Original Research Article

Trend and Instability Analysis of Milk Prices in Major Markets of India

ABSTRACT

The behavior of milk retail prices in the major consuming markets of India has been examined in this article using deseasonalised monthly milk retail prices from 1975-76 to 2022-23 and production and per capita availability of milk data. The entire period was further divided into two sub-periods and Compound Annual Growth Rate (CAGR) of production and per capita availability of milk, CAGR, Coefficient of Variation around the trend and Bandyopadhyay (1989) methodology were used to examine the price variability and convergence/divergence of milk retail prices. The study concluded that the production and per capita availability of milk was increasing continuously. The highest average milk retail price was recorded in Delhi market during TE2022. The growth rate of milk retail prices were increased in Delhi and Kolkata markets while in Mumbai and Chennai markets, it was reduced from sub-period I to sub-period II. The variability of milk retail prices were reduced from sub-period I to sub-period II in all the selected markets. The Mumbai market exhibited highest reduction in variability in milk retail prices while the Chennai market showed lowest reduction in retail price of milk from sub-period I to sub-period II. The positive and negative deviation trend lines were diverging during sub-period I while they were converging during sub-period II. This indicated that instability of milk retail price was reducing during sub-period II. The reduction of milk retail prices was caused by the increased production and per capita availability of milk, increased milk processing capacity and improvement in marketing infrastructure in the recent time.

Key words: Milk, Price, Growth rate, Instability, Convergence, Divergence.

1. INTRODUCTION

India has travel gone a long way to become the largest milk producer in the world. Presently, India produces 230.6 Million tons milk and contributes more than 25 per cent to total world's milk production. The per capita availability of milk has reached to 459 gram/day[4]. The total amount of milk and milk products consumed in India is 162.4 Million tons[17]. The rise in the milk production had primarily been attributed to ~~contributed by~~ the shift in the composition of dairy herd from traditional to crossbred cows and buffaloes, genetic enhancement, better management of stock and farmers' improved access to milk markets[10-11]. The increasing milk production had improved the competitiveness of Indian dairy in global context[13] and insatiability in milk production had reduced over time[14]. The demand of milk in developing countries is expected to rise by 25 per cent in 2025[8]. This increase in demand of milk is further expected to raise the price. Although, Birthal *et al*., 2018[5] pointed out that dairy yield is not much responsive to the output price but Chand, 2002[7] observed that apart from the domestic prices, international prices of milk and milk products also influence the competitiveness, export, import of milk and milk products. The price is one of the important factors affecting the choice of dairy products by the consumer[2, 6, 9, 12]. The demand for dairy products is highly responsive to changes in disposable incomes in both rural and urban areas[15]. Thus, among other things, price plays a strategic role in influencing the consumption of milk and milk products in different geographical markets and for market segments within a market. The behavior of milk prices in Indian markets is of significant importance influenced by a several factors ranging from seasonal fluctuations to policy interventions. In India, dairy sector is vast and complex supporting millions of farmers and serves as an essential component of the daily diet for a large section of the population. The pricing dynamics in India are often unpredictable and region-specific due to variations in demand, supply, and input costs.

2. MATERIAL AND METHODS

2.1. Data: The presented study has utilized secondary data to achieve its objectives. Thus, monthly retail prices of milk for major consuming markets i.e., Delhi, Mumbai, Chennai and Kolkata markets were collected for the period of 48 year i.e., 1975-2022 from Agricultural Prices in India[1] published by the Directorate of Economics and Statistics, Ministry of Agriculture and Farmer Welfare, Government of India, New Delhi. The data on production and per capita availability of milk were collected from same report only for 43 years i.e., 1980 – 2022 because year wise data on production and per capita availability of milk were available from 1980 onward. Thereafter, the entire period has been divided into two sub-period; sub-period I from 1975-76 to 1999-2000 and sub-period II from 2000-01 to 2022-23 to assess the growth rate of production and per capita availability of milk at national level, growth rate, variability and convergence/divergence of retail prices of milk in the selected markets over time.

2.2. Analytical tools: The CAGR was estimated to study the growth rates in milk retail price and Coefficient of Variation around the trend was computed to examine the variation in milk retail prices. Since, the price of milk is highly influenced by seasonality, thus, original data was deseasonalised through twelve month moving average method to estimate the growth rates and price variation. The CAGR was computed by converting the deseasonalised monthly retail prices into annual prices by taking the average of the monthly prices. In order to find out the growth rates, exponential function of the following form was estimated.

$$P_t = a\, e^{bt + u}t$$

Where, P_t = Retail price of milk, t = Time, a = Constant parameter, b = Growth rate and u_t = Random error term. Instead of using coefficient of variation (CV) around mean, CV around trend had been used due to non-stationary nature of time series data. In order to find out whether deviations in retail price of milk is increasing or decreasing over the time, a method suggested by Bandyopadhyay (1989)[3] had been used. In this method, a linear trend is fitted to the prices of each market and deviation (positive and negative) of observed values from the estimated value had been separated. Again, separate trends line of positive deviations (P^+) and negative deviations (P^-) of following nature was fitted.

$$P^+_t = a` + b`t$$
$$P^-_t = a`` + b``t$$

For each trend line, all the usual tests of significance and goodness of fit had been carried out.
An F-test of following nature had been employed to test the hypothesis that 'positive' and 'negative' trend lines are parallel.

$$F = \frac{(R^*_{yy} - R_{yy})/(v^* - v)}{R_{yy}/v}$$

Where, R^*_{yy}= Residual sum of squares due to linear fit on observed values, R_{yy}= Residual sum of squares from 'positive' deviation trend line plus Residual sum of squares from 'negative' deviation trend line, $v^* = n - k - 1$, $v = n - 2k$, where n =number of observations and k = number of parameters estimated. If $F > F_{k-1, n-2k}^{(\alpha)}$, then the hypothesis is rejected at the level of significance α. The inclination of these trend lines show whether the variability in prices is divergent or convergent by estimating the value of '**t***' at the point of intersection. The value of '**t***' at the point of intersection of positive and negative trend lines was estimated by using following formula:

$$t^* = \frac{(a'' - a')}{(b' - b'')}$$

If **t* > 0**, both the trend lines converge in the positive quadrant, and hence the variation is reducing. If **t* < 0**, both the trend lines diverge in the positive quadrant and hence the variation is increasing. The rate of convergence or divergence per unit of time is calculated by estimating:

$$|\tan \theta^{+} - \theta^{-}| = (b` - b``)/(1 - b`*b``)$$

Hypothesis: With the increasing milk production and improvement of market infrastructure and intelligence, it has been hypothesized that the price variability and instability (intra and inter market) would reduce over time and eventually price will converge.

3. RESULTS AND DISCUSSION

3.1. Growth rate of production and per capita availability of milk

The production and per capita availability of milk is continuously increasing from 1980 to 2022. The milk production was 31.6 million tons in 1980 which has increased to 230.6 million tons in 2022. The per capita availability of milk was only 128 gram/day in 1980 which has increased to 459 gram/day in 2022 (Fig.1). Thus, the milk production at national level has increased by more than seven hundred per cent while per capita availability of milk has increased by more than three hundred per cent between 1980 and 2022 (Table 1).

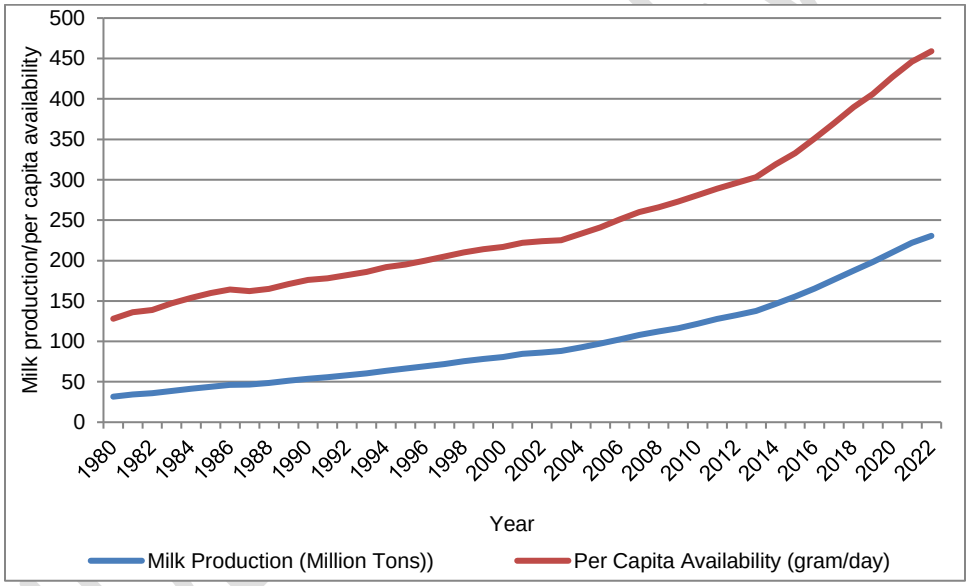


Figure 1. Production and per capita availability of milk in India (1980-22).

The rate of growth in milk production was estimated to be 4.66 per cent during sub-period 1 which had increased to 5.00 per cent during sub-period II. Similarly, the growth rate of per capita availability of milk was observed to be 2.51 per cent during sub-period I which had increased to 3.56 per cent during sub-period II (Table 1). Thus, growth rate of production and per capita availability of milk had increased from sub-period I to sub-period II.

Table 1: Growth rate (CAGR) of production and per capita availability of milk in India

(Per cent)

Period	Milk production	Per capita availability
Sub-period I (1980-99)	4.66	2.51
Sub-period II (2000-22)	5.00	3.56

Increase between 1980 and 1999	248	167
Increase between 2000 and 2022	246	212

3.2. Growth rate of milk retail prices

The average retail price of milk and estimated CAGR for selected markets had been presented in the table 2. The highest average retail price of milk in TE 1977, TE 2001 and TE 2022 was observed in Kolkata (Rs.4.26/litre), Mumbai (Rs.21.50/litre) and Delhi (Rs.61.79/litre) markets, respectively while lowest average retail price of milk in TE 1977, TE 2001 and TE 2022 was observed in Mumbai (Rs.1.08/litre), Chennai (Rs.11.02/litre) and Kolkata (Rs.50.33/litre) markets, respectively. The rates of growth of milk retail price were estimated to be 6.66 per cent, 9.12 per cent, 11.88 per cent and 8.16 per cent in Delhi, Mumbai, Chennai and Kolkata markets, respectively during sub-period I. In the sub-period II, the growth rate of milk retail prices in Delhi, Mumbai, Chennai and Kolkata markets were observed to be 7.12 per cent, 7.75 per cent, 5.42 per cent and 9.46 per cent respectively. The growth rate of milk retail prices were increased in Delhi and Kolkata markets, while in Mumbai and Chennai markets, the growth rate was reduced from sub-period I to sub-period II. The Chennai market had shown highest growth rate during sub-period I while during sub-period II, highest rate of growth of milk retail prices was recorded in the Kolkata market.

Table 2: Average milk retail price and its growth rate (CAGR) in selected markets.

Markets	Average milk retail price (Rs./litre)			Growth rate (Per cent)	
	TE -1977	TE -2001	TE -2022	Sub-period I (1975-99)	Sub-period II (2000-22)
Delhi	2.42	16.72	61.79	6.66	7.12
Mumbai	1.80	21.50	58.22	9.12	7.75
Chennai	2.02	11.02	54.36	11.88	5.42
Kolkata	4.26	15.05	50.33	8.16	9.46

The monthly milk retail price had been shown in figure 2. In 1975-76, retail price of milk was lowest in the Mumbai market while it was highest in Kolkata market. But, highest price was observed in Delhi market and lowest price was recorded in Kolkata market in 2022-23. Moreover, the fluctuation in milk retail prices has gradually reduced and milk retail prices have become more stable in recent period leading to the reduction in the coefficient of variation around the trend.

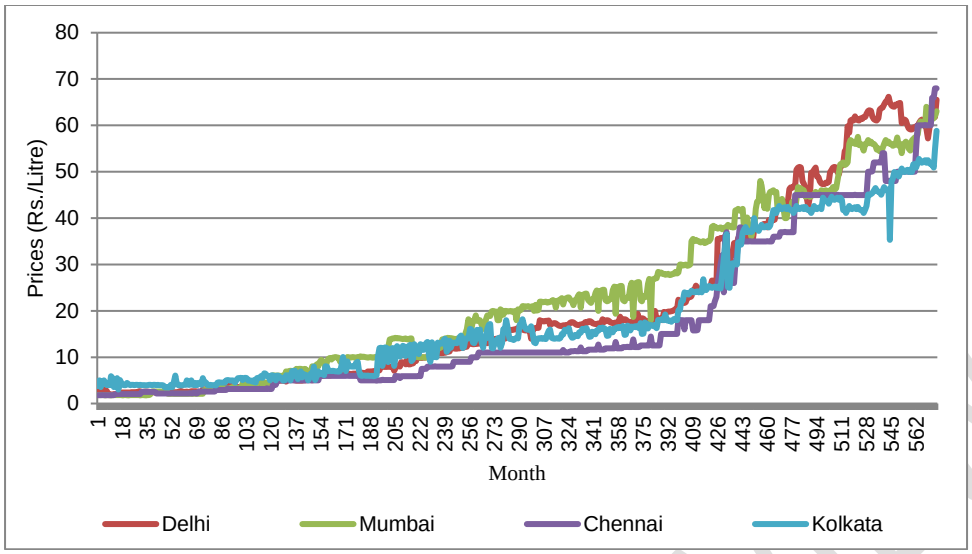


Figure 2. Monthly milk retail price in the selected markets (1975-22).

3.3. Variation in milk retail prices

Coefficient of variation around the trend had been calculated to ascertain the variation of milk retail prices and presented in the table 3. The calculated coefficient of variation around the trend for Delhi, Mumbai, Chennai and Kolkata markets were found to be 18.64 per cent, 19.27 per cent, 17.54 per cent and 20.54 per cent during sub-period I which were reduced to 13.12 per cent, 7.07 per cent, 14.50 per cent and 10.94 per cent during sub-period II, respectively. Similar pattern of milk retail prices was reported by Singh and Chandel, 2018[16]. The highest reduction in variability of milk retail prices were observed in the Mumbai market and lowest reduction in variability of milk retail price was recorded in the Chennai market from sub-period I to sub-period II. Since, Delhi market is located in the largest milk producing region, thus it was supposed to have lowest fluctuations in the retail price of milk but this was not the case. The possible reasons for this may be that, although, it is located in the highest milk producing region but at the same time, it is also the region of highest milk consumption and due to this, fluctuations of milk retail price was not lowest in the Delhi market. The reduction in variability of milk retail prices during sub-period II was primarily due to the increase in the rate of growth of milk production which led to the smooth supply of milk during this period.

Table 3: Variation in milk retail prices in selected markets.

(Per cent)

Market	Periods	
	Sub-period I (1975-99)	Sub-period II (2000-22)
Delhi	18.64	13.12
Mumbai	19.27	7.07
Chennai	17.54	14.50
Kolkata	20.54	10.94

3.4. Instability in retail prices of milk

The estimated regression coefficients of overall, positive and negative deviation trend lines and value of F-test for Delhi, Mumbai, Chennai and Kolkata markets had been given in the table 4. During the sub-period I, the estimated parameters for overall and negative deviation trend line were found to be statistically significant while estimated parameter for positive deviations trend line was observed to be statistically significant only for Chennai market. During sub-period II, the estimated parameters of overall, positive and negative deviation trend lines were statistically significant for all the selected markets except for Chennai market where estimated parameter of negative deviation trend line was not statistically significant. The F-test confirmed that, positive and negative deviation trend lines are not parallel for all markets for sub period I and sub-period II for all the markets.

Table 4: Regression coefficients of overall, positive and negative deviation trend lines for selected markets.

Period	Estimated parameters/ Hypothesis	Name of the market			
		Delhi	Mumbai	Chennai	Kolkata
Sub-period I (1975-99)	b	0.047**	0.067***	0.033***	0.044***
	b+	0.002	0.003	0.003**	-0.0003
	b-	-0.005***	-0.005***	-0.006***	-0.0080***
	F test ($H0:b^{+}=b^{-}$)	838.168***	804.145***	636.207***	698.173***
Sub-period II (2000-22)	b	0.213***	0.162***	0.202***	0.164***
	b+	-0.014*	-0.008**	-0.014***	-0.016***
	b-	0.020***	0.008**	0.005	0.011***
	F test ($H0:b^{+}=b^{-}$)	745.665***	580.791***	675.698***	759.639***

***significant at 99 per cent level; **significant at 95 per cent level; *significant at 90 per cent level

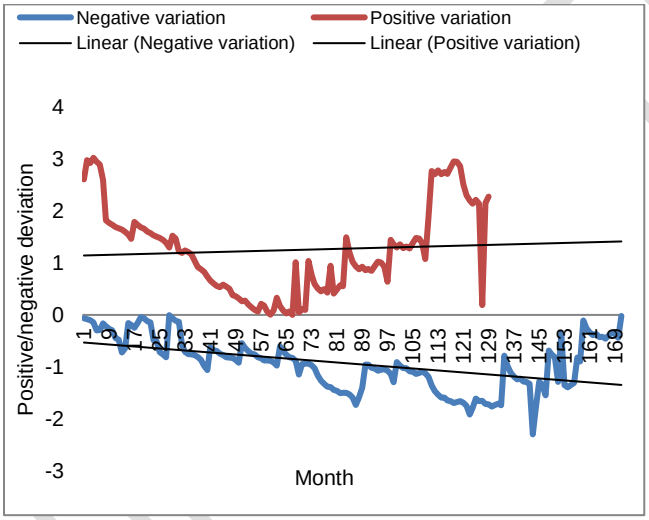
3.5. Nature of instability/stability in retail prices of milk

Once, it is ascertained that the positive and negative deviations trend lines were not parallel, the convergence/divergence of positive and negative deviation trend lines has been assessed by estimating the '**t***'. The estimated value of '**t***' along with the $|\tan \theta^{+}-\theta^{-}|$had been presented in the table 5. The estimated value of '**t***' were found negative for Delhi, Mumbai, Chennai and Kolkata markets indicating that positive and negative deviation trend lines were found diverging during sub-period I (1975-99) implying that the positive and negative deviation trend lines are moving away from each other and deviations was increasing during this sub-period while in sub-period II, the estimated value of '**t***' were found positive for selected markets revealing convergence of positive and negative deviation trend lines indicating reduction in deviation and positive and negative deviation trend lines were moving closer to each other. The rate of divergence of positive and negative deviation trend lines were estimated to be 0.006, 0.008, 0.009 and 0.008 for Delhi, Mumbai, Chennai and Kolkata markets, respectively during sub-period I. The rate of convergence of positive and negative deviations trend lines during sub-period II were found to be 0.034, 0.016, 0.019 and 0.027 for Delhi, Mumbai, Chennai and Kolkata markets, respectively. Thus, the positive and negative deviation trend lines were found diverging at very low rate during the sub-period I while during sub-period II, positive and negative deviation trend lines were converging at higher rate.

Table 5: Convergence/divergence of positive and negative trend lines of milk retail price in selected markets.

Particulars	Market			
	Delhi	Mumbai	Chennai	Kolkata
	1975-99			
t*	**-261.171**	**-260.974**	**-94.418**	**-270.432**
Conversion(C)/ Diversion (D)	D	D	D	D
$\|\tan \theta^{+}-\theta^{-}\|$	**0.006**	**0.008**	**0.009**	**0.008**
	2000-22			
t*	**305.961**	**347.812**	**460.518**	**284.695**
Conversion(C)/ Diversion (D)	C	C	C	C
$\|\tan \theta^{+}-\theta^{-}\|$	**0.034**	**0.016**	**0.019**	**0.027**

The positive and negative deviation trend lines was diverging at lowest rate in the Delhi market during sub-period I while it was converging at highest rate in Delhi market during sub-period II. Thus, instability in Delhi markets was reducing at higher rate compared to other markets and this may be because Delhi markets is surrounded by the major milk producing states like Uttar Pradesh, Rajasthan, Punjab, Haryana, etc. The graphical depiction of positive and negative deviation trend lines also support the convergence of positive and negative trend lines during sub-period II (Figure 3a, Figure 3b, Figure 3c and Figure 3d) and sub – period II (Figure 4a, Figure 4b, Figure 4c and Figure 4d).



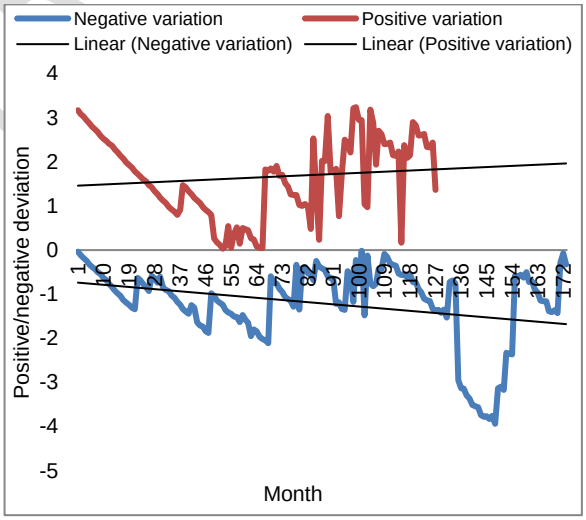


Figure 3a. Delhi market.

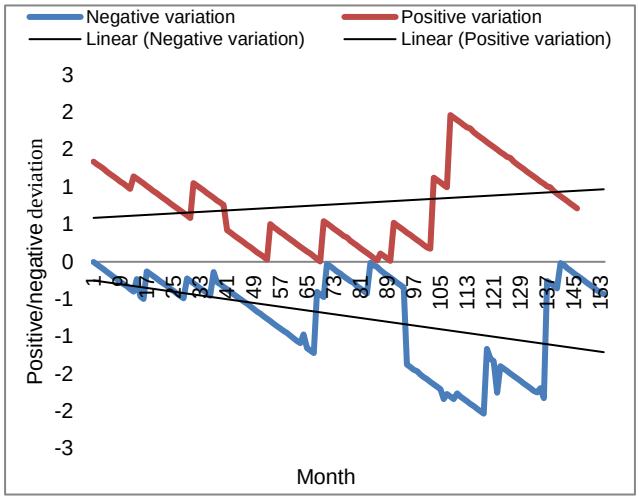


Figure 3b. Mumbai market.

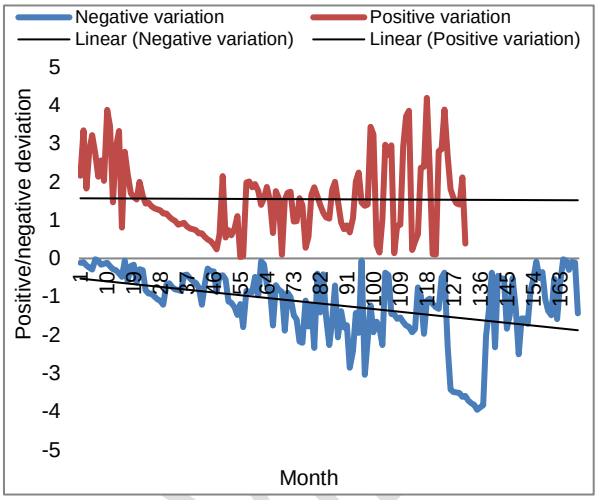
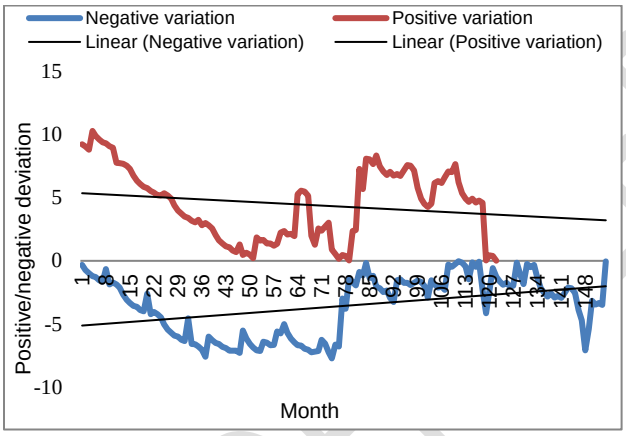


Figure 3c. Chennai market.

Figure 3d. Kolkata market.

Figure 3. Diversion of positive and negative deviation trend lines during sub-period I (1975-99).



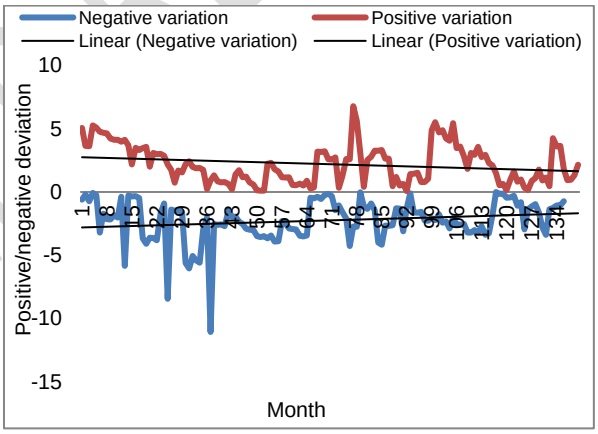


Figure 4a. Delhi market.

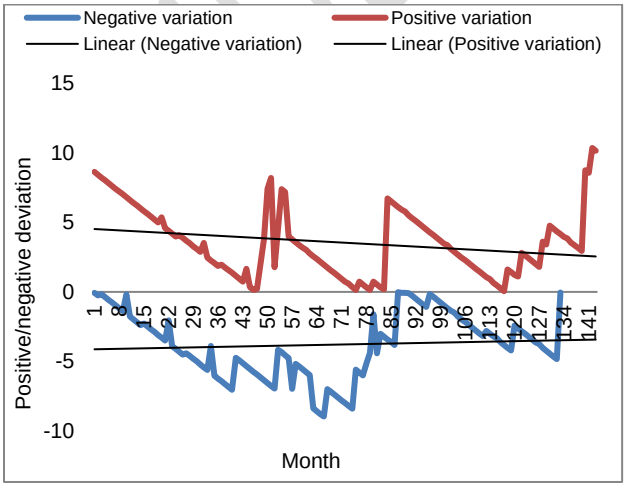


Figure 4b. Mumbai market.

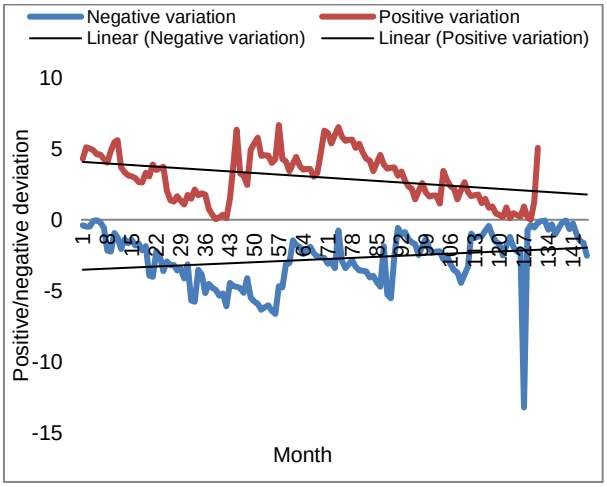


Figure 4c. Chennai market. **Figure 4d. Kolkata market.**

Figure 4. Conversion of positive and negative deviation trend lines during sub-period II (2000-22)

4. CONCLUSIONS

The growth rate of production and per capita availability of milk had increased over time. The highest milk retail price was observed in Delhi markets during TE 2022. The CAGR of milk retail prices were increased in Delhi and Kolkata markets, while in Mumbai and Chennai markets, the growth rate was reduced from sub-period I to sub-period II. The variability in the retail prices of milk were reduced in the sub-period II in all the markets as compared to sub-period I. Similar pattern of milk retail prices was reported by Singh and Chandel, 2018. This reduction in price variability in sub-period II may be happened due to the increased production and per capita availability of milk, stable milk supply chain and other marketing infrastructures during sub-period II. The highest reduction in variability of milk retail prices were observed in the Mumbai market and lowest reduction in retail price of milk was recorded in the Chennai market from sub-period I to sub-period II. Delhi market is located in the largest milk producing region, thus, it was supposed to have lowest fluctuations in the retail price of milk but this was not the case. The possible reasons for this may be that, although, it is located in the highest milk producing region but at the same time, it is also the region of highest milk consumption and due to this, variation of milk retail price was not lowest in the Delhi market. During sub-period I, positive and negative deviation trend lines were diverging while during sub-period II, it was converging in all the selected markets. The convergence of positive and negative trend lines during sub-period II could be possible due to the increased supply of milk, development of marketing infrastructures and other government's policies leading to the reduction in the instability of retail milk prices. The convergence of positive and negative trend lines was also observed during sub-period II, when positive and negative deviations were plotted on graph. Thus, it could be concluded that price variability and instability has reduced over time and there is a possibility that price variability and instability will further reduce over time as the production and per capita availability of milk and marketing infrastructure strengthen.

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