

Lean Target Adjustment Aligned with System Strategy Using

PROMTHEE-II

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Abstract

In this paper a leanness target adjustment method presented to find the best lean target plan after every leanness assessment process to avoid delayed rewarding and deviation from system strategies. The method is based on PROMETHEE II, and a case study is presented to illustrate the method.

Keywords

Lean, Target adjustment, PROMETHEE II, Multi Criteria Decision Making (MCDM)

1. INTRODUCTION

In most projects, not only there is a gap between planned progress and reality, but also the gap increases as time passes. However, this should not be true with “lean”, because lean is not a project; it’s a “continuous challenge”. The lean plan and targets should be updated continuously; otherwise, the motivation and enthusiasm of people fade due to the frustration caused by not meeting the target continuously. Furthermore, 50-70% of system improvement efforts fail due to several reasons, the main reason being strategy [1], which shows the importance of setting system strategy and avoid deviation from it.

The fundamental idea of lean is to maximize the product/service value from the customer perspective by minimizing waste through a continuous work flow. Recognizing that lean is a competitive advantage; many manufacturing and non-manufacturing companies consider it as their main strategy toward improvement. But not all are successful in their journey to lean. Because lean it is not achievable through one big step or simply by assigning a project, it is a “continuous challenge” which needs everyone`s involvement, especially management. Hence, this paper is devoted to facilitate management involvement in the lean process. It is necessary for a manager to understand lean and its steps from his/her own perspective thoroughly. From a management point of view, lean planning and control happens in two phases. Phase 1 is to plan and phase 2 is to control and adjust the plan. Phase one must be implemented at the beginning of the lean process and has the following steps:

- Identifying the system real status with respect to lean
- Providing a long term comprehensive lean plan to be implemented in time horizon T
- Preparing lean short term targets
- Identifying the proper measure and method for leanness assessment at each period

These three steps must be followed by control and adjustment phase steps at the end of each period. These steps are:

- Measuring the system leanness status
- Comparing the system real and planned lean status
- Adjusting the next period targets based on the system real achievement and initial plan in line with the lean strategies

In phase one, it is necessary to have a clear vision of the system constraints, and real status to map the lean comprehensive plan accordingly. Besides the comprehensive plan, a short term plan is also inevitable; as lean is

usually achievable through accomplishing the several short term targets. Moreover, a leanness measurement system is essential to evaluate leanness through a proper set of metrics; otherwise, it is not possible to evaluate the system performance and set the future targets. In general, hypothesis testing, data envelopment analysis (DEA), structural equation model and hypothesized model, mathematical modeling, weighted mean, fuzzy logic, balance score card (BSC) and analytical hierarchy process (AHP) are methods developed for performance measurement in the literature (2). However, there are not many papers in the literature investigating a leanness measurement specifically. In the most recent work by Vinodh and Chintha (3) a multi-grade fuzzy approach is presented to measure the system leanness based on a three-level taxonomy of lean initiatives as the conceptual framework. The initiatives are called enablers in the first level, criteria in the second level and attributes in the third level. Then, five experts are asked to grade the leanness attributes and define their associated weights. The grades (between 0-10) involve fuzzy definitions and a higher grade represents a better level of lean. Then, the leanness index is calculated using the grades and weights. Vinodh and Balaji (4), based on the same framework of lean metrics developed a decision support system to facilitate the computational efforts.

After phase one which must be implemented at the beginning of the lean journey, it is necessary to evaluate the system at the end of each period and compare the actual and planned lean status to “not lose sight of the goal”. Here is when some important questions are raised in which the answers play important roles in a company's successful experience of lean implementation. For instance, if the company is behind the lean schedule, management might ask: what should be the next period lean target? Is it necessary to provide a compensatory plan for the next period? Or should the company stick to the initial plan? Or generally, what would be the next step according to the system strategy and real information obtained from the assessment? These questions arise because the leanness assessment just provides information about “how lean the system is” and not “how lean the system should be”. Hence, this paper presents a method for continuous tracking of the system leanness and adjusting the future plan based on the real system status. The only work in literature investigated lean target identification is presented by Wan (5). In this work a leanness assessment and target identification method developed applying data envelop analysis (DEA). The proposed method provides an index which lets management know if the system is lean enough or should be leaner to be comparative. Thus, it doesn't provide the lean target scenario to be the next period goal.

In this paper, the objective is to find the best leanness target plan among a set of available scenarios applying PROMETHEE II. This method was first developed by J.P. Brans (6). Then, R. Nadeau, and M. Landary proposed the method for the first time at the University of Laval, Quebec, Canada, 1982 (7). Since then several PROMETHEE methods (III, IV, V, and VI) have been developed and applied in many areas such as health care, water resourcing and etc. The selection method based on PROMETHEE II is an interactive process for finding the best plan among the positional plans. The order-winning property of this method is the ability of contributing decision maker preferences in the decision making process, through a set of functions, called preference functions. The preference functions and their characteristics can be defined based on the system strategies toward lean, the actual level of lean, comprehensive lean plan and also a compensatory plan if applicable. The method helps companies and organizations establish an easy tracking methods in their efforts toward lean and perfection.

In section 2 of this paper explanation of PROMETHEE II with more details is provided. Section 3 describes the method proposed to evaluate and find the system lean status. In section 4 an illustrative case study is provided. Finally, section 5 presents the summary of the presented method, conclusion and future research.

2. PROMETHEE II METHOD

This section provides a brief explanation of PROMETHEE II method which is a Multi-Criteria Decision Making tool (MCDM). It targets the problems of $\max \{g_1(a), g_2(a), \dots, g_k(a) \mid a \in A\}$, where A is the alternatives set and $\{g_1(\cdot), g_2(\cdot), \dots, g_k(\cdot)\}$ is the evaluation set of criteria. The criteria can also have weights assigned to them $\{w_1, w_2, \dots, w_k \mid \sum_1^k w = 1\}$. The weights are to reflect the hidden relative importance of criteria in the decision-makers eyes. The main objective is then to find the best alternative. An example of the evaluation table which is the PROMETHEE II input is shown in Table 1(6).

TABLE 1
PROMETHEE II Evaluation (6)

	$g_1(\cdot)$	$g_2(\cdot)$	\dots	$g_j(\cdot)$	\dots	$g_k(\cdot)$
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	w_1	w_1	...	w_1	...	w_1
a_1	$g_1(a_1)$	$g_2(a_1)$...	$g_j(a_1)$...	$g_k(a_1)$
a_2	$g_1(a_2)$	$g_2(a_2)$...	$g_j(a_2)$...	$g_k(a_2)$
a_i	$g_1(a_i)$	$g_2(a_i)$...	$g_j(a_i)$...	$g_k(a_i)$
a_n	$g_1(a_n)$	$g_2(a_n)$...	$g_j(a_n)$...	$g_k(a_n)$

The PROMTHEE II decision making method is based on the difference between alternatives at each criterion defined by equation 1.

$$d_j(a, b) = g_j(a) - g_j(b) \quad \forall a, b \in A, \forall j \in K \quad (1)$$

As Brans and Mareschal (7) discussed, the preference function is a function of the difference within criteria expressed as equation 2

$$P_j(a, b) = F_j[d_j(a, b)] \quad \forall a, b \in A, \forall j \in K \quad (2)$$

And for which

$$0 \leq P_j(a, b) \leq 1 \quad \forall a, b \in A, \forall j \in K \quad (3)$$

The preference function can be any function of d_j which can reflect the decision maker's preferences properly. However, one can choose the preference function from "generalized criterion" which is a set of standard predefined preference functions. For defining the preference functions based on distance it is necessary to define at least one out of three famous thresholds called "indifference threshold", "strict preference threshold", or an "intermediate value between indifference threshold and strict preference threshold". It depends on the decision maker or analyst to choose the best type of preference function and its related thresholds to reflect the system strategies properly. In the next section, an example of preference functions suitable for lean target selection is presented. For more information regarding the generalized criterion and preference function one can refer to (7).

After setting the preference function and its threshold, the degree to which, alternative a is preferred over b under criterion j and vice versa is presented in equation 4 and 5.

$$\pi(a, b) = \sum_{j=1}^k P_j(a, b)w_j \quad \forall a, b \in A, \forall j \in K \quad (4)$$

$$\pi(b, a) = \sum_{j=1}^k P_j(b, a)w_j \quad \forall a, b \in A, \forall j \in K \quad (5)$$

Furthermore, the degree by which an alternative is preferred over another alternative under all criteria, called “positive outranking flow”, and the reverse flow called “negative outranking flow” are presented in equations 6 and 7:

$$\phi^+(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a, x) \quad \forall a \in A \quad (6)$$

$$\phi^-(a) = \frac{1}{n-1} \sum_{x \in A} \pi(x, a) \quad \forall a \in A \quad (7)$$

And thus the “net flow” will be:

$$\phi(a) = \phi^+(a) - \phi^-(a) \quad \forall a \in A \quad (8)$$

The alternative with the highest net flow is the most preferred one. If two alternatives have the same net flow they are indifference which means neither of them is preferred over the other one and decision maker can pick either of them.

One of the main advantages of PROMTHEE II is that there is no incompatibility among the alternatives and the best alternative can be identified, which makes it possible to reflect the system strategies in decision-making process. In section 3, the adoption of PROMTHEE II for a leanness target assignment is presented.

3. PRESENTED METHOD

As discussed before, after each leanness assessment process, adjusting the next period’s leanness level based on current system status is necessary. In the literature of the leanness measurement, usually the system performance is graded against the ideal lean performance. This type of grading might not be the most efficient one since usually

leanness assessment is based on the descriptive data provided by the human brain. When people are asked to grade the system leanness in a broad range, the real score might be exaggerated, hence it is recommended to let people grade leanness by having more information in hand. For instance, people can grade the system leanness by having information about the last period's actual grades and the current period target. By having this information on hand, one might provide more realistic information to be the basis of the leanness assessment. Table 2 shows an example of such questionnaire for leanness assessment.

TABLE 2
Sample of Questionnaire for Leanness Assessment

Metrics	1	2	...	5
Last period actual lean index			...	
Target lean index for this period			...	
Your score of lean				

Also, an integrated lean index might give management general information about the leanness of the whole system. However, more information gets lost by integrating the grades obtained from different initiatives, and the integrated lean index can be more disputable. Furthermore, management might not have the same strategies for different lean initiatives. Thus, integrating the leanness indices may cause problems in target setting as well. In addition, sometimes efforts in some areas won't result in a leaner system unless some other areas reach a better level of lean i.e. there are inter-correlated initiatives. In this case, to correct the effect of unbalanced leanness achievement, management can assign smaller weights to the leaner criteria and larger weights to the criteria which have not achieved the desired level of lean. Such a strategy can also be reflected by defining a proper set of preference functions. Hence, it is important to keep being lean by being balanced which is not possible by calculating only a single integrated lean index. Therefore, it is recommended to use a leanness method which provides management with more information about the leanness of different initiatives.

In this paper the focus is on lean short term target adjustment and thus developing a leanness measurement system is not the primary interest of this paper. One can choose any of the existing methods in literature for leanness

assessment. However, it is strongly recommended to have a unique measurement system throughout the process unless the selected method doesn't properly reflect the system performance and it is necessary to be changed. In the case study provided in this paper the method presented by Vinodh et al. (3) is used with the difference that the grades involving fuzzy definition are between 1 and 100. More explanation about the method is provided in the case study.

Following are the notations used in this paper:

j : Index of leanness enablers, $j \in K = \{1, 2, \dots, k\}$,

I_k^t : Actual lean index of enabler k in period t

R_k^t : Target lean index of enabler k in period t according to the compensatory plan

G_k^t : Target lean index of enabler k in period t according to the comprehensive plan

A_k^t : Current status lean index of enabler k in time t based on compensatory plan

B_k^t : Current status lean index of enabler k in time t based on the comprehensive plan

After a leanness assessment, a table similar to Table 3 can be prepared. This table in fact is a lean summary that provides important information for management.

TABLE 3

Leanness Report Summary

j	1	2	...	k
Actual lean index	I_1^t	I_2^t	...	I_k^t
Target lean index(compensatory)	R_1^t	R_2^t	...	R_k^t
Target lean index(comprehensive)	G_1^t	G_2^t	...	G_k^t
Lean status index based on the comprehensive plan	A_1^t	A_2^t	...	A_k^t
Lean status index based on compensatory plan	B_1^t	B_2^t	...	B_k^t
Lean Status(descriptive)				

A_k^t and B_k^t in the table are obtained from the equations presented in 9.

$$A_j^t = I_j^t - R_j^t \quad \& \quad B_j^t = I_j^{A,t} - G_j^t \quad \forall j \in K \quad (9)$$

If there is already any adjusted (compensatory) plan for the period t (current period), interpretation of period t lean status will be based on the compensatory plan as follows:

$$\begin{aligned} -0.5 \leq A_j^t \leq 0.5 & \quad \text{In line with the schedule} \\ A_j^t \leq -0.5 & \quad \text{Behind the schedule} \\ A_j^t \geq 0.5 & \quad \text{Ahead of schedule} \end{aligned} \quad (10)$$

If the initial plan is the only available plan for the current period, the interpretation of the lean status will be based on the initial/comprehensive plan by replacing A_j^t by B_j^t in the set of inequalities presented in 10. By applying this procedure, the information to complete Table 3 is provided and the report (complete table) is sent to the lean leaders in each area. They are responsible to provide a lean target scenario for the next period by considering the report. After receiving the k candidate lean target for the next period, the problem is to find the best target in line with the management strategy. If the strategy is to emphasize keeping the balance between each enablers' level of leanness, it means to compensate the behind schedule parameters as much as possible, and keep the other enablers almost at their level of lean or improve them slightly. The main issue is then the definition of preference functions which can reflect such a strategy.

Figure 1 shows an example of a suitable preference function for enabler j which is behind schedule. In this function, the preference of a decision maker increases sharply before s , but after s it grows slower. Moreover, the preference doesn't change for the value of distance between q and p and it is dropped to zero when the distance is more than q . This means that management eagerly wants the enabler j to become as lean as defined in the adjusted plan of time t to compensate its delay. Also, he/she prefers the improvement goes up to the planned value of time t but the preference will grow slowly after s , which means management doesn't want to be very optimistic. Hence, its preferences do not change if the distance is between the periods t adjusted plan and period $t+1$ initial plan. Also, the scenarios with a target greater than the initial plan of time $t+1$ are considered not realistic to be achieved and

preference for them at criterion j drops to zero. In other words, in the next period if the company achieves the current period target it will be satisfying for the management. The thresholds can also be set to smaller values if they are too optimistic to achieve or far from reality.

An example of preference functions for enablers that are in line with the schedule and those that are ahead of schedule is shown in Figure 2. For enabler j which is in line with the schedule or ahead of schedule, p is the preferred progress from time t to $t+I(\Delta t)$ from management point of view, called $\rho_j^{\Delta t}$. If the decision regarding the lean status of enabler j is based on the adjusted plan, the value of $\rho_k^{\Delta t}$ can be defined by interpreting the enabler j lean status based on the initial plan. For instance, if enabler j based on the adjusted plan has no delay but in comparison with the initial plan is behind the schedule, the value of $\rho_k^{\Delta t}$ can be $|B_j^t|$. If the interpretation of enabler j lean status is based on the initial plan, or if the enabler j with respect to both initial and adjusted plans is not behind the schedule, the value of $\rho_k^{\Delta t}$ can be set $|B_j^{t+1}| = I_j^{A,t} - G_j^{t+1}$. However, if $|B_j^t|$ or $|B_j^{t+1}|$ are still too rigorous to achieve, or reaching them might interrupt the balance between the enablers leanness, management can consider a smaller value for $\rho_k^{\Delta t}$.

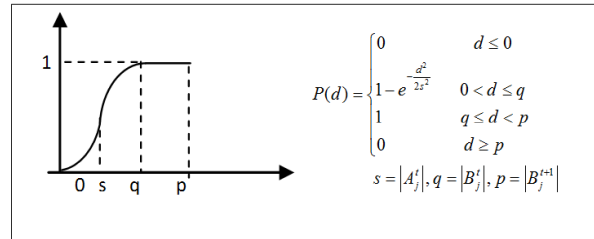


FIGURE 1

Preference Function for Enablers which Are Behind the Schedule

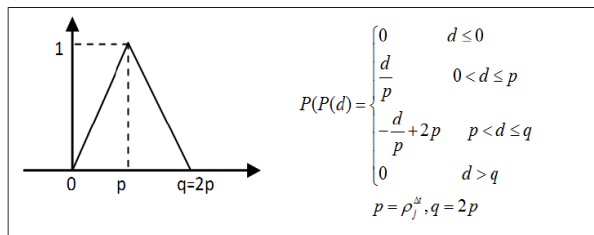


FIGURE 2

Preference Function for Enablers that Are in Line with the Schedule, or are Ahead of the Schedule

Any plan including initial plan, adjusted plan, and current status used as the basis of the distance calculations are necessary to be considered as one alternative in the evaluation table of PROMETHEE II; because the preference functions are defined based on the distance from these scenarios. The model automatically ignores the scenarios that don't have preferences by very small net flow. Of course this claim is true when the preference functions are defined correctly. As explained, PROMETHEE II method has an interactive decision environment, which provides the decision maker the opportunity to contribute his/her strategies to find the best targets among the available ones. In the next section an illustrative example is provided to give the reader a better understanding of the proposed method.

4. AN ILLUSTRATIVE CASE STUDY

In this section an example is provided for better understanding of the proposed method. In this example, five important lean enablers are: "management responsibility", "manufacturing management", "workforce", "technology" and "manufacturing strategy" and are presented by g_1 , g_2 , g_3 , g_4 , and g_5 , respectively. This framework might not be applicable to all organizations, and it is necessary to be modified and adopted based on the specific goals, strategies, and concerns of each company. Table 4 shows a lean comprehensive plan for a period of 18 months. It's assumed that the plan is the same for the five enablers and the presented method is implemented in Oct. 2010 as marked in the comprehensive plan table. The first step after implementing phase 1 is to measure the leanness level of the system. The lean summary of the current period is provided in Table 5. The lean report provided in Table 5 was sent to four groups of people in the company to identify the next lean target considering the current lean status. After analyzing the received information, five other lean target scenarios are proposed for the next period as shown in Table 6. The problem is to find the scenario that fits the system strategies better. As already mentioned, the scenarios which are the basis for the definition of preference function must be also considered as alternatives in the evaluation table. Figure 3 shows the preference functions defined for each enabler. From the figure the management strategy can be interpreted. For instance the management strategy for the first enabler which is behind schedule is to improve them up to time t compensatory target. By applying the PROMETHEE II method and calculating the equation 1-5 the final results are presented in Table 7. According to the result, alternative 7 or adjusted plan 4 has

gained the largest net flow index. Therefore, considering the current lean status, this scenario is recognized as the most compatible scenario with management strategies and will be announced to all departments to be the next period's lean target.

TABLE 4
Comprehensive Plan for All Enablers

Year	2010												2011					
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Comprehensive	2	5	7	10	15	20	25	35	40	50	60	70	75	80	85	90	95	100

TABLE 5
Lean Report Summary of the Proposed Example

	g ₁	g ₂	g ₃	g ₄	g ₅
Actual lean index	28.2	30.65	38.2	20.5	28.96
Target lean index(compensatory)	35	31	40	25	25
Target lean index(comprehensive)	40	40	40	40	40
Lean status index based on the comprehensive plan	-11.8	-9.35	-1.8	-19.5	-11.04
Lean status index based on compensatory plan	-6.8	-0.35	-1.8	-4.5	3.96
Lean Status	Behind the schedule	Almost in line with schedule	Behind the schedule	Behind the schedule	Ahead of schedule

TABLE 6
Lean Scenarios Evaluation

		g_1	g_2	g_3	g_4	g_5
		w_1	w_2	w_3	w_4	w_5
a_1	Actual lean index for the current period	35	31	40	25	25
a_2	Target Lean index according to the initial plan for period t	40	40	40	40	40
a_3	Target Lean index according to the initial plan for period t+1	55	55	55	55	55
a_4	Adjusted plan 1	35	40	50	25	40
a_5	Adjusted plan 2	35	40	45	30	37
a_6	Adjusted plan 3	40	38	50	35	30
a_7	Adjusted plan 4	45	45	45	45	47
a_8	Adjusted plan 5	45	40	48	30	30

TABLE 7

Net Flows Obtained for Each Scenario from PROMETHEE II Method

	$\phi(a_1)$	$\phi(a_2)$	$\phi(a_3)$	$\phi(a_4)$	$\phi(a_5)$	$\phi(a_6)$	$\phi(a_7)$	$\phi(a_8)$
$\phi(\cdot)^+$	0.00	8.41	2.72	5.72	6.43	9.87	9.99	6.60
$\phi(\cdot)^-$	12.18	5.46	0.0	5.46	8.02	7.28	5.48	5.87
$\phi(\cdot)$	-12.18	2.95	2.72	0.26	-1.59	2.59	4.51	0.73

5. CONCLUSION

The importance of lean target setting becomes more evident by knowing the fact that too difficult or too easy targets might prevent a company from a successful lean implementation. Hence this paper is devoted to establishing a method for finding the best target scenario for lean which is in line with the system strategies and goals. To do so, in this paper PROMETHEE II is considered to be the decision making tool. The preference function definition part of applying PROMETHEE II is the critical. Hence, section 3 is devoted to explain the preference function derivation

specifically for lean target identification. In this section it is explained how different strategies might lead to different type of preference functions. After setting all the parameters of the method, it finds the most compatible lean target scenario with the system strategies. The goodness of the model can be validated by running a hypothesis test over the result obtained from a questionnaire. Such a validation model can be found in the work presented by Vinodh et al. (2).

Since, the main advantage of PROMETHEE II is to insert the preferences in the method, defining a proper set of functions reflecting such preferences is very important; otherwise the obtained result will be questionable. Developing a decision support system (DSS) which facilitates the preference function derivation is an important future work. Such a DSS can convert the descriptive information of a decision maker to a mathematical form of preference functions. Moreover, in this paper there is no explanation for producing the candidate lean scenarios based on the lean summary table. An additional future work can be to develop a method for generating such lean target candidates from the existing information.

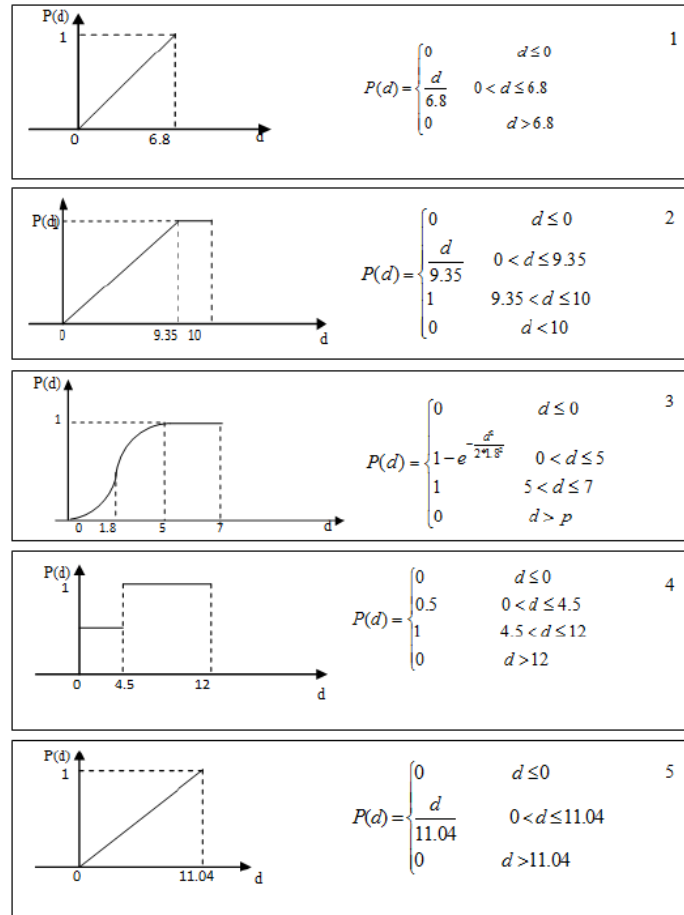


FIGURE 3

The Preference Functions for “Management Responsibility”, “Manufacturing Management”, Workforce”, “Technology” and “Manufacturing Strategy”, Respectively

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