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Full Length Research Paper

The diagnosis and improvement of TQM implementation in semiconductor industries

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Total quality management (TQM) improves product/service quality, increases customer satisfaction and improves competitiveness. However, experience shows that there is low successful rate. Few enterprises agree that they have successfully implemented TQM. An inadequate understanding of the techniques and suitable objectives of the TQM implementation not only causes problems or sub-par performance but also drives excess cost for businesses. With this in mind, a V-shaped performance evaluation model is proposed to examine the implementation performance of TQM practices. By this model, a company can diagnose the effectiveness and efficiency of TQM practices by considering the level of importance, the level of easiness to implement and the level of accomplishment of each TQM practice. The implementation of TQM in the semiconductor industry in Taiwan is investigated. Practices identified as the ones need to improve are put into House of Quality (HOQ) and corresponding improvement actions are proposed for managers to enhance the effectiveness and efficiency of TQM implementation.

Key words: Total quality management (TQM), semiconductor industry, V-shaped performance matrix, house of quality (HOQ), performance evaluation.

INTRODUCTION

In recent decades, developments in various industries have focused on productivity, with discussion topics focusing on cost, delivery dates, elasticity, etc. (Hammer and Champy, 1994). Recently and gradually, quality has come to be more respected, and constant quality improvement has been postulated to play a key role in successful performance in today's global marketplace (Powell, 1995; Prybutok and Cutshall, 2004; Yang, 2004; Mele and Colucio, 2006; Sitalakshmi, 2007). With this in mind, companies constantly introduce methods of quality improvement. Specifically, total quality management (TQM) has not only have been discussed ardently but have also been used to secure a competitive advantage. (Withers et al., 1997; Nilsson et al., 2001; Chan and Quazi, 2002; Martínez-Costa et al., 2008).

TQM may be more important for companies that use more advanced technologies and that deploy more effective quality management systems, such as firms in semiconductor industry. However, due to an insufficient understanding of the techniques and objectives of TQM, many businesses encounter problems or suffer from negative performance and cost overruns (Yang, 2006; Warwood and Roberts, 2004). A systematic method is needed to help managers evaluate the performance of TQM implementation and then take improvement actions to ineffective and inefficient TQM practices.

First, two set of performance control limits are proposed based on importance-easiness level and importance-accomplishment level of TQM practices. These two set of control lines constitute a V-shape, therefore, the implementation performance evaluation method is called V-shape performance matrix. The V-shape performance matrix was designed to determine whether any TQM practice implementation is ineffective or inefficient. We then associated TQM practices that were out of the performance control lines with improvement actions with house of quality (HOQ) to sort out critical improvement actions. The easy-to-use performance evaluation method can help to managers diagnose the ineffective and inefficient TQM practices

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and then prioritize improvement actions with the common method, HOQ, to improve TQM implementation.

The rest of the paper is organized as follows. We describe the TQM. V-shape performance matrix is proposed for TQM implementation diagnosis is presented in next section, followed by TQM implementation performance evaluation in semiconductor industry. We then propose an improvement method by linking ineffective and inefficient TQM practices and corresponding improvement actions. Conclusions are given accordingly.

TOTAL QUALITY MANAGEMENT

As a quality improvement tool, TQM has inspired numerous studies and has led to multiple practical applications in recent years. By 1970, Japanese industry had become as competitive as American industry - or even more so - by successfully applying Company-Wide Quality Control (CWQC) (Powell, 1995). In 1980, the concept of CWQC was similarly applied in American companies; at the same time, TQM was quickly adopted as a quality management tool (Yang, 2004).

Authors who were spearheading TQM research, like Deming, Juran and Crosby, proposed different TQM concepts. Deming introduced the fourteen criteria of TQM to emphasize their importance for leadership and to reduce variation in organization processes. Juran focused on quality plans, control and improvement, while Crosby advocated using quality improvement to reduce costs (from Galperin and Lituchy, 1999).

Dean and Bowen (1994) concluded that TQM involved three concepts: customer focus, continuous improvement and teamwork. As a quality management philosophy, TQM is used to ensure customer satisfaction and even to surmount customer expectations via multiple types of quality activities (Dean and Bowen, 1994; Ugboro and Obeng, 2000; Chan and Quazi, 2002; Li et al., 2008). Most research to date has confirmed the influence of TQM on company performance and has shown a positive relationship with performance or customer satisfaction (Terziovski and Samson, 2000; Hendricks and Singhal, 2001; Hansson and Eriksson, 2002).

Over the last two decades of TQM development, researchers with multiple different viewpoints have discussed the influence of various factors on TQM, including organization and cultural differences (Galperin and Lituchy, 1999), the overall operational performance of the organization (Lau and Idris, 2001), the efficiency of the organization (Fok et al., 2001), and the choice of management consulting options (Saremi et al., 2009). Because the term "quality" has such an extensive and varied set of meanings, director usually be confused by the indefinite meaning when they executed (Dean and Bowen, 1994; Shields, 1999; Sitalakshmi, 2007). TQM can undoubtedly improve firm performance, but it has a considerable failure rate in terms of actual execution. Bak (1992) concluded that 80% of English companies failed to attain the expected benefits when they introduced TQM. Furthermore, Jacob (1993) and Hubiak and O'Donnell (1996) both reported that about two-thirds of companies in the U.S. met with difficulty or even failure when they tried to introduce TQM. We find similar results in many other reports (Joseph et al., 1999; Noci and Toletti, 2000; Sureshchandar et al., 2001). In this context, substantial research efforts have attempted to explore the difficulty of implementing TQM or the reasons for its failures. Hellsten and Klefsjö (2000) conclude that TQM is a vast poorly-defined concept that is linked with vague descriptions; the executor often cannot understand the full meaning of a given TQM concept.

Most relevant studies mentioned it is difficult to implement TQM and the key factors for implementation. However, few previous studies proposed how to evaluate TQM implementation performance and how to improve ineffective and inefficient implementation. This study aims to fulfill this academic gap. We try to propose a performance evaluation method to determine which TQM practices are implemented effectively and efficiently and which are not.

To determine the performance of TQM practices, two set of performance control limits are proposed based on importance-easiness level relationships and importance-accomplishment level relationship of TQM practices. These two set of control lines constitute a V-shape, therefore, the implementation performance evaluation method is called V-shape performance matrix. Improvement actions for TQM practices out of the control lines are then developed by HOQ to help firms identify ways to improve TQM implementation.

V-SHAPE PERFORMANCE MATRIX

Under considering three indexes of TQM implementation, upper and lower performance control lines are determined. Because control lines constitute V shape, the proposed implementation evaluation matrix is called as V-shaped performance matrix in this study.

Implementation performance index

There are three indexes in our performance matrix. They are importance level, the easiness level and accom-plishment level for TQM introducing items. The level of importance determines items implementation priority. A firm needs to invest more resources in more important items.

Easiness level measure how easy to implement introducing items. When a firm has higher implement capability or higher support from top managers to implement an item, it is easy for the item to be implemented and always lead to higher implementation level. General speaking, the items with higher importance should improve its easiness to implement so that a firm successfully introduce TQM. Accomplishment level means how the actual accomplishment of an item is close to the expected accomplishment. Same as the easiness level, it is expected that the

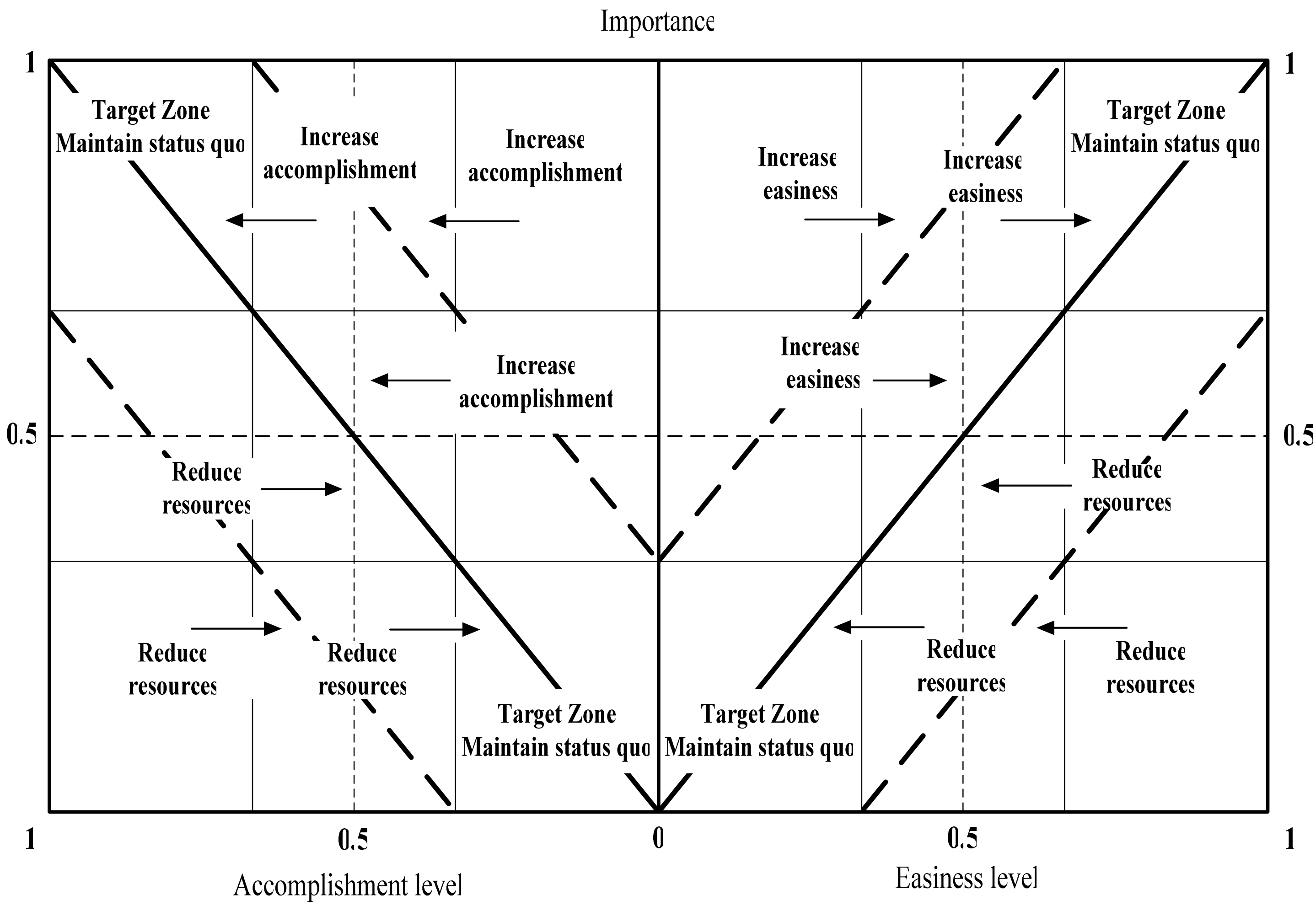

Figure 1. *V*-shaped performance matrix for TQM practice.

more important the item is, the higher accomplishment level it needs.

The difference between importance level and accomplishment level is defined as implementation effect-tiveness of a TQM introducing item; and the difference between importance level and easiness level is defined as implementation efficiency of an item. To measure the effectiveness and efficiency, this study uses μ_A, μ_E and μ_I to represent the mean scores for implementation, easi-ness and importance level for the 15 TQM practices. The performance of three indexes are calculated and converted to P_A, P_E and P_I via Formulas 1, 2 and 3. Then, P_A, P_E and P_I are plotted in the proposed performance matrix for firms to diagnose whether implementation of TQM introducing items are effective and efficient or not. According to P_A, P_E and P_I, performance control lines are constructed.

Firms can take necessary actions for items falling out of control lines to improve TQM introducing performance. With the k-scale used to assess accomplishment, easi-ness and importance for each implementation factor, the accomplishment, easiness and importance indices are as follows:

$$P_{A,i} = \frac{\mu_A - \min}{R} \quad (1)$$

$$P_{E,i} = \frac{\mu_E - \min}{R} \quad (2)$$

$$P_{I,i} = \frac{\mu_I - \min}{R} \quad (3)$$

$P_{A,i}$: accomplishment level index ; $P_{E,i}$: easiness level index;
$P_{I,i}$: importance level index for TQM practice *i*
μ_A: accomplishment level mean; μ_E: easiness level mean; μ_I: importance level mean
min: minimum value of *k* scale; R: full range of *k* scale

Lambert and Sharma (1990) and Lin et al. (2005) employed performance evaluation matrix to identify items need to improve. This study expands the concept of their performance matrix by integrating three performance indexes. The performance matrix is shown in Figure 1. With this simple and easy-to-use graphical analysis tool, firms can monitor and evaluate TQM introduction performance and then know improving directions.

In the performance matrix, the *Y*-coordinate demon-strates the importance level and easiness level and implementation level are shown as left and right X-coordinates. All index values ($P_{A,i}$, $P_{E,i}$ and $P_{I,i}$) fall between zero and one. Because it is expected that more

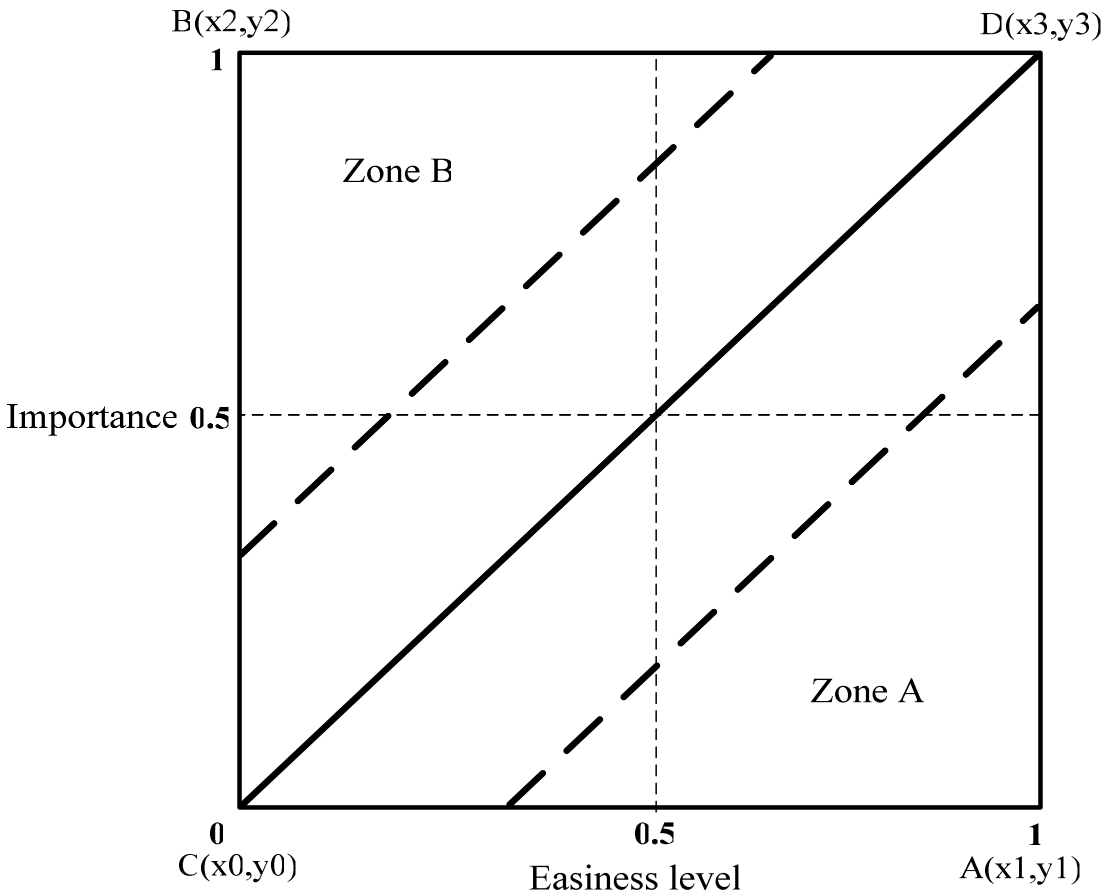

Figure 2. The right performance matrix and performance control lines.

important items should be easier to implement and achieve higher implementation level. Therefore, the target zone falls on diagonal line of left and right performance matrix. When an item is more far away from the diagonal, managers need to invest more resource to improve its implementation level or easiness to implement. Performance control lines are constructed along the diagonal lines and shown as the dotted lines in Figure 1.

V-shape matrix control limits

Different coordinate value of [$P_{A,i}$, $P_{I,i}$] and [$P_{E,i}$, $P_{I,i}$] results in different areas. The square area of a perfor-mance matrix is 1 × 1 = 1. Let target value, the diagonal line, be T and $T = P_{A,i} - P_{I,i}$ *or* $P_{E,i} - P_{I,i} = 0$. The performance matrix can be divided into two triangles with an area of 0.5 for each. Take 4 points in Figure 2 as examples, an isosceles triangle (ACD) with an area of ρ can be created by extending it to the target line $T = (y_i - x_i) = 0$.

Prior to calculating the area of the isosceles triangle (ACD), the original formula of (bottom weight)/2 was modified to (bottom weight) so that the computed ρ value (area index) would be between zero and one.

According to Figure 2, the coordinates of A are (1,0), indicating the maximum easiness $P_E = 1$ and the mini-mum importance level $P_I = 0$. The coordinates of B are (0,1), showing the minimum easiness level $P_E = 0$ and the minimum importance level $P_I = 1$.

The area of Zone A (ACD) can be computed as follows:

$$\rho_A = \overline{AC} \times \overline{AD} = |x_1 - y_1| \times (x_1 - y_1) \tag{4}$$

Similarly, the area of Zone B (BCD) is computed as follows:

$$\rho_B = \overline{BC} \times \overline{BD} = |y_2 - y_0| \times (x_3 - x_2)$$
$$\because y_0 = x_2 = 0,\ x_3 = y_2 = 1 \quad \therefore \rho_B = |(y_2 - x_2)| \times (y_2 - x_2) \tag{5}$$

Based on formulas (4) and (5), the equation for the area index can be described as formula (6):

$$\begin{gathered} \rho_i = \rho_{(x_i, y_i)} = | y_i - x_i | (y_i - x_i) \\ where \quad p: \text{the interested point} \\ \rho_i = 0 \sim +1 (x < y),\ \rho_i = -1 \sim 0 (x > y),\ i = 1 \sim n \end{gathered} \tag{6}$$

The different coordinates [$P_{A,i}$, $P_{I,i}$] and [$P_{E,i}$, $P_{I,i}$] of performance indices result in various areas. The upper control line and the lower control line can be calculated with the population mean μ_{Pi} and population standard deviation σ_{Pi} . After managers check the normality of area index ρ^i and ensure it follows normal distribution, we can derive:

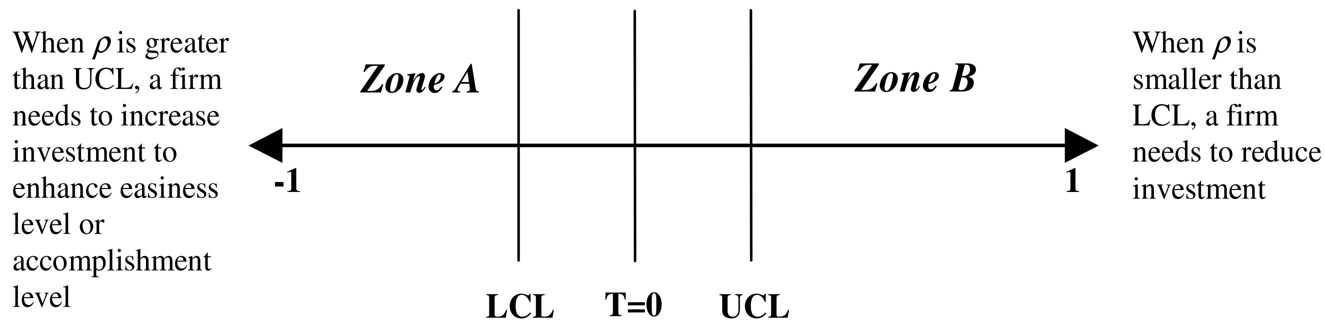

Figure 3. Logic of taking improvement actions.

$$\mu_{Pi} = \frac{\sum_{i=1}^{n} | y_i - x_i | (y_i - x_i)}{n} \quad (7)$$

$$\sigma_{Pi} = \sqrt{\frac{\sum_{i=1}^{n} (\rho_i - \mu)^2}{n}} = \sqrt{\frac{\sum_{i=1}^{n} (y_j - x_i)^4 - n\mu^2}{n}} = \sqrt{\frac{\sum_{i=1}^{n} (y_j - x_i)^4}{n} - \mu^2} \quad (8)$$

The performance control chart is defined by the Shewhart control chart setting the target value of upper and lower control limits to 0. For a normally distributed population, 99.73% falls within ±3 σ , implying a failure e rate of about 0.27%, whereas 95.44% of the population is within ±2 σ , indicating a failure rate of 4.56%.

Moreover, approximately 68.26% falls within ±1 σ , indicating a failure rate of about 31.74%. If ±3 σ and ±2 σ were used in this study, unqualified question factors would not be located because the questionnaire con-tained 25 questions and the failure rate was extremely low. Consequently, according to the 80/20 rule (Koch, 1997) (80% of the problems result from 20% of the factors), ±1 σ was used to establish the upper control line (UCL) and lower control line (LCL). The formulas are as follows:

UCL = T- σ
T= 0
LCL = T- σ

According to concept of Shewhart control chart the upper and lower performance control lines are defined as follows:

$$UCL = +\sqrt{\frac{\sum_{i=1}^{n} (y_j - x_i)^4}{n} - \mu^2} \quad (9)$$

$$T = y_i - x_i = 0 \quad (10)$$

$$LCL = -\sqrt{\frac{\sum_{i=1}^{n} (y_j - x_i)^4}{n} - \mu^2} \quad (11)$$

After calculating area index of each TQM practice, Managers and engineers can use UCL and LCL to determine whether a practice is in normal of abnormal status, falling out of UCL or LCL. When an items resulting in high area index ρ and fall in Zone B, the upper area of UCL in Figure 2, it means that the level of importance of a TOM practice is higher than the level of easiness (or accomplishment).

To implement important practice, a firm needs to investment more resources to increase easiness or accomplishment level to improve implementation efficiency or to improve effectiveness. When a practice results in low area index ρ and fall in Zone A, the lower of LCL in Figure 2, it means that the level of importance of the TQM practice is lower than the level of easiness or accomplishment. A firm can save the investment into the practice because of its low importance to move the practice toward target central line. Figure 3 demonstrates the concept of improvement actions.

TQM IMPLEMENTATION PERFORMANCE EVALUATION IN SEMICONDUCTOR INDUSTRY

Semiconductor industry is a capital-intensive and highly-competitive industry. To attain superior performance on high customer satisfaction, short cycle time, high yield, good on-time delivery and high utilization, most firms introduced TQM. However, they lack an effective performance evaluation system to diagnose which TQM introducing items are high-performing and which are low-performing. Knowing that firms can takes necessary actions for low-performing items.

Some famous and leading firms in semiconductor industry, such as TSMC, UMC, ASK, et al., are located in Taiwan. In addition, there are IC design houses, foundries, IC packaging firms, IC final testing firms and relevant companies (such as IP providers, design service providers and material and device providers). The supply chain of semiconductor manufacturing is quite complete

Table 2. Means and corresponding performance values for various TQM practices.

No.	TQM practices	μ_A	μ_E	μ_I	P_A	P_E	P_I
1	Leadership	3.306	3.25	3.889	0.576	0.563	0.722
2	Project team of improvement	3.306	3.111	3.694	0.576	0.528	0.674
3	Empowerment	3.278	3.472	3.889	0.569	0.618	0.722
4	Daily management	3.5	3.417	3.833	0.625	0.604	0.708
5	Culture change and development	3.333	3.389	3.861	0.583	0.597	0.715
6	Usage of SQC	3.194	3.278	3.722	0.549	0.569	0.681
7	Quality goal-setting, measurement, and management	3.417	3.361	4	0.604	0.590	0.75
8	Quality management system	3.278	3.167	3.583	0.569	0.542	0.646
9	Supplier evaluation and relationship	3.528	3.306	3.806	0.632	0.576	0.701
10	Customer service system	3.222	3.25	3.722	0.556	0.563	0.692
11	Training of quality tools	3.472	3.306	3.75	0.618	0.576	0.688
12	Customer satisfaction managing	3.361	3.306	3.778	0.590	0.576	0.694
13	Cross-functional management	3.472	3.556	3.917	0.618	0.639	0.729
14	Hoshin management	3.417	3.444	3.75	0.604	0.611	0.688
15	QCC activity	3.333	3.361	3.667	0.583	0.590	0.667

Table 1. Enterprise characteristics.

Company's primary business	%	Firm's annual revenue ($ Million)	%	Number of employees	%
Foundry	15.6	<15	35.9	<100	21.9
IC design	39.1	15-30	15.6	101-500	31.2
Packaging and testing	14.1	30-60	7.8	501-1000	14.1
Mask	3.1	60-150	7.8	1001-3000	10.9
Equipment/material provider	21.9	150-300	6.3	>3000	21.9
Others	6.2	300-600	6.3		
		>600	20.3		

in Taiwan. Therefore, to study the TQM diagnosis and improvement method in the semiconductor industry, Taiwan cases are suitable and are able to represent firms' behaviors in the semiconductor industry. This study chooses members of the Taiwan Semiconductor Industry Association (2008) as the research population to investigate the TQM implementation performance. The opinions of middle- and high-level managers are collected.

TQM practices

Many firms view introducing ISO quality management system as an antecedence for TQM introducing. Therefore, ISO clauses are included in TQM practices. TQM practices mentioned in related literature are also incurporated (Yang, 2006; Jung et al., 2009; Mahadevappa and Kotreshwar, 2004). After collecting from academic works, we interview semiconductor industry practitioners about the initial TQM practices whether these practices are adequate. Table 2 shows the finalized TQM practice in Semiconductor industry.

Performance evaluation

A questionnaire was design to investigate the importance, easiness and accomplishment level of TQM practices. There are 252 members in Taiwan Semiconductor Industry Association (2008). A total of 252 questionnaires were mailed to respondents; 64 copies were returned, representing a return rate of 25.4%. The valid responses included companies with a range of annual revenues from USD$10 million to $900 million, and workforces of 90 to 25,000 employees. Of the respondents, 78% were Vice-Manager or Managers; 22% described their job titles as Director or Vice-President. A detailed breakdown of the statistics from the responding companies is provided in Table 1.

The overall reliability coefficient was 0.8126. In principle, a greater Cronbach's α means greater reliability for a given questionnaire. Nunnally (1978) suggests that the Cronbach's α should be larger than 0.5 for practical

Table 3. Corresponding coordinates and index values in the *V*-shape performance matrix.

Performance matrix \ Statistic of area index	μ_P	σ_P	UCL	LCL	UCL Coordinate	LCL Coordinate
Importance vs. Accomplishment level	0.0104	0.0062	0.0062	-0.0062	(0 , 0.1187) (0.8813 , 1)	(0.1187 , 0) (1, 0.8813)
Importance vs. Easiness Level	0.0106	0.0064	0.0064	-0.0064	(0 , 0.1113) (0.8867 , 1)	(0.1113 , 0) (1 , 0.8867)

Table 4. Importance weights of abnormal TQM practice in HOQ.

Abnormal TQM practice (i)	Area ρ in importance-accomplish matrix	Area ρ in importance-easiness matrix	Total area (C_i)	Improvement priority
1. Leadership	0.0213	0.0255	+0.0468	1
3. Empowerment	0.0233	0	+0.0233	4
5. Culture change and development	0.0174	0.0139	+0.0313	2
9. Supplier evaluation and relationship	0	+0.0156	+0.0156	5
10. Customer service system	+0.0156	+0.0139	+0.0295	3
12. Customer satisfaction managing	0	+0.0139	+0.0139	6

applications and that α > 0.7 represents the minimum acceptable reliability. Thus, a high reliability coefficient implies that the questionnaire results are stable and consistent.

Next, μ_A, μ_E and μ_I, (the mean levels for accomplishment, easiness and importance as reflected by the 15 TQM implementation factors) were computed and converted to $P_{A,i}$, $P_{E,i}$ and $P_{I,i}$ for each practice using (1), (2) and (3). And area indexes, ρ, for the 15 TQM practices in the performance matrix were calculated using (6), as shown in Table 3.

After obtaining area indexes, the mean and standard deviation of area indexes were computed using (7) and (8). Then, the UCL and LCL for importance-easiness and importance-accomplishment were calculated by applying the population mean and population standard deviation to (9) and (11). The upper and lower control limits and coordinates in the performance matrix are listed in Table 4. Three performance values in Table 2 and the coordinates of the upper and lower performance control lines in Table 3 are mapped onto a *V*-shaped performance matrix as shown in Figure 4.

After mapping the *V*-shape performance control boundary, abnormal TQM practices outside UCL and LCL can be identified. It is apparent that six abnormal coordinates related to implementation factors fell outside the UCL: Practice 1, 3, 5, 9, 10 and 12. These abnormal practices outside of UCL and LCL can be classified three groups in Figure 5.

Abnormal TQM practices in the matrix of easiness and importance on the right-hand side of the *V*-shaped performance matrix are linked with high importance and low easiness level for implement. From the perspective of efficiency, this indicates that implementation may be very difficult. Therefore, additional resources need to be assigned to improve the system introduction process. The coordinates of such abnormal factors usually fall outside the UCL. These abnormal implementation factors include “Culture change and development” in practice 5, “Supplier evaluation and relationship” in practice 9, “Customer service system” in practice 10 and “Customer satisfaction managing” in practice 12. Additional resources must be assigned to enhance easiness level to implement and shift the coordinates toward the target zone.

Abnormal TQM practices in the matrix for accomplishment and importance on the left-hand side of the *V*-shaped performance matrix are of high importance and are associated with a low level of accomplishment. From the perspective of effectiveness, the implementation performance may not be satisfactory. Supplementary resources need to be allocated to enhance the implementation performance. The coordinates of such

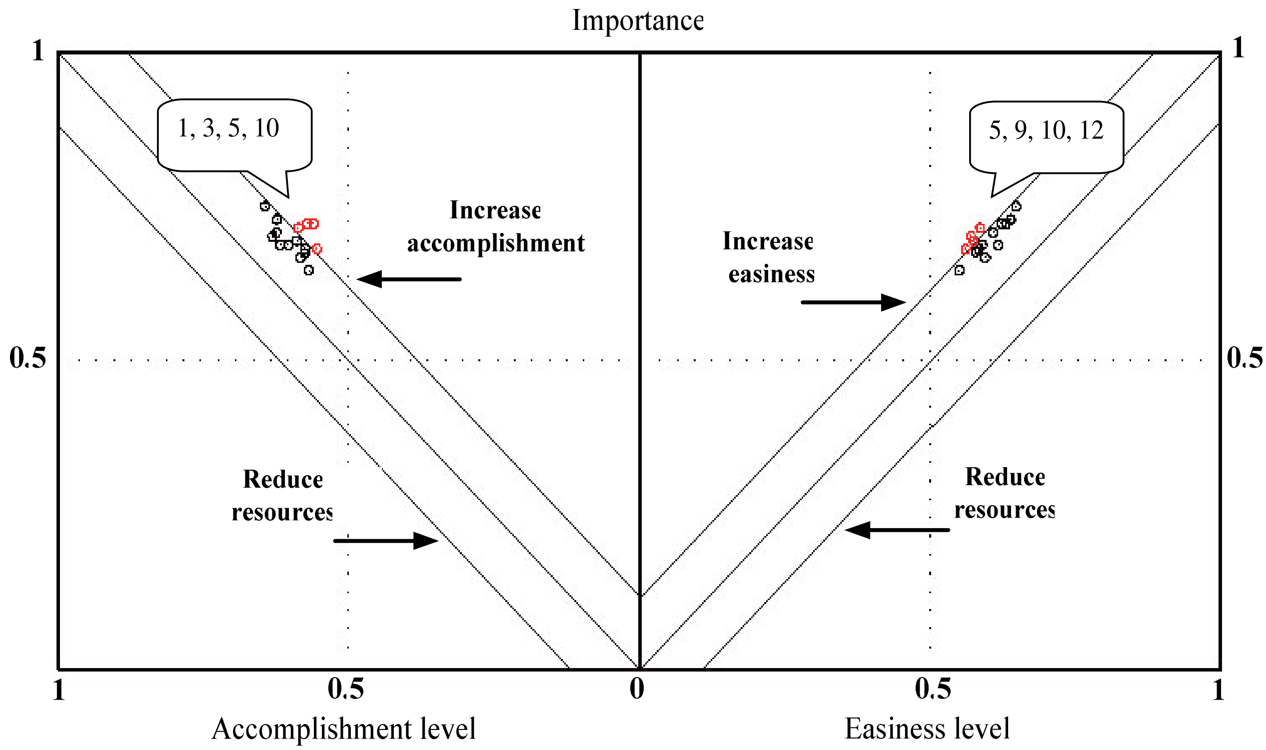

Figure 4. *V*-shape performance matrix.

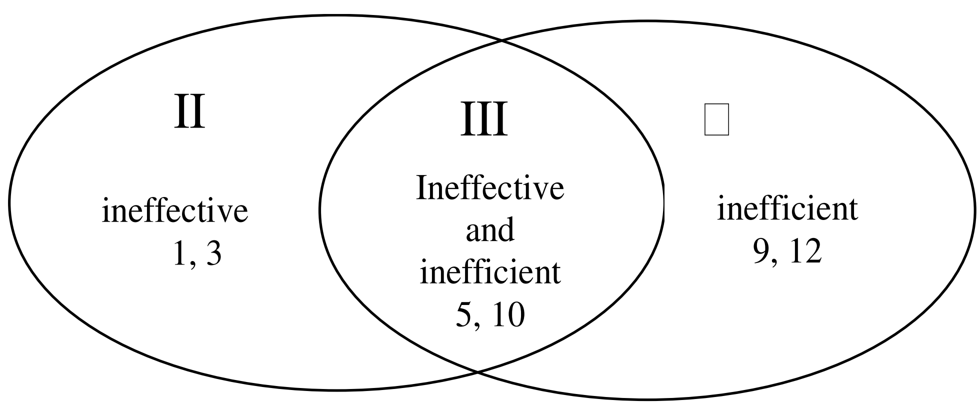

Figure 5. Three groups of abnormal TQM practices.

abnormal factors will usually fall outside the UCL. Such abnormal implementation factors include “Leadership” in practice 1, “Empowerment” in practice 3, “Culture change and development” in practice 5, and “Customer service system” in practice 10.

TQM practice 5 and 10 are both of high importance but are associated with low easiness level and accomplishment level. This suggests that the levels of effectiveness and efficiency of these abnormal implementation factors remain unsatisfactory; therefore, the implementation of these two practices lacks effectiveness and efficiency. Additional resources need to be allocated to promote both ease and accomplishment so that these two practices can shift towards the target zone.

IMPROVEMENT ACTIONS FOR TQM IMPLEMENTATION

A widely used quality function deployment method, House of Quality (HOQ), is adopted to identify and determine the priority of improvement actions TQM

Table 5. Improvement actions for TQM implementation.

	Improvement factors for implementing TQM	Source
Organization	1. Strong commitment and involvement of senior management 2. Changes to corporate culture 3. TQM implementation planning 4. Organizational and process reengineering 5. TQM implementation training 6. Total participation of organization members 7. Continuous improvement 8. Customer satisfaction orientation 9. Application of best practice	Tummala et al.(1995), Sila and Ebrahimpour (2002), Keng et al. (2007), Ismail(2007), Dean and Bown(1994)
Supplier	10. Examining the service quality of suppliers 11.Establishing long-term collaborative relationships with suppliers	Brah et al.(2000), Tummala et al. (1995), Ismail (2007)
External Support (consulting firms)	12.Examining the professional expertise of the consulting company 13.Examining communication between the consulting company and the enterprise	Yang et al.(2006)

practices with ineffective and inefficient implementation.

Determining the importance weight of abnormal TQM practices

Areas of abnormal TQM practices in importance-accomplishment and importance-easiness matrix are added to determine the importance weight (C_i) in HOQ. Abnormal implementation factors and improvement priorities are listed in Table 4.

Determining the improvement factors for TQM practices

To find the improvement factors, critical factors from literature review are determined first; then, expert interviews and KJ method are conducted to determine the proper improvement actions for TQM practices in semiconductor industry.

Since the mid-1980s, researchers have ascertained the critical factors to implement TQM. Tummala et al. (1995) identified seven key factors for introducing TQM: customer focus, leadership, strategic quality planning, design quality, employee participation and partnerships, fact-based management, and continuous improvement etc. Moreover, Sila and Ebrahimpour (2002) have proposed ten fundamental elements of TQM: customer focus and satisfaction, training and education, top management commitment, teamwork, and continuous improvement, etc.

A few important studies have been conducted to ascertain the main strategies together with key factors and concepts (Dean and Bown, 1994; Brah et al., 2000; Sureshchandar et al., 2001; Jacqueline et al., 2003; Yang et al., 2006; Ismail, 2007; Keng et al., 2007; Saremi et al., 2009). To determine strategies or actions for improving abnormal TQM practices, the key factors of total quality management proposed by related researches and experts are considered and integrated with the KJ method presented by Kawakita (2003) for a list of thirteen improvement actions that should be achieved to implement TQM, as shown in Table 5.

Establishing house of quality

Expert opinions are used to establish the correlation weight coefficient (W_{ij}) between abnormal TQM practice i and critical factor (that is, improvement actions) j. The correlation weighted coefficient (W_{ij}) can be measured using a 5-point scale. Point 5 represents an extremely strong correlation, 4 represent a strong correlation, 3 is a medium correlation, 2 is a weak correlation and 1 is an extremely weak correlation. A higher coefficient is appropriate for a stronger correlation and vice-versa. When the coefficient is determined, correlation weight coefficient and importance of abnormal TQM practice (C_i) are multiplied and obtain C_iW_{ij}. Then, the absolute weight (T_j) of each improvement action is computed by $\sum_i C_i W_{ij}$.

For example, weight of the strong commitment and involvement of senior management, $T_1 = 0.0468 \times 5 + 0.0233 \times 5 + 0.0313 \times 5 + 0.0155 \times 4 + 0.0295 \times 5 + 0.0319 \times 5 = 0.786 = 0.79$. The HOQ of critical factors for TQM implementation is demonstrated in Figure 6.

Upon completion of HOQ, priority was determined by sorting the absolute weights listed in Figure 6. The order of priority based on absolute weight in order is as follows: “Strong commitment and involvement of senior manage-

Definition of Weight		
Extremely Strong	5	5.0
Strong	4	4.0
Medium	3	3.0
Weak	2	2.0
Extremely	1	1.0

TQM Practice	Area Corresponding to Abnormal Index	Improvement Actions: 1. Strong commitment and involvement of senior management t	2. Changes to corporate culture	3. TQM implementation planning	4. Organizational and process reengineering	5. TQM implementation training	6. Full participation of employees	7. Continuous improvement	8. Customer satisfaction orientation	9. Application of best practice	10. Examining the service quality of suppliers	11. Establishing long-term collaborative relationships with suppliers	12. Examining the professional expertise of the consulting company	13. Examining communication between the consulting company and the enterprise
1. Leadership.	0.0468	5	5	5	5	5	5	5	4	5	4	3	3	4
3. Empowerment	0.0233	5	4	5	5	4	5	5	4	5	4	3	3	4
5. Culture change and development	0.0313	5	5	4	3	5	4	5	4	3	4	3	4	4
9. Supplier evaluation and relationship	0.0155	4	4	4	4	3	4	3	4	4	5	5	4	3
10. Customer service system	0.0295	5	4	4	3	4	4	3	5	4	4	3	3	3
12. Customer satisfaction managing	0.0139	5	4	4	4	4	4	4	5	4	4	4	5	3
Absolute Weight		0.79	0.72	0.71	0.65	0.70	0.71	0.66	0.69	0.68	0.66	0.53	0.56	0.58
Sort absolute weight		1	2	3	10	5	3	8	6	7	9	13	12	11

Figure 6. HOQ of abnormal TQM practices and critical factors for TQM implementation.

ment” in improvement action 1, “change of corporate culture” in improvement action 2, “establishment of TQM implementation planning” in improvement action 3, “total participation of organization members” in improvement 6, “TQM implementation training” in improvement action 5, “customer satisfaction-oriented” in improvement action 8, “application of best practice” in item 9, “continuous improvement and renovation” in improvement action 7, “examining the service quality of suppliers” in improvement action 10, “organizational and process reengineering” in improvement action 4, “examining communication between the consulting company and the enterprise” in improvement action 13, “examining professional expertise of the consulting company” in improvement action 12 and “establishing long-term collaboration relation with suppliers” in improvement action 11. Companies in semiconductor industry can take necessary improvement actions according their priorities to improve TQM implementation effectiveness and efficiency.

Comparing the priorities of improvement actions and critical factors in related literature, the results show commonality of agreement to the factors with high priorities for successful implementation of TQM and they are senior management’s strong commitment, organi-zational culture issues, employee participation and so on. It reinforces the thinking of quality management gurus. TQM Implementation training is quite important as well. Although firms often provide training for quality control and QC tools, firms need to invest more resources to train employees to TQM implementation skills. Application of best practice is in the 7th place. This is an interesting observation that there is always some other organization that lessons can be learn from. Customer orientation is a strong contender. Also, process reengineering emphasizes conformance to internal and external customer requirements by means of organization and process analysis and design. Consulting companies can provide some customized suggestions for firms implementing TQM. Therefore, communicating with consulting companies and evaluating their expertise are also improvement actions for ineffective and inefficient TQM implementation.

Conclusion

To cope with global competition, high performance on quality is essential for most enterprises. The implementtation of TQM generates quality and efficiency, increase customer satisfaction and improve competitive (Yang, 2006). Nevertheless, there is high failure rate in implementation of TQM. Management knows; however, they need a mechanism to evaluate the performance of TQM implementation and how to improve TQM implementation when the performance is not as good as expected. We try to close the gap that previous studies lack evaluation system to diagnose the effectiveness and efficiency of TQM implementation.

This study, therefore, propose a diagnosis method by simultaneously considering the effectiveness and efficiency of implementation. Importance level, accomplishment level and easiness level of implemented TQM practices are employed to constitute TQM implementation performance matrix to determine whether a TQM practice is effective and efficient with V-shaped performance control lines. A performance matrix with V-shape performance control lines is constructed to indentify the practices need to be improved. Ultimately, we use the HOQ approach to define various improvement actions and priorities these actions for implementing TQM. The top five improvement actions include “Strong commitment and involvement of senior management”, “establishment of TQM implementation strategies”, “total participation of organization members”, “change of corporate culture” and “organizational and process reengineering”.

Combining performance evaluation model and HOQ can be employed to systematically evaluate the implementation and find improvement actions. This is a simple and easy-to-use method for managers to diagnose problems and identify direction to increase resources to improve the performance of TQM implementation.

This initial study focuses on the TQM implementation in the semiconductor industry in Taiwan. Different systems specific to various industries should be evaluated in the future, with a view toward assessing if there exists relevant differences based on industries, cultures, legislation and human resources as they arise during the process of implementing TQM.

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