UNDERSTANDING THE COST OF CHANGE FUNCTION: A BASIS FOR USING AN EFFECTIVE SMALL STEP CHANGE STRATEGY

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ABSTRACT

This paper develops the cost of change function under the Continuous Improvement (CI) paradigm advocated by quality gurus such as Deming, Taguchi, and Shingo. CI is considered to be focusing on "frame bending" or minor changes while Organizational Change (OC) is considered to be focusing on "frame breaking " or major changes. The cost of change function is modified to be a discrete function incorporating a "monitoring" cost component and a "doing" cost element, which leads to a better understanding of the multiple tradeoffs: a) between the number of smaller steps to be taken to achieve the desired or planned change and the total cost of change, and b) between the total cost of change and the time needed to achieve the desired change. It is proposed to seek validation of the modified cost of change function by interviewing senior management personnel, who have project management and/or change management experience, such as managing six-sigma projects.

INTRODUCTION

Management of change has become one of the central issues in the management literature and of increasing importance to organizations [2], [6]. New terms and concepts are being added to the lexicon of management practice and theory at an accelerating pace. The terms include time based management, concurrent/simultaneous engineering, total quality management, continuous improvement, and six sigma programs, [19], [21]. Management practice has often been in the forefront of advocating these "new" management concepts and technologies as reported in Fortune, Business Week, etc. Researchers on the other hand have pointed out correctly that although these so called "new management" breakthroughs such as process reengineering [20] have in some instances produced impressive results [4], [8], many of these new management concepts and technologies have borrowed heavily from past management theories. Imai [11] and Deming [6] point out those organizations that seek effective strategies for implementing change mandated by changes in competitive conditions, often on a global scale, recognize also that there is a vital need to sustain the competitive advantage through Continuous Improvement.

The cost of change is of particular interest to top management as the goal of achieving superior profits requires formulation of strategies and implementing these strategies by managing both major changes and incremental improvement activities. The cost of change is directly related to profitability. Juran's [22] seminal work on the costs of quality helped focus top management attention and support on improving process and product quality. It is hoped that a better understanding of the drivers of cost of change will help managers to make more informed decisions as they manage the change process and its cost.

Poole and Van de Ven [16] have explored theories and models of Organizational Change and Innovation. They have identified four distinct process approaches to organizational change and innovation as: Life-Cycle Process Theory, Teleological Process Theory, Dialectical Process Theory, and Evolutionary Process Theory. The generative mechanism that drives change has been identified as regulated under the Life-Cycle Process Theory and as planned under the Teleological Process Theory. While

Life-Cycle Process breaks up the change process into repeatable stages: start-up, growth, harvest, and terminal, the Teleological Process Theory breaks up the change process into repeatable steps as: dissatisfaction, search/interact, envision/set goals, and implement goals. Lindeman et al [13] have proposed a goal theoretic perspective to explain the implementation process for six-sigma, which is a departure from the "best practices" approach that has been documented in the literature. The stages or steps identified in the Life Cycle and Teleological Process models can be considered drivers of cost incurred by the regulated or planned change in both Continuous Improvement (CI) and focusing on "frame bending" or minor changes and Organizational Change (OC) and focusing on "frame breaking" or major changes.

In this paper the change cost function is first developed based on the previous work of Pinto and Hahn [14]. Next a modified discrete cost of change function is developed which tracks costs as 'monitoring' and 'doing'. Support for this modification is based on change models used in the Organization Development and Continuous Improvement literature. An example problem is used to illustrate the efficacy of using small step change strategies and the multiple trade-offs available to management. Concluding remarks include suggestions for further work to validate the proposed modified change cost function.

The Change Cost Function

The change cost function can be defined as

$$C(y) = C(m+y-m) \qquad (1)$$

where,

y = the value of the change characteristic (e.g. addition of workers, reducing number of defectives, etc.)

m = current value of y.

The cost function C(y) can be expended in a Taylor Series around the current value m.

$$C(y) = \frac{C(m)}{1!} + \frac{C^{1}(m)}{2!}(y-m) + C^{11}(m)(y-m)^2 + \ldots \qquad (2)$$

The cost of change C(y) is a minimum at the current value of y = m, and $C^{1}(m)=0$.

The current cost C(m) is a constant and can be ignored since its effect is to uniformly raise or lower the value of C(y) at all values of y. The $(y-m)^2$ term is the dominant term in equation (2). (The larger power terms are ignored as the third differentials onwards can be conveniently assumed to be tending towards zero [22]).

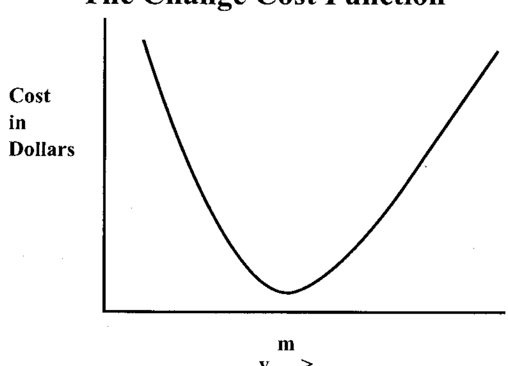
$$C(y) = \frac{C^{11}(m)(y-m)^2}{2!} \qquad (3)$$

$$C(y) = k(y-m)^2 \qquad (4)$$

In practice, for each change characteristic there exists some function which uniquely defines the cost and the deviation of the change characteristic from its target value. The shape and characteristics of the change cost function are presented in Figure 1.

Figure 1

The Change Cost Function



Characteristics:

1- Quadratic (parabolic)

2- Cost of change is minimum, when no change is contemplated from the present value m

3- Cost increases as y diverges from the current value of m

Efficacy of Small Step Change Strategy

The quadratic change cost function can be used to support the efficacy of a small step change strategy. Before we use the quadratic change cost function for the above purpose, it would be appropriate to review some of the previous operations management models that have used quadratic cost functions. In this paper we review the quadratic cost functions used to denote change in the aggregate production planning and control model developed by Holt, Modigliani, and Simon [10], and Taguchi's Continuous Quality Loss Function [22], which is also modeled as a quadratic function.

The Linear Decision Rule (LDR) [10] calls for adjustments of the work force each month with changes in the size of the workforce as wt-wt-1, where wt is the size of the work in period t.

The cost of hiring and lay offs = C2 (wt-wt-1)2 (the C's in the equation represent constants) and overtime costs and inventory connected costs are also partially modeled as quadratic functions. Sypkens [10] developed an extension of the LDR model which identified plant capacity as a decision variable in addition to the work force and production capacity.

Taguchi [22] has developed the continuous quality loss function as

$$L(z) = k_1 (z-p)^2 \qquad (5)$$

where L(y) = loss in dollars, when the quality characteristic is equal to y

z = the value of the quality characteristic (i.e., length, width, concentration, surface finish, flatness, etc.)

p = target value of z

k_1 = constant

The continuous quality loss function has been developed using Taylor Series expansion around the target value p as demonstrated earlier with the change cost function. Figure 1 shows the quadratic representation of the quality loss function, which has the following characteristics:

- is minimum at z = p

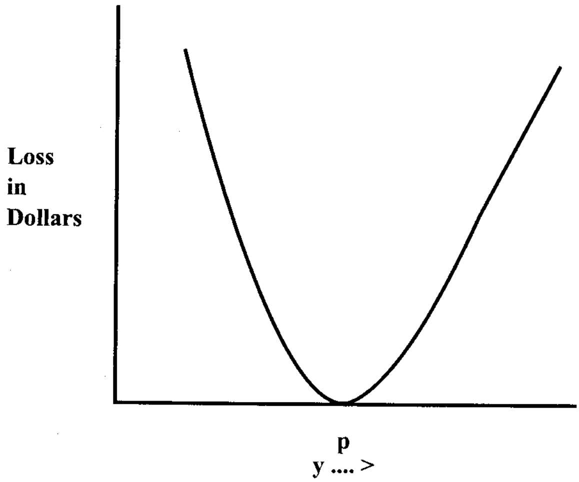
- increases as z deviates from p (a convex function)

- is expressed in monetary terms

The quality loss function is presented in Figure 2. In Figure 3 we contrast the direction of desired change implied by the quality loss function and the change cost function. In order to reduce customers loss owing to deviations from the target parameter of the quality characteristic a reduction in variation from the target value, of the quality characteristic, is desirable. The direction of change in the quality characteristic towards the target value implies that the direction of change is inward as indicated in Figure 3. In contrast the

Figure 2

The Quality Loss Function

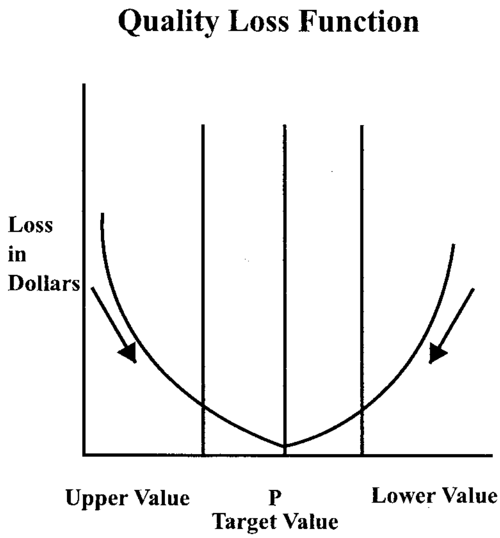


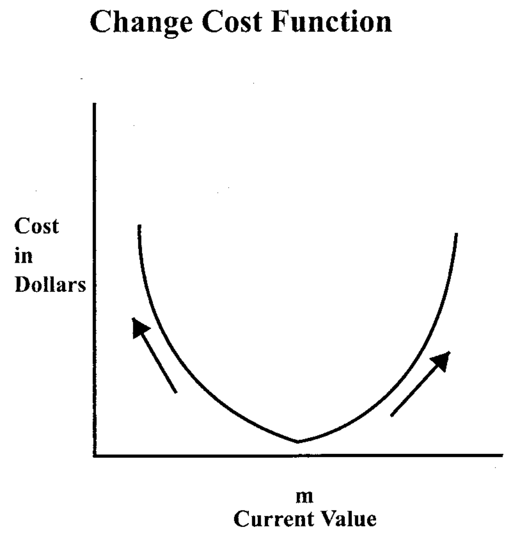
Characteristics:

1. Quadratic (parabolic)
2. Minimum when z = p, the target
3. Increases as z diverges from the target value

direction of change is outward from the current value and the cost is increasing at a quadratic rate in the change cost function as shown in Figure 3.

Figure 3



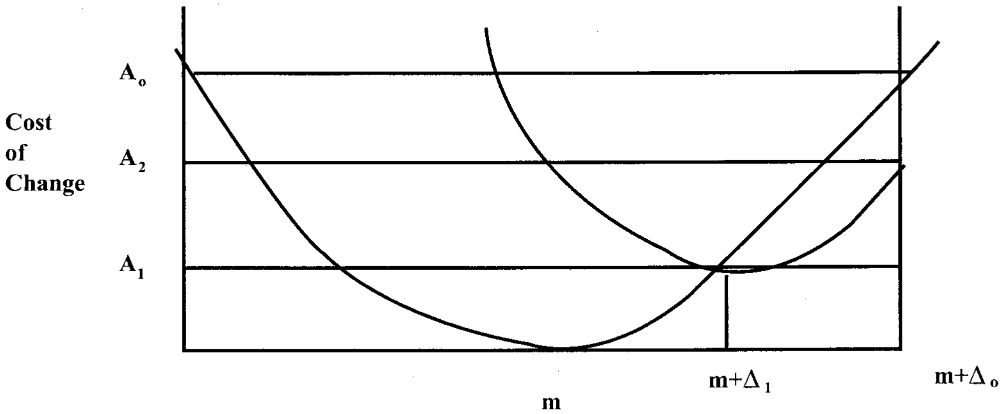


Direction of Change Implied

by the Quality Loss Function and Change Cost Function

The components of change costs could include a variety of organizational costs including training, additional labor costs owing to loss of efficiency during the interim period, and other capital costs.

Figure 4



A Change in a Two Steps

An organization that is currently at m for a characteristic wants to change to a value ?o for the same characteristic. The cost of this change has been estimated to be Δ_o. Instead of a single step change, the change effort is broken up into two steps. Let the first change be by an amount Δ_l and the corresponding cost A1 is obtained from the quadratic change cost function shown in Figure 4. Next, the target value of change A_o is obtained from an equilibrium value of $m + \Delta_l$. The additional cost of change is $A_2 - A_l$ dollars and the total cost of the two step change is A2 dollars. It can be seen that given the quadratic nature of costs and in fairly stable cost situations the small step change approach strategy is much more cost effective than the "bigger" step change approach strategy.

An Example

Let A_o = \$200,000 at a firm wishing to increase capacity by twenty five percent.

Then $C(y) = k\ (y\text{-}m)^2$

$A_o = k\ (m+\Delta_o - m)^2$

And $k = A_o/\Delta_o^2$

For our example, $k = \dfrac{200{,}000}{(.25)^2} = 3{,}200{,}000$

$$\text{And } C(y) = 3{,}200{,}000\ (y)^2 \qquad (6)$$

The change is contemplated in two steps under a stable cost environment for simplicity. Then cost of increasing capacity by 12.5 percent is

$C(y) = 3{,}200{,}000\ (.125)^2$

$= \$50{,}000$

Similarly, the cost of the second step increase in capacity will be an additional \$50,000 for a total cost of \$100,000 for change in total capacity by 25 percent in two steps of 12.5 percent changes each. This represents a savings of \$100,000 in total cost over the single step approach.

MODIFIED DISCRETE COST OF CHANGE FUNCTION

Organization Development (OD) focuses on planned change. The possible targets for planned organization change are identified as purpose, strategy, structure, culture, tasks, and technology [12]. The Lewin-Schein [12] model for managing planned change divides this process into unfreezing, changing, and re-freezing stages, which can be considered as a type of Teleological Process Model identified by Poole and Van de Ven [16]. In manufacturing, the major focus has been on planned improvement of tasks and technology using the objective of elimination of waste [19]. While the well known Shewart cycle for continuous improvement advocated by Deming divides the process into plan, do, check, and act (PDCA) phases, the popular six-sigma method uses define, measure, analyze, improve and control (DMAIC) as the five steps in process improvement. In other words the scientific method is used for the elimination of waste in small steps for achieving large performance gains as indicated by Imai [11] and Choi [4]. Punctuated equilibrium theorists [2] point out that organizations undergo major changes when there is a large shift in their environments. During transitional phases there are prolonged periods of small or incremental changes. This phase is considered to be the convergent period. Clearly, using continuous improvement processes during this period can lead to large performance gains.

One of the conceptual weaknesses of the continuous cost functions is that continuous improvement can be broken into a very large number of steps to justify obtaining an outcome of very small costs for achieving the desired change. Clearly, this would be an unrealistic outcome in terms of depicting the cost of change in practical applications. The steps or stages in the Poole-Van de Ven and Lewin-Schein change models and the six-sigma DMAIC cycle and Shewart (PDCA) cycle for continuous improvement can be collapsed into two stages or steps, with costs being incurred for "monitoring" and "doing" transactions during the change process.

For our previous example problem we now assume that the monitoring costs are $10,000 per change. Then, the trade-off between monitoring and doing costs leads to a better understanding of the total cost of change for various options of the small step strategy. The application of the modified discrete change cost function with monitoring costs and doing costs for the previous example problem is detailed in table 1. It is estimated that each cycle for doing and monitoring takes 2 weeks. A three step approach would yield monitoring costs of $30,000 and doing costs of $66,667 for a total cost of $96,667 and estimated time duration of 6 weeks.

Table 1: Estimation of Change Costs Using Discrete Cost of Change Function

OPTION	# OF STEPS	MONITORING COSTS	CAPACITY CHANGE PER STEP	DOING COSTS*	TOTAL COSTS	TIME
1	1	$ 10.000	.1250	$ 20.000	$ 210.000	2 weeks
2	2	$ 20.000	.0625	$ 100.000	$ 120.00	4 weeks
3	4	$ 40.000	.03125	$ 50.000	$ 90.000	8 weeks
4	8	$ 80.000	.01563	$ 25.000	$ 105.000	16 weeks

* Doing costs are obtained by using equation (6) for different values of y

CONCLUDING REMARKS

In this paper the change cost function is first developed based on the previous work of Pinto and Hahn [14]. Next, a modified discrete cost of change function is developed which tracks costs as 'monitoring' and 'doing'. Support for this modification is based on change models used in the Organization Development and Continuous Improvement literature. An example problem is used to illustrate the efficacy of using small step change strategies and the multiple trade-offs available to management has been shown in Table 1 including the notion of time-cost trade-offs. It is proposed that technological [1] and evolutionary process change models [21], and goal theoretic approaches [13] in the literature be examined to fine tune the notion of monitoring and doing transaction costs. Lindeman et al [13], and Hahn [9] indicate that improvement using six-sigma methodology lacks a theoretical underpinning and a basis for research other than "best practice" studies and six-sigma has not been carefully defined in the literature. Lindeman et al [13] propose using a goal theoretic perspective for understanding the six-sigma process. Cole [5] reports that John Young, CEO of Hewlett Packard (HP) set a goal of 10-fold improvements in hardware quality over the next decade in the early 1980's. This time span for improvement indicates that HP has likely used a continuous improvement strategy of change for improvements in hardware quality using either the six-sigma DMAIC or Shewart-Deming PDCA cycle approach. Lindeman et al [13] indicate that General Electric report spending $500 million on six-sigma improvement projects and estimate savings of $2 billion from these initiatives in their 1999 annual report, which clearly underscores the steep costs of planned change and also their substantial potential benefits. Finally, field research is proposed on six sigma type projects to help validate the modified cost of change function given the potential costs and benefits involved in the effective management of the change process.

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