesh were found to have a negative growth rate leading to a gradual reduction of buffalo milk (and also in total milk production) in those states.

Average milk production per year

The annual milk production (average) of states for the study period was examined. All major Indian states were examined for the study and their milk production is shown in Figure 5.

Uttar Pradesh was found to be the leader, followed by Rajasthan. Andhra Pradesh, Punjab and Gujarat, which all had healthy milk production. On the other hand, Kerala, Orissa, Uttarakhand and West Bengal were found to have lacklustre performance.

Conclusion

The study showed that feed resources like coarse cereal and fodder crops, and veterinary services like artificial insemination and services by veterinary hospitals have a significant influence on milk production. In addition, the correlation of milk production with crossbreed cows and buffaloes was established through Spearman's rho Correlation test. It indicated that the availability of suitable milk animal types, like crossbreed cows or buffalos, can substantially influence total milk production. Rajasthan and Bihar were found to have a promising growth rate of crossbreed and buffalo populations, which may surpass others if their progress continues. The growth rate of

the buffalo population for a number of states were found as concern points. Further, additional research is required to examine all the direct and indirect techno-commercial factors that could provide a more detailed cause and effect analysis.

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U potrazi za odrednicama proizvodnje mlijeka na tržištima u nastajanju: pristup uporabe panel podataka

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S obzirom na sve veću važnost mljekarskog sektora, posebice za život ljudi u ruralnim područjima te sve veću potražnju za mlijekom indijske populacije, veći prinos životinja koje proizvode mlijeko i dostupnost mlijeka postali su fokalna točka pozornosti. Cilj ove studije jest prepoznati odrednice proizvodnje mlijeka u Indiji te ispitati odnos populacija hibrida i bizona s količinom proizvodnje mlijeka u različitim državama Indije. Petnaest je velikih država Indije za ovu studiju uzeto u obzir te su odgovarajući sekundarni podatci analizirani od 2001. do 2009. godine. Izvor statističkih podataka je BAHS (*Osnovni podatci o stočarstvu*) (Vlada Indije), statistički sažetak, web stranica NDDB (Nacionalni odbor za razvoj mljekarstva), itd. Utjecaj grubih žitarica, krmnih biljaka, pašnjaka, umjetne oplodnje i usluga veterinarskih zavoda je ispitan s obzirom na njegovo značenje putem modela s konstantnim regresijskim parametrima (*Pooled OLS regression analysis*). Grube žitarice, krmno bilje, pašnjaci, umjetno osjemnjivanje i veterinarske usluge od značajnog su utjecaja na sveukupnu proizvodnju mlijeka država Indije. Osim toga, populacije hibridnih krava, autohtonih krava, bizona i koza ispitane su putem Spearmanovog rho korelacijskog testa te je otkriveno da i ove varijable imaju pozitivnu korelaciju s obzirom na količinu ukupne proizvodnje mlijeka (TMP). Studija je dodatno proširena grafičkim prikazima za usporedbu jačine populacije hibridnih krava i bizona među različitim državama, njihove stope rasta i na kraju statusa prosječne proizvodnje mlijeka u velikim državama Indije tijekom razdoblja od 2001. do 2019. Za Uttar Pradesh, Rajasthan, Gujarat, Punjab i Andhra Pradesh otkriveno je da imaju zdravu proizvodnju mlijeka. Međutim, Bihar i Rajasthan su se pokazale obećavajućim državama. Za države poput Orissa, Kerala, Uttarakhand i Zapadnog Bengala pokazalo se da postoje zabrinutosti.

Ključne riječi: *proizvodnja mlijeka, tržišta u nastajanju, panel podatci, grube žitarice, umjetno osjemenjivanje, veterinarski zavod, hibridna krava*