Chapter 5

LEAGILE STRATEGY IMPLEMENTATION IN DIABETES CARE

The main objective of this research is to investigate and understand how leagility can be applied in healthcare services, especially chronic care like cardio diabetes. The application of leagility can help in reducing the response time and cost of the healthcare but major challenge of a healthcare organization is to implement a leagile strategy in the organization.

In order to achieve the above-mentioned objective following research question was established:

RQ: Is it possible to differentiate lean and agile components of a drug and equipment supply chain in diabetes care? If yes, then how can be a decoupling point is identified to separate these parts.

5.1 Methodology

The study uses a case study approach to examine the concept of leagility in diabetes care. The case organization is a cardio diabetes specialty clinic from the Varanasi city in India. The organization was selected because it is a specialized clinic concentrated its service in the area of cardio-diabetes and metabolic disorders. Since diabetes increases the risk of cardiovascular disease two-folds and maximum death in diabetes is due to cardiac arrests, the two disease are closely associated and should be studied together (Resl et al, 2009). The study uses semi-structured interview and review of World Healthcare Organization (WHO) list of essential drugs to identify the critical supply in case of diabetes and cardiovascular disease (WHO, 2013). The Table-5.1 below list the essential drugs list of WHO for diabetes and cardiovascular disease.

Martin Christopher (2006) argues that demand variability and lead time are critical factors in deciding the lean or agile strategy in a supply chain. The other researchers have used ABC, VED and ABC-VED matrix analysis for inventory classification in healthcare in Indian context (Nigah et al, 2010; Gupta et al, 2013; Wandalkar, 2013).

Table 5. 1: Essential Drug List for Cardio Diabetes

Medicine	Description	Category
Gliclazide	Oral solid dosage form: (controlled release tablets) 30 mg; 60 mg; 80 mg.	Antidiabetic
Glucagon	Injection: 1 mg/ml.	Antidiabetic
Insulin injection (soluble)	Injection: 40 IU/ml in 10-ml vial; 100 IU/ml in 10-ml vial.	Antidiabetic
Intermediate-acting insulin	Injection: 40 IU/ml in 10-ml vial; 100 IU/ml in 10-ml vial (as compound insulin zinc suspension or isophane insulin).	Antidiabetic
Metformin	Tablet: 500 mg (hydrochloride).	Antidiabetic
Simvastatin	Tablet: 5 mg; 10 mg; 20 mg; 40 mg.	Lipid Lowering
Bisoprolol	Tablet: 1.25 mg; 5 mg.	Antiarrhythmic
Digoxin	Injection: 250 micrograms/ml in 2-ml ampoule. Oral liquid: 50 micrograms/ml. Tablet: 62.5 micrograms; 250 micrograms.	Antiarrhythmic
Epinephrine (adrenaline)	Injection: 100 micrograms/ml (as acid tartrate or hydrochloride) in 10-ml ampoule.	Antiarrhythmic
lidocaine	Injection: 20 mg (hydrochloride)/ml in 5-ml ampoule	Antiarrhythmic
Verapamil	Injection: 2.5 mg (hydrochloride)/ml in 2-ml ampoule. Tablet: 40 mg; 80 mg (hydrochloride).	Antiarrhythmic
Amlodipine	Tablet: 5 mg (as maleate, mesylate or besylate).	Antihypertensive
Enalapril	Tablet: 2.5 mg; 5 mg (as hydrogen maleate).	Antihypertensive
Hydralazine	Powder for injection: 20 mg (hydrochloride) in ampoule. Tablet: 25 mg; 50 mg (hydrochloride)	Antihypertensive
Hydrochlorothiazide	Oral liquid: 50 mg/5 ml. Solid oral dosage form: 12.5 mg; 25 mg	Antihypertensive
Methyldopa	Tablet: 250 mg.	Antihypertensive
Sodium nitroprusside	Powder for infusion: 50 mg in ampoule.	Antihypertensive
Furosemide	Injection: 10 mg/ml in 2-ml ampoule. Oral liquid: 20 mg/5 ml , Tablet: 40 mg	Heart Failure
Spironolactone	Tablet: 25 mg	Heart Failure
Dopamine	Injection: 40 mg/ml (hydrochloride) in 5-ml vial.	Heart Failure
Acetylsalicylic acid	Tablet: 100 mg.	Antithrombotic
Streptokinase	Powder for injection: 1.5 million IU in vial.	Antithrombotic

5.1.1Multi-Dimensional Scaling

This study used Multidimensional scaling (MDS) as an exploratory method.We have used a matrix of perceived similarities for categories of supplies to make a visual plot. The plot is used to find out the possible gap in the method proposed by Martin Christopher and a new method was suggested incorporating additional dimensions other than demand variability and lead time.

Multidimensional scaling (MDS) is a method to provide a visual representation of the pattern of proximities among a set of objects. MDS plots the categories on a map (common space) such that those categories that are perceived to be very similar are placed near each other on the map, and those perceived to be very different are placed far away from each other on the map (Kruskal & Wish, 1978).

MDS takes an input matrix giving dissimilarities between pairs of items and outputs a coordinate matrix whose configuration minimizes a loss function called stress (Borg & Groenen, 2005). The study uses direct input method for MDS, in which expert directly provides the score for the dissimilarity between the categories. The expert was asked to give a score on the scale of 1 to 10, where 1 being minimum dissimilarity while 10 corresponds to the highest dissimilarity. The Stress measures the correspondence between the distances among points implied by MDS map and the matrix input by the participants in the study. It is measured by a stress function given by:

$$Stress = \sqrt{\frac{\sum\sum(F(D_{ij}) - D_{ij})^2}{\sum\sum {D_{ij}}^2}}$$

The study uses direct input method for MDS, in which expert directly provides the input data D_{ij}. The $f(D_{ij})$ is a function of the input data d_{ij} ,where $f(D_{ij})$ is parametric monotonic function given by:

$$F(D_{ij}) = \alpha + \beta D_{ij}$$

The objective of MDS algorithm is to minimise the stress represented by the equation above for given α, β, *and* D_{ij}. Thus, the smaller the stress, the MDS Map better represents the input provided by the respondents. When the MDS map perfectly reproduces the input data then the stress is zero. A stress below 0.2 is acceptable for exploratory analysis.

5.1.2 Proposed Classification Rule

Inventory management in healthcare is influenced by many other criteria such as criticality, perishability and override financial concerns (Flores et al, 1992; Al-Qatawneh & Hafeez, 2013). Critical medicine is concerned with the management of life-threatening conditions that may require sophisticated life support and monitoring. The literature suggests the use of lead time and demand variability as main criteria for selection of supply chain strategy. This study created a focus group containing one diabetes expert, one cardiology expert, two pharmacists and one health administrator to finalize the criteria influencing supply chain decision other than lead time and demand variability. Three meetings of the focus group were conducted during September 2017 to October 2017 to finalize top three criteria for the selection of supply chain strategy. The three additional factors finalized for the selection of supply chain strategy were (1) Criticality (2) Perishability and (3) Cost. The focus group was interviewed to calculate priorities among the factors criticality, perishability and cost. The pairwise comparison was used to calculate the priority weight of the three factors. The judgment of a doctor was given highest rank followed by a pharmacist and then health administrator. The weight given to the judgment of doctors, pharmacist and health administrator was calculated using the Rank Reciprocal Method as listed in Table-5.2 (Sullivan, 1989). The two doctors and two pharmacists were given the equal score of 1.5 and 3.5 respectively.

Table 5. 2: Weight of Criteria

S.N.	Rank	(R_i)	Weight=$\frac{1/R_i}{\sum_{i=1}^{n} 1/R_i}$
Cardiologist	1	1.5	0.31
Diabetologist	1	1.5	0.31
Pharmacist 1	3	3.5	0.14
Pharmacist 2	3	3.5	0.14
Health Administrator	5	5	0.10

The weight matrix can be written as:

$$W = [W_1, W_2, W_{3,} W_4, W_{5,}] = [0.32, 0.32, 0.14, 0.14, 0.10]$$

The priority of the additional factors selected during the study was calculated using Analytical Hierarchy Process (Saaty, 2008). The Analytic Hierarchy Process (AHP) developed by Thomas L. Saaty in the 1970s, is a structured technique for organizing and analyzing complex decisions. The method has been used in fields such as government, business, industry, education, and healthcare (Saracoglu, 2013).

The audience recruited for the pairwise comparison was asked to compare the factors. The ranking was done as per the scale defined by Saaty (1990) listed in Table-5.3. If a factor F1 is preferred over factor F2 by a preference score of 3, then the factor F2 is preferred over the factor F1 by a preference score 1/3.

Table 5. 3: Preference Score for Pairwise Comparison

Preference score	Definition
1	Equally important or preferred
3	Moderately important or preferred
5	Strongly important or preferred
7	Very strongly important or preferred
9	Extremely important or preferred
2,4,6,8	Intermediate values, when compromise is needed

Table -5.4 lists the pairwise comparison results for the cardiologist.

Table 5. 4: Pairwise Comparison Matrix for the Cardiologist

	Criticality	Cost	Perishability
Criticality	1.00	5.00	7.00
Cost	0.20	1.00	3.00
Perishability	0.14	0.33	1.00
Sum	1.34	6.33	11.00

The elements in each column were divided by the column sum to get the normalized matrix. The row-wise average of the values gives the Eigenvector /priority vector as listed in Table-5.5.

Table 5. 5: Normalized Comparison Matrix for the Cardiologist

	Criticality	Cost	Perishability	Priority Vector
Criticality	0.74	0.79	0.64	0.72
Cost	0.15	0.16	0.27	0.19
Perishability	0.11	0.05	0.09	0.08

Now, the priority vector or Eigenvector for the cardiologist is givens as:

$$E_1 = [0.72, 0.19, 0.08]$$

To check the consistency of the judgment of the experts, Consistency Ratio (CR) was calculated using following steps:

Step 1: The pairwise comparison matrix [A] was multiplied with the Eigenvector [B] to get a resultant vector [C].

Step 2: The elements of matrix [C] were divided by the corresponding elements of the matrix [B] to get a vector [D].

Step 3: The average of the sum of the elements of vector [D] gives a value known as λ_{max}.

Step 4: The consistency index (CI) = (λ_{max} - n) / (n-1) was calculated.

Step 5: Random index (RI) was taken from the following table for the number of criteria used in decision-making.

n	1	2	**3**	4	5	6	7	8	9	10
RI	0	0	**0.58**	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Step 6: Finally the consistency ratio CR was calculated using following formula, CR = CI / RI.

Usually, a CR of 0.10 (10%) or less is considered acceptable.

The consistency ratio for the cardiologist was found as 0.057 which is below 0.10 and hence acceptable.

Similarly, the pairwise comparison matrix for the Diabetologist is listed in the Table -5.6 as below:

Table 5. 6: Pairwise Comparison Matrix for the Diabetologist

	Criticality	Cost	Perishability
Criticality	1.00	3.00	5.00
Cost	0.33	1.00	3.00
Perishability	0.20	0.33	1.00
Sum	1.53	4.33	9.00

Once the pairwise comparison matrix for the Diabetologist was found the normalized matrix was calculated in the next step, Table-5.7.

Table 5. 7: Normalized Comparison Matrix for Diabetologist

	Criticality	Cost	Perishability	Priority Vector
Criticality	0.65	0.69	0.56	0.63
Cost	0.22	0.23	0.33	0.26
Perishability	0.13	0.08	0.11	0.11

Thus, the priority vector or Eigenvector for the Diabetologist are givens as:

$$E_2 = [0.63,0.26,0.11]$$, with a CR= 0.033

Pairwise comparison matrix of the Pharmacist -1 is listed in the Table-5.8 below.

Table 5. 8: Pairwise Comparison Matrix for the Pharmacist -1

	Criticality	Cost	Perishability
Criticality	1.00	3.00	5.00
Cost	0.33	1.00	3.00
Perishability	0.20	0.33	1.00
Sum	1.53	4.33	9.00

Using Table-5.8, normalized comparison matrix for the pharmacist -1 was calculated and listed in Table -5.9.

Table 5. 9: Normalized Comparison Matrix for the Pharmacist-1

	Criticality	Cost	Perishability	Priority Vector
Criticality	0.65	0.69	0.56	0.63
Cost	0.22	0.23	0.33	0.26
Perishability	0.13	0.08	0.11	0.11

Now, the priority vector or Eigenvector for the first Pharmacist are givens as:

$$E_3 = [0.63,0.26,0.11], \text{ with a CR=0.033}$$

Similarly, pairwise comparison matrix of the Pharmacist -2 is listed in the Table-5.10 below.

Table 5. 10: Pairwise Comparison Matrix for the Pharmacist -2

	Criticality	Cost	Perishability
Criticality	1.00	5.00	5.00
Cost	0.20	1.00	1.00
Perishability	0.20	1.00	1.00
Sum	1.40	7.00	7.00

Using Table-5.10, normalized comparison matrix for the pharmacist -2 was calculated and listed in Table -5.11.

Table 5. 11: Normalized Comparison Matrix for Pharmacist-2

	Criticality	Cost	Perishability	Priority Vector
Criticality	0.71	0.71	0.71	0.71
Cost	0.14	0.14	0.14	0.14
Perishability	0.14	0.14	0.14	0.14

The priority vector or Eigenvector for the second Pharmacist is givens as:

$$E_4 = [0.71,0.14,0.14]$$, with a CR=0.0

Finally, the pairwise comparison matrix for the health administrator was created as listed in Table-5.12.

Table 5. 12: Pairwise Comparison Matrix for the Health Administrator

	Criticality	**Cost**	**Perishability**
Criticality	1.00	5.00	5.00
Cost	0.20	1.00	1.00
Perishability	0.20	1.00	1.00
Sum	1.40	7.00	7.00

Using Table-5.12, normalized comparison matrix for the health administrator was calculated and listed in Table -5.13.

Table 5. 13: Normalized Comparison Matrix for Health Administrator

	Criticality	**Cost**	**Perishability**	**Priority Vector**
Criticality	0.71	0.71	0.71	0.71
Cost	0.14	0.14	0.14	0.14
Perishability	0.14	0.14	0.14	0.14

The priority vector or Eigenvector for the health administrator is givens as:

$$E_5 = [0.71,0.14,0.14]$$, with a CR=0.0

Once the priority vector for the five experts is known, the priority score matrix (PSM) for the factors can be calculated as a weighted sum, as described below:

$$PSM = W_1 * E_1 + W_2 * E_2 + W_3 * E_3 + W_4 * E_4 + W_5 * E_5$$

$$PSM = 0.31 * [0.72,0.19,0.08] + 0.31 * [0.63,0.26,0.11] + 0.14 * [0.63,0.26,0.11]$$

$$+0.14 * [0.71,0.14,0.14] + 0.10 * [0.71,0.14,0.14]$$

$$PSM = [0.68,0.21,0.11]$$

As the results show criticality is the most important factor followed by cost and perishability. The cost has a direct effect on the affordability of the healthcare services while perishability of the product erodes the profit margin of the healthcare provider. The discussion of the supply chain for the individual drug is out of the scope of this study, hence the list of the medicine and equipment was divided into homogeneous groups. On the basis of five critical factors, the study proposes a two-stage rule to classify the groups in lean, leagile and agile categories.

Using Global Supply Chain Matrix proposed by Christopher (2006), type of supply chain strategy can be determined at first stage. Then using the rule proposed by this study the final strategy for hospital supplies can be decided. The higher the criticality of an item the greater is the need to stock the item beforehand. In this case we don't have option to order the product as the need arises. To compensate the inventory carrying cost the supply chain should be managed lean and waste should be minimized. If the criticality is less and purchasing cost is high then item should be stocked to avail the economies of scale. In case of low criticality and low cost, perishability becomes the dominant factor. If the perishability is high the items should be purchased as demand arises and supply chain should be agile enough to respond the demand. The assumption taken for this study is that the storage cost of the medicine is not high and the pharmacy doesn't store highly perishable items. The Table -5.14 below elaborates the two-stage rule-based method (TRBM) for matching the right supply chain with the product used in healthcare services.

Table 5. 14: Rules for TRBM Method

Lead Time	Demand Variability	Type	Criticality	Cost	Perishability	Final Type
Short	Short	Lean	High	Low/High	Low/High	Lean
Large	Short	Lean	High	Low/High	Low/High	Lean
Short	Large	Agile	High	Low/High	Low/High	Lean
Large	Large	Leagile	High	Low/High	Low/High	Lean
Short	Short	Lean	Low	High	Low/High	Lean
Large	Short	Lean	Low	High	Low/High	Lean
Short	Large	Agile	Low	High	Low/High	Lean/Agile
Large	Large	Leagile	Low	High	Low/High	Lean
Short	Short	Lean	Low	Low	High	Leagile
Large	Short	Lean	Low	Low	High	Leagile
Short	Large	Agile	Low	Low	High	Agile
Large	Large	Leagile	Low	Low	High	Leagile

If the criticality is high we stock the products beforehand. The hospital should use lean practices to reduce the cost of procurement. When criticality is low second preference is given to the cost. If the inventory carrying cost is high and criticality is less we can procure as the need arises. In this scenario the choice of the supply chain strategy is agile. When criticality and cost both are low, preference is given to perishability and in this scenario the choice of the supply chain strategy becomes agile.

Once the product is matched with the supply chain strategy the decoupling point can be decided for each category. The methodology of the research can be summarised in Figure 5.1, as follows:

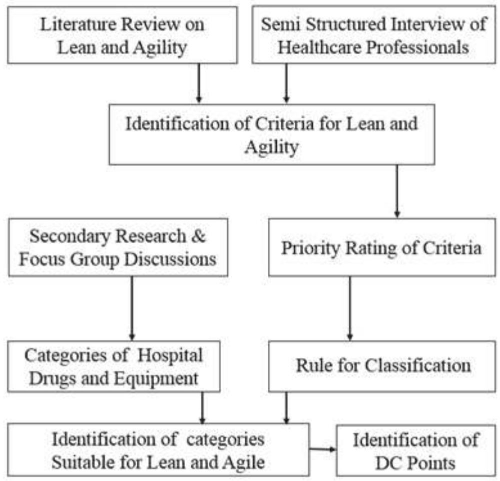

Figure 5. 1: Research Methodology for the Case Study

5.2 The Case Study

The case study organization is a specialized private hospital located in Varanasi city of India. It is a healthcare organization providing care in cardio diabetes specialty. The hospital is located in heart of the city and easily accessible from two railway stations, a bus stop, and an airport. The hospital has qualified doctors and paramedical staffs providing cardio diabetes care and has more than fifty patients visit per day.

Leagile Strategy in the case Hospital

The healthcare services are known as knowledge-intensive service provided by trained professional. The intangible and inseparable nature of the service makes it impossible to store them before consumption. However, providing healthcare services requires the use of some kind of goods like medicines, equipment, nursing aids and food supplements. The successful treatment process depends on the availability of these tangible components and hence the availability of these goods at right time, right quality and affordable cost, becomes very important.

The diabetes care is complex in nature and involves various service components like doctor's consultation, diabetes education, diet counseling, lab investigation etc. These components require different physical goods. Chase (1996) argues that the backend part of the service operation operates much like a factory; hence lean practices can be adopted from the manufacturing sector in case of services. Rahimnia and Moghadasian (2010) observe that irrespective of the disease the patients admitted in the hospital require the same type of physical goods; hence the supply chain for these goods should follow the lean approach. They make this inference while discussing a case of healthcare service dealing injuries and accidents (trauma). The same observation may not be true in case of chronic care like diabetes. We discussed the case with the doctors and administration of the case organization using semi-structured interview process. The findings of the semi-structured interview were included to prepare a more representative list of the hospital supply in case of diabetes care Table -5.15. The list was categorized into eleven homogeneous groups with the help of doctors and administrator of the case health organization. The product list and categories may vary from hospital to hospital but the study provides an approach to implementing the leagile concept in the professional services like healthcare.

Table 5. 15: Categories of Supply for Diabetes Care

Name	**Category**	**Description**
CAT1	Antidiabetic	Gliclazide, Glucagon, Metformin
CAT2	Insulin	Fast, Intermediate Acting, Insulin Pen
CAT3	Lipid Lowering	Simvastatin
CAT4	Antiarrhythmic	Bisoprolol, Digoxin etc.
CAT5	Antihypertensive	Amlodipine,Enalapril,Hydralazine
CAT6	Heart Failure	Furosemide, Spironolactone, Dopamine

CAT7	Antithrombotic	Acetylsalicylic acid, Streptokinase
CAT8	Nursing Aids	Normal Saline, Disposal Injection
CAT9	Footwear	Diabetes Footwear
CAT10	Assistive Technology	Glucometer, Pedometer
CAT11	Food Supplement	Dietary Fibre, Protein Powder

To explore the use of concept of leagility in the case organization we analyzed these categories using Global Supply Chain Matrix (Figure 5.2)

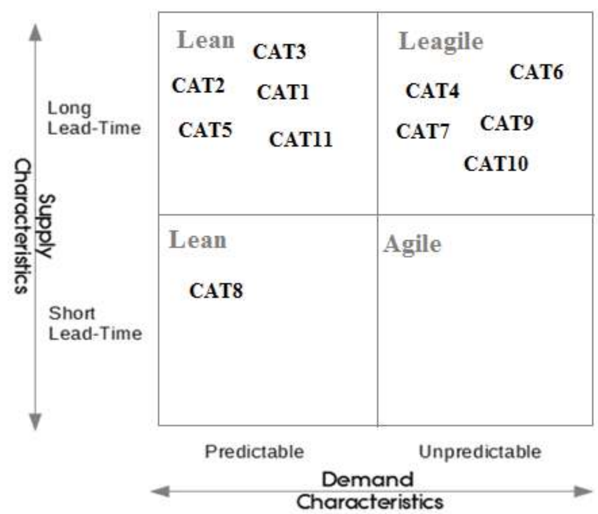

Figure 5. 2: Global Supply Chain Matrix Analysis

The classification of hospital supplies using Global Supply Chain Matrix works well if the other factors affecting the supply chain strategy are kept constant. To explore whether the selected categories are similar for criteria other than demand and lead time variability MDS analysis was done. An expert working in the area of cardio-diabetes management was asked to rate these categories on a scale of one to ten. Where a score of one being least dissimilar while a score of ten being most dissimilar. A distance matrix was created using the score provided by the expert (Table-5.16).

The software used for the statistical analysis in the study is SPSS 20. The algorithm used for the MDS is PROXSCAL, which performs multidimensional scaling of proximity data to find a least-square representation of the objects in a low-dimensional space (Commandeur & Heiser, 1993).

Table 5. 16: Distance Matrix using Dissimilarity Score

	CAT1	CAT2	CAT3	CAT4	CAT5	CAT6	CAT7	CAT8	CAT9	CAT10	CAT11
CAT1	1	3	2	9	4	8	8	2	3	4	6
CAT2	3	1	3	9	5	7	5	2	5	2	5
CAT3	2	3	1	8	3	5	7	5	7	7	5
CAT4	9	9	8	1	5	3	3	5	7	9	7
CAT5	4	5	3	5	1	5	5	7	7	9	7
CAT6	8	7	5	3	5	1	2	5	9	7	8
CAT7	8	5	7	3	5	2	1	5	9	9	8
CAT8	2	2	5	5	7	5	5	1	7	8	9
CAT9	3	5	7	7	7	9	9	7	1	7	9
CAT10	4	2	7	9	9	7	9	8	7	1	9
CAT11	6	5	5	7	7	8	8	9	9	9	1

The Stress-I value for the multi-dimensional scaling was found 0.21. The stress measure should be below 0.15 but a score of 0.21 is acceptable for the exploratory research. The Dispersion Accounted for (DAF) and Tucker's Coefficient of Congruence are close to 1 and hence acceptable (Table 5.17).

Table 5. 17: Stress and Fit Measures

Stress-I	.21459
Dispersion Accounted For (D.A.F.)	.95395
Tucker's Coefficient of Congruence	.97670

The result of the multidimensional scaling (MDS) is depicted in the Figure –5.3 below. As clearly visible from the plot, there are significant dissimilarities among the categories selected for the cardio-diabetes clinic. This made us conclude that the classification on basis of the Global Supply Chain Matrix is not sufficient and we need to account other factors like criticality, perishability, and cost at the time of selecting supply chain strategy.

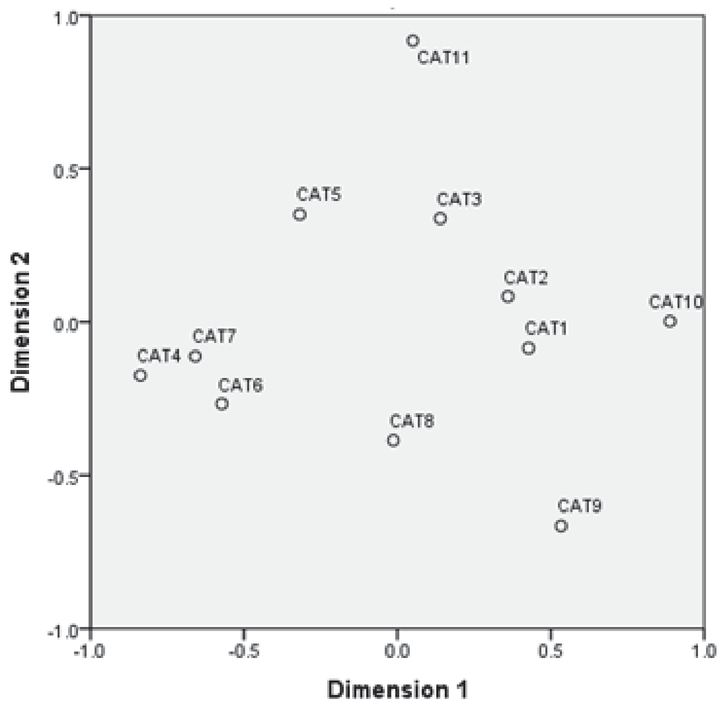

Figure 5. 3: Plot of Categories Using MDS

Using the TRBM method discussed in the methodology section the final type of the supply chain strategy was calculated. The criticality of the supply was given highest preference, followed by cost and then perishability. Table -5.18 below list the results for all eleven selected categories using Global Supply Chain Matrix (GSCM) and proposed Rule-Based Methodology in Table-5.14.

Table 5. 18: Two Stage Rule-Based Methodology.

Name	Lead Time	Demand Variability	Strategy	Criticality	Cost	Perishability	Final Strategy
CAT1	High	Low	Lean	High	Low	Low	Lean
CAT2	High	Low	Lean	High	High	High	Leagile*
CAT3	High	Low	Lean	High	Low	Low	Lean
CAT4	High	High	Leagile	High	High	Low	Lean
CAT5	High	Low	Lean	High	High	Low	Lean
CAT6	High	High	Leagile	High	High	Low	Lean
CAT7	High	High	Leagile	High	High	Low	Lean
CAT8	Low	Low	Lean	High	Low	Low	Lean
CAT9	High	High	Leagile	Low	High	Low	Leagile
CAT10	High	High	Leagile	Low	High	Low	Leagile
CAT11	High	Low	Lean	Low	Low	Low	Lean
Based on Global Supply Chain Matrix				Based on Proposed Rule			

*The insulin requires cold supply chain hence the item is kept in a different category than other items requiring leagile strategy.

5.3 Results & Discussion

The result of the case study suggests that category CAT1 (Antidiabetic medicines), CAT3 (Lipid Lowering Drugs), CAT4 (Antiarrhythmic Drugs), CAT5 (Antihypertensive drugs), CAT6 (Heart Failure Drug), CAT7 (Antithrombotic Drugs), CAT8 (Nursing Aids) and CAT 11 (Food Supplements) should follow the lean strategy hence the decoupling points should be very close to the end user i.e. patients. These items should be procured and stored in the hospital well in advance. The agility can be achieved in case of these categories by product bundling (making a bundle of medicines prescribed together) for example keeping the antidiabetic drugs like Metformin, Vitamin D, and Lipid-lowering drugs together in a bundle.

The assortment of the medicine and equipment prescribed together can further reduce the waiting time at the hospital pharmacy and hence enhance customer service level.

The CAT2 (Insulin) require cold supply chain and cold storage. These category items are perishable and the supply chain for these products should be agile. The demand for the insulin should be forecasted and the expected demand should be met by assuring the right supply.

The categories, CAT9 (Footwear), and CAT10 (Assistive Technologies) fall under leagile strategy and decoupling points should be as close to the producer as possible. The supply chain of the medicine and medical equipment can be described as a multi-echelon supply chain as depicted below in Figure 5.4:

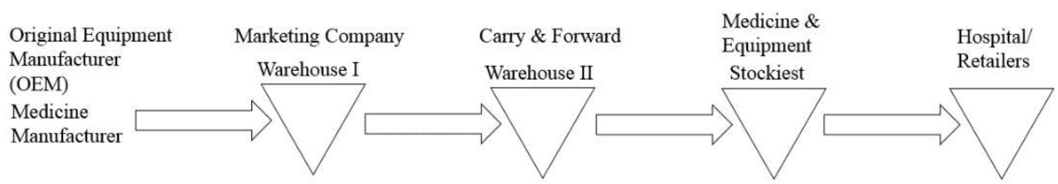

Figure 5. 4: Multi-echelon supply chain for Medicines and Equipment

As discussed above the category CAT1 (Antidiabetic medicines), CAT3 (Lipid Lowering Drugs), CAT4 (Antiarrhythmic Drugs), CAT5 (Antihypertensive drugs), CAT6 (Heart Failure Drug), CAT7 (Antithrombotic Drugs), CAT8 (Nursing Aids) and CAT 11 (Food Supplements) items should be procured and stocked at the hospital pharmacy. These products should be procured directly from producer in bulk to avail the economy of the scale. There is evidence that collaborative purchasing can reduce the cost of purchase in case of the pharmaceutical supply chain (Stokoe & Deady, 2003). The collaborative procurement needs trust among various players for a successful implementation (Bhakoo & Chan, 2011).

CAT2 (Insulin) should be kept at hospital pharmacy to meet the demand for a period (say one month in case of insulin) and should be replenished through the stockiest as the inventory level start depleting and reaches below reorder point. Thus the decoupling point lies at a hospital pharmacy in the case of the first group while at a stockiest level in the second case. The items in the third group of category CAT9 (Footwear), and CAT10 (Assistive Technologies) follow leagile strategy and should be kept in hospital to meet the demand. There should be a periodic review of the items and inventory should be replenished directly from manufacturer/marketing Company to minimize the cost of procurement. The diabetes footwear is customized for every patient and it comes with different, design material and size. The pressure offloading of the shoes is done to reduce the risk of foot ulcer in case of diabetic neuropathy. The customization part of the diabetic shoes i.e. pressure offloading and insole insertion should be done as late as possible at the hospital.

5.4 Conclusion

Healthcare is a professional service require expert from the healthcare to meet the uncertain service demand. The intangible, perishable and inseparable nature of the services makes it difficult to adopt lean and agile strategy from the manufacturing. To provide successful healthcare services the professionals need tangible items/physical good like medicines and medical equipment. The supply chain of these tangible items should use the concept of leagility to provide the efficient and affordable healthcare. The hospital supply chain in case of chronic care is highly complex and one strategy doesn't fit all products. The study proposes and uses two-stage rule-based methodology (TRBM), which combines the Global Supply Chain Matrix proposed by Christopher (2006) and rules proposed in this study.

The insulin supply chain needs strategic supply chain partnership down the stream to meet the demand while the items like Assistive Technologies and Footwear need strategic partners at the upper part of the supply chain. Implementing an effective leagile strategy require matching the supply chain with the product then identifying the decoupling point differentiating the lean and agile part of the supply chain. At last but not the least there should be a strategic partnership with the player identifies at decoupling point to reduce the supply chain risk and ensure the timely delivery of the products.

5.5 Limitation of the Study

The study uses a homogeneous group of the goods required for delivering healthcare services to discuss the application of leagility in the healthcare services. There may be intragroup variation in the choice of the strategy applied to the item. The selection of supply chain strategy also depends on the financial capacity and risk appetite of an organization and this study does not take these factors into account.

5.6 Future Directions

The future direction of the study may include the exploration of the suitability of the lean and agile strategy for the different type of organizations (private, public, large and medium scale etc.). To become cost efficient as well as responsive a diabetes care supply chain need to be lean as well as agile. The winning supply chain must perform well in the area of supply chain partnership. The next chapter of this thesis discusses the patient’s utility for the various diabetes care attributes.