SUPPLY CHAIN MANAGEMENT OF TOMATO PRODUCTION AT MADANAPALLE REGION: A CASE STUDY

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Abstract

Active players/Stakeholders in the entire supply chain of tomato production at Madanapalle region starting from the seed manufacturer to the buyers in the market were identified. A survey was conducted in 34 sampled villages with 690 small/medium business farmers who were interviewed to know the cost of tomato production and also to know about the satisfaction levels of the services provided by various stakeholders in the supply chain. Interviews with all the remaining players/stakeholders in the supply chain were conducted through an unstructured questionnaire. During this study each player's revenue and risks were noted and observed that farmer and urban end user got most affected due to market pricing. A new pricing model is proposed and will help in developing a rural-urban linkage.

Keywords: *Supply chain, Stakeholders, Pricing, Risk*

Introduction

The supply chain includes all activities and processes to supply a product or service to the final customer. Often, the supply chain includes more than one company in a series of supplier–customer relationships. Supply chain in agri product context particularly related to tomato will include activity starting from seeds suppliers to the end consumer. Supply chain management is the act of optimizing all activities throughout the supply chain, so that products are supplied in the right quantity, right quality, to the right location, at the right time, and at the optimal cost. Supply chain management and the closely related concept of logistics are necessary cornerstones of competitive strategy, increased market share, and shareholder value for most organizations. Logistics is a critical part of the supply chain. The co-ordination and, perhaps, integration of the logistics systems of all the organizations in the supply chain are necessary requirements for successful management of the supply chain. Yet the logistics area, in a large number of such organizations is managed by people who did not have an opportunity to gain professional competencies in managing/integrating it [ref. [1],[2], and [3].

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Having recognized the importance of logistics in supply chain area, many of the organizations have the aim to improve their logistics functional area. Another factor contributing to the recognition of logistics has been increased customer sensitivity to not only product quality but also to the associated price. The responsibility of the logistics manager includes a number of activities. The number and importance of these activities to the business varies according to the particular emphasis placed on the logistics function. Traffic and Transportation involves the physical movement or flow of raw materials or finished goods and involves the transportation agencies that provide service to the firm. Customer Service levels play an important part in logistics by ensuring the customer gets the right product, at the right time and place. Logistics decisions about product availability and right price are critical to customer service. Supply chain modeling must be fact-based. Independent participants can assert facts and avoid "taking sides" that may be risky for employees. The objective is not to build a model. The objective is to model the sensitivity of one variable against others.

Background

Madanapalle is a town located in the Chittoor district of Andhra Pradesh. It is one of the biggest Revenue Divisions in India (it covers almost half of the Chittoor district). It is a fast-growing city at the center of an agricultural region noted for its fruits and vegetables, especially tomatoes. Madanapalle is a centre of vernacular culture. Madanapalle has pleasantly mild, to warm summers with average high temperatures of 30 to 35 degrees Celsius (86 F to 95 F). Temperatures do not exceed 40 degrees Celsius (104 F) and winters are cold with temperatures between 7 to 15 degrees Celsius (44.6 F to 59 F). Usually summer lasts from March to June. This climate is ideal for tomato growing. One can find 125 or more villages in and around Madanapalle where tomato growing farmers are available. Madanapalle comprises of vast tomato market that incorporates sales and marketing of tomato only. Four to seven hundred tones of tomatoes per day will be sold at this market depending on peak and non-peak season. Local demand will be only thirty five to forty thousand kilograms tomatoes per day. Pricing at this market will be a primary issue in this study. In the recent past there has been a significant growth in number of nursery players. All the players/stakeholders in the supply chain are studied with respect to their revenues and risks.

Objective

The existing system of operations at the production and market levels are performing over a period of time. The objective of this study is to explore possibilities of improvement for the same. From an operations research perspective, the objectives are to achieve optimization in terms of benefits to all stakeholders in the supply chain.

Methodology

Existing upstream and downstream flow operations are studied to obtain a representative picture of the system. To arrive at total costs upto the yield of the agri product tomato, farmer's survey is conducted at 34 sampled villages out of 125 villages where farmers grow tomatoes. Accordingly around 690 farmers were interviewed with a structured questionnaire to know the cost of tomato production and also to know about the satisfaction levels of the services provided by various stakeholders in the supply chain. Mostly the interviewed farmers were either at small or medium level. Interviews with all the remaining players/stakeholders in the supply chain were conducted through an unstructured questionnaire. Pricing being the most challenging issue, a new pricing method is developed in order to balance the satisfaction levels of stakeholders involved at the market level. For model testing, a primary data which constitutes the buyers maximum quoted price before auctioning and seller's minimum expected price is collected.

Players/stakeholders in the supply chain

Figure 1 show the players/stakeholders involved in the supply chain. Each player will be studied in detail.

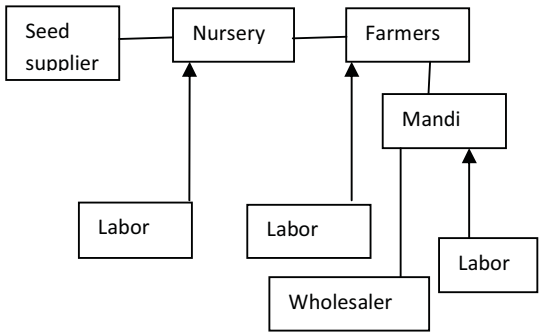

Figure 1

Seeds Suppliers

In this we consider both seeds suppliers as well as seeds manufacturers. In the seeds manufacturing unit, inputs will be supplied by the farmers under the guidance of seeds manufacturing unit manager and payment will be done in three phases. Seeds wholesaler will procure seeds from various manufacturing units under different brands with different variety numbers. In the past, farmers used to dry the tomatoes seeds and use it for growing. With the advent of seed culture they used to buy dry packets of tomato seeds and planted in this fashion till 2000 – 2001. Now the trend changed after 2001. Plants or saplings are developed in the nurseries from the dry seeds and farmers buy the saplings from the nurseries. So the farmers now depend on the sapling developers rather than the seed seller. Before 2001 its customers are farmers and now nursery owners have taken the role of customers. In Madanapalle region the sales of tomato seeds will be 3 to 4 tons per month. They export seeds too. Risks involved in this activity will be that there are situations faced which affect the yield. Other than natural calamities farmers blame the seed sellers that the yield suffered from the previous year due to the "duplicate seeds" given. Disease infected plants develop once in every two - three years, the seed companies then make the necessary changes.

Nursery Owners

At Madanapalle, there has been tremendous increase in the number of nursery owners in the recent past due to good profits in the business. Customers will be of course farmers. For customers outside Madanapalle region, nursery owners will get order and deliver the seedlings between third and fourth week whereas for local farmers they can collect it personally provided the right variety is available. Average nursery owner's sales quantity will be three hundred thousand seedlings per month and sales revenue will be ₹ 45, 00 per month which will be a quite good amount. Risks will be to sell the seedlings between 17^{th} and 25^{th} day of sowing the seeds. For outside farmers risks will be zero as they deliver by order. For local farmers sometimes right kind of variety may not be available. By merely looking at seedling one may not be able to identify the variety of tomatoes it actually is so some nursery owners take advantage of this situation and sell to farmers with wrong variety. However there exist some loyal nursery owners who not only supplies seedlings to the farmers but also help in guiding them with right kind of variety of

seedlings with the right usage of pesticide. They also try to guide the farmers in minimizing their investment. This part is essential since the low yield will increase the cost of production and the farmer may shift to other nursery owner. Sometimes local farmers take seedlings on debt as they do not have money. Loyal nursery owners do not exploit the farmers to give them the produce in exchange.

In general the relationship between the nursery owner and farmer is very cooperative. As number of nursery owners is growing at a rapid pace, these relationships will help in being competitive.

Farmers

Farmers will plant 10000 seedlings per acre which are purchased for nursery owners. Total yield per acre will vary from 6125 to 11375 kilograms (kgs). Yield will vary due to the season, inputs, and variety of seeds. The average cost of production from the farmer's survey will be approximately ₹2.95 per kg. Revenue for the farmers will vary very high starting from a loss like ₹2.00 to ₹18.00 per kg. This variation is due to the seasonal demand. If any particular variety leads to a low yield then government will compensate some percentage of amount in the cost of production. However recently they are not getting any compensation due to the seedlings purchased by a farmer from a nursery owner who doesn't have any license. In fact government has not given license to any nursery owner. So risk factor will be to get yield at production level and getting right price at the market level.

Market/Mandi Agents

Market agents play an important role in mediating between sellers and buyers. During mediating process, it is observed in the existing system buyer will have more benefit than seller. This is the reason why the price at market level has high fluctuation. In the existing system, auctioning will be followed in marketing procedures. Marketing agents will also help in giving loans to sellers/ farmers when it is necessary. Every seller is attached to only one marketing agent whereas buyers will buy from any agent/s. According to the government regulations, market agents should take maximum 4% commission from any player like seller or buyer, but they are charging 10% commission from the sellers. Risks for these marketing agents will be to satisfy both buyers as well as sellers. On any

day marketing agents have to balance price to satisfy both buyers as well as sellers which is a challenging task. In general buyers and sellers have non cooperative in nature whereas marketing agents have to play cooperative role with both buyers and sellers. In reality degree of cooperation will be more with buyers when compared to sellers with respect to marketing agents. During the field it is observed that auctioning marketing procedures are appearing artificial and some buyers too feel that marketing agents are biased towards few buyers. This motivates to develop a pricing model which in general will be beneficial to all stakeholders and also it will be transparent. More details about the proposed pricing model will be discussed in section 4.0.

Buyers

In this market buyers are mostly representatives of various urban stakeholders. Some buyers will come directly to the market from outside the Madanapalle region without representatives through their own vehicle. These buyers will participate in the auctioning system and arrange vehicles to transport it to the respective destinations. Usually buyers will choose mostly one way transport system through effective cost minimization approach through search from the transport provider. Buyers who represent urban stakeholders will bear the transportation cost and tend to buy with competitive price in accordance with the urban prices. During auctioning period these buyer representatives will consult with the respective urban buyers. Risk involved will be maintaining relationships with both marketing agents and urban buyers.

Transport providers

There exist transport providers in the upstream and downstream. Transport vehicles in the upstream will go to various villages with empty crates from the market and will bring tomato filled crates to the market. These crates are owned by the marketing agent and will charge ₹6 per crate to the farmer and will adjust it during the selling transaction. These transport operator charges ₹10 to ₹15 per crate to the farmer for transporting their tomato crates from their village to market. Usually transport operator operates thrice daily and for each trip they can carry maximum 100 crates. Variation in charges will be according to the distance from the market. Risk involved will be timely delivery.

Transport vehicles in the downstream will be from market to various urban markets through buyer representatives. In this, transport provider tries to search for vehicles which go empty to those urban destinations. They try to maintain good network with many other transport providers who deals with other commodities. In this stream, these transport vehicles are of higher capacity of 600 crates. These vehicles will charge ₹10,000 to ₹ 20,000 depending on distance.

Besides the above stakeholders mentioned, there exist many other stakeholders viz Government offices like agricultural/horticultural, marketing officials and tomato processing unit owners.

Supply Chain Integration

Supply chain integration is essential for all the stakeholders to go in a cooperative approach and aim for a systemic optimization in terms of benefits rather than individual benefit maximization. As government is one of the important stakeholders, it has to either delete the nursery owner or give license to the nursery owner through a supply chain management approach. It should be done in phases through performance. Those nursery owners who got good feedback given by farmers should be provided with a license and rest should be given a chance to improve their performance. If those who are unable to improve their performance then they should be discarded. Once the regulation from government imposed, seeds supplier should follow cooperative approach like selling seeds to only licensed nursery owners.

From the survey of farmers, the following table shows the satisfaction levels of various stakeholders. From the table 1 it is observed that transport operator has highest satisfaction level mean when compared to that of other stakeholders. Next will be nursery owners and least being the agricultural extension officer (AEO). These satisfaction levels will indicate that all these stakeholders should adapt cooperative approaches in order to get systemic benefit.

End consumers at the urban places often observe fluctuation in tomato prices. Urban market agents fix the price according to the supply. In some urban places, marketing agents prefer local suppliers so as to enable local suppliers to get a maximum benefit. Also a regional conflict among public will lead to local supplier's preference. This will increase the tomato prices at those urban places.

Market agents along with the buyers and sellers should adapt the following proposed pricing model to get a systemic benefit.

Tomato Pricing Model

Market commissioning agents

Let us denote market commissioning agents as MCA_i

(i = 1,2,3,--,l)

Table 1

	N	Minimum	Maximum	Mean	Std. Deviation
SL of Seedling seller	688	.00	5.00	2.8183	1.14856
SL of AEO	688	.00	5.00	1.8663	.94668
SL of Prices at market	688	.00	5.00	2.1061	.95400
SL of Maketing procedures	687	.00	5.00	2.4119	1.03751
SL of Mandi agent	688	.00	5.00	2.4898	1.19187
SL of Transport operator	688	.00	5.00	3.2137	1.03897
Valid N (listwise)	687				

Farmers/sellers

Sellers can be identified as S_{ij} where i denote the i^{th} mandi agent and j denotes the j^{th} farmer attached to the respective mandi commissioning agent. Here $j = 1,2,3,---,m_i$

Buyers

Buyers can be defined by B_{ijk} where first subscript indicates the market commissioning agent, second subscript indicates the respective seller/farmer and third subscript indicates the buyer. The following pricing model is based on matching game approach [4].

For each market commissioning agent there may be several farmers/sellers attached but each farmer will be attached to one and only one market commissioning agent. Buyers are free to buy from any farmer/s and also from any market commissioning agent/s. In the existing system, market commissioning agent will facilitate auction at market. Before the beginning of auction, buyers can look at micro level at the quality of tomatoes by overturning the one, two or three crate of tomatoes and this number will depend upon number of crates of tomatoes available for sale. Usually women labourers were hired by farmers for grading. After the completion of this process labeling (code) will be done by writing in a piece of paper with name of the farmer and number of crates available for sale.

Many farmers expressed that auctioning at mandi seems to be biased towards mostly buyers. Hence the following system is proposed:

Each market agent should invite farmers/sellers to enter the data of quoting the minimum price/crate for which they can sell, in a computer along with the number of crates available for sale. All farmers will enter the data independently and even market agent cannot access the data. The process of data entry by farmers/sellers will go parallel across market agents. However buyers may be common to different market agents. After looking at the quality of tomatoes at every farmer across all market agents, buyers will now enter the data of maximum price/crate for which they can buy. Fractional lots will not be allowed to buy. Once the data entry is finished, buyer should reconfirm about the quoted price. After reconfirmation, one cannot change but can withdraw from the competition of buyers. Actual buyer will be selected by computer through finding maximum difference between the seller and a buyer. The allocations for each stakeholder namely seller/farmer, market commissioning agent, and buyer will be calculated as follows:

Stakes for sellers S_{ij} =

$$
\begin{aligned}
&[0.96 * Max\{MxP_{ijk}, k = 1,2,3,\text{—}\} \\
&if \;\; Max\{MxP_{ijk}, k = 1,2,3,\text{—}\} < MnP_{ij} \\
&Otherwise \\
&MnP_{ij} \;\; if \; 1.04 * MnP_{ij} = \\
&Max\{MxP_{ijk}, k = 1,2,3,---\} \\
&MnP_{ij} + (0.96 * Max\{MxP_{ijk}, \\
&k = 1,2,3,---\} \\
&-1.04 * MnP_{ij}) / 3 \\
&\;\; if \; 1.04 * MnP_{ij} < 0.96 * \\
&Max\{MxP_{ijk}, k = 1,2,3,---\} \\
&MnP_{ij} - (1.04 * MnP_{ij} - 0.96 * \\
&Max\{MxP_{ijk}, k = 1,2,3,---\} / 2 \\
&\;\; if \; 1.04 * MnP_{ij} > 0.96 * \\
&Max\{MxP_{ijk}, k = 1,2,3,---\}]
\end{aligned}
$$

Cost of purchase for buyers B_{ijk} =

$$[1.04 * Max\{MxP_{ijk}, k = 1,2,3,—\}$$
$$if\ \ Max\{MxP_{ijk}, k = 1,2,3,—\} < MnP_{ij}$$
$$Otherwise$$
$$Max\{MxP_{ijk}, k = 1,2,3,---\}$$
$$if\ 1.04 * MnP_{ij} = 0.96 * Max\{MxP_{ijk},$$
$$k = 1,2,3,---\}$$
$$Max\{MxP_{ijk}, k = 1,2,3,---\} - (0.96 *$$
$$Max\{MxP_{ijk}, k = 1,2,3,---\} - 1.04 * MnP_{ij}) / 3$$
$$if\ 1.04 * MnP_{ij} < 0.96 * Max$$
$$\{MxP_{ijk}, k = 1,2,3,---\}$$
$$Max\{MxP_{ijk}, k = 1,2,3,---\} +$$
$$(1.04 * MnP_{ij} - 0.96 *$$
$$Max\{MxP_{ijk}, k = 1,2,3,---\} / 2$$
$$if\ 1.04 * MnP_{ij} > 0.96 *$$
$$Max\{MxP_{ijk}, k = 1,2,3,---\}]$$

If two or more buyers quoted the maximum price which happens to be optimum then the quick auction can be held only for those buyers. In that case agent will get only 4% commission from each of those buyers and sellers/farmers. This will ensure that market agent will not try to get the data and leaked the same. All the farmers will be able to enter the data and the competitive prices will be quoted as they verify from the other markets through mobile phones.

In the proposed system, we observe that the stakes of both market commissioning agents and farmers will be a win-win situation when compared to the existing system. For buyers too we can consider it as wining situation since more price if it is quoted then chances of getting the right kind/quality of tomatoes will be high and at the same time differential reduction in price will occur which leads to a winning situation. To compare the existing and proposed methods of pricing, the table 2 will help in analysis

Table 2

Sellers/ Farmers stake	Buyer stake	Commission Agents Stake	Explanation
0	1	1	Seller's are at loss and buyer and commission agents are gaining
1	0	1	Seller's and commission agents are gaining while buyers are at loss
1	1	0	Seller's and buyers are gaining while commission agents are getting less commission
1	0	0	Sellers are benefited and buyer's and commission agents are at loss
0	1	0	Buyer's are gaining and sellers and commission agents are at loss
0	0	1	Commission agents are gaining while sellers and buyers are at loss
1	1	1	All the agents are benefited through the use of the model
0	0	0	All that agents stakes are at loss through the use of the model

The proposed pricing model explains different combinations which test the model keeping the actual situation as the base and derives which agent's stakes are benefited by the use of the model. We can see in table-2 , "1" represent that agents stake are getting benefited through the use of the proposed model and "0" represent the loss. There are 8 different situations that can be occurring while using the model which are shown in the table 3.

First combination "1, 1, 1" where model is a exact replica of what is the current procedure followed by the market in which farmer quoted price, the auctioning price and market agent's stake is similar to that in actual market.

Now the second combination is (1, 0, 1) where buyer is has to pay more than what he would be actually paying in the market. In this situation we can see that the buyer who had quoted in the beginning of the auctioning could not get chance to buy but another buyer purchased due to the influence of marketing agent's artificial auctioning.

The third combination (0, 1, 1) we can see the farmer's stake gets reduced. The possibility of such an event happening when farmer has a very less idea about the current market price, and results in quoting low price based on the cost of production rather than market price which leads to low stakes for the farmers.

Table 3

SELLERS STAKES 1= BENEFIT 0 =LOSS	BUYERS STAKES 1=BENEFIT 0=LOSS	AGENTS COMISSION 1 =BENSFIT 0= LOSS	Total
1	1	1	98
0	0	0	0
1	1	0	0
1	0	1	149
0	1	1	7
1	0	0	0
0	0	1	1
0	1	0	160

.

But in the current market it is observed that farmer does a good back ground check like enquire different people through phone and many other ways before actually quoting the price. Another point to take into consideration is farmer are good seller's and have ample amount of experience in the respected field, and also looking at the data collected of around 500 farmers we have observed that farmers are very good marketer of their product are capable of pushing their product prices to the maximum though quoting high prices. So the chance of such event happening is very low.

The fourth combination "0, 1, and 0" shows market agent and farmers are getting low stakes than the actual situation and buyer had to pay very low price for their purchase. This event would mean that the buyer has quoted fewer prices in the model and has quoted more during auctioning. For example suppose farmer Mxp was "200" in the model and he actually quoted Mxp as 230 during the auctioning in such a case we can see that auctioning price is more than the model price. But such a condition is not possible as through the use of the model we welcome more buyers who can freely quote there price as they do in the actual auction. So Mxp quoted in the model is equal to Mxp quoted during actual auctioning.

The fifth combination "0, 0, 1" both the buyer and seller are at loss in their stakes and the market agent is benefited. This means that Mxp is exceptionally high and Mnp is exceptionally low. Which we have seen from the above examples would not happen as buyer and sellers are very much informed about the current prices in the market.

Now the remaining three combinations "0, 0, 0," "1, 1, 0" "1, 0, 0" are not feasible with our model thus cannot take place through the use of our model. "0, 0, 0" in which

none of the agent's stakes are benefitted as we have seen earlier that either even if Mxp and Mnp equals to 0 buyer stake will be benefitted.

The table-3 shows counts which supports the explanations mentioned above for each combination. More precisely 24% of the total observations derived positive relationship as "1, 1, 1" and all the agents are benefited through the use of our model than in actual market. 36% can be counted as positive outcome which can be added to the above 24% of observation. So it can be concluded that the proposed model derives 60% positive outcome from the total observations.

38% observations belongs to "0, 1, 0" which states that buyers are benefited whereas marketing agents and seller stakes are at loss. The reason for such a situation can be that, farmer actually willing to purchase that tomato's at far high prices were not promoted by the mundi agents or the product had a high potential to sell are high price but market agents could not exploit it through effective marketing of the product which would actually results in a greater loss for the farmers. If these 160 would have been participle in our model would result in a overall gain for the total stakeholders.

Thus we can conclude form the analysis that our model if used in the actual situation would be a more effective and beneficial than the actual mundi that if followed by the farmers.

Conclusions

Among the various stakeholders in the supply chain, it is observed that farmers and end urban consumers are most affected. Farmer's problems can partially be solved using the proposed pricing model at the market. Also market agents should explore the opportunity for more buyers like processing unit owners to participate. Cold storage facilities to be provided in the vicinity of the market so that in case of excess supply, it can be stored and can use it for the same next day.

Also they can invite processing unit owners to provide a cold storage in the market and encourage them to store. According to this unit owner, one can store for one month and then process it without loosing any properties. This can lead to effective inventory management. For improving satisfaction level of farmers from stakeholders particularly government departments, nursery owners and market agents, more innovative cooperative approaches are needed. Maximizing productivity at farmers end will be another area of

improvement. Government officials particularly AEO should give services to the farmers efficiently to enable the farmers to maximize their benefits.

In the proposed pricing model, it is to be observed that the system will maximize its transparency as well as the benefits to all the three players. As farmers are more important players in the system, this transparency will enable them to improve the supply of tomatoes to the market. This system can be implemented on trial basis. This system seems to be sustainable. In order to claim the sustainability frequent feedback can be taken from all the three players. Once this proposed system is successful then information system can be developed to enable the buyers from any region can participate in the market without eliminating market agents through local representative. Sellers/farmers can also access the buyer's demand and take decision of supply tomatoes accordingly.

On the other side end urban consumers difficulties in high fluctuation of prices can be solved if the concerned urban stakeholders can encourage outside supplier's i.e local rural buyers to participate in the urban market. Overall costs can be minimized if one can use efficient logistics by creating a direct urban- rural linkage. This cost minimization will help in solving end consumer difficulties. From the proposed pricing model one can find farmers as consistent estimators in terms of pricing and these farmers can be eligible for establishing direct rural –urban market linkage through online by inviting urban buyers to buy from the village itself. There is a large scope of further research in this area of efficient logistical system under urban- rural linkage particularily from this Madanapalle region. According to retailer of tomato processing products there is an another alternative approach of solving for end urban consumer difficulties will be to purchase tomato puree whenever cost of raw tomato per kilogram will be more than ₹20. Though this product enter into the market two decades ago but many urban consumers are not aware of this product and its equation.

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