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Dynamics of arrivals and prices of Apple and Banana in APMC Nagpur

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Abstract
This Research project presents a comprehensive study of data from 2004 to 2024 in Dynamics of arrivals and prices of Apple and Banana in APMC, Nagpur. The study aims to examine the trends and variations through Compound Growth rate, Coefficient of variation, seasonal and cyclical indices. In the present study, the secondary data on arrivals and prices of Apple and Banana for the period of 20 years i.e. from 2004-2024 collected from Agmark.net and APMC office Nagpur to analysed growth rate, variability, trends, seasonal and cyclical behaviour of Apple and Banana in APMC, Nagpur. Apple – (*Malus Domestica)* temperate fruit and 4rth among most produce fruit in world after banana, orange and grapes (NHB). According to USDA (2024-25) – India rank 5th in global production and contribute 3%. Banana - (*Musa sp.*) 2nd important fruit crop in India after Mango. Banana grown in 120 countries among that India lead the world (NHB).
There are different analytical tools used like CAGR, CV, SI and CI. Growth rate of arrivals of Apple declined significantly by 0.51% per annum during second period and prices increased by 0.73% and 0.47% per annum during first and overall period respectively. For Banana arrivals declined by 1.39, 2.45 and 1.57 percent per annum during first, second and overall period respectively. Banana prices increased by 0.76 and 0.30 percent per annum during first and overall period respectively. The variability in arrivals and prices of Apple was high in first period (2004-14). In case of Banana variability of arrivals was high in overall period (2004-24) and prices in first period (2004-14). The trend analysis revealed that, both prices and arrivals of Apple followed cubic trend and exponential trend followed by arrivals of Banana and cubic by prices. There exist seasonality in the arrivals and prices of Apple and Banana in APMC Nagpur. Higher values of arrivals of Apple found in the months of August followed by September and October, after it start declining. Prices of Apple was high during April, may and june. Higher arrivals of Banana found in a month of August, September and October then it start decreasing. Prices was high during December, January, February and March. cyclical variations observed in both arrivals and prices of Apple and Banana. The higher arrivals of Apple recorded during the year 2010, 2015, 2018 and 2019, while prices during 2011, 2012 and 2016. Similarly for Banana high arrival during the year 2004, 2008 and 2012. From 2021 to 2024 Banana shows negative cyclical indices. It means least arrival during these year in APMC Nagpur. Prices high during year 2010, 2011 & 2012.

Keywords: Growth rate, trend, variability, seasonal indices, cyclical indices

1. Introduction
An Agricultural Produce Market Committee (APMC) is a marketing board established by state governments in India to ensure farmers are safeguarded from exploitation by large retailers, as well as ensuring the farm-to-retail price spread does not reach excessively high levels. APMCs are regulated by states through their adoption of an Agriculture Produce Marketing Regulation (APMR) Act (anonymous APMC).
Nagpur is one of the largest markets in India and Asia. Nagpur APMC was notified on 16th Nov 1974 under section 39A of Maharashtra Agricultural Produce Marketing (Regulation) Act 1963, and started working on 21st January 1975 (apmcnagpur.com).
Apple (*Malus domestica* Borkh) is commercially the most important temperate fruit, fourth among the most produced fruits in the world after Banana, Orange and Grapes (NHB). According to USDA (2024), India ranks 5th in Apple production having 255000 MT production and contributing 3% of global production. China is first in apple production followed by European Union, US and Turkey. Apple producing states are Uttarakhand, Himachal Pradesh, Jammu and Kashmir. Highest Apple production is in Jammu and Kashmir

called Apple State of India (Shilpa and Ajit Sharma, 2021) [19].

Banana evolved in the humid tropical regions of S.E. Asia with India as one of its centers of origin. Banana and plantains are grown in about 120 countries. Total annual world production is estimated at 86 million tonnes of fruits. India leads the world in banana production with an annual output of about 14.2 million tonnes. Other leading producers are Brazil, Ecuador, China, Philippines, Indonesia, Costa Rica, Mexico, Thailand and Colombia (NHB).

2. Objectives

The objectives of the paper are given below:

1. To estimate the growth rate of arrivals and prices of Apple and Banana.
2. To analyse the variability in arrivals and prices of Apple and Banana.
3. To study the trends in arrivals and prices of Apple and Banana.
4. To analyse the seasonal and cyclical indices in arrivals and prices of Apple and Banana.

3. Methodology

3.1 Selection of market

The Agricultural Produce Market Committee, Kalamna, Nagpur was selected for the study.

3.2 Selection of commodity

Apple and Banana were selected for the study.

3.3 Period of study

The study was based on month-wise data of arrivals and prices of Apple and Banana from Agricultural Produce Market Committee, Nagpur for the period of last 20 years i.e. (2004–2024).

3.4 Source of data (Secondary data)

The study was based on secondary data consisting of monthly prices and arrivals of Apple and Banana collected from Agriculture Produce Market Committee, Kalamna, Nagpur. The website www.agmarknet.nic.in was also used for the purpose.

3.5 Analytical tools

The tools were used to estimate growth, variability, trend, seasonal and cyclical indices as below:

3.5.1 Growth rate in arrival and prices

The compound growth rate of arrivals and prices of Apple and Banana was worked out by using exponential method:

$$Y = ab^t \quad (1)$$

Where,
Y = Arrivals or Prices
a = constant
b = Regression coefficient
t = time period

This equation estimated after transforming (1) as follows:
log

$$Y = \log a + t \log b$$

Annual compound growth rate in percentage was calculated as

$$CAGR = [\text{Antilog}(\log b) - 1] \times 100$$

3.5.2 Variability in arrival and prices

To study the degree of instability in arrivals and prices of Apple and Banana was measured by using coefficient of variation.

$$CV\% = \frac{\sigma}{\bar{X}} \times 100$$

$$\sigma = \frac{\sqrt{\sum (X - \bar{X})^2}}{n}$$

σ = Standard Deviation
$\bar{X}$ = Arithmetic mean
X = Variable
n = Number of observations

3.5.3 Trends in arrival and prices

The trends in arrivals and prices of Apple and Banana were computed for the series data of 2004–24. To trace the path of process different parametric trend models were used. Among the competitive trend models, the best models were selected based on their goodness of fit (measured in term of R^2) value and significance of the coefficients.

3.5.4 Seasonal and cyclical indices in arrivals and prices

The seasonal indices in arrivals and prices were worked out by using simple average method.

$$SI = \frac{\text{Monthly average of arrival and prices}}{\text{Average of monthly average}} \times 100$$

Cyclical Indices were calculated for the arrivals and prices of Apple and Banana by using residual method.

$$\text{Cyclical Indices} = \frac{\text{Original yearly value}}{\text{Estimated trend value}} \times 100$$

$$= \frac{T \times C \times I \times 100}{T}$$

$$= (C \times I) \times 100$$

Where,
T = Trend, C = Cyclical component, I = Irregular component

Sr. No.	Function	Equation
1	Linear	Y = a + bX
2	Logarithmic	Log Y = Log a + Log bX
3	Exponential	$Y = ab^X$
4	Power	Y = a (bx)
5	Quadratic	$Y = a+bx+cx^2$
6	Cubic	$Y = a+bx+cx^2+dx^3$
7	Inverse	1/X and Y
8	Square root	$Y = a+b\sqrt{x}$

Growth rate of arrivals of Apple significantly declined by 0.51% per annum during second period and prices increased by 0.73% and 0.47% per annum during first and overall period.

4. Results and Discussion

4.1 Growth rates of arrivals and prices of Apple and Banana

Table 1: Growth rates of arrivals and prices of Apple during the study period 2004-24

Sr. No.	Period	CGR%	
		Arrival	Prices
1	First period (2004-14)	0.22^{NS}	0.73***
2	Second period (2015-24)	-0.51**	-0.01^{NS}
3	Overall period(2004-24)	-0.06^{NS}	0.47***

Note: * = significant at 10%, ** =significant at 5%, *** = significant at 1%, NS is non-significant

Table 2: Growth rates of arrivals and prices of Banana during the study period 2004-24

Sr. No.	Period	CGR% (Arrivals)	CGR% (Prices)
1	First period (2004–14)	-1.39***	0.76***
2	Second period (2015–24)	-2.45***	-0.01NS
3	Overall period (2004–24)	-1.57***	0.30***

Table 3: Variability in arrivals and prices of Apple during the study period 2004-24

Sr. No.	Period	CV% (Arrival)	CV% (Prices)
1	First period (2004–14)	78.68	48.80
2	Second period (2015–24)	76.17	27.11
3	Overall period (2004–24)	78.47	43.72

The coefficient of variation for arrivals of Apple were 78.68, 76.17, and 78.47 percent for first, second, and overall period respectively. The highest variability in arrivals of Apple in APMC, Nagpur market was during the first period (2004–14) i.e. 78.68%. The coefficient of variation for prices of Apple were 48.80, 27.11, and 43.72 percent for first, second, and overall period respectively. The highest variability in prices of Apple in APMC, Nagpur market was observed during first period (2004–14) i.e. 48.80%.

Table 4: Variability in arrivals and prices of Banana during the study period 2004-24

Sr. No.	Period	CV% (Arrival)	CV% (Prices)
1	First period (2004–14)	101.12	28.61
2	Second period (2015–24)	81.08	3.60
3	Overall period (2004–24)	139.01	22.69

The coefficient of variation in arrivals of banana were 101.12, 81.08 and 139.01 percent for the first, second and overall period respectively. The variability in arrival of Banana in APMC, Nagpur market was high during the overall period (2004-24) i.e. 139.01%. Similarly for the prices of banana coefficient of variation were 28.61, 3.60 and 22.69 percent for the first, second and overall period respectively. The highest variability in prices of Banana in APMC, Nagpur market was observed during first period (2004-14) i.e. 28.61%.

4.2 Trends in arrivals and prices of Apple and Banana

Table 5: Trends in arrivals of Apple during study period 2004-24

Sr no.	Equation	Parameter estimated				
		R2	constant	b1	b2	b3
1	Linear	0.013	7289.1	-7.97	-	-
2	Logarithmic	0.003	7524.1	-265.8	-	-
3	Exponential	0.003	4753	-	-	-
4	Power	0.001	0.024	3894.4	-	-
5	Quadratic	0.024	6098.6	21.55	-0.123	-
6	Cubic	0.026	6636.1	-4.94	0.15	-0.001
7	Inverse	0.004	6426.5	-3854.4	-	-
8	Sq. Root	0.008	7599.3	-122.6	-	-

Table 6: Trends in prices of Apple during study period 2004-24

Sr no.	Equation	Parameter estimated				
		R2	constant	b1	b2	b3
1	Linear	0.39	2778.6	21.29	-	-
2	Logarithmic	0.34	-1006.7	1412.6	-	-
3	Exponential	0.45	2700	0.0048	-	-
4	Power	0.39	0.32	1133.9	-	-
5	Quadratic	0.44	1749.2	46.81	-0.106	-
6	Cubic	0.46	2795.5	-4.75	0.43	-0.002
7	Inverse	0.04	5498.1	-6098	-	-
8	Sq. Root	0.4	1087.9	410.8	-	-

Table 7: Trends in arrivals of Banana during study period 2004-24

Sr no.	Equation	Parameter estimated				
		R2	constant	b1	b2	b3
1	Linear	0.37	23211	-115	-	-
2	Logarithmic	0.41	48586	-8726	-	-
3	Exponential	0.62	28600	-0.016	-	-
4	Power	0.44	-0.98	336081	-	-
5	Quadratic	0.43	30067	-284.9	0.7053	-
6	Cubic	0.43	32686	-414	2.041	-0.004
7	Inverse	0.08	8206.6	45537	-	-
8	Sq. Root	0.42	33422	-2323	-	-

Table 8: Trends in prices of Banana during study period 2004-24

Sr no.	Equation	Parameter estimated				
		R2	constant	b1	b2	b3
1	Linear	0.59	308	1.08	-	-
2	Logarithmic	0.76	35.54	89.67	-	-
3	Exponential	0.58	297.4	0.003	-	-
4	Power	0.8	0.25	136.7	-	-
5	Quadratic	0.85	193.6	3.91	-0.012	-
6	Cubic	0.87	162	5.47	-0.028	
7	Inverse	0.23	453.7	-592.2	-	-
8	Sq. Root	0.72	201.2	22.93	-	-

Among the competitive parametric model, Exponential and cubic model were found best fitted for arrivals and prices of banana respectively. For trend analysis of arrivals the range of R^2 varies from 0.08 to 0.62 where maximum value of R^2 i.e. 0.62 obtained at Exponential model which was the best fit model. In trend analysis of prices range of R^2 varies from 0.23 to 0.87 where maximum value of R^2 i.e. 0.87 obtained at cubic model which was the best suited model.

4.4 Seasonal and cyclical indices in arrivals and prices of Apple and Banana

Among the competitive parametric models Cubic model was found best fitted both for the arrivals and prices of Apple. For the trend analysis of arrivals, the range of R^2 varies from 0.001 to 0.026 where maximum value of R^2 i.e. 0.026 was obtained at cubic model which was best suited. In trend analysis of prices, range of R^2 varies from 0.04 to 0.46 where maximum value of R^2 i.e.0.46 was obtained at cubic model which was the best fit model.

Table 9: Seasonal indices of arrivals and prices of Apple during study period 2004-24

Month	Arrivals	Prices
Jan	85.26	78.88
Feb	66.59	88.34
Mar	44.87	105.64
Apr	22.98	113.77
May	17.44	141.07
Jun	23.48	142.64
Jul	91.82	109.09
Aug	210.16	96.23
Sep	207.17	97.79
Oct	188.10	83.41
Nov	128.89	72.20
Dec	113.24	70.94

The result of seasonal indices indicated that the highest arrival of Apple in APMC, Nagpur market was during the month of August (210.16), followed by September (207.17), and October (188.10). In case of prices, it was noticed that highest in June (142.64), followed by May (141.07) and April (113.77).

Whereas Seasonal indices of arrival of apple were lowest in the month of May (17.44), followed by April (22.98) and June (23.48). In case of prices, it was lowest in the month of December (70.94), followed by November (72.20) and January (78.88).

Table 10: Seasonal indices of arrivals and prices of Banana during study period in 2004-24

Month	Arrivals	Prices
Jan	51.56	100.66
Feb	50.14	102.02
Mar	53.66	101.52
Apr	49.97	99.04
May	52.45	98.87
Jun	81.99	99.12

Jul	137.40	99.00
Aug	183.07	99.10
Sep	204.17	100.25
Oct	177.85	100.46
Nov	106.38	99.05
Dec	51.38	100.91

Similarly, in case of Banana result of seasonal indices indicated that the highest arrival of Banana in APMC, Nagpur market was in the month of September (204.17), followed by August (183.07) and October (177.85) and lowest in April (49.97) followed by February (50.14), followed by December (51.38) and January (51.56).

In case of prices of banana, it was observed that seasonal indices value was highest in the month of February (102.02), followed by March (101.52), followed by December (100.91) and January (100.66). Lowest in May (98.87) followed by July (99) followed by April (99.04) and November (99.05).

Table 11: Cyclical indices of arrivals and prices of Apple during study period 2004-24

Year	Arrivals	Prices
2004	95.45	100.67
2005	87.07	95.24
2006	83.23	84.90
2007	104.88	93.51
2008	105.86	64.52
2009	86.89	82.70
2010	128.67	81.18
2011	91.61	125.05
2012	89.04	116.51
2013	109.22	115.19
2014	100.52	113.03
2015	121.76	100.54
2016	89.49	144.17
2017	101.12	115.59
2018	148.14	99.16
2019	145.58	92.77
2020	98.05	103.73
2021	92.20	108.50
2022	112.36	94.17
2023	73.28	87.31
2024	35.58	81.57

The cyclical variation observed in the arrivals and prices of Apple and Banana during study period 2004-24. From the result of cyclical indices it is observed that the heavy arrivals of Apple found in 2018 followed by 2019, 2010 and 2015 year and least arrivals in the year of 2023 and 2024. In case of prices of Apple highest values for cyclical indices found in the year 2016 followed by 2011 and 2012. Lowest indices in 2008 followed by 2010 and 2024 indicated that prices was low during these years.

Table 12: Cyclical indices of arrivals and prices of Banana during study period 2004-24

Year	Arrivals	Prices
2004	401.45	67.63
2005	242.93	74.53
2006	176.41	94.79
2007	246.28	92.01
2008	301.99	87.80
2009	178.69	86.18
2010	59.54	129.26
2011	184.62	125.49
2012	264.24	121.66
2013	130.58	117.75
2014	89.93	115.19
2015	112.69	111.31
2016	142.21	108.27
2017	210.45	105.39
2018	213.94	102.66
2019	197.74	100.07
2020	211.21	94.35
2021	-1046.73	93.28
2022	-167.60	92.64
2023	-27.90	90.89
2024	-22.65	88.86

For the Banana, from the result of cyclical indices we can conclude that heavy arrival found in 2004, followed by 2008 and 2012, as higher indices values of arrival of Banana during these years. Banana arrival shows negative cyclical indices from the year 2021 to 2024. This signifies that the actual arrival value is lower than what expected based on the overall cyclical pattern.

For prices highest prices of Banana found in 2010 followed by 2011 and 2012. There is sudden increase in price of Banana in the year 2010 as there is less arrival in market and then started decreasing. Lowest value of indices during the year 2004 and 2005 indicated low prices of Banana during these years.

5. Conclusion

- Growth rate of arrivals of Apple declined significantly by 0.51% per annum during second period and prices increased by 0.73% and 0.47% per annum during first and overall period respectively. For Banana arrivals declined by 1.39, 2.45 and 1.57 percent per annum during first, second and overall period respectively. Banana prices increased by 0.76 and 0.30 percent per annum during first and overall period.
- The variability in arrivals and prices of Apple was high in first period. In case of Banana variability of arrivals was high in overall period and prices in first period.
- The cubic trend was followed by both arrivals and prices of Apple in APMC, Nagpur. The exponential trend was followed by arrivals of Banana and cubic by the prices of Banana.
- There exist seasonality in the arrivals and prices of Apple and Banana in APMC Nagpur. Higher values of arrivals of Apple found in the months of August followed by September and October, after it start declining. Prices of Apple was high during April, may and June. Higher arrivals of Banana found in a month of August, September and October then it start decreasing. Prices was high during December, January, February and March.
- Cyclical variations observed in both arrivals and prices of Apple and Banana. The higher arrival of Apple recorded during the year 2010, 2015, 2018 and 2019, while prices during 2011, 2012 and 2016. Similarly for Banana high arrival during the year 2004, 2008 and 2012. From 2021 to 2024 Banana shows negative cyclical indices. It means least arrival during these year in APMC, Nagpur. Prices high during year 2010, 2011 & 2012.

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