ABSTRACT

The purpose of this study is to extend the scope of value chain analysis (VCA) methodology. Previous research on value chain analysis has focused on process aspects of value chain. This research makes the methodology more robust and innovative by including elements that extend its application to the analysis of supply chain network structure. The VCA approach is tested on a value chain network design problem in the dairy sector. Case study and action research are used in developing the methodology.

Keywords: value chain design analysis methodology, value chain analysis, emerging economy, dairy supply chain

INTRODUCTION

Value chain consists of those specific parts or activities of firms that actually add value to a specific product or service (Hines and Rich, 1997). Value chain is hence a more stringent view of the value adding processes of any firm as compared to supply chain which covers all the activities that occur in the transformation of goods or services to serve customers. The supply chain process may be classified into three major categories according to Monden (1993). These are 1. non-value adding (NVA), 2. necessary but non-value adding (NNVA) and 3. value adding (VA). Value chain on the other hand focuses on value adding activities.

In this research we study the application of a methodology for the analysis of value chains, called value chain analysis or VCA, for analyzing supply chain networks and test it in the context of a large dairy processor in an emerging economy. Value chain analysis is a structured methodology identifying the value-adding and non-value adding processes within a supply chain. It analyzes the effects of all the core activities on cost and/or differentiation of the value chain (Zokaei and Simons, 2006, p.147). VCA analyzes where in the chain costs may be reduced and differentiation enhanced (Dekker, 2003, p.5).

The research in value chain analysis has either focused on development of the methodology, its application to a particular setting or both. The objective of the research has been on development of methodology for the analysis of the particular steps involved in a supply chain, the wastes generated and time taken within the chain in order to make the chain lean (Rother and Shook, 1998; Jones and Womack, 2002). The application of the methodology has mainly focused on the developed world (see for instance Zokaei and Simons, 2006) with few exceptions in the
developing region (Seth, Seth and Goel, 2008). In these few studies in developing world the objective has mainly been application the value stream mapping tool for the analysis of value chain. The value stream maps hence created prove useful in identifying value and waste within the chain. However as far as development of the value chain analysis methodology is concerned we see little work in this area. Furthermore the value chain analysis research has in general focused on the identification of the different forms of waste within the supply chain rather than the design of the value chain.

The design problem has been taken up as a separate area of research in the operation research domain where the objective is to develop models for optimal design solutions. However, in practical settings less than complex mathematical models are often required both to understand the existing design inefficiencies and to capture the intricacies inherent in real life settings. So where the value chain analysis research has picked the value chain as the object of study the value chain design literature has emphasized development of mathematical operations research models for the design of the chains. However a methodology for analysis of value chain designs is yet to be seen.

The purpose of this research is to test the power of the value chain analysis methodology to understand value chain network designs by applying the methodology to a real life emerging market dairy supply chain. In the process a new methodology for the analysis of value chain designs is developed.

The supply chain network design problem being targeted in this study belongs to dairy sector supply chain. We present application of the most relevant ‘state-of-the-art’ value chain analysis methodology to the network design problem. In case where the methodology could not be completely analyzed for analysis of supply chain network, it was modified. Rest of the paper is organized as follows. Section 2 talks about application of the value chain analysis methodology to the network design problem and required modifications. Section 3 is application of the methodology to analyze a supply chain network in the dairy sector. We end the paper with conclusion and future research directions.

LITERATURE REVIEW

Value chain consists of those specific parts or activities of firms that actually add value to a specific product or service (Hines and Rich, 1997). Value chain is hence a more stringent view of the value adding processes of any firm as compared to supply chain which covers all the activities that occur in the transformation of goods or services to serve customers. The supply chain process may be classified into three major categories according to Monden (1993). These are 1. non-value adding (NVA), 2. necessary but non-value adding (NNVA) and 3. value adding (VA). Value chain on the other hand focuses on value adding activities. Value Chain Analysis (VCA) is a structured method of analyzing the effects of all the core activities on cost and/or differentiation of the value chain (Zokaei and Simons, 2006, p.147). VCA analyzes where in the chain costs may be reduced and differentiation enhanced (Dekker, 2003, p.5).

The research in value chain analysis may be classified into two major categories: that deal with application of value chain analysis methodology to a particular setting and report findings, 2. that
develop methodology for analyzing value chains. In what follows, we discuss the two streams separately.

*Application of Value Chain Analysis*

Donaldson, Ishii and Sheppard (2006) provide a step-by-step guide for the implementation of customer value chain analysis with an example. They present three case studies that highlight the tool’s utility and important features to support design decision making, including: (1) confirmation of the product’s business model, (2) recognition of the critical stakeholders, and (3) clarification of the value proposition to be embedded in the product.

Zokaei and Simons (2006) use the Food Value Chain Analysis methodology using lean paradigm, value stream mapping and value chain analysis to improve consumer focus in agri-food sector. The authors present a case study of UK red meat supply chain in which they identify the misalignments in both product attributes and supply chain activities.

Francis, Simons and Bourlakis (2008) conduct a case based research employing the value chain analysis methodology to examine the beef foodservice sector. The research provides explanation and analysis of supply chain operations within the Argentine beef industry. It highlights specific supply chain waste elimination opportunities at both producer and processor level. It also establishes valuable learning points for the UK beef industry as a whole.

Singh and Sharma (2009) provide an application of value stream mapping in a manufacturing firm. VSM is the process of visually mapping the flow of information and material (known as current state map) as they are and preparing a future state map with better methods and performance based on the analysis of current state value chain map Womack (2000). Through their case study, Singh and Sharma show that value chain mapping is a useful analytical tool for making the manufacturing firms lean. Other applications of value stream mapping and analysis may be found in Barker (1994), Brunt (2000), Seth and Gupta (2005), Abdulmalek and Rajgopal (2007).

*Development of Methodology for Value Chain Analysis*

Hines and Rich (1997) develop the seven value stream mapping tools to understand the supply chain and identify supply chain wastes. The authors show the usefulness of the tools for identifying and removing the seven commonly accepted wastes in the Toyota Production System (Shingo, 1989). The purpose of their paper is to help researchers and practitioners identify wastes and find an appropriate route for their reduction and possible removal in individual value chains.

The value chain analysis methodology has been developed and extended by other researchers since the work of Hines and Rich. Rother and Shook (1998) and Jones and Womack (2002) specifically develop the value stream mapping tool for visualizing the extended value chain in order to identify and reduce wastes in the system to make it lean.

Taylor (2005) presents application of value chain analysis and lean methodology in agri-food sector and develops a methodology to apply lean value chain analysis techniques to a food product supply chain. The objective is to improve the multi-echelon supply chain.
DeToro and Tenner (1997) provide an approach for process improvement. Their model is based on the principles established by Crosby, Deming, Juran and Feigenbaum. The steps involved in their continuous improvement process are:

1: *Understand the customer*
2: *Assess efficiency*
3: *Analyze the process.*
4: *Improve the process.*
5: *Implement changes.*
6: *Standardize and monitor.*

Niami et al, (2007) identify four phases in policy-making process and the roles of quantitative analysis in term of their contribution to success factors in different phases. They identify the following phases in the policy making process: establishing a change environment, developing options and making decisions, implementing the decisions, anchoring the achievements into practice.

Xiaobo, Xu, Zhang, He (2007) conduct a modeling and performance analysis in the design stage of a supply-assembly-store chain with produce-to-stock strategy. They construct technique for analyzing stationary probability distributions of numbers of components and finished goods inventories. The authors claim that performance measures of the system, such as work-in-process of components, inventory amounts of finished products may be obtained using these distributions.

Gunasekaran and Ngai (2008) have developed a unified framework for modeling and analyzing BTO-SCM and suggest some future research directions. The framework is based on review of literature on modeling BTO-SC. They divide the modeling literature based on configuration level issues such as design and distribution decisions and coordination level issues such as material flow decisions. They report the use of both optimization models such as linear and non-linear programming and simulation models for the analysis of supply chains.

Persson and Araldi (2009) present a template that integrates SCOR and discrete event simulation for dynamic analysis of supply chains. They use two case studies to test the template in real environment. The tests showed the template to be useful in visualizing supply chain configuration and in doing ‘what if” analysis in dynamic simulation settings.

Beamon and Ware (2010) develop a procedure to assess the performance of a supply chain system and its sub-systems, assist in identifying problem areas, and provide a framework for continuous improvement of supply chain systems. The authors call this approach ‘Process Quality Model (PQM)’. PQM addresses the following questions:

What aspects of quality should be measured?
How should these aspects of quality be measured?
How can these measures be used to evaluate, improve and control the overall quality of the supply chain system?

The PQM consists of seven integrated modules:

*Module 1: define the process and activities being performed*

*Module 2: identify customers and their requirements, expectations, and perceptions*

*Module 3: define quality*

*Module 4: identify current quality performance measures*

*Module 5: evaluate current processes and set quality standards*

*Module 6: improve process*

*Module 7: control and monitor process*

Arkhipov and Ivanov (2011) assess a Supply Chain's potential ability to adapt structurally in an agile environment to extend the existing approaches to Supply Chain (SC) design. The authors determine a new metric, 'SC adaptation potential', and propose a method for its assessment. The approach taken by the authors makes it possible to integrate the analysis of SC structure complexity and adaptability. The authors consider usage of adaptation potential for SC structuring. The analysis of adaptation potential made it possible to take the decisions on the determination of a number of elements in a SC, their variety, and the interrelations between them with regard to the potential ability SC to adapt SC structurally in order to ensure flexibility and resilience.

Publications on lean and VCA application in agri-foods sector are limited (dekker, 2003; Zokaei and Simons, 2006). Very few empirical studies exist on application of lean and VCA in food industry (Zoskaei and Simons, 2006), less research on dairy supply chain in developing markets.

Value chain analysis research has focused on application and development of methods required for improving value chains in different sectors. No study using these methods has so far been carried out for the analysis of supply chain networks. However, a detailed analysis of the application of the value chain analysis methodology to understand its the comprehensiveness to capture the inherent intricacies of supply chain networks is missing. We hence have a compelling case for a study that would analyze the effectiveness of existing tools and initiate development of new tools for analysis of supply chain networks.

This research is hence expected to contribute to value chain analysis literature by enhancing the methodology for analysis of supply chain networks. We specifically follow the methodology by Taylor (2005). However, future research may be undertaken to demonstrate the applicability of these tools on case study organizations.
APPLICATION OF VALUE CHAIN ANALYSIS METHODOLOGY TO NETWORK DESIGN PROBLEM

The value chain analysis methodology modified for and applied to the agriculture sector by Taylor (2005) consists of seven steps. In what follows, each step is analyzed for its applicability with respect to the network design problem in dairy sector. A summary is presented in table 1.

1. **Create an understanding of the potential of value chain analysis**
   The purpose of this step is to create awareness within the target organization for the importance of value chain analysis exercise. Specifically the top management of the organization needs to be convinced of the potential of the value chain analysis exercise to suggest opportunities for cost saving. Corporate commitment or ‘buy-in’ to the concepts, implications and benefits of a lean supply chain is important for any VCA project. In this regard the scope, objectives and deliverables of the project need to be clearly presented to the top management. It is also important that the company nominate a representative to form a joint value chain analysis team. This is necessary to create ownership for the project and ‘buy-in’ for the results of the exercise. The nominee should be of sufficient seniority to liaise directly with the board, authority to access all divisions and functions of the company, be capable of taking a holistic view and be open to new ideas and approaches.

   The step seems logical and relevant as far as the analysis of value chain network is concerned. Without full commitment from top management of the company and senior company officials’ ownership of the project it may be extremely difficult to successfully
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Specification of concepts</th>
<th>Application on Network Design Problem</th>
<th>Additions/deletions suggested in existing approach for VCA</th>
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<tr>
<td>1</td>
<td>Create understanding of the business potential of value chain analysis</td>
<td>The top management needs to be made fully aware of concepts, implications and potential benefits of an integrated and lean supply chain. Not only this, they should also be sold on the project. Corporate commitment is crucial for the success on any organizational project as it brings top management support and enthusiasm for the project which are critical elements for its success. As in case of any value chain analysis project, it is important that the top management of the organization where the network re-design exercise is being suggested is convinced on the benefits of the project.</td>
<td>This step is relevant for supply chain network design. However, collection of data for development of as-is network map would follow.</td>
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In the traditional value chain analysis methodology the purpose of this step is to understand the scope of the processes that make the supply chain system. The task for the VCA team is then to draw the current state supply chain map in order to present a clear picture of the supply chain. The next step is to select a specific value stream for initial analysis and improvement. The key is to focus on a part of the complex supply chain for targeted efforts. Once the selected value stream has been analyzed and improved other value streams from the larger complex supply chain system may be picked for further analysis. The step makes sense when solving the supply chain network design problem. An understanding of the inherent supply chain system is desired for any improvement exercise. Moreover, in addition to the selecting the target value stream selecting the target network is an important element of the network analysis exercise. Even within the value stream the supply chain network would usually be made of a complex web of several facilities dispersed over a large geographical region. It therefore becomes important to pick a target network to focus the analysis effort on. Once the target network is analyzed and improved, other networks may be considered for supply chain network design (re-design) exercise.

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<tbody>
<tr>
<td>2</td>
<td>Develop overall supply chain structure map and select target value stream</td>
<td>Add the 'selection of target network' step.</td>
</tr>
<tr>
<td></td>
<td>Mapping of individual facilities along the chain</td>
<td>Since we are considering the whole network and the objective is to find the best operating network structure mapping of individual facilities does not remain relevant in case of designing the supply chain network.</td>
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<tr>
<td>4</td>
<td>Develop the whole chain current state map</td>
<td>The current state map is needed in the network design exercise. However, the current state map would outline the existing condition of the supply chain network rather than that of supply chain processes as in the case of VCA exercise. A detailed map of the current structure showing the location of facilities with respect to each other, existing vehicle routes and associated costs is required for an in-depth analysis of the target supply chain network.</td>
</tr>
<tr>
<td>5</td>
<td>Identify whole chain issues and opportunities</td>
<td>Once the current state network structure map is ready, the next logical step is analysis of the map to identify issues and opportunities. However as in the previous stage, identification of issues and opportunities would take a different approach as in the network structure we are not merely concerned with flow within the supply chain but with travel distances and time.</td>
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Rather than drawing the whole chain map, this stage entails drawing future network map based on understanding developed from the analysis of as-is location structure and vehicle routes.

The future state map needs to be validated within the organization.

As for the VCA exercise, the future state map along with improvement recommendations need to be shared with the organization’s top management team and agreement reached on 1. whether or not to proceed with joint improvement initiatives and 2. how the savings in cost or otherwise would be shared if there is a willingness for going ahead with the implementation of the future state map of the network.

A 'deployment of the to-be map' step to be added after this step.

<table>
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<tr>
<th>Step</th>
<th>Activity Description</th>
<th>Description</th>
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<td>6</td>
<td>Develop the whole chain Future State Map &amp; recommendations</td>
<td>Rather than drawing the whole chain map, this stage entails drawing future network map based on understanding developed from the analysis of as-is location structure and vehicle routes. The future state map needs to be validated within the organization.</td>
</tr>
<tr>
<td>7</td>
<td>Creating a receptive organizational context</td>
<td>As for the VCA exercise, the future state map along with improvement recommendations need to be shared with the organization's top management team and agreement reached on 1. whether or not to proceed with joint improvement initiatives and 2. how the savings in cost or otherwise would be shared if there is a willingness for going ahead with the implementation of the future state map of the network. A 'deployment of the to-be map' step to be added after this step.</td>
</tr>
</tbody>
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Table 1: Application of VCA to Network Design Problem
run a project as the interest and support required for the success of any project may be missing.

2. **Develop overall supply chain structure map and select target value stream**

   A holistic view of the supply chain helps see the sequence of activities within the supply chain and flow of material and information over the supply chain. Supply chain map enables organizations to identify processes along the chain and their linkages. James and Womack (2002) recommend selection of a focal value stream from the larger value chain as target for further analysis. Taylor suggests that both output and flow volumes within the chain be identified in order to pick the target value chain for further analysis. The selection follows three steps:

   1. Decide scope of the project
   2. Select a specific pathway along the more complex supply chain
   3. Identify target product group

First is the selection of the scope of the project in terms of distance along the chain to be included. For example, in a particular value chain analysis exercise we may want to analyze the chain upstream up to second tier i.e. suppliers and suppliers’ suppliers.

Selection of a specific pathway relates to flow volumes. Usually a segment that has significant volume serves as a good choice because improvements made on this segment can have significant impact on business.

Third aspect is the selection of a target product or product group. Out of the various products that a company deals in, there are few that are bread and butter for the organization and their supply chains need to be studied in more detail. According to the Pareto Principle, 20% of a company’s products account for 80% of its revenues. Tapping, Luyster and Shuker (2002) show two ways to identify the product whose value chain would be studied i.e. product-quantity analysis and product routing analysis.

   1. Product-quantity analysis
   2. Product-routing analysis

Product-quantity analysis helps identify the critical few items (the difference makers) from the trivial many with the help of pareto chart. Pareto chart is a graphical representation of products on x-axis and their cumulative contribution on y-axis. For product quantity analysis, the products are listed on the x-axis and their cumulative production quantities on the y-axis. To conduct PQ analysis:

   1. Obtain three to six months of production data for the firm under analysis
   2. List down the quantity of each product run by the organization during the analysis period in descending order
   3. Find cumulative quantity of products by adding the quantity of the second most produced product to the quantity of highest produced item and so forth.
4. Find cumulative percentages of each product produced

5. Draw a pareto chart to identify the critical few items

Product-routing (PR) analysis is required if a conclusion cannot be reached using the PQ analysis. In PR analysis products with similar processing requirements are grouped together. The total volume required for the different groups of products hence created is recorded. The group with highest volume is selected for further analysis.

The following steps may be taken for PR analysis:

1. Show process sequence for each product type listed by volume
2. Group the products that have same process routes
3. Analyze the mix of product routes

Suitability for analysis of supply chain networks

Though title of the second stage speaks about development of a supply chain structure map, the map that is referred to at this stage is different from what is required of a supply chain network map for improvement analysis of the supply chain network structure. As far as value chain analysis is concerned the map being developed is a high level map showing the processes within the value chain and their linkages. Though such a map is helpful in understanding how the value chain works (see figure 1) this is not sufficient for an in-depth analysis of the value chain network. So, in developing a methodology for analysis of value chain networks, it is important that in addition to this holistic map a detailed network map be developed showing locations of facilities within the network and their linkages in terms of vehicle routes (see figure 2). Such a map would help in visualizing the geographic regions where density of the facilities is high, where it is low and where the vehicle routes are long and where vehicle utilization is low i.e. vehicle has to travel long distances for collection or delivery of small number of units. This would hence contribute to understanding where the density of facilities warrants establishment of a collection or distribution center, where facilities need to be opened or closed and vehicles need to be re-routed to improve vehicle utilization.

The purpose of selecting a target value stream is to ‘cut a slice’ from the complex supply chain network to that is easy to understand and analyze. The improvement efforts are then targeted towards this part of the value stream. As far as analysis of the supply chain network is concerned this is a valid step. However, how the target value chain network is selected may be slightly different then that suggested by Taylor. Other than ‘deciding on the scope of the value chain project in terms of distance covered along the chain’ it is important that a target network cluster is selected from the overly complex network of facilities making the supply chain. This may be done on the basis of volume flowing within the network, condition of the network (if results could be demonstrated on a fairly well performing network then this may create space for analysis of rest of the networks) and/or priority of the company’s top management.
3. **Analysis of individual facilities along the chain**

   In a value chain analysis exercise this step is performed to collect data at the individual facility level. This data is expected to help in the analysis of the overall value chain. However, there is an additional purpose of this step i.e. analyzing the operational inefficiencies at the plant level and developing strategy to overcome the sources of waste and exploit the opportunities for improvement.

   In the analysis of value chain network though data at individual facility level is required to understand the larger value chain, analysis of individual facilities is not required as the performance of the network is dependent on the collective functioning of various facilities rather than efficient operation of an individual facility. However, individual facility level data is important to understand if the facility should remain open or be closed, or if the facility should fall on a different route. Data on individual facility include facility capacity, average daily volume, utilization and distance from central depot or

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**Figure 1** – Holistic view of the supply chain (the numbers in bracket show the number of units)

**Facility ID:**
- Capacity:
- Utilization:
- Average daily volume:
- Distance from central depot or nearest unit on vehicle route:

**Route 1**
- Total Distance:
- Total Travel Time:
- Total volume:
- Vehicle Capacity:
- Vehicle Utilization:

**Figure 2**: Example of detailed map of the target value chain network
nearest facility on a vehicle route (see figure 2). The data on capacity, average daily volume and subsequently facility utilization gives information on correct use of a given facility. Facilities with low average daily volume when compared with additional distance the vehicle on a particular route need to travel to pick or deliver that quantity of good may not justify including the facility on the route. Similarly if the facility utilization is low then either the capacity needs to be reduced or facility closed down/ not served.

4. Developing a current state map of the whole value chain

In a value chain analysis exercise the current state map is developed with specific focus on recording three key elements: information flows, physical product flows and time. The characteristics of each plant along the chain are summarized in a data box showing features (such as plant availability, total stock, production performance and quality performance) that impact the whole value chain. Moreover, this stage requires demand mapping with data on forecasts, orders placed and production achieved. The current state map however developed, aggregates the processes at macro level. For instance, the cross docking facility operation is considered (Jones and Womack, 2002) one process though there may be several cross docking facilities in a given supply chain network.

Though there is emphasis on physical product flows and time in developing the current state map of the value stream network, it is important that the individual facilities are looked at separately rather than as an aggregate unit. A micro level analysis of this type would better highlight the kind of issues relevant in the analysis of supply chain network exercise such as opening or closing of an individual facility and re-routing of vehicles to save time and cost. A macro level picture of the supply chain without considering individual facilities at a particular tier forgoes the opportunity to solve issue and bring improvements at the echelon level. Though value chain analysis methodology considers the processes within the larger supply chain and the individual manufacturing units it ignore the interrelated network within facilities at the echelon level. To cater to the need of looking at the network of facilities at the echelon level current state map of the value chain network would show physical location of facilities and travel distances or travel times among facilities and associated vehicle routes. Data associated with each route would be tabulated in a data box as shown in figure 2. This data would include total route distance, total travel time, volume on route, capacity of vehicle travelling on the route, vehicle utilization and route density (volume per kilometer). Route distance and volume are recorded to calculate route density. In order to justify a route it is important that the volume delivered or collected is sufficient as compared to the distance travelled by the vehicle. Any volume of good whose profit can outweigh the cost of travelling the distance on the route should be sufficient, though it would mainly depend on the company running the operations whether or not it considers a given volume on route to be justified against travel required to deliver or collect that volume of good. Capacity of vehicle and its travel time on the route are important parameters for they tell whether or not the vehicle chosen is large enough to cater to the volume on a given route. Utilization, on the other hand, would highlight if we are using an oversized vehicle for the volume on the route under consideration.
Moreover, in the case of existing ‘value chain analysis methodology’ where physical product flows are mapped only the time delay between processes is noted. In the network map, however, we are not only concerned about the time delay but the nature of delay i.e. how the delay is caused. So whereas the current state map in the ‘value chain analysis methodology’ points out where there are opportunities to reduce delays the current state map of the network (in the analysis of value chain network/ design methodology), by considering physical locations of facilities and distances between them, would highlight how the delay is caused and hence an opportunity to understand the cause of the delay and remove it.

5. **Identify whole chain issues and opportunities**

The development of the whole chain map highlights existing value chain issues and improvement opportunities. Jones and Womack (2002) classify these issues and opportunities into two major categories, those related to physical flows and those related to information flows. Taylor (2005) suggests classification of a third category of issues and opportunities, those related to organization, management and control of the supply chain.

Though physical and information flows are relevant in the context of AVCD methodology, the issues and opportunities in this exercise may be more specifically categorized into those related to facility location and vehicle routing (Nagy & Salhi, 1996). The objective of targeting these issues and opportunities is to reduce cost & time. Re-structuring the network may provide opportunities for saving cost and time through opening/closing of facilities and re-assigning of vehicles to facilities. The opportunities become evident once the current state map and associated data points have been plotted.

Moreover, it is suggested that a process activity mapping approach (Hines and Rich, 1997) be used to identify efficient combination of facilities and routes. The general approach has five stages:

1. The study of the flow of the processes
2. The identification of waste
3. A consideration of whether the process can be rearranged in a more efficient sequence
4. A consideration of a better flow pattern, involving different flow layout or transportation routing
5. A consideration of whether everything that is being done at each stage is really necessary and what would happen if superfluous tasks were removed

Following modifications are suggested to the general approach to suit the value chain network context.

1. The study of facilities and routes
2. The identification of underutilized facilities, route inefficiencies and losses
3. The consideration of whether facilities on a given route should be closed or more facilities should be opened
4. A consideration of better transportation routes that may be created by either shortening existing routes (exclude some facilities from the route), creating new ones, lengthening them or simply restructuring by exchanging facilities between two different routes. The data recorded on individual facilities and routes should help with stages one through three. A vehicle routing matrix is suggested to help in determining better routes for the network (see table 2).

Once the analysis on the current state map is complete, a future state map then may be developed considering the issues and opportunities highlighted. The extent of potential savings from the re-structuring effort may then be calculated.

6. Develop the whole chain future state map & recommendations

Womack and Jones (2002) suggest future state maps (future state 1) be drawn for individual facilities before developing future state maps for the whole chain. According to them the improvements identified in this first stage should be implemented first before going to the next stage. The objective of the next stage (future state 2) of improvements is to introduce smooth and leveled pull along with frequent shipments between each of the facilities. In the third stage (future state 3) possibilities of relocation of facilities are
### Route: ABC
### Vehicle Capacity:
### Total Route Distance: 63

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Distance from previous</th>
<th>Cumulative Distance</th>
<th>Shortest Distance from Central Depot</th>
<th>Average volume at time of pick up/delivery</th>
<th>Cumulative Capacity</th>
<th>On Vehicle Route</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>Central Depot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Yes</td>
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<td>Facility 1</td>
<td>10</td>
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<td>Check if it may be adjusted on another route</td>
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<td>0</td>
<td>N/A</td>
<td>7000</td>
<td>Yes</td>
<td>Add other facilities to fully utilize vehicle</td>
</tr>
</tbody>
</table>

**Table 2: Vehicle Route Matrix**
explored. The authors provide general guidelines for determining which facilities to relocate.

During the first two stages improvements are achieved mainly by ensuring waste elimination and flow consistency within existing supply chain structure and relationships. Such operational changes have limited impact on supply chain performance (Taylor, 2005). More radical improvements may be achieved by developing a ‘lean vision’ and bringing strategic changes such as those targeted in future state 3.

Since network design is concerned with interaction between facilities the first stage in the ‘value chain analysis’ exercise becomes redundant. Frequent shipments should be targeted along with opportunities for relocation. Moreover, while developing future states in the ‘analysis of value chain network/design’ focus should be impact of opening & closing facilities and re-routing on the performance of the supply chain under consideration. A future state supply chain network/design map would show possibilities for opening & closing of facilities as well as development of new routes.

7. Create a receptive organizational context for value chain improvement

At this stage it is important to sell the finding to the top management team in the organization, convincing them of the impact of the supply chain improvement project. Next it is essential to sign an equitable and mutually acceptable benefits sharing agreement outlining how the costs and savings would be shared if the project moves forward. This is as true for improvements in the value chain network/design as for the value chain itself.

Make the value chain network action plan

The plan should show

1. what the team plans to accomplish, step by step
2. measurable goals for team members
3. clear checkpoints with real deadlines and responsible individual

TESTING THE NEW APPROACH

Case Study Organization

The new approach was applied to Engro Foods, a leading dairy processor in Pakistan. Engro Foods has 44 percent market share in the processed milk business in the country. The company operates a complex milk collection network with 916 milk collection centers which collect 89 percent of company’s total milk. With the expansion, which is being financed by Rs 5 billion of debt (57 percent) and Rs 3.7 billion of internal funds (43 percent), the company expects to significantly increase its milk collection infrastructure which will help sustain future growth.

Engro Foods milk collection network is divided into five zones. Each zone is comprised of four to five areas. Each area has between forty and fifty milk collection centers. Rural dairy farmers supply milk to their closest milk collection center. Milk collected at the milk collection centers is brought to the central area office in tankers of capacity ranging between 5000 and 10,000 liters.
The milk is chilled brought to the area office is chilled and transferred into larger tankers which then transport the milk to the processing plant.

The location of milk collection centers is dependent on the availability of milk i.e. milk collection centers are located where there is enough milk available to justify their setup. However, the company has to carefully decide on the number and location of area offices. Moreover, it is a challenging task to determine feeder routes for collection of milk from the milk collection centers and capacity of vehicle that would go on a certain route. Most often these decisions are based on experience of the area managers and their rough analysis of the network of milk collection centers. However, a comprehensive methodology for the analysis of the network design to come up with area locations and routes that would reduce network design inefficiencies in terms of cost and time was required. The objective of this study is to fill this gap in the practical environment by demonstrating the application of the methodology developed for analyzing supply chain networks in the previous section.

In what follows, the application of the ‘revised VCA methodology for value chain network analysis’ on the case study organization is discussed step by step.

1. Create organizational buy-in for the ‘Analysis of Value Chain Design’ Project

It is important that for the success of any project that the organization for which the project is being conducted has full understanding and appreciation for the AVCD exercise (Taylor, 2005). A plan was hence made to explain the potential of the AVCD exercise to the senior management team in the test organization and to bring them on board.

As a first step the human resource department was contacted to identify the people who:

1. Were involved in operational improvements within the organization
2. Were at a significantly senior level to either make the decision or influence the decision makers, and
3. Would be interested in the project

The objective of the first step was to find the people who best fitted the above criteria.

The second step was to get an initial set of interviews with the relevant people to better understand their needs and to give them an overview of the AVCD exercise. The interviews with the people in operations department served three purposes. Firstly, they allowed the AVCD team to understand the current issues facing the organization. This understanding was helpful in creating the role of the AVCD exercise in addressing the current issues. It was important that the AVCD exercise provided solution to the problems that the management team valued. Secondly, they served as a means to refine the AVCD presentations (that were to be made in front of the operations team) to align them with the goals of the organization. Thirdly, they helped in establishing an initial buy-in for the project as well as creating rapport with the senior management team at the organization.

The third step was to make a series of presentations in front of the senior management team. The purpose of these presentations was to make the objective of the AVCD exercise clear to the team
and to explain how this exercise will address organizational problems and how it will affect organizational performance. The presentations also presented an opportunity for the management team at the organization under consideration to clarify their queries about the project. The questions also acted as a means to include management concerns while planning the project. The presentations also provided a platform for exchange of ideas on making the project more profitable for the organization.

The final step at this stage was to gain management approval for and their involvement in the project. The former meant submission of a formal proposal highlighting project milestones, resource requirements, timeline and expected results for approval. The latter was required to create project ownership within the organization which is necessary for project success (Taylor, 2005). As a result a person from the operations team, who had understanding of the system and had access to resources within the organization, was appointed to help with the execution of the project.

Another outcome of this stage was the decision to focus on the upstream supply chain which the top management team at the host organization was most concerned about. This is an important step in any AVCD exercise since it guides focus on a certain portion of the supply-delivery network. The discussion that follows is focused on a portion of the supply chain (in the case discussed in this paper it is the upstream supply chain). So from this point forward wherever supply chain is mentioned it means either the upstream or the downstream supply chain and not the supply chain in its entirety.

2. Create and validate the structure of as-is network

The purpose of the AVCD exercise is to understand the structural inefficiencies in the value chain design and identify opportunities for enhanced performance. In order to accomplish this task it is imperative that the analyst has an understanding of the as-is supply chain network. A supply chain structure map is hence required to portray the flow of goods along the chain. However, since most firms are a part of a complex supply chain network it is common that organizations do not have such maps developed (Taylor, 2005).

Hence at the second stage of the AVCD process the first task was to develop as-is drawings of the supply chain structure for the organization under consideration. These drawings are visual representations of the flow of goods along the chain and structure of the supply chain and are useful in creating a pictorial easy understanding of the supply chain under consideration. The drawings developed were based on the revised methodology developed in the previous section and were different from the current state maps used in ‘Value chain analysis methodology’. The reason for using modified drawings was that it was not possible to capture the entire functioning of the supply chain structure with the kind of maps used in ‘value chain analysis’ approach. Though ‘value chain analysis’ maps provide a pictorial representation of the processes and the flow of goods and information within the supply chain they do not capture the structural elements of the supply chain. Even when the revised methodology was being applied to the network under consideration it was felt that there was need for additional elements for developing and understanding the current structure. Most companies usually divide their supply chain into zones and areas for better management and it is important to understand this division to get a complete picture of how the organization under consideration operates its supply chain.
In order to understand this operation a different set of drawings were developed. The first drawing developed in this respect in being termed ‘exploded view of the supply chain structure’. The drawing may be divided into two major components. The first component, structural diagram, (see figure 3A) shows the high level structure of the supply chain and explains how the supply chain is structured in terms of zones and areas. Most large companies divide their supply chains into zones and areas for simplicity of managing the chain. The second component is the supply chain operations map (see figure 3B). This component explains how the supply chain functions within the realm of the high level structure.

The Structural Diagram

The structural diagram is similar to the bill of materials for a final assembly product (Heizer, 2000). As the bill of materials the structural component of the ‘exploded value chain structure view’ is divided into several levels. The levels show the construction of the collection system. Each level is made of one or more entities (entities are the individual building blocks that make up a certain level e.g. in level III ‘dairy farms’ would be one entity and ‘milk collection centers’ would be another entity) and shows both the entities and the number of each entity that make that level. For instance, in figure 1 each area (level II) is comprised of 1 – 2 dispatch points and 30 – 40 collection centers (level III).

In the case under consideration the larger collection system (the upstream supply chain) is divided into zones (level 1). Each zone consists of several areas (level II). Within each area operates a milk collection system (level 3). The structure of the milk collection system in different areas is similar except for the number of entities which are different in different areas.

The structural diagram shows how the supply chain is structured and is useful in determining the building blocks of the larger supply chain network.

The Supply Chain Operations Map

The supply chain operations map is a pictorial representation of a slice of the larger supply chain. It shows how the supply chain functions i.e. where the material originates, how it flows through the system and where it ends. The map shares components with the structural diagram. The rectangular blocks that appear both in the structural diagram and the supply chain operations map depict the resources utilized within the supply. They appear at the lowest level in the structural diagram. In the operations map they form the building blocks of the supply chain and signify resources through which the materials flow within the supply chain. The rectangular blocks represent resources physical resources to which the company vehicles must go to pick the material. The ovals blocks represent the different outside players who are involved in the supply chain operations of the organization under consideration. The arrows connecting these blocks represent material flow.

In our case the village milk collection center, milk collection centers, dispatch points and farms represent the physical resources where vehicles stop by for collecting milk. Independent farmers, dodhis (small milk collectors and suppliers), preferred farmers, direct farmers, mini contractors and milk contractors are the different types of suppliers that supply milk to one or more of the previously mentioned physical resources.

The plant acts as the focal point where all the milk collected is finally taken to for processing.
Once the map has been created it is imperative to validate it by comparing it with the system in running. This was done by involving the managers operating within the collection system. Any discrepancy was corrected till the map was acceptable to all the stakeholders within the organization.
Figure 3: Exploded view of the Supply Chain Structure
Figure 3A: The Structural Diagram
Figure 3B: The Supply Chain Operations Map
3. Select Target Network of As-Is System

Once the high level as-is supply chain structure map has been created the next step is to select the target network from the large hugely complex supply chain network which is composed of several smaller networks (Jones and Womack, 2002). This is necessary because it is not possible to analyze the whole system at once. It is hence important to pick the portion of the supply i.e. the target network that would be analyzed further. Once the analysis of this ‘portion’ of the supply chain has been done other portions may be picked and the exercise be repeated for these segments.

Selection of a target network involves several aspects. First, it is important, from a practical standpoint, to consider access to data and other resources in selecting a target network. If only limited data is available (if this is the case some data will have to be collected which will increase the cost of conducting the AVCD exercise) and access to resources is costly, then it will be tough, if not impossible, to carry out the AVCD exercise. It should be noted that the cost of carrying out the exercise should be low as compared to the savings reported after the exercise to justify its application.

Another aspect in selecting a target network is evaluating individual networks’ impact, and hence the impact of the improvements made in the target network once selected, on the performance of the overall supply chain. This is important because the level of impact on the overall performance will determine the worthiness of the ‘analysis of value chain design’ exercise and will justify its extension to other networks. The evaluation is carried out in several steps leading to the calculation of volume to cost ratios of the different networks that make the supply chain. The steps will be discussed once the benefits of calculating the ‘volume to cost ratio’ has been discussed.

The volume to cost ratio is a performance indicator. If a unit can process highest volume at lowest cost among all competing units then it is the best performing unit. A unit with low volume to cost ratio requires significant attention and provides opportunity for both increase in volume and decrease in cost. The ‘contribution to cost’ indicator, as its name suggests, provides insight into the contribution each unit makes to the overall supply chain cost. This is another important indicator as it signifies which unit if improved may have the highest impact on the overall performance of the supply chain.

Moving on to the discussion of evaluation steps, the first step was to pick the smallest unit of analysis (this is the smallest unit that encompasses all the supply chain activities - the supply chain is collection of several units like this and the target network is one of the these units). This was a simple task once the supply chain structure map had been made. The smallest unit is the second lowest level in the supply chain structure map, the level at which supply chain operations map is drawn. In the case under analysis this unit was the ‘milk collection area’. Once the smallest unit had been identified the second step was to rank the different units making the supply chain (network) in descending order based on the annual volume processed by each unit (Tapping, Luyster and Shuker, 2002). Bahawalpur and Arifwala were the two areas that were shortlisted based on volume. The third step was to list the monthly operational cost of each unit (see figure 4-1). The fourth step was to calculate the ratio of volume to operating cost (see figure 4-2). The target network would be the unit with the highest volume to operation cost ratio (VOCR). A better VOCR suggest that the unit is comparatively performing well since it is
supplying the highest volume in the supply chain at a relatively lower cost. In this case Arifwala was chosen for further analysis.

Once the evaluations were made, a critical step was to discuss the results with the operations team at the concerned organization. This served two purposes. First, it allowed the operations team to see how different networks contribute to the overall performance of the supply chain. Second, it helped the analyst understand the needs and requirements of the people within the
organization. The operations team usually understands the issues in the supply chain and is in a good position to point out the specific areas that need immediate attention. They may also highlight other relevant factors in selecting the target network that are important to them. For instance, time to implement the solution may be an important factor in deciding which network to start with.
Figure 5: Current State Map
4. Developing the Current State Map

Developing the current state map required intense data collection on all the facilities, their physical locations, volumes, road networks, distances between facilities and vehicle routes. Google map of the area was used as a starting point and then milk collection centers were located on the map by consulting with people who go on milk collection routes. In number of cases the team developing the map had to visit the centers itself, noting collection center locations, distances between them and the routes trended. Developing the map was a laborious task and one person had to sit down and put each dot (collection centers are represented by dots) on the map by hand. Moreover, several milk collection managers and supervisors had to be consulted to get a reasonable estimate of the distances between various facilities and average daily volumes at the collection centers. However, the exercise was worthwhile as it gave the team an idea of the existing configuration of facilities and the actual movement of the vehicles. The map was helpful in viewing the areas with low density and routes with potential for improvement. A simplified version of the map is shown in figure 5.

Once the map was drawn a large scale printout of the map was taken for further analysis because it was not possible on a computer screen to analyze specific sectors on the map while keeping the whole picture in perspective.

Unlike the ‘value chain analysis’ methodology where all the information is shown on map, the vehicle route matrix was tabulated separately rather than showing on the map. Given that several value route matrices had to be constructed and putting everything on the map would not leave it legible, it was considered more appropriate to enumerate the matrices separately and use them in conjunction with the map.

Details of analysis are discussed in the next section.

5. Analyze the Current State Map

The analysis was carried out in consultation with the Area Manager who pointed out milk collection issues being faced by his team. Problems like existing of areas with hot milk, variability in availability and adulteration in milk were pointed out. In terms of improving the network, the managers main concern was reduction in cost while making sure quality and collection volume did not get compromised. Vehicle route matrix was found to be a good tool for analyzing facilities and routes. It was used in conjunction with the network map developed to figure out areas for potential improvement.

Following points were kept into consideration while doing the analysis, as identified in the ‘analysis of value chain network’ methodology:

1. General overview of facilities and routes to get a holistic picture of areas and routes
2. The identification of underutilized facilities, route inefficiencies and losses
3. The consideration of whether facilities on a given route should be closed or more facilities should be opened
4. A consideration of better transportation routes that may be created by either shortening existing routes (exclude some facilities from the route), creating new ones, lengthening them or simply restructuring by exchanging facilities between two different routes
In addition to the above, possible relocation of the ‘main collection centers’ called PHEs (Plate Heat Exchangers, a name given because these areas provided milk chilling facility) was considered. Availability of a chilling facility at the new location, chilling cost and access to road network, were among the factors considered in picking a new location for the PHE. Moreover, it was required that a location that would decrease the total distance travelled be selected. The analysis elucidated the potential of saving cost if PHE was relocated from Ghaziabad to Chichawatni. Several people belonging to the milk collection system at the network being considered were consulted to determine if there could be constraints to opening a PHE at Chichawatni. Rest of the analysis was started upon developing confidence in the possibility of opening a PHE at Chichawatni since route networks would be affected from the selection of candidate PHE.

The milk collection centers and the routes were analyzed using the current state map and the vehicle route matrix. The facilities were evaluated on the basis of daily volume present (hence utilization), whether the facility was on a given route and the distance to be travelled if not on route. It was noted that if the volume to distance ratio of the facilities is calculated it could give a fair idea of the significance of including the facility on a given route. Volume distance ratio (VDR) indicated if enough volume was being collected to justify the cost of traversing the extra distance to collect this quantity of milk. Moreover, VDR of a given route also explained its efficiency as compared to other routes. So a volume to density data ratio was added on the vehicle route matrix for further analysis. VDRs were calculated for all the existing routes. Routes with low VDRs were picked for further analysis.

Vehicle route matrices were then used along with current state map of the value chain network to determine desired changes in the network. Though the analysis revealed several facilities with low utilization and low VDR, only one facility was suggested to be closed for operation because of the need of the organizations in the milk processing business to collect maximum volume. However, several changes to vehicle routes were suggested based on the analysis. Routes analysis included, in addition to the current state map and vehicle route matrix, consideration of vehicle capacities, vehicle travel time and loading/unloading time. Analysis for one of the routes is shown in table 3 for illustration purpose.
Route: OLD  
Vehicle Capacity: 4 T  
Total Route Distance: 86 km  
Volume on Route: 3000 L

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Distance from previous</th>
<th>Cumulative Distance</th>
<th>Shortest Distance from Central Depot</th>
<th>Average volume at time of pick up/ delivery</th>
<th>Cumulative Capacity</th>
<th>On Vehicle Route</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Depot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>162/9L</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>120</td>
<td>120</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>58 EB</td>
<td>14</td>
<td>28</td>
<td>28</td>
<td>350</td>
<td>470</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>66 EB</td>
<td>10</td>
<td>38</td>
<td>20</td>
<td>700</td>
<td>1170</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
If vehicle goes on this route it must traverse additional 48 kms with possibility of adding 4 more collection centers with total volume of 1330. This gives volume to distance ratio of 27.7 ltrs/km. Since volume to cost ratio before this point is 34.7 ltrs/km it may be justified to move to a different path if one exists with better volume to cost ratio. Check for alternatives on the map. Alternate route exists. Alternate route can add 2 collection centers on route with total volume of 1770 and additional 28 kms giving a volume to cost ratio of 63.21 ltrs/km. This can improve route performance. Pick alternate route and include 2 new collection centers.

<table>
<thead>
<tr>
<th>Vehicle Code</th>
<th>Volume (liters)</th>
<th>Distance (Kms)</th>
<th>Volume to Distance Ratio</th>
<th>Cost (Rs)</th>
<th>Volume to Cost Ratio</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 EB</td>
<td>500</td>
<td>1670</td>
<td>27.7 ltrs/km</td>
<td>10</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>84 EB</td>
<td>400</td>
<td>2070</td>
<td>34.7 ltrs/km</td>
<td>15</td>
<td>No</td>
<td>Remove</td>
</tr>
<tr>
<td>173/9L</td>
<td>130</td>
<td>2200</td>
<td>63.21 ltrs/km</td>
<td>0</td>
<td>No</td>
<td>Remove</td>
</tr>
<tr>
<td>172/9L</td>
<td>400</td>
<td>2600</td>
<td></td>
<td>7</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>20/11L</td>
<td>400</td>
<td>3000</td>
<td>Yes</td>
<td>5</td>
<td>Better suits on other vehicle route</td>
<td></td>
</tr>
<tr>
<td>Central Depot</td>
<td>3000</td>
<td></td>
<td>Route volume to distance ratio is 35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Vehicle Route Matrix
6. Prepare Final Network Structure Map

The final map was built upon the current structure map. The PHE that was to keep working was labeled ‘E’ (standing for Existing PHE), the PHE that was to go was labeled ‘O’ (standing for Old) and the proposed new PHE was labeled ‘N’. The collection center that was suggested to be dropped from the network was circled. The area covered by each PHE was highlighted to indicate which area belonged to which PHE (see figure 6). In addition to this new route details were prepared (see table 4) and expected cost savings from the re-structuring exercise were calculated.

![Future State Map](image)

Figure 6: Future State Map
Route: NEW
Vehicle Capacity: 4 T
Total Route Distance: 66
Volume on route: 2940

<table>
<thead>
<tr>
<th>Facilities</th>
<th>Distance from previous</th>
<th>Cumulative Distance</th>
<th>Shortest Distance from Central Depot</th>
<th>Average volume at time of pick up/delivery</th>
<th>Cumulative Capacity</th>
<th>On Route</th>
<th>Vehicle Capacity</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Depot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>162/9L</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>120</td>
<td>120</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>161/9L</td>
<td>10</td>
<td>24</td>
<td>12</td>
<td>1000</td>
<td>1120</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58 EB</td>
<td>12</td>
<td>36</td>
<td>28</td>
<td>350</td>
<td>1470</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66 EB</td>
<td>10</td>
<td>46</td>
<td>20</td>
<td>700</td>
<td>2170</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>163/9L</td>
<td>8</td>
<td>54</td>
<td>12</td>
<td>770</td>
<td>2940</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Central Depot | 12 | 66 | 0 | N/A | 2940 | Yes | The volume to distance ratio for the modified route is 44.5, an improvement of 28% |

Table 4: Vehicle Route Matrix for Modified Route
A total of four routes were suggested for modification. Total savings from the shifting of PHE and development of new routes were expected to be approximately twenty five thousand dollars annually. The savings were coming from one target network and the one that was already performing better than the rest of the supply chain. Considering this it can be safely assumed that the exercise when carried out on the whole network would have significant impact on cost and time.

7. Create a receptive organizational context for value chain improvement

This was an obvious follow up step on the previous one. Once the analysis was complete a presentation was scheduled for the company top management where the exercise was explained and benefits of the revised structure were discussed at length. The team involved in the exercise was able to convince the top management of the importance of analyzing the supply chain network in this fashion and redesigning the value chain network for improved performance. As a next stage, the management team wanted a similar exercise to be carried out on the value chain network closest to its plant with identifiable action steps that could be implemented for the results to be seen.

Based on the study conducted a new methodology for analysis of value chain networks is proposed. See table 5.
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Specification of concepts</th>
<th>Method</th>
<th>Tools/ Techniques/ Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Create understanding of business potential of AVCD</td>
<td>company meetings. Identification of key players in the organization. Scheduling meetings. Delivering presentations. Using previous case studies.</td>
<td>MS Office, outlook, powerpoint, literature review</td>
</tr>
<tr>
<td>2</td>
<td>Create and validate the structure of as-is value chain network</td>
<td>draw high level map showing the functioning of the supply chain</td>
<td>powerpoint</td>
</tr>
<tr>
<td>3</td>
<td>Select target network of as-is system</td>
<td>use volume flow analysis, volume to operation cost ratio (VOCR), company requirements</td>
<td>i) product quantity analysis (Tapping et al., 2002), ii) VOCR analysis</td>
</tr>
<tr>
<td>4</td>
<td>Develop the current state map</td>
<td>Take a structured walk-through of the on-ground existing system. Draw a physical location map of the network (initial network map may be taken from google maps). Identify road networks and existing vehicle routes. Populate the map with relevant data. Discuss the map with relevant people within the organization.</td>
<td>MS Office. Field observation and data collection. Data requirements: locations of facilities, volumes at facilities, distance between facilities and vehicle routes.</td>
</tr>
</tbody>
</table>
### Table 5: Methodology for Analysis of Value Chain Networks

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Analyze the current state map: location structure and route network</td>
<td>Analyze the effect of addition, deletion and relocation of main depots of cost and time. Consider requirements of a main depot and limitations of candidate locations. Analyze the utilization of existing facilities and location density of the facilities on areas belonging to vehicle routes. Use the current state map in conjunction with vehicle route matrix. Consider vehicle capacities, vehicle travel time, loading/unloading time, volume distance ratio. Based on this analysis, decide where to close or open a facility and which routes to alter. Discuss the effect of possible changes on network operation &amp; performance with people on the ground. Understand implementation issues of the to-be system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>i) current state map ii) vehicle routes analysis matrix iii) participant in-depth interviews and discussions iv) analytical thinking</td>
</tr>
<tr>
<td>6</td>
<td>Prepare final network structure map</td>
<td>Based on understanding developed from the analysis of current state of the network, develop the final network structure map. Identify facilities closed, opened, relocated and areas covered by the main depots. Show routes on the map or identify new routes separately on the vehicle route matrix.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adobe photoshop. An understanding of the issues in the current network developed through analysis and discussions</td>
</tr>
<tr>
<td>10</td>
<td>Calculate &amp; present cost savings/ create a receptive organizational context for value chain improvement</td>
<td>Compute operating cost of as-is system. Compute operating cost of to-be system. Subtract cost of as-is system from cost of to-be system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Analytical thinking, excel</td>
</tr>
</tbody>
</table>

Mumtaz and Chatha Innovative Methodology for Analysis of Supply Chain Networks
CONCLUSION AND FUTURE RESEARCH DIRECTIONS

In this study value chain analysis methodology was modified to apply to network design problem. The revised methodology was then tested on a real life milk collection network in a developing economy. Case study approach and action research were used to understand the issues in analyzing a value chain network and to test the applicability of the revised value chain analysis methodology to analyze a given value chain network. The revised methodology was fairly useful in analyzing the value chain network. However, it was noted that some additional considerations during the analysis would make the exercise more meaningful and useful. Based on the understandings developed from the application of the methodology to a real life milk collection network, further adjustments were made to the methodology as identified in section 3.

The new approach was developed during the process of understanding and re-designing the milk collection network structure of a large dairy processor in Pakistan. The initial plan of the research was to apply the value stream analysis methodology and understand its applicability for analyzing supply chain networks, with specific application in the dairy sector of a developing economy. The approach was taken from the work of Hines and Rich (1997), Rother and Shook (1998), Womack and Jones (2003) and Taylor (2005). The methodology presented by Taylor (2005) was taken as the benchmark because it was closest to the situation under study (the paper presents a case of VCA application in the agri-food sector) and most recent as well. However, as the value chain analysis methodology and its associated tools were applied to understand the milk collection network and prepare the new structure map, it was realized that a new methodology and tools are required for analyzing the value chain structure and re-engineering it. Though the new methodology does not differ from the value chain analysis methodology in concept, the focus is different and hence the requirement for analysis and tools.

The study showed that value chain analysis methodology could not be applied in its current form to analyze a supply chain network structure. The methodology was modified to cater to the specific requirements of analyzing a supply chain network. The methodology was tested on a real life milk collection network in a developing economy. Future research may focus on testing the application of this methodology on other cases. Though the methodology is expected to be robust in its application to other network analysis problems, a test exercise would provide a strong case for believing this.
References


Rother, M. and J. Shook (1998). Intro. Learning to see: value stream mapping to create value and eliminate muda. The Lean Enterprise Institute, Brookline, MA.


