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A comparative evaluation study of maize supply chain in Northern and Southern districts of Karnataka

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Abstract
Karnataka district is famous for Maize production and industrial glucose extraction as well. Both the districts are interlinked together in northern and southern districts and it is easy to get full-fledged information about the complete supply chain. Totally 280 samples were selected for the survey, of which 120 maize farmers, 60 commission agents, 60 traders and 20 processing units and 20 buyers. The supply chain of Maize starts with Farmers, then it's linked to commission agent followed by traders, processing units and buyers. The commission agents play a very important positive role in connecting the maize famers and traders to sell their produce. The price spread worked out for the above said channel indicated that the price spread was Rs. 927.15/q, and Rs. 739.54/q of maize. Technical efficiency and Scale efficiency of supply chain in Northern and Southern Karnataka the mean technical efficiency of supply chains of maize in northern and southern Karnataka were ranged from 81.00 to 97.20 percent and 92.70 to 85.70 percent respectively. The technical efficiency was higher in southern Karnataka maize supply chains, because e- tender market is performing well in south Karnataka simultaneously increase control over the quality, supply reliability and price stability. An added advantage of this models was that it provided flexibility and better understanding between the farmers and commission agents for value addition like drying and better packing reduced wastage better volume of flexibility to processing units leads to improved supply chain practices.

Keywords: Indian mustard, path coefficient analysis

Introduction

Supply Chain Management

The real measure of supply chain success is how well activities are coordinated across the supply chain to create value for consumers, along with increasing the profitability of every link in the supply chain. Supply-chain management (SCM) is "the management of the entire set of production, distribution, and marketing processes by which a consumer is supplied with a desired product". Supply chain management is the integrated process of producing value for the end user or ultimate consumer. It is a philosophy for integrating all the activities in the life of a product or service from the earliest source of raw materials to the ultimate consumer and beyond disposal.

Mapping the supply chain is the first step in supply chain management which includes mapping the actors (who undertake specific objectives) in the supply chain and the movement of the raw material from the maize farmer to buyers.

Supply chain of Maize

The major stakeholders in the supply chain of maize are as follows:

Village aggregators/ traders: They play an important role in the maize supply chain, as they operate at the producer point i.e. in the villages. In some cases, some farmers themselves act as village aggregators, who collect the grain from small growers and sell to the big trader through commission agents or directly, depending on the volume of tradable maize in the area. The village aggregators often act as agents for commission agents during peak period of maize marketing season since they are located close to maize farmers. Therefore, they are often the most reliable link between the commission agent and the maize growers. They collect maize on a cash basis, from the doorsteps of scattered small and marginal farmers. They also provide price information to the farmers as given to them by the commission agents. In some cases, like in Tamil Nadu, traders also offer harvesting and threshing services at farmers fields and purchase grain directly at field.

However, pooling of resources and preliminary grading and drying of grains at one platform may give some premium price to the farmers.

Commission Agent/Broker: He acts as a middleman between farmers or traders and processors/ end-users. He decides the price of maize based on quality (moisture %, broken/ unbroken grains, colour etc.), market demand - supply, and makes the trade happen. The moisture is determined by moisture meter or by putting hand inside the grain heap by the trader. Sometimes, these commission agents provide financial help also to farmers during growing season. They take the advantage of having information about the potential buyers and sellers. Usually, they charge around 2-3 percent commission on the total cost of produce brought for sale. They arrange to supply maize to the feed industry, starch industry, exporters, etc.

Commodity Exchanges: Maize is one of the most important cereals being traded in large volumes on electronic platform of commodity exchanges like MCX, NCDEX, NSEL, etc. It is being traded on Futures as well as Spot Exchanges. In these cases, usually aggregators or traders purchase the produce from the farmers and make the lot as per the specification of the Exchanges. The buyers are usually large feed manufacturers or the integrated poultry industry. Usually the graded and standardized lot of grains are kept in accredited warehouses. Such chain actors are expected to play bigger role in future as it brings large number of buyers and sellers virtually from any parts of the country at single platform. Though, export of grain on such platform is currently not allowed.

Feed industry: It manufactures feed and gets the supply of raw material as per demand and quality parameters. Along with maize, other raw materials are also procured and are sent to the manufacturing unit. The final product is distributed to end-customers through various channels such as direct to customer, through dealers or through contract farming/integration. The feed industry also keeps the bulk stock of the maize grains for 4-6 months to meet any exigencies in supply.

Import and export: India has become a net exporter of maize in the recent years. Maize is exported in grain as well as in poultry feed form to other countries. At the same time, India also imports maize in small quantities (12,261 tonnes in 2011 and 2,355 tonnes in 2012), mainly for starch making, popcorn making or feed manufacturing during the lean season.

Materials and Methods

Correlation analysis

In order to study the nature and magnitude of association between arrivals and prices of maize crop, the correlation analysis was adopted. Further the correlation co-efficients were tested for their statistical significance. Arrivals & prices variables were used to find whether relationship exists between them or not.

Partial budgeting

In order to compute the costs and returns in maize among north and south Karnataka, partial budgeting techniques was employed.

i. Cost of cultivation

To estimate the costs and returns from cultivation of Maize, it is necessary to know about the concepts. The various concepts used were presented below for better understanding.

ii. Costs

The total costs were divided into two broad classes

1. Variable cost
2. Fixed cost

(1) Variable costs

(a) Land Preparation: Cost incurred for preparing land to sow seeds like ploughing, harrowing and covering of seeds.
(b) Seed: Cost of seed purchased per hectare.
(c) FYM and Fertilizers: Cost of chemicals and Fertilizers actually paid by farmers.
(d) Weeding: cost of the weeding per hectare.
(e) Plant protection chemicals (PPC): Cost incurred in the purchase of plant protection chemicals.
(f) Harvesting and threshing: Cost incurred for harvesting and threshing and miscellaneous charges were taken.
(g) Interest on Working Capital: This was calculated on the entire working cost of the enterprise at the rate of interest of 12 percent per annum.

(2) Fixed costs

(a) **Interest on fixed Capital**: This was calculated on the entire fixed cost of the enterprise at the rate of interest @ 6.25 percent per annum.

Total Cost of Cultivation

Cost of cultivation included variable and fixed costs.

a) Cost of production per quintal: it was calculated by dividing the total cost per hectare by the yield obtained per hectare of Maize.

iii. Returns

a) Gross returns: Gross returns were computed on the basis of actual prices at which individual farmers sold their produce.
b) Net returns: It was calculated by deducting total cost from total returns partial budgeting technique was employed.

Price spread analysis

Price spread in general, is referred to as the difference between price paid by the consumer and the price received by the growers/farmers for an equivalent unit of the product.

Price spread analysis estimates the share of different market functionaries in the consumer's rupee and this would facilitate the understanding of the relative efficiencies, otherwise existing in alternative channels of marketing. Concurrent margin method was used to analyze the price spread since concurrent margin is one, which takes into account the prevailing prices at successive stages of marketing at a given point of time.

The analysis involved computation of different marketing costs and profit margin at each stage and their expression as a percentage to the consumer's rupee. Various costs incurred in the marketing process were considered for each of the identified channels and price spread was worked out. The profit margin for each market functionaries in the market

channel was computed by subtracting the price paid and the marketing cost incurred by the intermediary from the price received by the intermediary on the sale of the product. Thus marketing costs and marketing margins were distinguished and the price spread was worked out.

$$\text{Price spread} = \frac{(\text{Consumer price} - \text{Net price of producer})}{\text{Consumer price}} \times 100$$

Farmer's share in consumer rupee (%)
Further, the farmer's share in consumer rupee was calculated with the help of the following formula.

$Fs = (Fp/Cp) X 100$

Where,
Fs = Farmer's share in consumer rupee (%)
Fp = Farmer's price
Cp= Consumer's price

Data Envelopment Analysis (DEA) and its applications in supply chain
DEA was first introduced by Charnes and Cooper (1978) [4] as a linear programming (LP)-based methodology for performing analysis of how efficiently a company operates. Its analyzed units are denoted as "DMU," which stands for decision-making units. It is a nonparametric programming approach to frontier estimation. In other words, it means DEA does not require the existence of a particular function to specify the relationships or trade-offs among the performance measures in the computation of efficiency and it utilizes the concept of efficient frontier as an empirical standard of excellence. These advantages of DEA enable managers to evaluate any measures efficiently as they do not need to find any relationship that relates them. In addition, the concept of efficient frontier proves to be a valid measure of performance comparison.

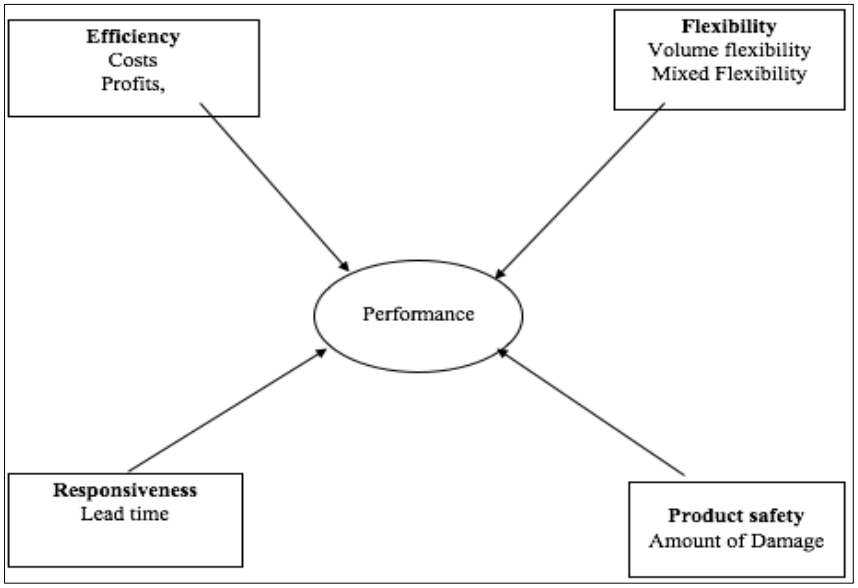

Fig 1: Conceptual framework of maize supply chain performance with key performances indicators

Terms used in supply chain analysis
Labour charges: Each bag contains 60kg of grains were for l bag loading of labour charges is Rs. 3.

Rent: Based on their area in per ft^2 of land the yearly prices are fixed by the APMC.

Licence Renewal: Every ten years the licences should be renewed prices by the APMC.

Miscellaneous: Refreshment for labour and related expenses.

Commission @ 4%: Commission charges on total value of transaction.

Transportation Charges: It's based on the distances of Kms and end destinations. Charges are levied on per quintal basis.

Processing cost: The processing cost varies from processors to processors because its depends on the year of installation, installed capacity, power consumption in a day, Utilised capacity.

Result and Discussion

Table 1: Trends in Arrivals and Prices of Maize in selected markets of Northern and Southern Karnataka

SI. No	Markets	Trend equation	
		Arrivals (Quintal)	Prices (Rs./ Quintal)
	Northern Karnataka		
1	Belagavi	y = -41279x + 2E+06	y = 92.109x + 568.2
2	Haveri	y = -43576x + 2E+06	y = 76.182x + 686.5
	Southern Karnataka		
3	Davanagere	y = 21246x + 1E+06	y = 85.818x + 596
4	Chitradurga	y = 70493x + 555079	y = 65.467x + 684.43

It could be seen from the table 1 that North Karnataka districts witnessed negative trend in arrivals. Whereas southern districts witnessed positive trends in arrivals in selected markets. With respect to price both Northern as well

as southern Karnataka districts expressed positive trends over the period of nine years. This may be due to increase in demand for maize over the years due to its multi-dimensional usage across various industries.

Correlation coefficients between Annual Arrivals and Average Prices of Maize in selected markets of Northern and Southern Karnataka

Correlation coefficients between annual arrivals and average prices of maize in the selected markets of Northern and Southern Karnataka selected markets were analyzed and are presented in Table 2.

Table 2: Correlation coefficients between Annual Arrivals and Average Prices of Maize in selected markets of Northern and Southern Karnataka (2008-2017)

SI. No	Markets	Correlation coefficient
	Northern Karnataka	
1	Belagavi	-0.56
2	Haveri	-0.44
	Southern Karnataka	
3	Davangere	0.10
4	Chitradurga	0.39

Source: Krishimaratavahini.kar.nic.in

It could be seen from the Table 2. that the correlation coefficient between annual arrivals and average prices of maize in Belagavi and Haveri markets of Northern Karnataka were found to be -0.56 and -0.44 respectively. This denoted the normal dynamics in any market. Hence as arrivals increases prices fall due to mis match in demand and supply in Northern Karnataka. For Davangere and Chitradurga markets in Southern Karnataka correlation coefficients were found to be 0.10 and 0.39 respectively. This indicated a positive relationship between arrivals prices of maize.

Mapping the Activities and the Major Players in Maize Supply Chain

Supply chain of Maize

Mapping the supply chain is the first step in supply chain management which includes mapping the actors (who undertake specific objectives) in the supply chain and the movement of the raw material from the maize farmer to buyers.

Mapping the Supply Chain of Maize in Northern Karnataka (Channel – I)

Farmers→Commission Agent →Traders → Processors → Buyers

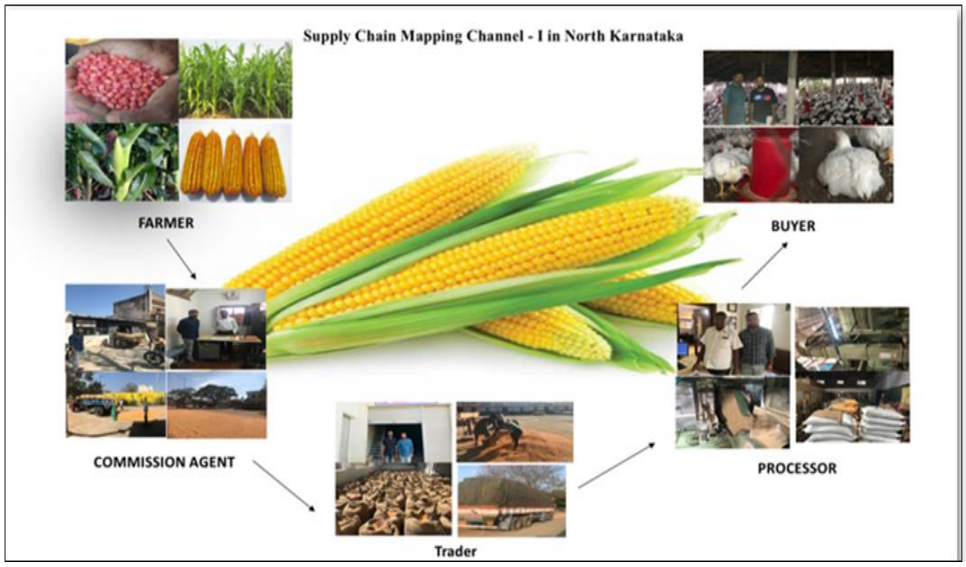

Fig 1: Supply Chain Mapping in Northern Karnataka (Channel-I)

The supply chain map for maize in Northern Karnataka (Channel-I) is depicted in the Fig. 1. In the supply chain, farmers are linked to buyers through commission agents, traders and processors. Farmers brought their produce to the APMC market yard. Through the commission agent their maize produce was auctioned in the APMC market yard. Whoever bids the highest price for the commodity used to take the lot. Commission agents played a decisive role in Northern Karnataka as they were price fixers in the market. The value of the commodity was paid to the farmer in cash. The commission agents charged 2 percent from the farmers as well as traders on the total value of the produce before handling the produce to the traders. In addition to it, APMC market charge of 1.5 percent of the value of the commodity was also collected from the trader. Further the traders traded the maize across the states to processors. The processed maize from the processors were sold to the bulk buyers like dairy, goat rearing and poultry. The whole maize trade took place within the state. The absence of e-market tendering was the main reason behind lacuna observed in the marketing of maize in the APMC market yard.

Supply Chain Participants (Channel-I)

i) Farmers

After the harvest of the produce the farmers brought their produce to the APMC market yard. Due to their acquaintance with the commission agent they used to place their produce at the commission agent's yard and then the commission agent would make an auction.

ii) Commission Agent

Commission agents are registered in the respective APMC market under the APMC act. In Northern Karnataka districts like Belagavi and Haveri, commission agents are the main players in the maize supply chain as they are the price deciders.

iii) Traders

Every trader had their market place allotted by the APMC with the yearly charges levied based on the price per square foot. Every 10 years the traders had to renew their license. The traders used to quote the price based on the quality of maize and the highest price bidder could take over the entire lot. In case, if the farmers think that price is not viable, then he can reject the price and he can go for the next auction. After the purchasing the produce traders had to pay commission (2%) as well as market fee (1.5%) on the total value of his produce. Then only the goods will be handed over to trader. Farmers used to receive their amount the next day i.e. a day after the sale of their produce. Then traders were selling their produce further to processors.

iv) Processors

Processors purchased maize from traders and used to manufacture poultry as well as animal feed. Processed maize in the form of feed was ultimately sold to the buyers (poultry units, goat rearing units and dairy units).

v) Buyers

In Belagavi and Haveri districts dairy and goat rearing units were in abundance. Currently poultry units were also increasing in the area. Hence there was a tremendous demand for maize in the form of feed and for the same reason the the demand for maize was found to be rapidly increasing in the area.

Mapping the Supply Chain of Maize in Northern Karnataka (Channel – II)

Farmers→Traders → Processors

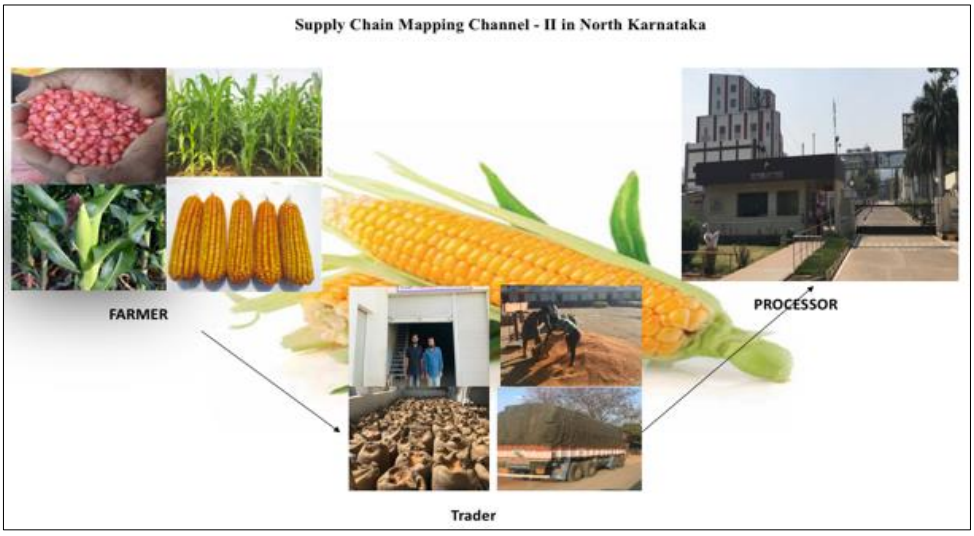

Fig 2: Supply Chain Map in Northern Karnataka (Channel-II)

The supply chain map for maize in Northern Karnataka (Channel-II) is depicted in the Fig. 2. Commission agent was absent in this supply chain. In this supply chain traders purchase directly from farmers. They had also formed a union which helped them to source the produce from the farmers in bulk quantities. Small traders supplied maize to big trader for some commission. Then big trader sold the bulk of the produce to the processing industry.

Mapping the Supply Chain of Maize in Southern Karnataka (Channel – I)

Farmers→commission agent →Traders → Processors → Buyers

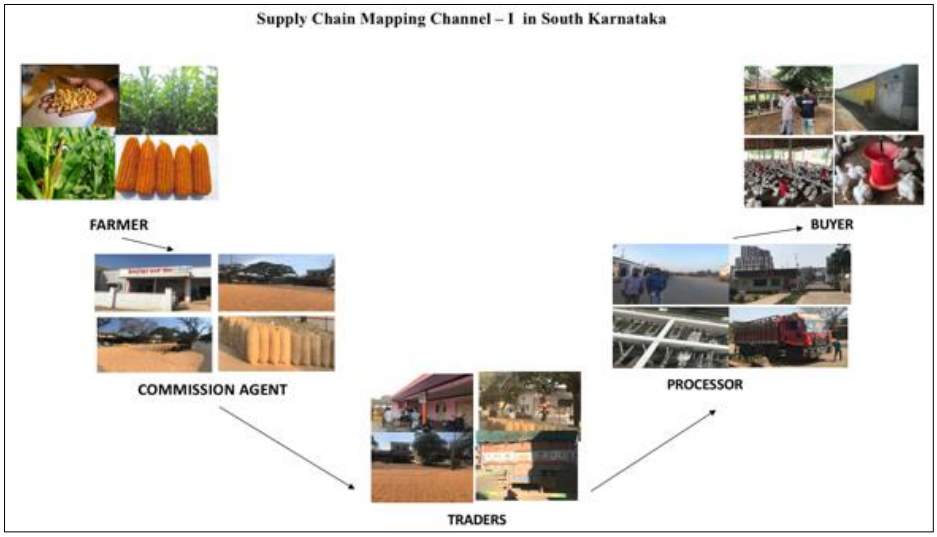

Fig 3: Supply chain Map in Southern Karnataka (Channel-I)

The supply chain map for maize in Southern Karnataka (Channel-I) is depicted in the Fig. 3. In this supply chain of Southern Karnataka districts, the farmers were linked to the ultimate buyers through commission agents, traders and processors. In Southern Karnataka a cordial relationship existed between farmers and commission agents since generations. Here interstate trade was prevalent and the commodities moved to Tamil Nadu, Andhra Pradesh and Telangana.

Supply Chain Participants

i) Farmers

After the harvest of the produce the farmers brought their produce to the market. Commission agent assisted him in making gate entry and in getting the lot number. Lot number comprised of date of arrival, quantity of the commodity and personal details of farmers.

ii) Commission Agents

Commission agents were registered in the respective APMC market under the APMC act. They used to take lot numbers and participate in the bidding process. Bidding process used to take place twice in a week i.e. on Wednesday and Friday. For this process they charged 1.5 percent value of the produce for the traders.

iii) Traders

Every trader had their market yard allotted by the APMC with the yearly charges levied based on the price per square foot and every 10 years the traders had to renew their license. The traders used to quote the price based on the quality of maize. They used to bid the price to purchase commodities. The highest bidder among them would subsequently win the bidding and would take over the lot. If trader paid the amount of purchase, then he could take the produce only after paying 1.5 percent of amount traded as a fee to APMC.

iv) Processors

Processor purchased produce from trader and the maize produce was extensively used in the preparation of poultry feed. In this case, the transportation cost was borne by the trader himself.

v) Buyers

Buyers comprised of poultry farmers like Venkateshwara hatcheries Pvt. Ltd. and Suguna Pvt. Ltd. They used to buy huge quantities of poultry feed from these processors.

Mapping the Supply Chain of Maize in Southern Karnataka (Channel – II)

Farmers→Traders →Bulk Traders →Processors → Buyers

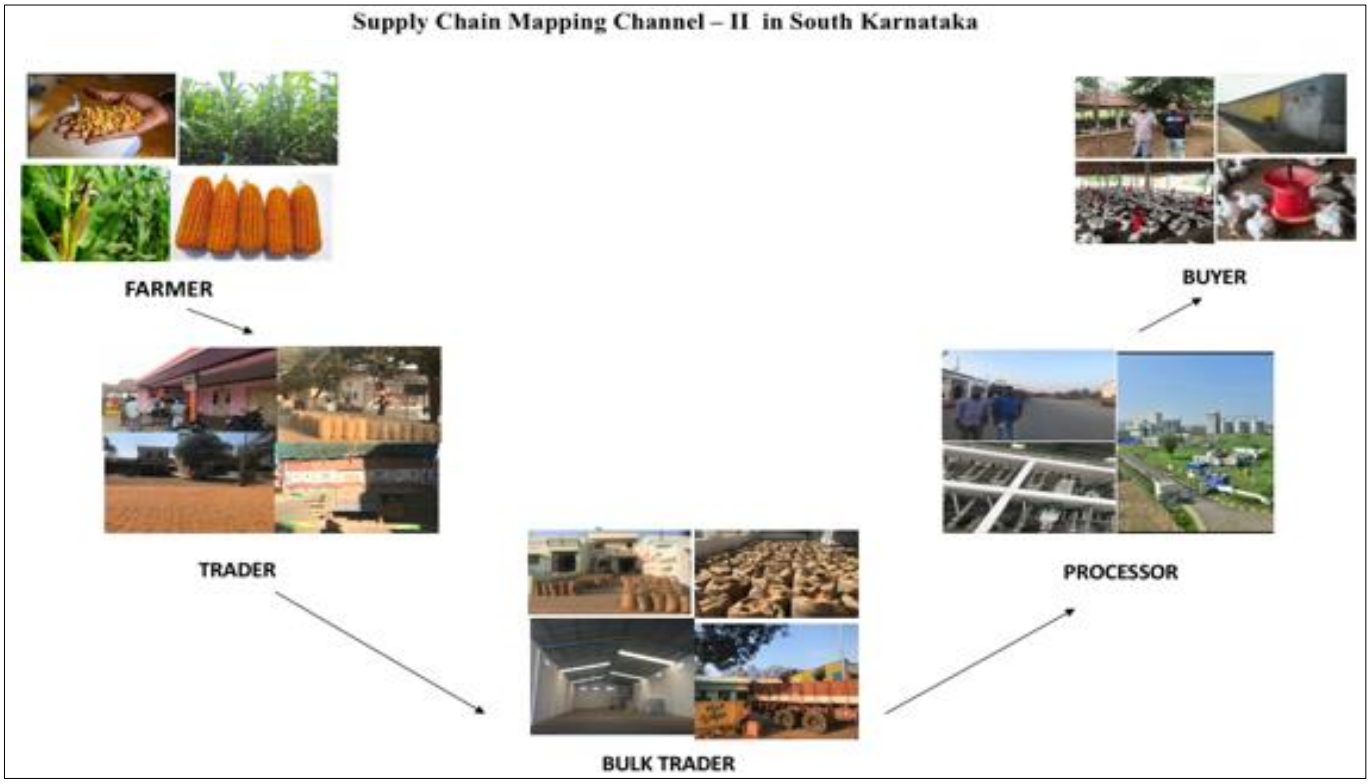

Fig 4: Supply chain Mapping channel-II Southern Karnataka

In channel-II trade took place similar to that of channel-I in south Karnataka but the only exception being the bulk traders who were involved in the trade.

Supply Chain Process Flow in e – market (e-Tender)

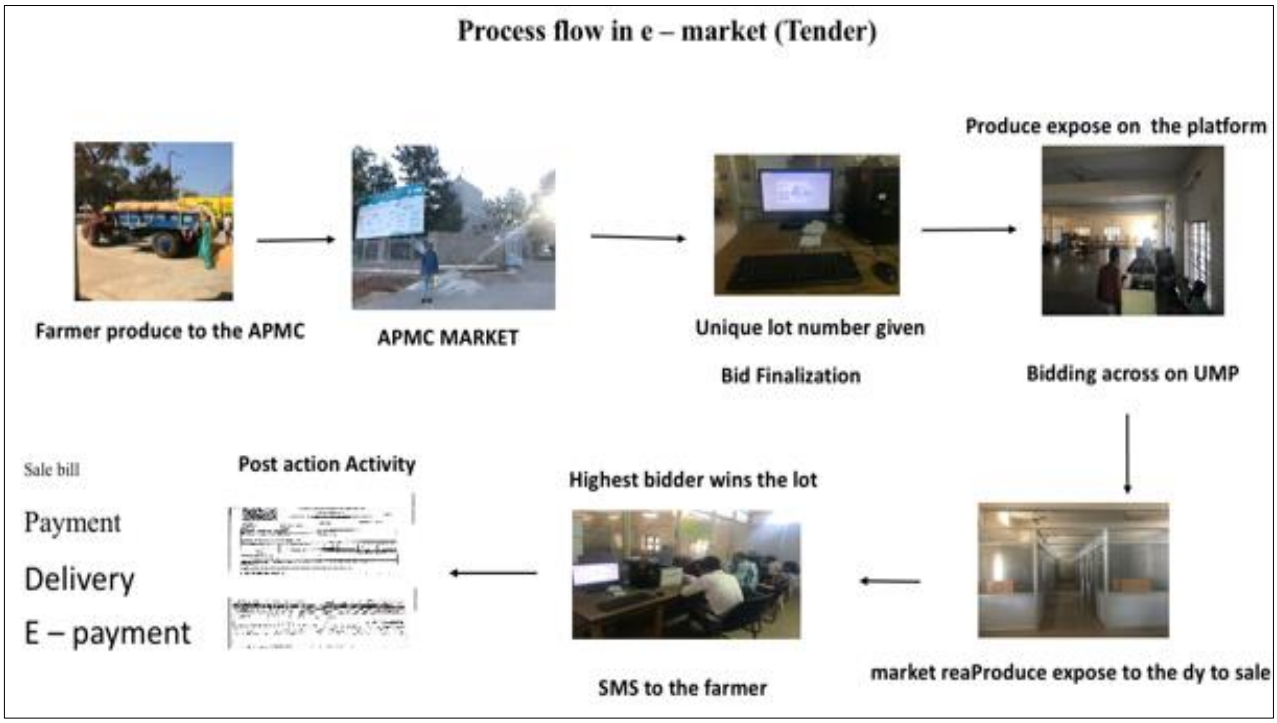

Fig 5: Supply Chain Process Flow in e – market (e-Tender) in Karnataka

The process of e-tendering system followed in APMC is depicted in figure 5.9. The produce brought by the farmers was registered first at kiosks installed at the entrance of the APMC gate. Here details like name, address of the farmer, name and variety of the produce, number of bags, name of the commission agent etc. was entered and officials at the entry gate issued an entry slip with all the above details and an automatic and unique lot number was generated. Immediately after the process was over farmers would get confirmation message about lot number. Farmers were free to choose any commission agent who arranges for display along with entry slip.

Traders checked the quality of the maize kept in the bidding place. Based on the preferences, traders quoted their bids online only within the specified time provided either by using their own infrastructure or could make use of the computer provided by the APMC. There was a provision for the traders to change their bids before final submission. However, the trader was permitted to increase the bid price but not permitted to re quote at lower price than earlier bid. After completion of the cut-off time highest bidder was given the lot only after farmer expressed his willingness to sell. The bid winner was declared with the help of the software that generates lot-wise bid winners list and price quotations. The result was declared through an electronic display, loud speaker announcements in the market yard, SMS and printouts.

Price Spread analysis

Price spread of the players in the supply chain players of Northern and Southern Karnataka were analyzed and presented in Table. 3.

Table 3: Price spread of Maize supply chain in Northern and Southern Karnataka

SI. No	Particulars		Northern Karnataka		Southern Karnataka	
			Price (Rs./q)	%	Price (Rs./q)	(Rs./q) %
	Farmer					
1	Gross price received		1553		1430	
2	Production cost		865.30		886.44	
3	Net price received		803.39		627.76	
	Commission Agent					
4	Purchase price		1553		1430	
5	Marketing cost					
	A	Packing cost	15	4.45	15	5.26
	B	Loading and unloading	10	2.97	7	2.45
	C	Weighing charges	3	0.89	3	1.05
	D	Miscellaneous	7	2.08	7	2.45
I	**Total cost (a + b + c + d)**		**35**	**10.38**	**32**	**11.22**
6	Marketing margin		52		38	
	Traders					
7	Purchase price		1640		1500	

8	Marketing Cost					
	A	Transportation	75	22.25	40	14.03
	B	Labour cost	5.83	1.73	5	1.75
	C	APMC charges @ 1.5%	19.5	5.78	18	6.31
	D	Miscellaneous	8	2.37	5	1.75
II	**Total cost (a + b + c + d)**		**108.33**	**32.14**	**68**	**23.84**
9	Marketing margin		185.67		123	
	Processing Unit					
10	Purchase price		1934		1691	
11	Marketing cost					
	A	Transportation charges	85	25.22	90	31.56
	B	Electricity cost charges	2.5	0.74	3.2	1.12
	C	Labour cost charges	6.25	1.85	7	2.45
	D	Processing cost	100	29.67	85	29.80
III		**Total cost (a + b + c + d)**	**193.75**	**57.48**	**185.2**	**64.94**
	Overall Total cost (I+II+III)		**337.08**	**100.00**	**285.2**	**100.00**
12	Sales price		2480.15		2169.54	
13	Marketing margin		352.4		293.34	
14	Price paid by the consumer		2480.15		2169.54	
15	Price Spread		927.15		739.54	
16	Farmers share in consumer rupee		62.62		65.91	

Note: Figures in the parenthesis indicate percent to each column total.

Price spread of Maize supply chain in Northern and Southern Karnataka

The price paid at the farm gate for the assessment of the price spread of Northern and Southern Karnataka was taken as Rs. 1553/q and 1430/q and the final price paid by the consumer in the on an average, Rs. 2480.15 and 2169 This range is being taken as a bench mark to determine the price spread across the channel.

Since, there is no marketing activities at farmers' level of Northern and Southern Karnataka there is no marketing cost and margin. The total marketing cost was worked out to for commission agent Rs. 35/q, out of which Rs. 108.33/q is incurred at the traders level and Rs. 337.08/q is incurred at the processing level.

The marketing cost at the commission agent level of Northern and Southern Karnataka included packing charges which has the highest share of Rs. 15 per q and Rs. 15 per q followed by loading and unloading charges Rs. 10/q, and Rs. 7/q weighing charges Rs. 3/q and miscellaneous charges (Rs. 7/q).

The marketing cost at the trader's level included transportation charges which had the highest share with Rs. 75/q, and Rs.40 followed by labour charges of Rs. 5.83/q and Rs. 5/q APMC charges 1.5 percent Rs.19.5/q and Rs.18/q Miscellaneous charges Rs. 8/q and Rs. 5/q

The marketing cost at the processing level included transportation charges which had the highest share with Rs. 85/q, and Rs.90/q followed by electricity charge Rs. 2.5/q, and Rs. 3.2/q. labour charge with Rs. 6.25/q and Rs. 7/q. Processing cost Rs. 100/q and Rs. 85/q

The total marketing margin of Northern and Southern Karnataka was Rs. 538.07/q and Rs. 416.34/q where the processing units had the lions share with Rs. 352.4/q and the traders with Rs. 108.33/q. and Rs. 68/q. The farmer's share in consumer's rupee was 62.62 percent and 65.91 percent.

The price spread worked out for the above said channel indicated that the price spread was Rs. 927.15 per quintal, and Rs. 739.54 per quintal of maize. There is direct relationship in terms of proportions attributed to marketing margins and marketing cost with price spread. It means that as the price spread increases the proportion of marketing margin and cost decreases.

Technical efficiency and Scale efficiency of supply chain in Northern and Southern Karnataka

The results of Data Envelopment Analysis with constant return to scale technical efficiency (CRSTE), Variable return to scale technical efficiency (VRTSTE), and Scale efficiency (SE) of supply chain of maize in northern and southern Karnataka are given in Table 4

Table 4: Technical efficiency and scale efficiency of Maize supply chain

S. No.	Particulars	CRSTE	VRTSTE	SE
I	**Northern Karnataka**			
1	Mean	0.810	0.972	0.831
2	Standard deviation	0.169	0.067	0.154
3	Minimum	0.346	0.75	0.473
4	Maximum	1	1	1
II	**Southern Karnataka**			
1	Mean	0.927	0.857	0.944
2	Standard deviation	0.08	0.046	0.057
3	Minimum	0.82	0.929	0.82
4	Maximum	1	1	1

It could be seen from the Table 4 that the level of technical efficiency for Northern Karnataka maize supply chain ranged from 34.00 to 100.00 with mean efficiency of 81.00 percent in constant return to scale. Given the current state of technology, technical efficiency among supply chain members can be increased by 19.00 percent through better supply chain management practices like minimization of costs, lead time, and amount of damage. The technical efficiency as calculated by using variable return to scale indicated that efficiency ranged from 75.00 to 100.00 with mean efficiency of 97.20 percent, which inferred that Northern Karnataka maize supply chain was more efficient in the study area and scale efficiency ranged from 47.30 to 100.00 with mean efficiency of 83.10 percent. This revealed that they had the scope to increase efficiency by decreasing the production cost and wastages at farm level.

Table 5: Shows the Northern Karnataka

Northern Karnataka						
DMU	**CRSTE**	**VRSTE**	**SCALE**		**Peer groups**	**Peer weights**
1	1	1	1	-	1	1
2	1	1	1	-	2	1
3	1	1	1	-	3	1
4	1	1	1	-	4	1
5	1	1	1	-	5	1
6	1	1	1	-	6	1
7	0.89	1	0.89	irs	(28), (19), (17), (6)	(0.521), (0.156), (0.111), (0.213)
8	0.796	1	0.796	irs	(28), (19), (2),(6), (17)	(0.367), (0.27), (0.017), (0.083), (0.263)
9	0.651	0.801	0.813	irs	(17), (28),(25)	(0.406), (0.583), (0.011)
10	1	1	1	-	10	1
11	0.936	0.978	0.957	irs	(28), (6), (3) (5)	(0.675), (0.067), (0.065), (0.193)
12	0.986	1	0.986	irs	(2), (6), (4)	(0.054), (0.184), (0.762)
13	1	1	1	-	13	1
14	0.835	1	0.835	irs	(19), (13), (2)	(0.375), (0.614), (0.01)
15	1	1	1	-	15	1
16	0.779	1	0.779	irs	(19), (17)	(0.944), (0.056)
17	0.867	1	0.867	irs	17	1
18	0.644	1	0.644	irs	(19), (2)	(0.697), (0.303)
19	1	1	1	-	19	1
20	0.853	1	0.853	irs	(19), (2)	(0.825), (0.175)
21	0.696	1	0.696	irs	(19), (17)	(0.885), (0.115)
22	0.771	1	0.771	irs	(2), (19)	(0.429), (0.571)
23	0.724	1	0.724	irs	(19),(28),(17)	(0.358), (0.241), (0.401)
24	0.5	1	0.5	irs	(19), (28), (17)	(0.31), (0.596), (0.093)
25	1	1	1	-	25	1
26	0.818	1	0.818	irs	(19), (17), (28)	(0.456), (0.542), (0.001)
27	0.868	1	0.868	irs	(28), (19), (17)	(0.35), (0.366), (0.059), (0.226)
28	1	1	1	-	28	1
29	0.751	1	0.751	irs	(17), (28),(25)	(0.026), (0.149), (0.826)
30	0.647	1	0.647	irs	(19), (2)	(0.737), (0.263)
31	0.802	1	0.802	irs	(17), (21), (22)	(0.32), (0.015), (0.665)
32	0.739	1	0.739	irs	(22), (26), (25), (5)	(0.382), (0.255), (0.049), (0.314)
33	0.684	0.75	0.912	irs	(22), (26), (5)	(0.338), (0.162), (0.5)
34	0.87	1	0.87	irs	(22), (5), (25), (17)	(0.263), (0.327), (0.101), (0.31)
35	1	1	1	-	35	1
36	0.827	1	0.827	irs	36	1
37	0.797	1	0.797	irs	(17), (22), (5), (25)	(0.496), (0.019), (0.352), (0.133)
38	0.645	1	0.645	irs	(22), (21), (17)	(0.052), (0.045), (0.902)
39	0.473	1	0.473	irs	(22), (21)	(0.937), (0.063)
40	0.5	0.866	0.577	irs	(22), (21),(17)	(0.547), (0.268), (0.185)
41	0.803	0.992	0.809	irs	(22), (21),(17)	(0.39), (0.015), (0.595)
42	0.764	1	0.764	irs	(17), (22), (25), (5)	(0.09), (0.38), (0.043), (0.487)
43	0.851	0.912	0.934	irs	(17), (22), (25),(5)	(0.002), (0.047), (0.258), (0.693)
44	0.647	0.988	0.655	irs	(22), (17), (21)	(0.37), (0.606), (0.025)
45	0.802	0.923	0.869	irs	(22), (5), (25), (17)	(0.308), (0.276), (0.061), (0.354)
46	0.425	0.731	0.582	irs	(22), (17), (25)	(0.401), (0.503), (0.096)
47	0.814	1	0.814	irs	47	1
48	0.63	1	0.63	irs	(17), (22),(25),(5)	(0.067), (0.457), (0.005), (0.471)
49	0.685	0.962	0.712	irs	(220, (5), (25) (17)	(0.248), (0.448), (0.08), (0.224)
50	1	1	1	-	50	1
51	1	1	1	-	51	1
52	1	1	1	-	52	1
53	0.894	0.914	0.978	irs	22	(0.258), (0.742)
54	0.346	0.738	0.468	irs	25	(0.785), (0.215)
55	1	1	1	-	55	1
56	0.884	1	0.884	irs	56	1
57	0.616	0.857	0.719	irs	(22), (26), (5)	(0.468), (0.247), (0.286)
58	0.593	1	0.593	irs	(22), (26), (5)	(0.704), (0.058), (0.025), (0.213)
59	0.798	0.968	0.824	irs	(22), (26), (5)	(0.501), (0.435), (0.065)
60	0.715	0.937	0.762	irs	(22), (26), (5)	(0.486), (0.407), (0.125)

Southern Karnataka						
DMU	**CRSTE**	**VRSTE**	**SCALE**		**Peer groups**	**Peer weights**
1	0.91	1	0.91	irs	(16,10)	(0.380),(0.620)
2	0.902	1	0.902	irs	20	1
3	1	1	1	-	3	1
4	0.908	1	0.908	irs	(22),(10)	(0.051),(0949)
5	0.891	1	0.891	irs	(22),(10)	(0.296),(704)
6	0.991	1	0.991	irs	(22),(16),(14)	(0.034),(0.086),(0.880)
7	0.82	1	0.82	irs	20	1
8	1	1	1	-	8	1
9	0.889	1	0.889	irs	(16),(22)	(0.151),(0.849)
10	1	1	1	-	10	1
11	0.88	0.941	0.935	drs	(29),(10),(14)	(0.552),(0.330),(0.118)
12	0.874	1	0.874	irs	(16),(10)	(0.176),(0.824)
13	0.855	1	0.855	irs	(16),(10)	(0.600),(0.400)
14	1	1	1	-	-14	1
15	0.939	1	0.939	irs	(22),(16),(14)	(0.767),(0.233)
16	1	1	1	-	16	1
17	1	1	1	-	17	1
18	1	1	1	-	18	1
19	0.945	1	0.945	irs	(16),(14),(22)	(0.283),(0.058),(0.659)
20	1	1	1	-	20	1
21	0.993	1	0.993	irs	(22),(14)	(0.151),(0.850)
22	1	1	1	-	22	1
23	0.976	1	0.976	irs	(16),(14),(10)	(0.111),(0.333),(0.556)
24	0.894	0.929	0.963	irs	(16),(10)	(0.284),(0.716)
25	1	1	1	-	25	1
26	0.92	1	0.92	irs	(16),(10)	(0.340),(0.660)
27	0.928	1	0.928	irs	(22),(16),(20)	(0.229),(0.224),(0.547)
28	0.951	1	0.951	irs	(16),(17),(14),(10)	(0.5220),(0.09),(0.207),(0.262)
29	0.959	1	0.959	drs	29	1
30	0.993	1	0.993	irs	(25),(14),(22)	(0.647),(0.219),(0.135)
31	0.903	0.981	0.921	irs	(5),(28),(19),(20)	(0.039),(0.019),(0.942),(0.000)
32	1	1	1	-	31	1
33	0.897	1	0.897	irs	(5),(28),(20)	(0.345), (0.380), (0.275)
34	0.946	1	0.946	irs	34	1
35	1	1	1	-	35	1
36	0.772	0.823	0.938	irs	(25),(5)	(0.646), (0.354)
37	0.813	0.917	0.887	irs	(25),(5)	(0.834), (0.166)
38	0.914	1	0.914	irs	(19),(28),(5),(20)	(0.392), (0.173), (0.280), (0.155)
39	0.873	1	0.873	irs	19,28,5,20	(0.371), (0.014), (0.419),(0.196)
40	0.82	0.859	0.955	irs	25,5	(0.718), (0.282)
41	0.991	1	0.991	irs	5	1
42	0.965	1	0.965	irs	42	1
43	0.999	1	0.999	irs	(5),(12),(27)	0.917,0.06,0.077
44	0.912	1	0.912	irs	(5),(19),(27),(28)	0.150,0.542,0.116,0.191
45	0.995	1	0.995	irs	(5),(20),(19)	0.054, 0.009, 0.938
46	0.858	0.888	0.966	irs	(25),(5)	0.776, 0.224
47	0.814	0.903	0.902	irs	(28),(20),(19)	0.194, 0.637, 0.168
48	0.935	1	0.935	irs	5	1
49	1	1	1	-	49	1
50	1	1	1	-	50	1
51	0.947	1	0.947	irs	(19),(5),(20)	(0.036), (0.554), (0.409)
52	0.85	1	0.85	irs	5	1
53	0.697	0.824	0.846	irs	(25),(5)	(0.648), (0.352)
54	0.827	0.962	0.86	irs	(19),(28),(20)	(0.306), (0.053), (0.463), (0.178)
55	1	1	1	-	55	1
56	0.777	0.93	0.836	irs	(25),(5),(28),(20)	(0.488),(0.194),(0.264), (0.054)
57	1	1	1	-	57	1
58	1	1	1	-	58	1
59	1	1	1	-	59	1
60	0.673	0.857	0.785	irs	(25),(28),(20)	(0.168), (0.630), (0.202)

It could be observed from above table that in maize supply chain of Northern Karnataka, the efficient DMUs under the assumption of CRS and VRS were DMU 1, DMU 2, DMU 3, DMU 4, DMU 5, DMU6, DMU 10, DMU 13, DMU 15, DMU 19, DMU 25, DMU 28, DMU 35, DMU 50, DMU 51, DMU52 and DMU 55. It could be noted that the DMUs that were seen as more efficient and very much referenced peers by other relatively inefficient DMUs of the same or different

peers. The "Peers" are more efficient DMUs that have similar input usage as that of the less efficient thereby representing the best practices that can be adopted by the less efficient DMU. The "lambda" values (peer weights) are computer generated weights to be assigned and used in the linear combination of the each peer's inputs so that a less efficient DMU could achieve its best practice target. For example, it could be inferred from the Annexure 3, that, DMU 7 needed to use peer weights 0.521, 0.156, 0.110, and 0.213 percent of DMU 28, DMU 19, DMU 17 and DMU 6 respectively in order to become highly efficient under VRS. In Northern Karnataka supply chain, most of the DMUs were efficient under the assumption of VRS but peered DMU would do best practices and technology to improve the supply chain efficiency with available inputs; so all DMUs can adopt and show more efficiency. Increasing returns to scale means supply chain members can increase their supply chain efficiency if they could operate at full technical efficiency levels, while decreasing returns to scale indicates that efficiency can be improved if the DMU reduces its inputs used in the supply chain. It showed that most of the DMUs experienced increasing returns to scale with scale inefficient except DMU 1, DMU 2, DMU 3, DMU 4, DMU 5, DMU6, DMU 10, DMU 13, DMU 15, DMU 19, DMU 25, DMU 28, DMU 35, DMU 50, DMU 51, DMU52 and DMU 55, which depicted constant returns to scale with 100 percent scale efficiency.

It could be seen from the Table 5 that, the level of technical efficiency for maize supply chain in Southern Karnataka ranged from 82.00 to 100.00 with mean efficiency of 92.70 percent in constant return to scale. Given the current state of technology, technical efficiency among supply chain members can be increased by 8.30 percent through better supply chain management practices. The technical efficiency calculated by using variable return to scale indicated that the efficiency ranged from 92.90 to 100.00 with mean efficiency of 85.70 percent, which inferred that Southern Karnataka supply chain was more efficient in the study area and scale efficiency ranged from 82.00 to 100.00 with mean efficiency of 94.40 percent. It revealed that they had the scope to increase efficiency by decreasing the production cost and wastages at farm and processing level.

It could be observed from Annexure 5.4 that in Southern Karnataka maize supply chain, the efficient DMUs under the assumption of CRS and VRS were DMU 3, DMU 8, DMU 10, DMU 14, DMU 16, DMU 17, DMU 18, DMU 20, DMU 22, DMU 25, DMU 32, DMU 35, DMU 49, DMU 50, DMU 55, DMU 57, DMU 58, and DMU 59. It could be noted that the DMUs that were seen as more efficient and very much referenced peers by other relatively inefficient DMUs of the same or different peers. It showed that most of the DMUs experienced increasing returns to scale with scale inefficient except DMU 3, DMU 8, DMU 10, DMU 14, DMU 16, DMU 17, DMU 18, DMU 20, DMU 22, DMU 25, DMU 32, DMU 35, DMU 49, DMU 50, DMU 55, DMU 57, DMU 58, and DMU 59, which depicted constant returns to scale with 100 percent scale efficiency.

It could be concluded from the above results that, the mean technical efficiency of supply chains of maize in northern and southern Karnataka were ranged from 81.00 to 97.20 percent and 92.70 to 85.70 percent respectively. The technical efficiency was higher in Southern Karnataka maize supply chains, because e- tendering was performing well in South Karnataka which increased control over the quality and brought price stability. An added advantage of this model was that it provided better understanding between the farmers and merchants for value addition like drying, better packing, reduced wastages leading to improved supply chain practices. Hence they excelled in efficiency. These findings are in line with the study of Erkan *et al.* (2010) [9] on the efficiency comparison of supply chain management and information systems practices: a study of Turkish and Bulgarian small- and medium sized enterprises in food products and beverages reported that managing most of the supply chain management (SCM) practices enhance the SCM efficiency.

Conclusion

There was a positive relationship between arrivals prices of maize in Southern Karnataka, whereas there was a negative relationship between arrivals prices of maize in Northern Karnataka. Most of the sample farmers of Northern Karnataka were illiterates compared to Southern Karnataka and even primary and secondary education was more in the southern districts of Karnataka. Northern Karnataka farmers were better experienced on the various aspects of maize production and hence were better equipped to cultivate quality maize and in turn could fetch better price in the market. Northern districts of the Karnataka had the highest land holding due to its family structure of joint family nature. Occurrence of drought and high commission charges were the major constraints faced by the farmers in the study area. Majority of Southern Karnataka commission agents were having more access towards market information through e–tender website and APMC price board in comparison with their northern counterparts and hence there was a quick flow of accurate information among the commission agents operating in Southern Karnataka districts. Commission agents were realizing more profit in Northern Karnataka than Southern Karnataka.

APMC was playing the major role of market information source for the processors through website and price board for the processing units operating in Northern Karnataka as well as Southern Karnataka. Traders in Northern Karnataka were earning higher marketing margin compared to their southern counterparts. Southern Karnataka processing industries were having higher installed capacity and also lesser power consumption in comparison with their Northern counterparts. Price fluctuation and poor maize quality were the major constraints bothering the processors of Northern Karnataka as well as Southern Karnataka. Majority of Southern Karnataka sample buyers were having the highest annual turnover than the Northern Karnataka buyers which was the resultant of good performance of the hatcheries, processors linkage with input suppliers and periodical health care inspection of the chicks. The technical efficiency was higher in Southern Karnataka maize supply chains, because e- tendering was performing well in South Karnataka which increased control over the quality and brought price stability.

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