“8A” Framework for Value Stream Selection – An Empirical Case Study

Gopalakrishnan Narayanamurthy*

University of St Gallen, St Gallen, Switzerland.

Anand Gurumurthy

Indian Institute of Management Kozhikode (IIMK), Kozhikode, Kerala, India.

Roger Moser

University of St.Gallen, St.Gallen, Switzerland.

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**Corresponding author*

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Abstract

Purpose – Before initiating the implementation of change for transforming and improving the value stream of an organization through lean thinking (LT), it has to first select a right value stream. Several implementation studies have been documented in literature, but not many studies have touched on to the aspects of value stream selection. The purpose of this study is to propose and empirically validate a framework for selecting a value stream to implement LT.

Design/methodology/approach – 8A framework is proposed by reviewing the literature on LT implementation case studies, where a value stream is generally selected for LT implementation. Single case study methodology has been adopted to validate as well as demonstrate the application of 8A framework for selecting a value stream in an Indian educational institute. Since multiple qualifiers are considered simultaneously, a multi-criteria decision making approach has been employed for choosing the value stream.

Findings – Utility of the proposed 8A framework for value stream selection was confirmed through its successful application in an educational institute. Out of three alternatives in the case organization, 8A framework chose teaching alternative for further LT implementation. Qualitative cross-validation and sensitivity analysis conducted also confirmed the robustness of the value stream selection made using the 8A framework.

Research limitations/implications – Framework proposed in this study comprehensively captures all the important qualifiers that were overlooked by the widely adopted first tenet of LT. Future research can attempt to generalize the applicability of 8A framework in different contexts including manufacturing, healthcare, and software development. A further study can be carried out in two similar case organizations or in two value streams of the same case organization to compare the differences in the lean implementation outcomes when one organization chooses its value stream for LT implementation randomly, while another chooses it by applying the 8A framework.

Practical implications – Through structured evaluation of the comprehensive set of qualifiers in 8A framework using multi-criteria decision making, an informed decision can be been taken by the practitioners in selecting a value stream from the available alternatives before proceeding with the implementation of LT.

Originality/value – After questioning the existing procedure of value stream selection for LT implementation, this study is the first to propose and validate an 8A framework that overcomes the limitations of the existing procedure. Study is also unique in the choice of the case organization as not many research papers have been documented on LT from the context of educational institutes.

Keywords: Value stream; Lean thinking; 8A framework; Case study, Educational institute; Multi-Criteria Decision Making.

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1. Introduction

Selecting a suitable value stream is an important prerequisite for implementing any change initiative ranging from lean thinking (LT) to sustainable thinking (Davenport, 1993; Faulkner and Badurdeen, 2014; Tyagi et al., 2015). Lacking focus on the critical value stream will lead to unnecessary dissipation of organization's energies, resources, and time during the change initiative (By, 2005; Rafferty et al., 2013), which in turn definitively increases the failure rate of change initiative (Al-Haddad and Kotnour, 2015; Jacobs et al., 2013; Jansson, 2013; Michel et al., 2013; Rouse, 2011). Organization planning to implement a change initiative, LT in this case, needs to first select a suitable value stream by comprehensively evaluating it on key qualifiers.

LT implementation involves a complete change in philosophy of operations carried out in the organization (Bhasin and Burcher, 2006). LT implementation journey, in most of the cases, is irreversible in nature and demands huge investment of resources from an organization (Poppendieck and Poppendieck, 2003). For successfully managing the change and overcoming the resistance of employees towards implementing LT, value stream in which it will be implemented needs to be selected with utmost care. Therefore, to efficiently attain the objective of lean journey, right value stream needs to be selected at the beginning itself. However, hardly any study exist in the literature of LT that addresses this issue.

Value stream selection for LT implementation is similar to selecting a process for improvement initiative. Difference lies in the level of granularity as value stream has multiple process within and a process can traverse across multiple departments/functions. Inefficiencies in a process within a value stream combines together to contribute to the value stream inefficiency (Abdulmalek & Rajgopal, 2007). Multiple value stream inefficiency contributes to the inefficiency of the entire shop floor. Hence, the choice of value stream in a shop floor and choice of process within a value stream is a key decision before beginning the LT implementation. This study develops a framework and procedure for choosing the value stream (can also be applied to choose a process within the value stream) for LT implementation.

1.1. Motivation

The first tenet of LT proposed by Womack and Jones (2009) focuses on identifying value defined by the end customer for selecting a value stream. But implementation of this tenet is followed differently in different organizations and thereby exists a confusion in handling this complex decision. For instance, in literature, a value stream that has plenty of wastes as reflected in declining sales, market share, etc. has been chosen for LT implementation based on the immediate needs and requirements of the firm (e.g. Abdulmalek & Rajgopal, 2007). This disconnect between theory and practice clearly shows that the first tenet “identifying value” proposed by Womack and Jones (2009) is missing few key qualifiers which are considered to be very important by the practitioners/researchers while selecting a value stream for LT implementation. This is the primary motivation for conducting this research. In this study, we attempt to identify qualifiers, develop a framework, and demonstrate a procedure for selecting a value stream to implement LT using the framework. The following two research questions (RQs) will be addressed in this research:

> **RQ 1:** Along with end customer value, what are the other important set of qualifiers that have been considered in literature while selecting a value stream for LT implementation? Can these qualifiers be grouped into factors and sub-factors to form a framework?
>
> **RQ 2:** Based on the framework developed, how can an organization choose a value stream for LT implementation? What are the steps it should follow to prioritize and choose a value stream for LT implementation by considering the framework developed in RQ1?

To answer these two research questions, set of factors and sub-factors were identified by reviewing the studies in LT implementation literature which were adopting case study methodology and were documenting the selection of value stream. By adopting a normative and judgmental approach, a classification scheme (i.e. framework) for the same has been proposed. It is a known fact that any evaluation is a complex process, where a number of trade-offs is to be made among different qualifiers. Hence, the use of Multi-Criteria Decision Making (MCDM) model is necessary and the Analytic Hierarchy Process (AHP) – one of the widely utilised MCDM model by the practitioners (Cheng et al., 2002) has been used in this study to select a value stream for lean implementation in an Indian educational institute. Figure 1 depicts the procedure adopted to carry out this research.

“Insert Figure 1 here”

2. Literature review

To understand the relevant studies existing in the domain of current research topic, we reviewed the case studies on LT implementation literature because selection of value stream, implicitly or explicitly, is only documented in this literature. Other empirical survey and review studies in LT implementation literature do not touch upon the aspect of value stream selection as their primary objective is to generalize the findings by collecting data from multiple organizations (or respondents) than to document how it was done in a particular organization. We also reviewed the literature on process reengineering and process improvement literature to see if there were studies discussing the procedure of selecting a value stream for LT implementation. As we did not find studies relevant to this research question in these streams of literature, we have not included them in this section. But, the insights drawn from these reviews have been used in building the framework for value stream selection discussed in next section. Detailed review on lean implementation in education literature has been documented in Narayanamurthy et al., (2017b) and hence is not repeated in this study.

2.1. LT implementation case studies

Through the review of LT implementation case studies, we tried to understand the qualifiers considered and procedure adopted to select a value stream or process within a value stream (hereon called as value stream in general) for implementing LT. Many case studies exist in which lean was implemented in a selected value stream (Seth and Gupta, 2005; Lee and Jo, 2007; Staats et al., 2011; Narayanamurthy et al., 2017a; etc.), but no details have been provided on how or through what procedure the value stream was selected. Some of them have used the logic given by Womack and Jones (2009) in identifying the product and its corresponding value stream. Although value addition plays a role in value stream selection, research and practice has shown that this decision making generally goes beyond it by bringing in several other key factors which plays a pivotal role in implementing LT. The objective of this review is to expand the 1st tenet by capturing other key unexplained qualifiers that needs to be considered while selecting a value stream.

Detailed review of the studies are presented in Table 1. Reviewing the case studies of LT implementation helped in identifying the qualifiers (highlighted text in Table 1) considered for selecting a value stream. None of the studies reviewed have discussed on how a value stream can be selected for implementing LT. Supporting our claim of no literature on value stream selection, Zellner (2011) had mentioned that no research has investigated how process improvement procedure can be supported or executed methodologically using a structured overview of methods or techniques to reduce uncertainty on the way from the current situation (as-is) to future situation (to-be). Therefore, the framework to be developed for value stream selection in this study is not only limited to LT implementation, but can be extended to other process improvement initiatives such as six sigma, total quality management, etc.

"Insert Table 1 here"

Review of the case studies dealing with implementation of LT showed that most of the studies directly proceeded with LT implementation in a value stream and did not explain why that particular value stream was chosen. Very few studies clearly documented the rationale for choosing a particular value stream before proceeding with LT implementation. Some studies also retrospectively explained after LT implementation what went wrong or what extra could have been considered while selecting their value stream. Through this review, it was observed that qualifiers considered for selecting a value stream were discussed both explicitly and implicitly in few studies. For instance, Kasul and Motwani (1997) have mentioned factors such as employee empowerment and top management support explicitly and factors such as scope for waste reduction and ability to measure it while implementing lean manufacturing in a value stream in the company implicitly. Similarly, Gunasekaran et al. (2000) while discussing the experience of a small company named 'Valeo', explicitly mentioned cost-benefit as an important factor influencing the choice of the process but other factors such as scope for waste reduction and task redundancy were implicitly considered while making the choice. In this review, both these explicit and implicit factors were studied to understand how a value stream was chosen for lean implementation. In the review, it was also seen that no clear consensus existed in literature on the qualifiers that needs to be considered for selecting a value stream for implementing LT. Studies have considered diverse set of factors and also factors specific to the context of study. In the current business scenario of high competition, it is necessary for an organization to consider all the qualifiers that affect a value stream outcome as the value streams in any organization operate interdependently. These gaps in the literature are being addressed in this study by proposing an 8A framework for value stream selection and demonstrating its applicability in a case organization.

3. 8A framework for value stream selection

Based on the qualifiers obtained from the review, we developed an 8A framework to comprehensively capture the key qualifiers of a value stream. 8A framework proposed in this study consists of autonomy, accessibility, associativity, alignment, affordability, achievability, acceptability and assessable qualifiers (as shown in Figure 2). None of the existing studies have explicitly mentioned these 8A qualifiers, at least with the same nomenclature that we have created. Using a normative and judgemental approach, supported by the domain knowledge, the classification scheme (framework) for the qualifiers was established.

"Insert Figure 2 here"

Table 2 provides literature support on the identified 8A qualifiers from LT implementation case studies literature. Literature support indicated for the 8A qualifiers in Table 2 are based on the explanation provided in Table 1. 8A qualifiers selected helps in identifying the value stream from where the organization should start its LT implementation thereby providing concrete initial guidelines apart from reducing the complexities and uncertainties involved in initial stages of implementing LT. Each factor and underlying sub-factors are described in detail in Narayanamurthy and Gurumurthy (2014) with their operationalized definition and literature support. Table 3 summarizes the description of factors in 8A framework.

"Insert Table 2 here"

"Insert Table 3 here"

Complete factor and sub-factor structure is as shown in Table 4. As 8 factors and 38 sub-factors are to be considered for the selection of a suitable value stream for LT transformation, it becomes imperative to use MCDM models. Also, MCDM approach is employed to solve problems where selection occurs among a finite number of alternatives by making appropriate explicit trade-offs

(Rao, 2007). In the current study, alternative needs to be chosen by making explicit trade-offs between the factors such as affordability and achievability, accessibility and associativity, achievability and acceptability, etc. Therefore, MCDM methodology is an appropriate tool to choose an optimal alternative for LT implementation.

“Insert Table 4 here”

4. Choice of methodology for value stream selection

Post identifying the factors and sub-factors for selecting a value stream for lean implementation, it is necessary to understand the methodology through which these factors and sub-factors can be considered for making a decision on the value stream to be chosen. Analytic Hierarchy Process (AHP) works based on a hierarchical structure of factors and sub-factors, which is the case in our 8A framework for value stream selection. AHP was developed by Thomas Saaty as a practical approach in solving relatively complex decision making problems (Bayazit, 2005). The methodology as explained in Saaty’s (1980) book has three main steps: structuring the hierarchy, performing paired comparisons between elements and decision alternatives and synthesizing results. Once the hierarchy is created, the general approach of AHP model is to decompose the problem and make pair-wise comparison of all the factors in a given level with the related factors in the level just above to which it belongs. Pair-wise comparisons of factors at each level were done on a scale of relative importance: 1 reflecting equal weight and 9 reflecting absolute importance. Further details on the scale are available in Saaty (1980) and Bayazit (2005).

4.1. Rationale for AHP

In this study, AHP is chosen, as it is user friendly and assists the managers to make a choice among the alternatives. AHP is one of the very few MCDM models capable of handling many criteria, even if some of the criteria’s are qualitative. AHP methodology helps in ensuring harmony in group decision-making by calculating the geometric mean of individual pair-wise comparisons (Zahir 1999; Mathiyazhagan et al., 2014). Wide variety of other MCDM models are discussed in the literature including Elimination and Choice Translating Reality (ELECTRE), Preference Ranking Organization Method of Enrichment Evaluations (PROMETHEE), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytic network process (ANP), Joint

Probability Decision-making (JPDM), Equivalent Cost Analysis (ECA), and Multi-Attribute Utility Theory (MAUT) (Gurumurthy and Kodali 2012). ELECTRE and TOPSIS methods have limited acceptance by the scientific and practitioner's communities (Harputlugil et al. 2011). In comparison to AHP, ANP needs several pair-wise comparison matrices and a complex survey process for non-expert participants (Mathiyazhagan et al., 2014). AHP has been chosen in this study for its versatility and capability to model any decision-making situations and integrate with other methodologies such as QFD, meta-heuristics, SWOT analysis, data envelopment analysis, etc. (Vaidya and Kumar, 2006; Ho 2008). AHP methodology has found its application in various decision making problems in diverse fields including logistics (Chan et al. 2006), flexible manufacturing systems (Bayazit, 2005), and supply chain management (Gaudenzi & Borghesi, 2006). Since the current problem involves both quantitative and qualitative factors and requires a simple practitioner friendly procedure for considering all of them, AHP methodology is found to be more suitable.

5. Validation of 8A framework for value stream selection

Anchoring on to the proposed 8A framework, AHP methodology is used to perform value stream selection for lean implementation in a case organization which is conducting process improvements to attain higher efficiency. Research questions determine the approach to be adopted from positivist and interpretivist paradigms (Morgan & Smircich, 1980). As this study tries to answer 'how', 'what' and 'why' form of research questions on value stream selection within an organization for lean implementation, case study research methodology is used (Yin, 2014). We have followed the methodology as prescribed in literature (Eisenhardt, 1989; Siggelkow, 2007). The case company chosen is not randomly sampled, but rather chosen based on how they contribute to the research questions being asked (Siggelkow, 2007). Best-fit case organization for this study would be the one getting ready for lean journey and is at the stage of value stream selection for LT implementation.

5.1. Case organization – An Indian educational institute

Case organization chosen was an educational institute located in southern part of India with administrative staff strength of 66 people and batch strength of 356 students. Management institute case organization comprises of 64 fulltime faculty members and 26 adjunct faculty members distributed across 8 departments. Institute's major functional areas were admission, alumni, institute administration, academic administration, placement, and research & publications. The case institute offers various programs such as postgraduate programme (PGP) in management, management development programme (MDP), faculty development programme (FDP), executive post graduate programme (EPGP) and fellow program in management (FPM). Case organization has implemented few low hanging process improvement initiatives in scheduling, grading, and elective bidding in the past. For instance, the scheduling process was transformed such that the variability in number of sessions per day was reduced close to zero.

Educational institute chosen for our research was getting ready for initiating new lean based improvement projects. In addition, we authors had access to the top management team of the institute and therefore eased our data collection efforts (convenience sampling). Even though the case organization chosen for this study was based on convenience sampling, it was ensured that the case organization satisfies all the characteristics of being a best-fit candidate (Zhu et al., 2008). This project with the educational institute is an ongoing one and therefore provides us with the opportunity in future to longitudinally study the impact of selecting a value stream using 8A framework on the ease of LT implementation and its impact on the quantifiable improvements attained.

Educational institute was deciding upon the available alternatives for lean journey. To choose an alternative i.e. a value stream for subjecting it to improvement initiatives through LT, top management shortlisted three domains namely admission (PR1), administration (PR2), and teaching (PR3). Using the 8A framework described above, a step by step procedure was followed to choose the right value stream.

5.2. Validation of 8A framework

AHP methodology for value stream selection is simultaneously demonstrated as we move along the case study. Gurumurthy and Kodali (2012) has discussed about the steps to be followed in deploying the AHP model, which is being adopted for the current study as discussed below:

Step 1. Define the problem and determine the objective and alternatives along with the identification of the important elements involved. The problem identified in our case is the selection of a suitable value stream from the alternatives for LT implementation. The factors and sub-factors identified from the literature survey are as shown in Table 4. The alternatives in the case organization are represented as PR1, PR2, and PR3.

Step 2. Structure the identified elements in a hierarchy from the top through the intermediate levels to the lowest level. Figure 3 shows the schematic of AHP model for evaluation of alternatives. In Figure 3, the goal is at the first level, 8A factors are at the second level, sub-factors are at the third level, and finally the alternatives are at the last level.

"Insert Figure 3 here"

Step 3. Construct a set of pair-wise comparison matrices for each of the lower levels. The pair-wise comparisons are done in terms of which element dominates another and the detailed procedure for constructing pair-wise comparison and performing relevant mathematical calculation are available in Gurumurthy and Kodali (2012). Table 5 shows the pair-wise comparison matrix for level 2. In this case, a pair-wise comparison matrix is constructed for the factors. For instance, pairwise comparison is carried out between the factors 'autonomy' and 'accessibility', autonomy is considered to be more important than accessibility. Hence 2 is entered in the row 1, column 2, while 0.5 (reciprocal of 2) is entered in row 2, column 1 in Table 5. In this study, the weight values are provided by authors who were associated with the educational institute when it decided to start the lean based improvement initiatives.

Step 4. After conducting the pair-wise comparisons, the consistency is determined using the Eigen value. To obtain the Eigen values, the column of numbers is normalized by dividing each entry by the sum of all entries. Each row of the normalized values is then summed up to calculate the average to arrive at the principal vectors (PV) or Eigen values as shown in Table 5.

"Insert Table 5 here"

Step 5. Consistency of the judgements of the decision makers were checked using the procedure followed by Gurumurthy and Kodali (2012) and Wabalickis (1988). If the consistency ratio is less than 10%, judgments are considered consistent. Else, the quality of judgments have to be improved to have consistency ratio less than or equal to 10%. Consistency ratio value was found to be lesser than the prescribed threshold in the current study's pairwise comparison data and hence the weight values prescribed were inferred to be consistent (consistency ratio values for all the levels in AHP hierarchy are listed in Table 6).

"Insert Table 6 here"

Step 6. Steps 3-5 are performed to have relative importance of each sub-factors within a given main factor. Table 7 illustrates a sample sub-factor analysis under the main factor 'Autonomy'. Same procedure described above to compute the consistency of the judgements was followed and the judgements were found to be consistent for all the sub-factor analysis. Similar to Table 7, seven more tables were formed (not shown due to the space limitations and repeatability of the content) for the remaining sub-factors within other main-factors.

"Insert Table 7 here"

Step 7. Alternative analysis for the lowest level of sub-factor was carried out. Table 8 illustrates the alternative analysis for the sub-factor 'High process inter-linkages (HPI)' within Associativity (ASS). HPI can be easily inferred to be maximum for PR3 and not much significant for the PR1 and PR2 as these alternatives were only contributors for the smooth conduct of PR3. Similar alternative analysis was carried out for rest of the sub-factors under all 8A factors yielding another 38 tables (not shown due to the space limitations and repeatability of the content).

"Insert Table 8 here"

Step 8. Principal vectors (PVs) or weight values for each main factor, sub-factor and alternative are consolidated. Each value in "PVs for sub-factor" column (L3-Wt) is multiplied by the respective value of "PVs for main-factor" column (L2-Wt), which is finally multiplied by the value for each respective alternative to get the desirability index of the alternatives for each sub-factor. Desirability index for each of the sub-factors is summed up to get the overall desirability index for each alternative (as shown in Figure 4). The data summary of the complete analysis as well as the overall desirability index is provided in Table 9.

"Insert Figure 4 here"

"Insert Table 9 here"

6. Results and Discussion

From the overall desirability index for three alternatives shown in Figure 4, it is clear that the PR3 i.e. the teaching alternative is the best choice for implementing LT under the given circumstances of the case institute. Following it in the order of priority for LT implementation is the administrative alternative (PR2) and finally the least preferred is the admission alternative (PR1). From the spider chart in Figure 5, further clarity can be obtained on how PR3 outperforms rest of the two alternatives across the factors of 8A framework proposed for value stream selection. It could also be seen that even though PR2 was ranked second in overall desirability, PR1 which was ranked third outperforms it on associativity, alignment, affordability and achievability dimensions. PR2 retains the second position by having much higher acceptability which is the highly weighted factor among all the eight dimensions (as shown in Figure 6). Figure 6 plots the weights of the 8A factors to be considered while selecting a value stream for lean implementation. Acceptability tops with maximum weight followed by affordability. The least weighed factor turns out to be associativity. These weight values of 8A factors reveals the important characteristics, if not all, that a value stream needs to possess for it to be chosen for lean implementation.

"Insert Figure 5 here"

"Insert Figure 6 here"

Spider charts in Figure 7 provides an in depth view of each of the factors in 8A framework by plotting the evaluation of the alternatives over the sub-factors within each of the 8 factors. PR3 almost outperforms rest of the two alternatives in all the sub-factors. Figure 7 also helps in understanding how PR1 outperforms PR2 over associativity, alignment, affordability and achievability by reviewing the scores of sub-factors within the main factors. For instance, in the case of achievability, PR1 is receiving priority in comparison to PR2 as it has higher scope for waste removal, several low hanging implementable lean solutions, and far higher effectiveness of lean improvements implemented.

"Insert Figure 7 here"

Figure 8 plots the weightages of sub-factors within each of the factors in 8A framework. Inferences drawn on each of the weightages of sub-factor would be similar to those inferences that was drawn on the weightages of factors in 8A framework. The only difference is that the weightages of factors are with respect to the goal of value stream selection for LT implementation and weightages of sub-factors are with respect to the corresponding factor. For instance, 'informed decision making' sub-factor weighs the most and 'reduce individual authority' weighs the least for 'autonomy' factor.

"Insert Figure 8 here"

Quantitative results obtained as a result of the application of MCDM method were cross validated by qualitatively studying the characteristics of alternatives in the case organization. This qualitative validation helped in assessing the proposed 8A framework by checking its capability to capture the actual characteristics of the alternatives and choose the optimal alternative for attaining the goal. Cross-validation of the MCDM results obtained is described in the sub-section below.

6.1. Cross-validation

Value stream selected through the application of 8A framework was studied in comparison to other alternatives to qualitatively understand their characteristic on 8 factors and 38 sub-factors. The information gathered during this process of cross-validation was useful in analysing the results obtained with the application of 8A framework and AHP. This cross-validation helped in triangulation of the outcome.

PR3 comparatively has lesser concentrated authority and ensures distributed autonomy as all the course instructors have complete freedom on how they want to conduct their classes. Academic Dean and Chairperson of specific academic programs mostly act as value stream owners to ensure smooth conduct of PR3. Informed decision making is ensured through meetings and by providing a chance to all the concerned to express their views before the decision is made. PR3 remains high on all these sub-factors and hence scores high on autonomy in comparison to PR1 and PR2. PR1 lacks in terms of outcome accountability and PR2 primarily adopts mechanistic structure as most of its tasks are redundant. PR3 has high accessibility in comparison to other two alternatives. Employer's approachability is comparatively high with PR3 as both administration employees and course instructors are interested in the best conduct of classes. Information assurance is high with PR3 as the institute measures and stores data associated with tasks in PR3 to identify potential improvement gaps. Accessibility for data on PR1 and PR2 is difficult in comparison to PR3. Dedicated employees are appointed to record wide range of data starting from attendance to feedback from students only in PR3.

Alignment is very high for PR3 in comparison to two other alternatives as it is the core value stream of the institute delivering value to its customers. PR1 and PR2 can be called as support value streams for smooth conduct of the core value stream (i.e., PR3). Competitiveness and reputation attained by the institute in the market is largely based on the quality of value delivered in PR3. PR3 scores the maximum in the affordability dimension in comparison to its alternatives. PR3 gains higher benefits to cost ratio as the value stream efficiency could be improved to great extent by implementing LT. PR1 and PR2 being the support value stream for PR3 has lesser potential to deliver benefits in comparison to the cost incurred. Sufficient input man-hour is available with PR3 as the institute has most of the employees solely dedicated to work in PR3.

PR3 is high on achievability. Effectiveness of improvements is really high in PR3 as it is the value stream valued by the customer and represents the purpose of the existence of the institute. Scope for waste removal is also tremendously high in PR3. Process improvements in PR1 and PR2 contributes only to the attainment of effectiveness in PR3. Therefore, it is appropriate to begin LT implementation from PR3. Attaining acceptability will be easier in PR3 when compared to rest of the alternatives. Top management ensures a supportive work culture to encourage employee suggestions and creative solutions to improve the efficiency of the value stream. Customer involvement in PR3 was attained through gathering regular feedback from companies visiting to recruit students and from students attending the courses. PR3 was the thoroughly assessed value stream in the institute. Institute designed metrics, both subjective and objective, to evaluate its quality. Employee metrics in the institute tried to capture the soft aspects of human resources in PR3 through the feedback process from the students and peers. Customer metrics assesses customer experience of value delivered by the institute. They can be assessed through placement outcomes, students winning competitions, etc. Though PR1 and PR2 had metrics for assessment, they lacked the comprehensive data collection followed in PR3 for assessment. PR1 and PR2 also lacked thorough listing of metrics that could enable post-implementation comparison. Availability of these metrics and data in PR3 will enable the institute to compare the outcomes before and after lean implementation.

Therefore, case organization was considering to proceed with implementing lean in PR3 value stream which was chosen by using the 8A framework and AHP methodology. Cross-validation performed increased the confidence on the alternative identified by the 8A framework. 8A framework along with the AHP methodology acts as a complete package that a case organization can use for selecting a suitable value stream.

6.2. Sensitivity analysis

As the overall desirability index for alternatives can vary based on the weights assigned (calculated based on the values assigned to the factors) by the decision makers in pairwise comparison process, it is necessary to check the extent of impact that the change in weights can have on the overall desirability index. Sensitivity analysis helps in confirming the robustness of the alternative ranking obtained as a result of the AHP application. If alternative ranking based on overall desirability index changes in the sensitivity analysis, then it indicates that the ranking is not robust and varies based on the weights assigned by the evaluator. If alternative ranking remains constant, then it confirms that the value stream selected for LT implementation remains unchanged irrespective of the variations in the weights of the factors. Sensitivity analysis performed by varying the weightages of the factors to wide extremes is being plotted in Figure 9. From the graphs shown in Figure 9, it can be clearly inferred that on changing the weights, the normalized overall desirability index for the alternatives changes, but the final decision on value stream to be selected remains unchanged as PR3 is always ranked first with higher desirability index (normalized overall desirability index of PR3 remains always 1 as it has attained maximum ratings across all the factors and sub-factors). Other two value streams, PR1 and PR2, moves between second and third when weights of certain factors varied beyond certain threshold.

"Insert Figure 9 here"

Ranking order of PR3, PR2 and followed by PR1 remains unchanged while varying the weights of autonomy, accessibility, and assessable factors. PR1 moves to second by pushing PR2 to third when the weight of associativity, alignment, affordability, and achievability are varied beyond a certain threshold. In the case of acceptability factor, PR1 is pushed from second position to third at the initial weight values and stays at third from then on. Intersection points in the sensitivity analysis graphs indicates to us the weight values of a factor at which the alternatives ranking would change. For example, PR1 would be ranked second when the weight of associativity is greater than 30%, alignment is greater than 45%, affordability is greater than 80%, achievability is greater than 30%, or acceptability is less than 10%.

As shown in the sensitivity analysis, PR3 selected through 8A framework and AHP methodology stood robustly to be the most preferred value stream for LT implementation. Therefore, PR3 (i.e. the teaching alternative) was chosen as the best alternative for lean implementation and case organization decided to focus on it for starting the lean journey.

7. Conclusion

Current study started with an assertion that hardly any research has been carried out to develop a framework that can assist in evaluating value streams and choosing the right one for implementing LT. After considering the practical aspects of value stream selection through some of the case examples, it was found that the first tenet of LT proposed by Womack and Jones (2009) can be improved further to become more comprehensive. Hence, the current study focused on developing and validating a framework for value stream selection. Framework developed in this study would assist in choosing a right value stream before initiating the implementation of LT for transforming and improving the value stream of an organization. Factors and sub-factors that needs to be evaluated while selecting a value stream for implementing LT were identified from lean implementation literature. These identified qualifiers were grouped hierarchically using the classification scheme to form the "8A framework" with 8 factors and 38 sub-factors. This answers the first research question raised.

A MCDM model, namely AHP, has been used to select a value stream in an Indian educational institute based on the 8A framework developed. This is expected to act as a structured decision support system helping managers to select a value stream with potential to deliver positive outcomes on lean implementation. This in turn answers the second research question. From the results of AHP, it is evident that for the given case organization and its circumstances, PR3 is the best alternative for lean implementation. Sensitivity analysis has been conducted to assess the robustness of the results. As a whole, this study addressed the question of how a top management should make a decision of choosing a particular value stream for implementing LT and proceed with committing its resources for LT transformation.

7.1. Research implications

After questioning the existing procedure of value stream selection for LT implementation, this study is the first to propose and validate an 8A framework that overcomes the limitations of the existing procedure. "8A framework" addresses the gaps identified in the widely adopted first tenet of LT, "identifying value", proposed by Womack and Jones (2009). First tenet of LT has been strengthened by expanding its scope through listing of several other key qualifiers that needs to be considered while selecting a value stream. The proposed framework have also been empirically validated in an Indian educational institute to bridge the conceptual and empirical plane. This study has an impactful contribution to the change management and LT literature by answering the 'how' question on widely accepted first tenet of LT. This research is unique in the choice of the case organization as not many papers have been documented on LT from the context of educational institutes. This study is first to report about the selection of a value stream for implementing a change through LT in an educational institute in an emerging market.

Future research can attempt to generalize the applicability of 8A framework in different contexts including manufacturing, healthcare, and software development. Applicability of the "8A framework" can also be generalized by conducting an exploratory survey. Decisions by the managers may vary depending upon the circumstances that prevail within each organization such as the allocated budget, nature of processes, human resource availability, top management commitment, etc. The proposed 8A model with the AHP methodology provides adequate rationale and customization based on the experience and judgements of the decision makers for the value stream selection decision. Research in future can study two similar case organizations or two value streams of the same case organization to compare the differences in the lean implementation outcomes when one organization chooses its value stream for LT implementation randomly, while another chooses it by applying the 8A framework. Future research can also test the applicability of "8A framework" in selecting a value stream for implementing other process improvement initiatives such as six sigma, total quality management, etc.

7.2. Practice implications

"8A framework" comprehensively assesses the available value stream alternatives and helps in choosing one for implementing process improvement initiatives and for managing the change introduced. It also supplements the other tools such as business canvas model which are used by practitioners to design and improve a business model. Post designing the business model using the business canvas model, firms can use the "8A framework" to select a value stream for further improving it by deploying lean tools and techniques. "8A framework" proposed in this study helps practitioners by reducing the uncertainties and ensuring the consideration of all the key qualifiers while selecting a value stream for change through lean implementation. Therefore, through structured evaluation of the comprehensive set of qualifiers in 8A framework using multi-criteria decision making, an informed decision can be been taken by the practitioners in selecting a value stream from the available alternatives before proceeding with the implementation of LT. As LT ultimately involves huge resource consumption, expensive investments, and tends to be often irreversible, 8A framework will be a highly supportive tool for practitioners in providing a structure for selecting a value stream.

Note

1. Conceptual paper on process selection model was presented in the *Twenty Fifth Annual Conference of Production and Operations Management Society (POM 2014)*, 9-12 May 2014, Atlanta, USA.
2. Initial version of MCDM applied process selection model was presented in the *NITIE-POMS International Conference 2014*, on the theme “Manufacturing Excellence: Imperative for Emerging Economies”, 18-21 December 2014, jointly organized by National Institute of Industrial Engineering and Production and Operations Management Society, Mumbai, Maharashtra, India.

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Figures

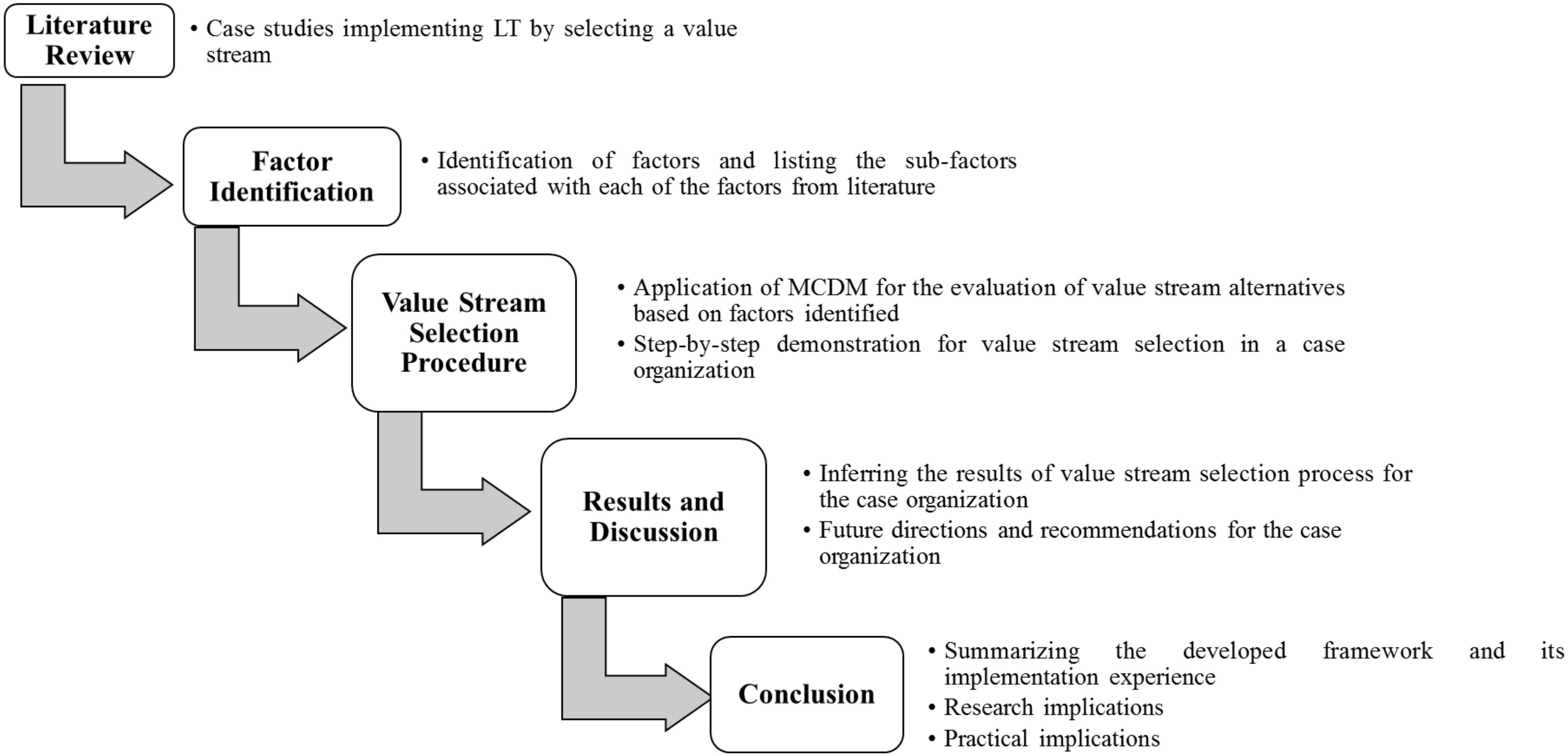


Figure 1: Procedure adopted in this study

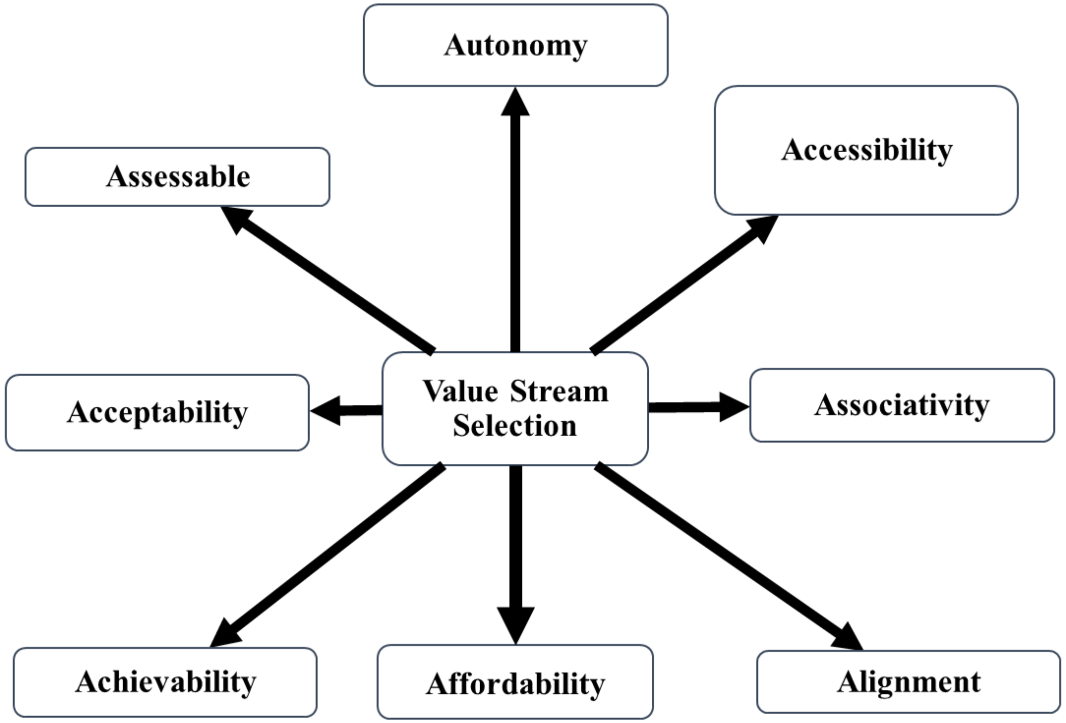


Figure 2: 8A Framework for process selection

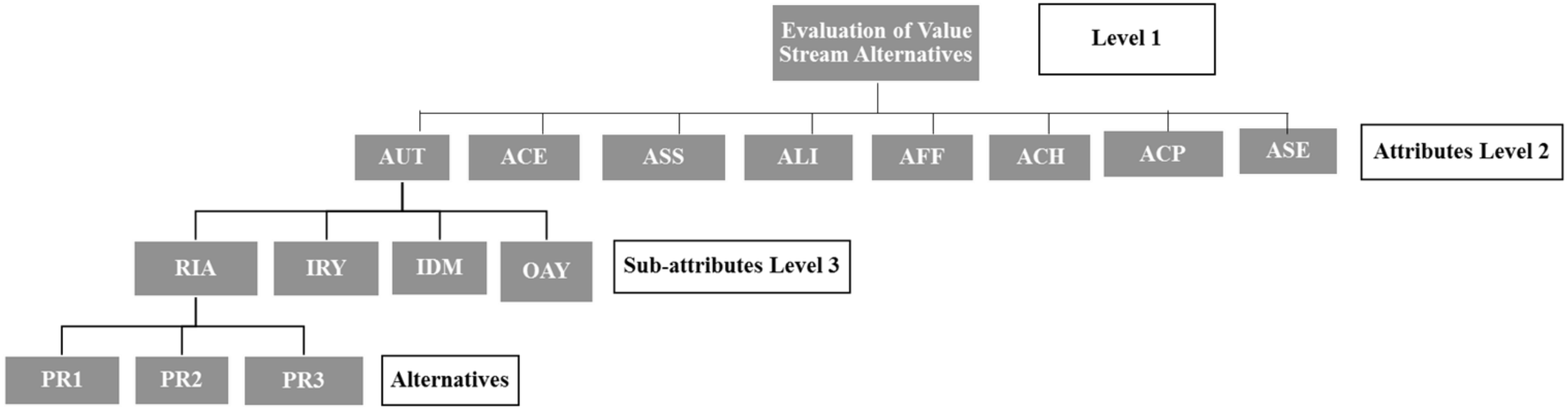


Figure 3: Schematic of AHP model for value stream selection to implement LT

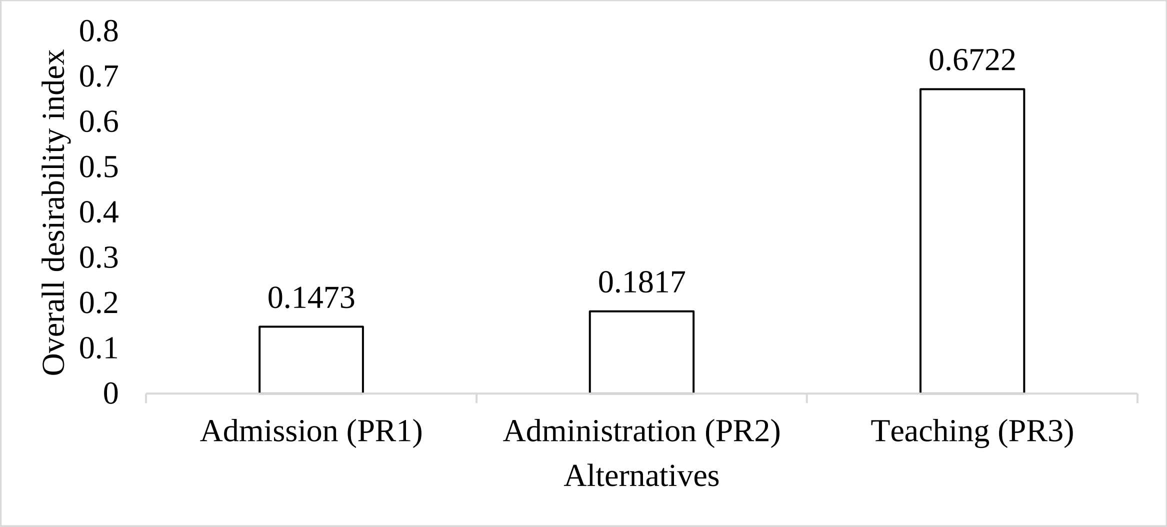


Figure 4: Overall desirability index for three alternatives

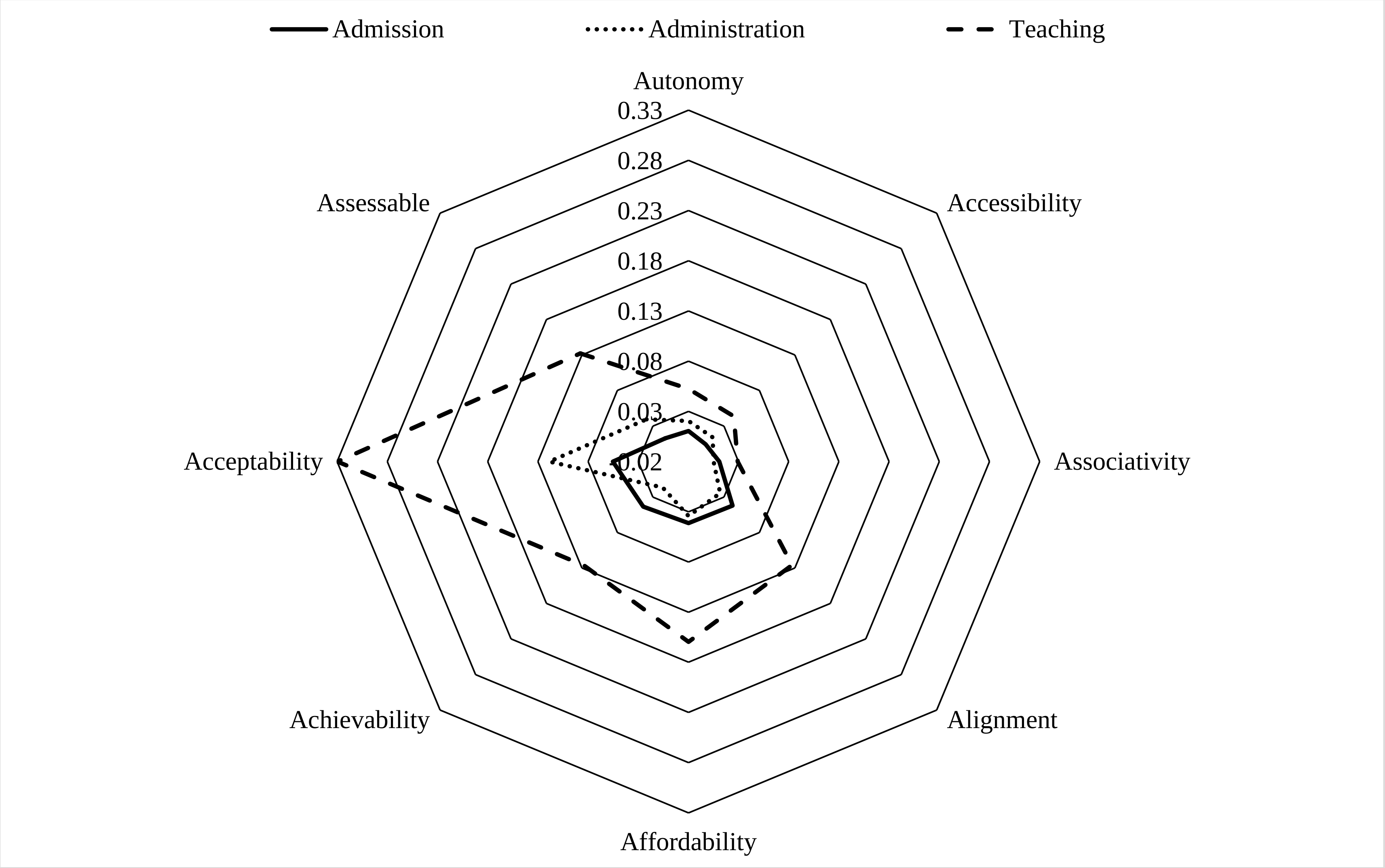


Figure 5: Performance of three alternatives across the factors of 8A framework

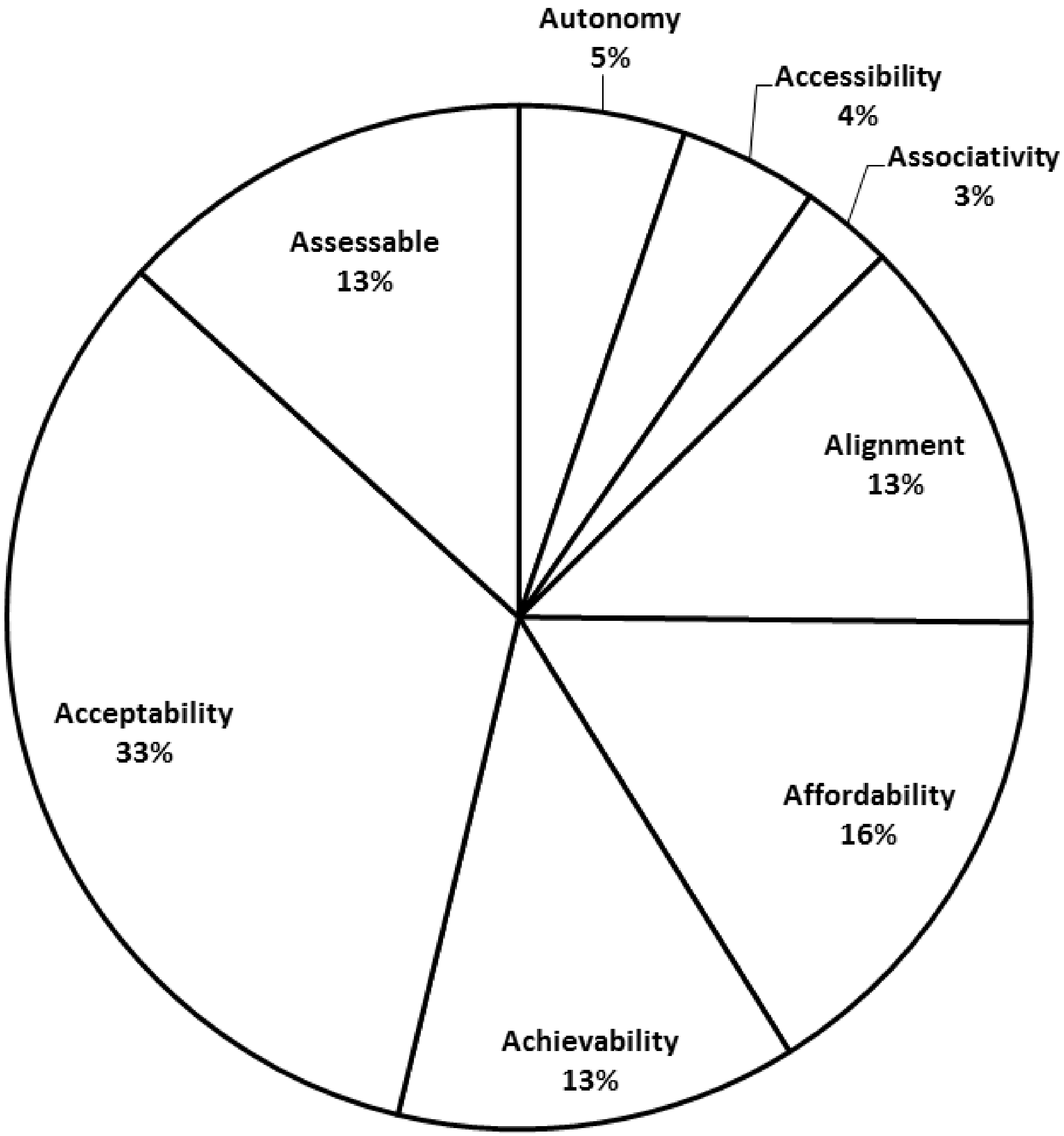
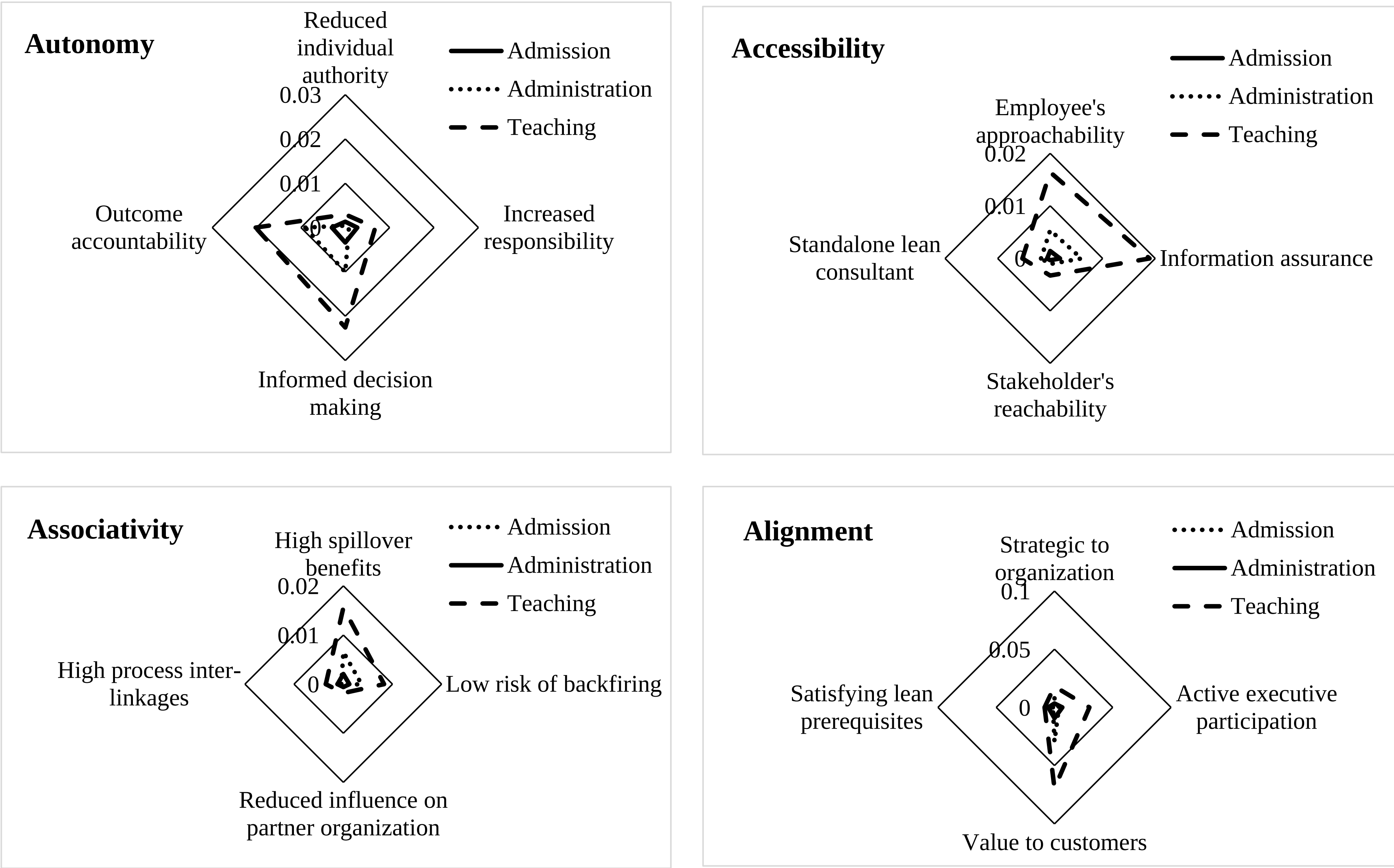


Figure 6: Weights of factors in 8A framework



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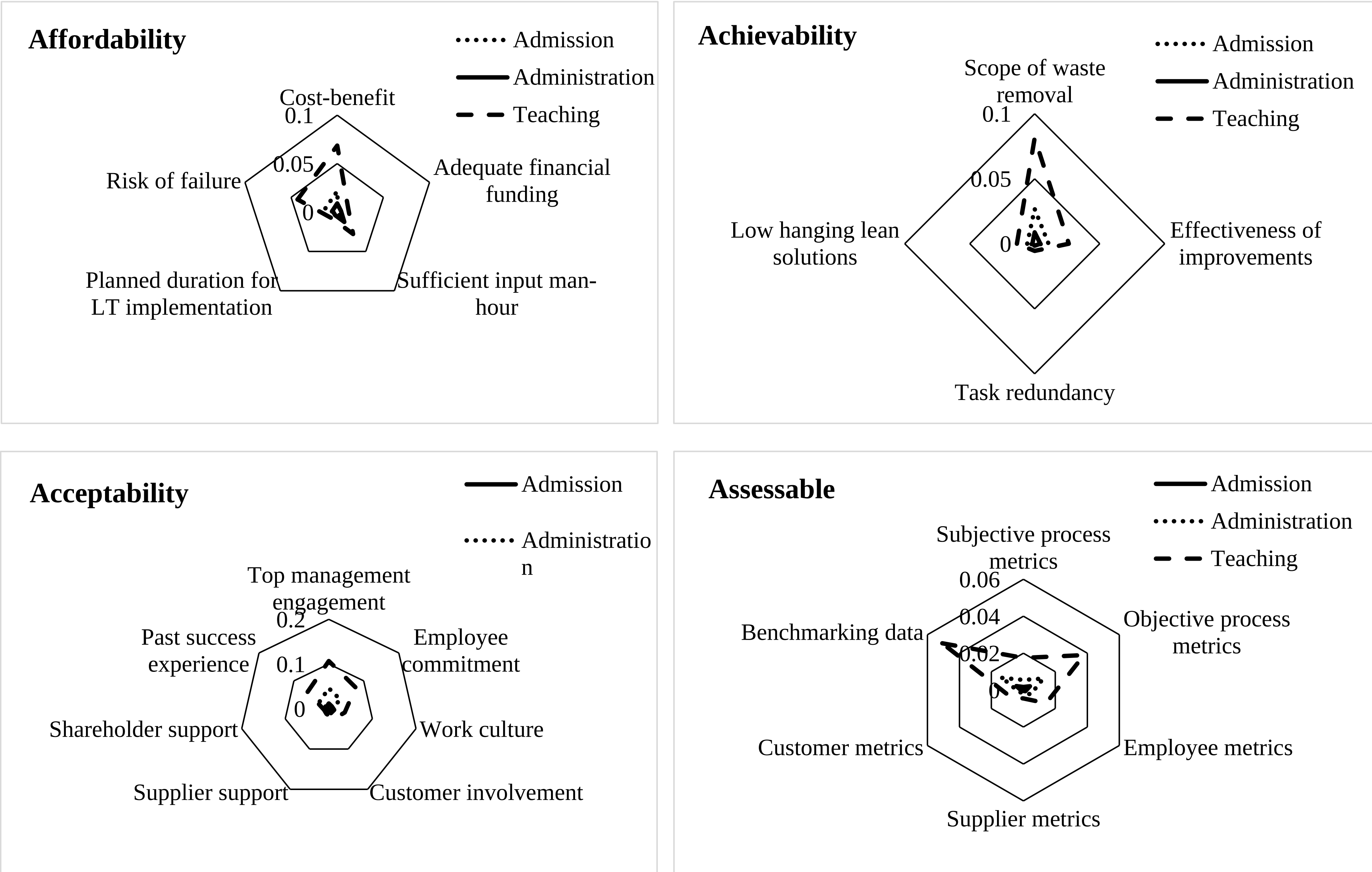

Figure 7: Performance of alternatives across the sub-factors within the factors of 8A framework

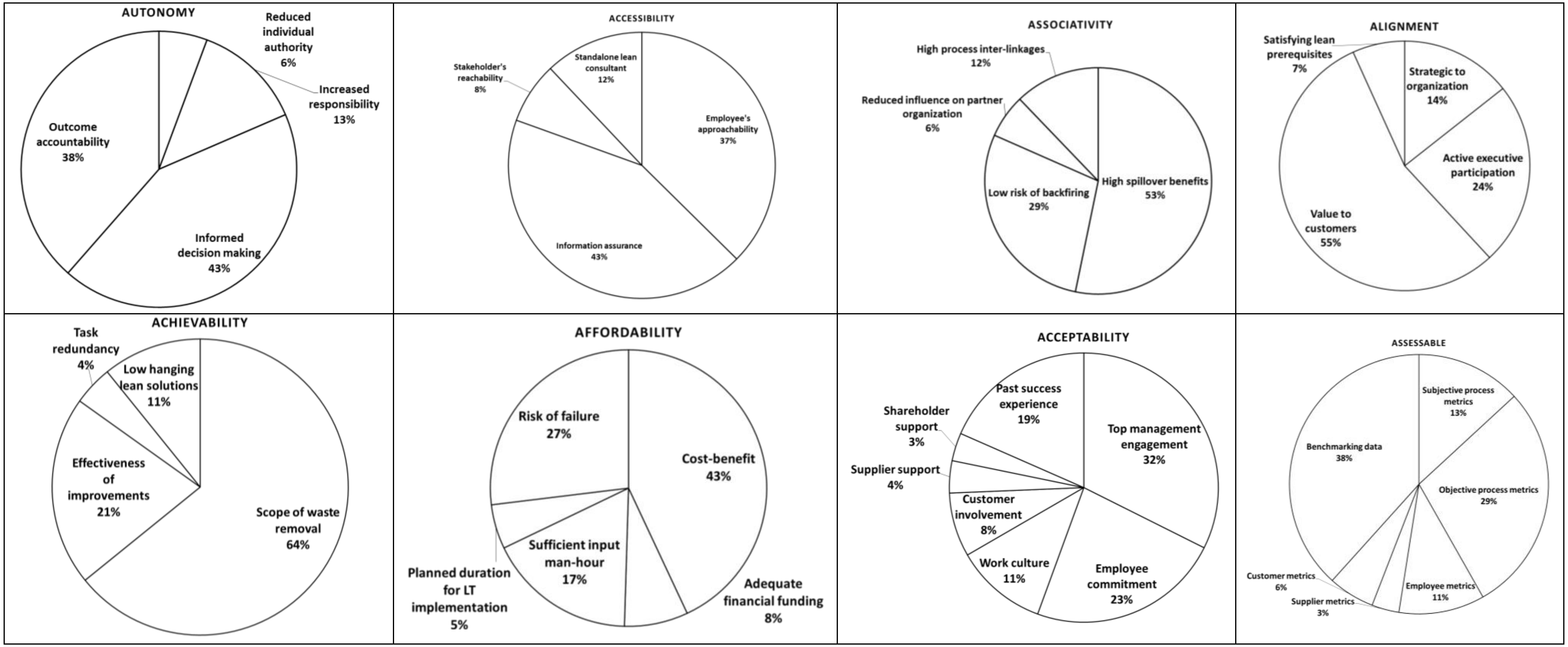

Figure 8: Weights of sub-factors within each factors of the 8A framework

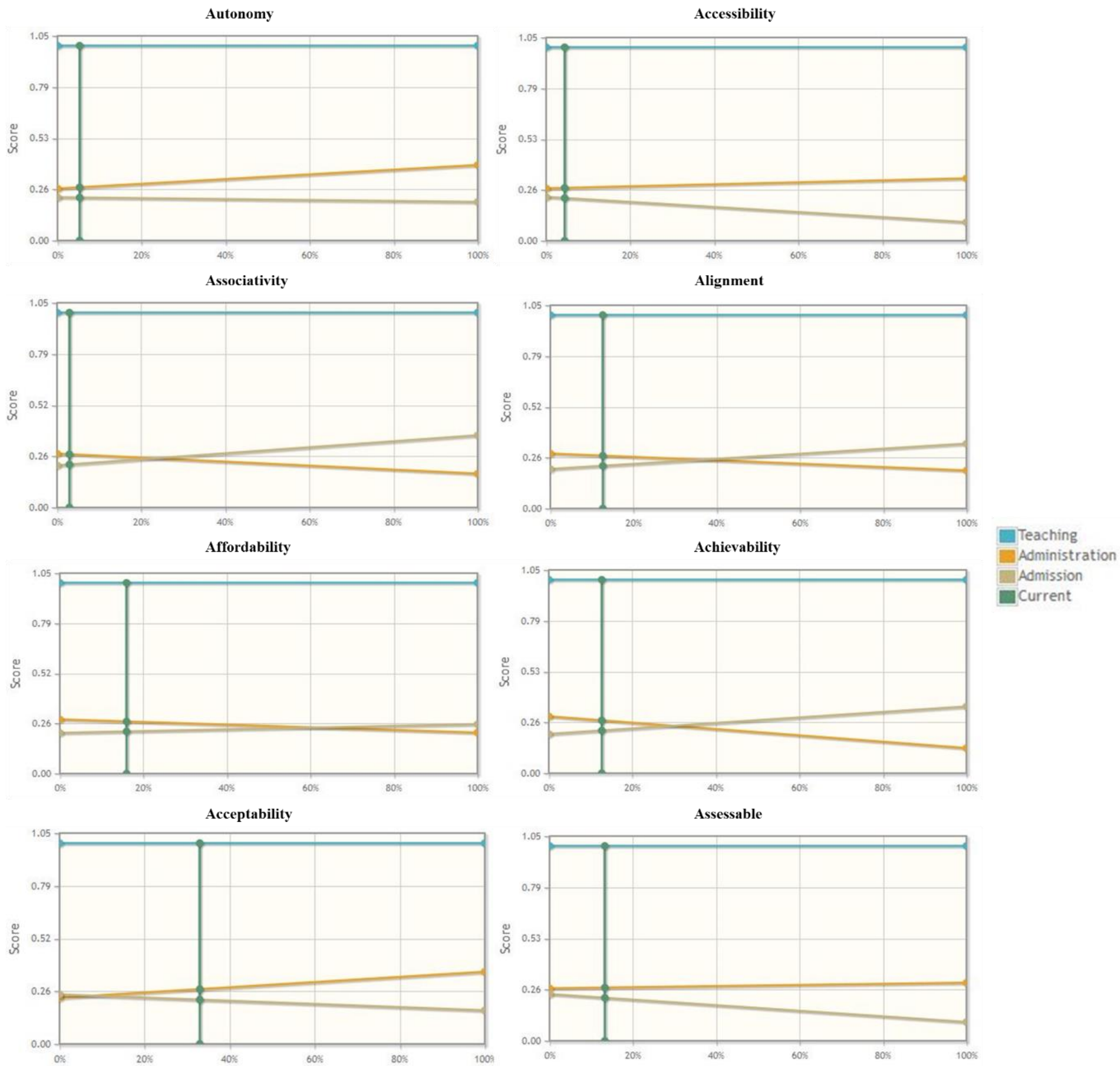

Figure 9: Sensitivity analysis of the alternatives across the factors of 8A framework

Tables

Table 1: Literature of case studies on LT implementation

Reference	Industry Type	Insights
Bamber and Dale (2000)	Traditional aerospace manufacturing	Reported the findings of an application of lean production methods to a traditional aerospace manufacturing organization. Two main stumbling blocks to the application were identified to be the **redundancy programme and a lack of employee education** in the concept and principles of lean production.
Detty and Yingling (2000)	Electronics	Study **quantifies** the lean thinking impact on the total system. Decision to implement lean manufacturing is seen to be a difficult one as the process being transformed needs to undergo huge changes in **employee management, plant layout, material and information flow and production scheduling/control methods**. Decision to adopt lean manufacturing techniques are based on the **past experiences of others who have previously adopted lean and anticipated benefits in future**.
Crute et al. (2003)	Aerospace component suppliers	Listed the factors affecting the lean implementation as **change strategies, effects of company culture, product focus, senior management commitment and consistency of focus, and time and space for performance improvement**. Study concluded that difficulties that arise in lean implementation had more to do with individual plant context and management than with the entire sector specific factors.
Motwani (2003)	Automotive components	Critical factors involved in the implementation were identified to be **strategic initiative** where **top managers act as leaders** in defining and communicating a **vision of change, an organizational environment willingness to learn, culture readiness, information technology leveragability and knowledge-sharing capability, balanced network relationships, change management practices, and process management practices**.
Abdulmalek and Rajgopal (2007)	Steel	Outcome was contrasting the "before" and "after" scenarios, thereby focussing to **capture the amount of improvement** attained. **Benefits were measured** through reduced production lead-time and lower work-in-process inventory. Focus in this study was on the value stream of one product family, namely annealed products. But, no explanation was provided on how this particular value stream was selected. **Data metrics on the processes involved in the value stream** were collected before and after improvement to conduct **assessment**. **Availability of the information** on the process is mentioned to facilitate and validate the decision to implement lean manufacturing.

Reference	Industry Type	Insights
Lee and Jo (2007)	Automotive industry	Successful LT implementation is dependent upon several organizational/internal factors at recipient sites, like **long-term management strategies, labour-management cooperation, employee and union involvement, open communication, corporate history, pre-existing interpretative mechanism of production technology, level of worker skills, and investments in training**. Some of the external factors are **market situations, international division of labour, local institutional environment, work norms, supply chain structure and social culture**.
Sahoo et al. (2008)	Forging	Addressed the implementation of lean philosophy in a forging company with a focus on radial forging production flow lines by taking a systematic approach using value stream mapping (VSM). **Reduction in set-up time** and **work-in-process (WIP) inventory level** were observed through the **assessment**.
Doman (2011)	Education	**Students work as a team** to identify waste and redesign the **university's grade change administrative process**. Grade change process was chosen as the internal audit noted the process to have huge **inefficiencies** and **bureaucracies. Budget constraint, competition, waste elimination, and advancing the university's academic mission** were some other motivators.
Liker and Morgan (2011)	Body and Stamping Development at Ford	Lean transformation was focussed on the stamped and welded steel structures of the underbody, upper body, and closures of Ford Motor Company. Reason for choosing this product family is because it is on the **critical path of all new vehicle programs** in the auto industry and historically a **major bottleneck** to launching new models on time, at targeted cost, with high quality. **People interest** was developed by **tying transformation with performance appraisals**.
Pool et al. (2011)	Coffee	Studies the impact of principles of **'flow' and 'pull'** production on semi-process industry by introducing cyclic schedules. Reasons for pursuing lean implementation are capability to **achieve improvements in the underlying shop floor operations, perceived potential for a higher performance on customer service, and low efficiency of its planning procedures and organization**.
Bo & Dong (2012)	Chinese enterprise	Discusses a set of steps for Chinese enterprises to realize lean value stream to **reduce costs, increase efficiency and improve product quality**. The initial step is to select a product family. When selecting the product family, the VSM team should take following factors into account: **size of the product line and share of the business, contribution to the net profit, criticality for the business, market position, technology outlook and potential for gainful growth.**

Reference	Industry Type	Insights
Bortolotti and Romano (2012)	Italian banking service	Lean management is applied to streamline delivery process by focussing on activities in the bank counters, back office and private credit offices. Some of the implicit reasons considered for choosing delivery process were **opportunity to listen to the voice of the customer, and to devise metrics based on customers wants to assist in attaining the objective of customer satisfaction**. Problems motivated for choice of this process were **high customers waiting time**, **high variability and low standardisation of procedures, frequent data entry errors, unnecessary movement of workers due to a wrong layout design, workers spent much time reworking documents, and lack of communication** between different offices that produced misalignments in procedures and difficulties in detecting errors. Benefits attained were reduction of the operational costs, decrease total lead times of the three processes and improve the customer satisfaction in terms of a reduction of customer complaints and a better perception of the service quality.
Jaca et al. (2012)	Distribution company that specialises in food distribution	Reason for choosing distribution process were **growing competition in the market**. **Top management** recognizing the need for change in the organisation. In the case company, the warehouse managers, the human resources department and the methods department were **convinced about the need for the change**. **Improvement committee** comprising of the warehouse manager, the human resources manager, the methods department technician and the person in charge of warehouse activities was set up. **Improvement opportunities were identified** in warehouse processes, order preparation, storage location, warehouse cleanliness, or reduction of maintenance costs. Improvement opportunities that were most **feasible in terms of time, cost and impact to warehouse management** were only selected. **Primary issue of resistance** of certain warehouse employees were removed by discussing with them the objective of the initiative.
Middleton and Joyce (2012)	BBC Worldwide, London.	Examined how the lean ideas behind the Toyota production system can be applied to software project management by investigating the **performance of a nine-person software development team** employed by BBC Worldwide based in London. Software development process was chosen as application of lean ideas was found to **improve its capability**. User requirements, likely patterns of use, and technology performance was **unclear** which demanded an lean alternative to have a fast process that produces software deliverables quickly to respond. In addition, this process was found to have **more WIP and more bottlenecks** than previously expected.

Reference	Industry Type	Insights
Radnor et al. (2012)	Healthcare	Reported the implementation of Lean in hospitals and showed that **application of specific lean tools tends to produce small-scale and localised productivity gains**. Case studies were implementing LT to **achieve efficiency** or to **gain foundation Trust status**. **Internal team** and **external consultants** were found to help in implementing LT and **overcome professional resistance to management change**. Staff members view Lean as a tool focusing on 'muda', i.e. **waste reduction** only, and neglect the wider aspects of 'mura' and 'muri', namely the **management of demand and capacity**, as well as the **creation of an efficient and safe workplace**.
Crespo de Carvalho et al. (2014)	Healthcare	Processes associated with operating rooms and emergency services were chosen as these operations and processes had **significant value addition from patients' perspective**.
Vlachos (2015)	Tea	Examines the adoption and implementation of LT in a food company. Characteristics looked into in the process of lean implementation were the following: **finding a change agent, getting the knowledge, finding a lever and suspend grand strategy, top management support, expert knowledge, operational easiness, redefining value, and detecting waste**.
Gupta et al. (2017)	Tyre manufacturing	Investigates the processes and the associated wastes of a radial tyre manufacturing unit in India using system dynamics modeling. Key factors considered in the study were **scope for waste reduction, level of employee skills, manpower availability, and machine availability.**

*Highlighted text indicates the qualifiers considered in the model proposed for process selection

Table 2: LT implementation case studies literature on 8A factors identified

Reference	Autonomy	Accessibility	Associativity	Alignment	Affordability	Achievability	Acceptability	Assessable
Bamber and Dale (2000)	✓						✓	✓
Detty and Yingling (2000)			✓		✓	✓	✓	✓
Crute et al. (2003)	✓	✓		✓	✓	✓	✓	✓
Motwani (2003)	✓			✓	✓		✓	✓
Abdulmalek and Rajgopal (2007)		✓	✓			✓		✓
Lee and Jo (2007)			✓				✓	✓
Sahoo et al. (2008)	✓			✓		✓		✓
Doman (2011)	✓	✓	✓			✓		✓
Liker and Morgan (2011)			✓	✓			✓	✓
Pool et al. (2011)		✓		✓	✓	✓		
Bo & Dong (2012)		✓	✓	✓	✓	✓		✓
Bortolotti and Romano (2012)				✓	✓	✓	✓	✓
Jaca et al. (2012)	✓	✓	✓	✓	✓	✓	✓	✓
Middleton and Joyce (2012)			✓		✓	✓	✓	✓
Radnor et al. (2012)		✓	✓	✓		✓	✓	✓
Crespo de Carvalho et al. (2014)			✓	✓		✓		
Vlachos (2015)	✓	✓		✓		✓	✓	✓
Gupta et al. (2017)		✓	✓		✓	✓		✓

Table 3: Description of factors in 8A Framework

Factor	Description
Autonomy (AUT)	Autonomy here refers to the freedom for employees associated with a value stream in implementing LT without hindrance.
Accessibility (ACE)	Value stream to be selected for lean implementation needs to be owned by the organization with complete accessibility for easier control and change.
Associativity (ASS)	Associativity of a value stream factor captures the impact that a lean solution implemented on a value stream has on other value streams in the organization. Associativity attempts to understand and encapsulate the relationship and inter-linkages between different value streams.
Alignment (ALI)	Alignment of the value stream indicates how much important the current value stream is for the organization in achieving its mission and vision. Alignment captures the tenant proposed by Womack and Jones (2009) (i.e. "identifying value" for implementing LT).
Affordability (AFF)	Affordability captures the feasibility of LT implementation by evaluating the requirements of resources (both financial and human resources).
Achievability (ACH)	Achievability denotes the scope for implementing LT solutions in that value steam. Achievability captures the amount of non-value adding activity prevailing in the value stream which when reduced could provide enormous benefits to the organization.
Acceptability (ACP)	Acceptability captures the involvement of employees, top management, and customers in a value stream. Acceptability ensures the involvement and commitment of all employees at different hierarchy levels for implementing LT.
Assessable (ASE)	Assessable factor of a value stream denotes the feasibility to quantify the improvements before and after implementation of LT.

Table 4: Sub-factors of identified 8A factors

1) Autonomy (AUT)	**2) Accessibility (ACE)**	**3) Associativity (ASS)**	**4) Alignment (ALI)**
a) Reduced individual authority (RIA) b) Increased responsibility (IRY) c) Informed decision making (IDM), and d) Outcome accountability (OAY)	a) Employee's approachability (EAY) b) Information assurance (IAE) c) Stakeholder's reachability (STR), and d) Standalone lean consultant (SLC)	a) High spillover benefits (HSB) b) Low risk of backfiring (LRB) c) Reduced influence on partner organization (RIP), and d) High process inter-linkages (HPI)	a) Strategic to organization (STO), b) Active executive participation (AEP), c) Value to customers (VTC), and d) Satisfying lean prerequisites (SLP)
5) Affordability (AFF)	**6) Achievability (ACH)**	**7) Acceptability (ACP)**	**8) Assessable (ASE)**
a) Cost- benefit (COB) b) Adequate financial support (AFS) c) Sufficient input man-hour (SIM) d) Planned duration for LT implementation (PLT), and e) Risk of failure (ROF)	a) Scope of waste removal (SWR) b) Effectiveness of improvements (EOI) c) Task redundancy (TRY), and d) Low hanging lean solutions (LHL)	a) Top management engagement (TME) b) Employee commitment (ECT) c) Work culture (WCE) d) Customer involvement (CIT) e) Supplier support (SST), f) Shareholder support (SHS), and g) Past success experience (PSE)	a) Subjective process metrics (SPM) b) Objective process metrics (OPM) c) Employee metrics (EMS), d) Supplier metrics (SMS), e) Customer metrics (CMS), and f) Benchmarking data (BMD)

Table 5: Pair-wise comparison matrix of the factors – level 2

Factors	AUT	ACE	ASS	ALI	AFF	ACH	ACP	ASE	Principle Vector	Rank
AUT	1	2	4	0.25	0.33	0.2	0.2	0.25	0.053	6
ACE	0.5	1	3	0.17	0.33	0.33	0.25	0.25	0.044	7
ASS	0.25	0.33	1	0.2	0.25	0.5	0.125	0.25	0.029	8
ALI	4	6	5	1	0.5	0.5	0.5	0.5	0.126	5
AFF	3	3	4	2	1	2	0.25	2	0.160	2
ACH	5	3	2	2	0.5	1	0.25	1	0.127	4
ACP	5	4	8	2	4	4	1	4	0.330	1
ASE	4	4	4	2	0.5	1	0.25	1	0.132	3
Sum	22.75	23.33	31	9.62	7.41	9.53	2.825	9.25	1	

Table 6: Inconsistency ratios of all first 3 levels in AHP hierarchy

Level	Criterion	Inconsistency ratios
1	Value stream selection for lean implementation	9%
2	Acceptability	8%
2	Accessibility	9%
2	Achievability	9%
2	Affordability	8%
2	Alignment	9%
2	Assessable	9%
2	Associativity	8%
2	Autonomy	7%
3	Active executive participation	1%
3	Adequate financial support	9%
3	Benchmarking data	7%
3	Cost-benefit	5%
3	Customer involvement	6%
3	Customer metrics	5%
3	Effectiveness of improvements	4%
3	Employee commitment	6%
3	Employee metrics	7%
3	Employee's approachability	7%
3	High process inter-linkages	7%
3	High spillover benefits	5%
3	Increased responsibility	3%
3	Information assurance	5%
3	Informed decision making	8%
3	Low hanging lean solutions	5%
3	Low risk of backfiring	8%
3	Objective process metrics	7%
3	Outcome accountability	8%
3	Past success experience	6%
3	Planned duration for LT implementation	7%
3	Reduced individual authority	8%
3	Reduced influence on partner organization	7%
3	Risk of failure	3%
3	Satisfying lean prerequisites	5%
3	Scope of waste removal	7%
3	Shareholder support	7%
3	Stakeholder's reachability	7%
3	Standalone lean consultant	7%
3	Strategic to organization	7%
3	Subjective process metrics	5%
3	Sufficient input man-hour	8%
3	Supplier metrics	7%
3	Supplier support	7%
3	Task redundancy	9%
3	Top management engagement	6%
3	Value to customers	5%
3	Work culture	8%

Table 7: Sub-factor analysis under the main factor ‘Autonomy (AUT)’ – level 3

Sub-factors	RIA	IRY	IDM	OAY	Principal Vector	Rank
RIA	1	0.25	0.17	0.2	0.057	4
IRY	4	1	0.2	0.25	0.129	3
IDM	6	5	1	1	0.430	1
OAY	5	4	1	1	0.385	2
Sum	16	10.25	2.37	2.45	1	

Table 8: Alternative analysis for the sub-factor ‘High process inter-linkages (HPI)’

Alternatives	PR1	PR2	PR3	Alternative Analysis	Alternative Analysis (Standardized)	Rank
PR1	1	4	0.25	0.0004	0.075	3
PR2	0.25	1	0.14	0.0012	0.229	2
PR3	4	7	1	0.0036	0.696	1
SUM	5.25	12	1.39	0.0052	1	

Table 9: Desirability index evaluation

PVs for Main-factors	Sub-Factors Abbreviation	PVs for Sub-factors	Alternatives Analysis			Desirability index for alternatives		
L2-Wt		**L3-Wt**	**PR1**	**PR2**	**PR3**	**PR1**	**PR2**	**PR3**
AUT = 0.053	RIA	0.057	0.280	0.094	0.627	0.0008	0.0003	0.0019
	IRY	0.128	0.263	0.079	0.659	0.0018	0.0005	0.0045
	IDM	0.430	0.094	0.280	0.627	0.0021	0.0064	0.0143
	OAY	0.385	0.094	0.280	0.627	0.0019	0.0057	0.0128
ACE = 0.044	EAY	0.374	0.060	0.231	0.708	0.0010	0.0038	0.0117
	IAE	0.431	0.070	0.223	0.707	0.0013	0.0042	0.0134
	STR	0.075	0.075	0.229	0.696	0.0002	0.0008	0.0023
	SLC	0.120	0.075	0.229	0.696	0.0004	0.0012	0.0037
ASS = 0.029	HSB	0.532	0.271	0.085	0.644	0.0042	0.0013	0.0099
	LRB	0.284	0.280	0.094	0.627	0.0023	0.0008	0.0052
	RIP	0.062	0.075	0.229	0.696	0.0001	0.0004	0.0013
	HPI	0.122	0.075	0.229	0.696	0.0003	0.0008	0.0025
ALI = 0.126	STO	0.144	0.268	0.117	0.614	0.0049	0.0021	0.0111
	AEP	0.238	0.094	0.167	0.740	0.0028	0.0050	0.0222
	VTC	0.551	0.271	0.085	0.644	0.0188	0.0059	0.0447
	SLP	0.068	0.089	0.352	0.559	0.0008	0.0030	0.0048
AFF = 0.16	COB	0.430	0.218	0.091	0.691	0.0150	0.0063	0.0475
	AFS	0.074	0.064	0.237	0.699	0.0008	0.0028	0.0083
	SIM	0.174	0.094	0.280	0.627	0.0026	0.0078	0.0174
	PLT	0.052	0.117	0.268	0.614	0.0010	0.0022	0.0051
	ROF	0.269	0.211	0.084	0.705	0.0091	0.0036	0.0303
ACH = 0.127	SWR	0.642	0.229	0.075	0.696	0.0187	0.0062	0.0567
	EOI	0.207	0.258	0.105	0.637	0.0068	0.0028	0.0167
	TRY	0.043	0.068	0.199	0.733	0.0004	0.0011	0.0040
	LHL	0.108	0.271	0.085	0.644	0.0037	0.0012	0.0088
ACP = 0.33	TME	0.324	0.072	0.279	0.649	0.0077	0.0298	0.0694
	ECT	0.232	0.072	0.279	0.649	0.0055	0.0214	0.0497
	WCE	0.111	0.226	0.101	0.674	0.0083	0.0037	0.0247
	CIT	0.077	0.279	0.072	0.649	0.0071	0.0018	0.0165
	SST	0.039	0.075	0.229	0.696	0.0010	0.0029	0.0090
	SHS	0.034	0.229	0.075	0.696	0.0026	0.0008	0.0078
	PSE	0.184	0.072	0.279	0.649	0.0044	0.0169	0.0394
ASE = 0.132	SPM	0.131	0.070	0.223	0.707	0.0012	0.0039	0.0122
	OPM	0.286	0.075	0.229	0.696	0.0028	0.0086	0.0263
	EMS	0.107	0.060	0.231	0.708	0.0009	0.0033	0.0100
	SMS	0.034	0.063	0.194	0.743	0.0003	0.0009	0.0033
	CMS	0.058	0.091	0.218	0.691	0.0007	0.0017	0.0053
	BMD	0.383	0.063	0.194	0.743	0.0032	0.0098	0.0375
Overall desirability index						0.1473	0.1817	0.6722
Rank based on desirability index						3	2	1

Author’s Biography

Gopalakrishnan Narayanamurthy is Postdoctoral Research Fellow at the University of St Gallen, Switzerland. He is also Visiting Faculty at LM Thapar School of Management, India. He completed his doctoral studies from the Indian Institute of Management Kozhikode, India. During his doctoral studies, he has been a Fulbright-Nehru Doctoral Research Fellow at Carlson School of Management, University of Minnesota. His research is in the area of healthcare operations management, process improvement, and sharing economy. His research has been accepted for publication in Journal of Service Research, International Journal of Operations and Production Management, International Journal of Production Economics, and Computers & Operations Research among others.

Anand Gurumurthy is Associate Professor in the area of “Quantitative Methods and Operations Management (QM&OM)” at the Indian Institute of Management, Kozhikode (IIMK), Kerala, India. Prior to this appointment, he was Assistant Professor with the Mechanical Engineering Department of Birla Institute of Technology and Science (BITS) Pilani, Pilani Campus, Rajasthan, India, where he also completed his PhD Degree in the area of Lean Manufacturing and ME Degree in Manufacturing Systems Engineering. He received his BE Degree in Mechanical Engineering from the University of Madras, India. He has around 14 years of teaching/research experience. He started his career as a Production Engineer with one of India’s leading industrial houses—the TVS Group. He has published around 50 papers in peer-reviewed national and international journals such as International Journal of Operations and Production Management, International Journal of Production Research, International Journal of Production Economics, Production Planning and Control, Journal of Manufacturing Technology Management, etc. He has also presented many papers in various national/international conferences. His current research interests include the application of lean thinking in service sectors, humanitarian supply chain management and unique applications of multi-criteria decision-making models.

Dr Roger Moser is Assistant Professor of International Management with a focus on India and Director of the ASIA CONNECT Center at the University of St Gallen, Switzerland. Dr Moser is also Adjunct Faculty of Business Policy and Strategy at the Indian Institute of Management Udaipur. His research focuses on global sourcing, access-based infrastructure solutions in rural and semiurban India as well as market entry and expansion strategies in Asia. He has published in Journal of Operations Management, Journal of Service Research, Journal of Supply Chain Management, Journal of Business Research, Technological Forecasting and Social Change, International Journal of Production Economics, European Journal of Operational Research, among others.