

Progress in Quality Control and the Evolution to TQM: from the late 1940s to the 1990s

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Key word:

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Abstract: While until the mid-1990s there was little consensus on the content and the definition of total quality control (TQC) and total quality management (TQM) in Japan as well as in the West, it seems that a reasonable one was reached in the both regions in the late 1990s. In this paper, the author first discusses a four-stage development process of quality control (QC) and quality management (QM). He next investigates the concepts, elements, and practices of TQM, the majority of firms and many QC/QM professionals recognized it to be, which promoted from QC and TQC. Then he refers to the effect of TQM and proposes an idea on the structure of TQM. Finally, it is argued that a synergy between TQM and JIT production system will be required to reap full benefit from TQM.

1. Introduction

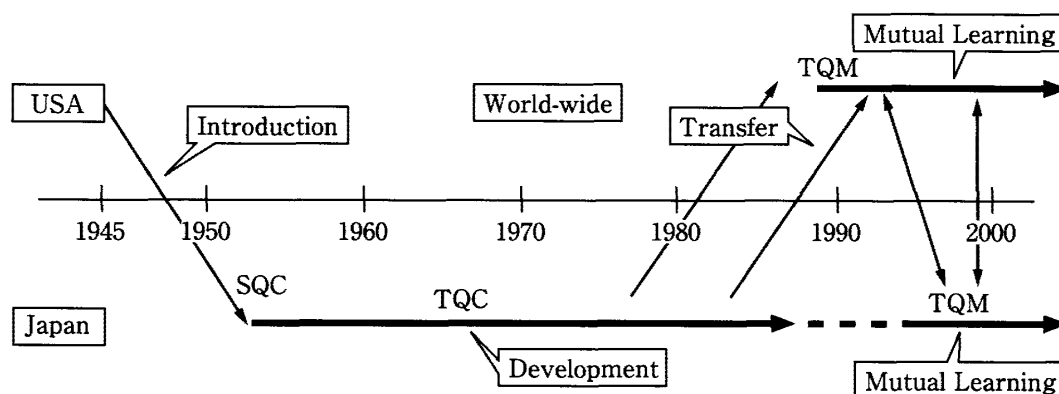
Quality control had been developing since its infancy (Radford, 1992). Shewhart's first book, published in 1931, is well known as a watershed of modern QC. Such QC was regarded as a management tool which applied a theory of mathematical statistics in order to control manufacturing process¹⁾. However, there was little doubt that its actual application to manufacturing operations was spurred by the Second World War, with the need to manufacture the products essential to the war as economically as possible and in large scale. The development and the diffusion process of QC afterwards to TQC and TQM in America and other countries including Japan and the UK, can be seen in the relevant important literatures as follows: Kogure, 1988; Kondo, 1988; Roche, 1989; Morrison, 1981, 1994; Juran, 1995; Juran and Godfrey, 1999. According to them it is clear that there existed quite a few differences in promotion processes and ways of implementation, not only among countries but within the same country. Therefore, while so-called TQC/TQM had widely spread, they had remained to be lacking in a general consensus of their contents and methodology. However, it seemed that a reasonable one regarding the content and the definition of TQM began to be reached world-wide after around 1997²⁾.

In this paper, first, the author describes four stages of the introduction and development of

1) For a more thorough understanding, see Hitomi, 1996, 302.

2) See, e.g. Dale, 1997 and Costin, 1999.

Figure 1 Introducing and developing process of quality control



QC and QM in Japan after the Second World War, and the feature and effectiveness in each of the stages. Then he proposes an idea on the structure of TQM based on the discussion on concept and elements of TQM, and he briefly considers the relationship between TQM and firms' performances as well. Finally, he proposes a diagram for linking TQM and Just-in-Time (JIT) production system in order to take further effect of TQM.

2. Four stages of introduction and development of QC

The development process in QC/QM after the Second World War in Japan can be divided into four major stages as follows (see Figure 1).

2.1 The first stage: Japan's introduction and learning of QC

QC in Japan began with introduction from America through the series of lectures by civil communication section (CCS) in 1949 (Wood, 1989) and by Dr. Deming in 1950. The emphasis of those courses was put on statistical quality control (SQC). Dr. Juran who then asked to come to Japan in 1954 emphasized quality control as a management tool in particular. After that, QC began to diffuse into many companies and every department and everybody (from top management to shop workers) within the same company.

2.2 The second stage: evolution and development to TQC

Japan continued evolving its SQC and QC to TQC. These states were evident from the following statements in the reports of the Deming Prize Committee (1961, 1963):

- Quality control is strongly progressing not only in manufacturing, but also in sales, R&D and administration departments. Company-wide QC is supporting the daily works. (Teijin Company: 1961).
- In order to promote the real TQC, especially in sales, purchasing, accounting, and other indirect departments, the company is using wide QC concept called TQC as the effective management tool (Nihon Kayaku Company: 1963).

Hence, it might be said that the prototype of Japanese-style TQC was formed between 1961 and 1965 as a result of the progress and diffusion of the initial SQC activities. Consequently the

features of Japanese-style TQC which was called company-wide quality control (CWQC) too were proposed in 1969 as follows:

- company-wide quality control
- QC circle activities
- management diagnosis of QC
- application of statistical methods
- education and training in QC
- nation-wide facilitating organizations such as the Japanese Union of Scientists and Engineers (JUSE) and Japan Standards Association (JSA)

As a result of steady progress afterwards, the above features were revised under the following ten categories in 1987:

- (1) Top management led the QC initiative in which every department and everybody participated;
- (2) viewing 'quality first' thoroughly in a company;
- (3) management by policy deployment;
- (4) diagnosis of QC and its practice;
- (5) quality assurance activities were used in all aspects from the development of product concept, development of new product, to production and after sales service;
- (6) QC circle activities;
- (7) education and training in QC;
- (8) development and application of QC tools;
- (9) diffusion of QC from manufacturing industry to service sector;
- (10) contribution of nation-wide facilitating organizations of QC.

Quality of Japanese products continued to raise its reputation during this period. Some examples of this rise in reputation of Japan's product/service quality were reported in 1970 (*Modern Manufacturing*, 1970). National Broadcasting Corporation (NBC) of America televised Japanese QC activity in June 1980. A typical example of the gap in quality of Japanese and American products was shown in the study conducted by Ford Motor Company as follows. In the early 1980s, Ford's internal studies found that the deficiency rate for Ford vehicles to Japanese vehicle was a remarkable 6 to 1 (Cole, 1999, 216). In consequence, as Cole described, in the early and mid-1980s, American manufacturing managers, in internationally competitive markets such as auto and semiconductors/electronics, were wringing their hands in despair having to compete with the Japanese. Such advantageous states of the Japanese quality, as Juran (1992) showed, were kept on between the mid-1970s and beginning of the 1990s.

2.3 The third stage: transfer of Japanese-style TQC to the West and the evolution to TQM

The West, including America and the UK, learned and introduced the so-called Japanese-style TQC throughout the 1980s and the first half of 1990s. Many missions and individuals (over 1000 persons) visited JUSE annually to learn Japanese-style TQC and they also undertook factory tours to observe the actual practices. Quite a few organizations in the West introduced so-called Japanese-style TQC by adopting an incremental approach. Such learning occurred both sequentially and simultaneously resulting in a large change (Cole, 1999, 237). Successful organizations didn't just adopt the Japanese quality system en-block, but they adapted it depending on their particular situations. In summary, contents of TQC differed between Japan and the West mainly because of the national cultural differences (Witcher, 1995; Kanji and Yui, 1997; Yui, 1998). In the

UK, for instance, principles and concepts of TQC/TQM were regarded as more important than techniques whereas in Japan it was just the opposite. According to Cole, American firms did indeed learn a great deal about quality improvement and how to do it from Japan. Although the Americans' learning might be incremental, the resulting aggregate changes seemed to be large (Cole, 1999, 234-8). Meanwhile, since the end of the 1980s the term of TQC was changed to TQM in the West and it gained world-wide use. The origin of the term is not necessarily clear, but in my view, Feigenbaum (1983) did first use the term in his book *Total Quality Control 3rd ed.*, followed by Rehder and Ralson (1984), Oakland (1989) etc.

2.4 The fourth stage: Japan's adaptation of TQM from the West and their mutual learning

In Japan, there was little consensus on the definition of TQC among researchers and practitioners. They didn't have a common notion regarding what TQC was, throughout a decade and a half before mid 1990s (JSQC, 1994; Akao, 1995; Yui, 1995) except a few achievements including Kogure's book in 1988. It was no surprise that TQC began to face criticism, because of the ambiguity of its contents or the excessive usage of formats. Therefore, in Japan, JUSE decided to change the terminology from TQC to TQM in April 1996, and emphasized the role of TQM as the means to formulate and support a corporate strategy.

However, since late in the 1990s, the progress of quality improvement seems to have declined world-wide including both the West and Japan comparing to the growth from the late in the 1980s through early in the 1990s. Therefore they will need to rebuild their TQM efforts by further mutual learning. In the next section, with the help of the literature review and the survey data, we discuss the concept and elements of TQM and its effect on firm's performance.

3. Concept and elements of TQM and the effect on firm's performance

Despite the publication of many papers and books on TQM, the term had remained hazy and ambiguous until the early or mid-1990s as mentioned above, in both Japan and the West. Due to this ambiguity, according to Dean and Bowen (1994), TQM came to function as a sort of Rorschach test, to which people's reactions vary as a function of their own beliefs and experiences. In order to dispel the ambiguity of TQM, the author believed that it would be reasonable to examine the core concept and practical aspects which a majority of firms and many authors considered as important.

3.1 Literature review on the content of TQM

Kanji and Asher (1993) proposed a pyramid model that comprised four principles and eight concepts. According to them, each of these four principles translates into practice by using two core concepts. Boaden (1997) developed some principles and practices based on the survey of TQM elements (Table 1). Apparently practices in Table 1 are considered to include techniques. Dean and Bowen (1994) described TQM as *"a philosophy or an approach to management that can be characterized by its principles, practices, and techniques"*. Golomski (1995) defined as *"philosophy, a set of concepts, and a collection of methods for improving organization"* as well.

Table 1 Principles and practices of TQM

Principles	Practices
Customer focus, with emphasis on the customer-supplier relationship, internally and externally	Training and education considered as an investment
The commitment of everyone to quality improvement, especially managers	The use of teams and teamwork
The involvement of everyone within the organization in quality improvement	The use of appropriate tools and techniques, reviewed regularly
A focus on processes	Goal-setting, measurement and feed-back for all aspects of the business
Continuous improvement as a philosophy	

Source: Boaden (1997)

Grant, Shani and Krishnan (1994) insisted: *"TQM extends quality improvement methods to all functions and all management levels. TQM is a company-wide philosophy of quality improvement."* As seen above TQM might comprise philosophy/principles, concepts, and practices (elements and techniques).

3.2 Empirical study on the content of TQM

In our survey (Kanji and Yui, 1997), data were sampled from 101 Japanese companies in the UK, and their parent companies in Japan, of which number were ninety-eight. Three companies were omitted, because they did not have similar operations in Japan. Of 101 and 98 questionnaires mailed in the survey, 46 and 45 which were complete were returned, giving us usable response rates 45.5% and 45.9% respectively. One of the questions required the respondents to state whether a number of items listed were regarded as concepts and elements of TQM, and then whether any of them had been used. An analysis of the responses indicated that in the UK a majority of companies surveyed regarded concepts as important. A summary of the results in terms of elements is given in Table 2. It indicates that implementation of TQM means the application of most of the elements of TQM in both the countries. It is clear that Japanese TQM group were the most frequent users of those elements, followed by the UK TQM group, the Japanese non-TQM group and then non-TQM group in the UK. However, it is interesting to note that benchmarking and quality cost systems were not widely used in both countries at that time. Thus, there is still room for learning and improving their quality activities further.

3.3 An idea on the structure of TQM

A proposal of an idea on the structure of TQM (Table 3) can be made based on the discussion so far. It comprises four layers: the principles form the foundation, followed by concepts, management systems/tools/operational arts and, finally, goals/aims.

Table 2 TQM elements and their implementation (number of respondents)

Elements	UK (46)		Japan (45)	
	TQM (26)	Non-TQM (20)	TQM (35)	Non-TQM (10)
Commitment/leadership of CEO	85 %	55 %	80 %	70 %
Management by policy development	73	55	89	90
TQM facilitating organization	50	20	83	20
Use of 7 QC tools or SPC methods	62	60	91	90
Benchmarking	42	35	29	10
Education and training of QC	85	65	94	90
Participation of everyone	85	50	89	60
Participation of every department	65	25	66	10
Cross-functional management	42	10	54	30
Quality circles (QC circle activities)	54	35	91	70
QA activities from idea and development of new products to after sales	54	40	71	70
Quality diagnosis	50	60	80	40
Quality cost system	31	40	46	30
Quality system standards	85	60	83	90
JIT production system	50	15	37	30
Average	61	42	72	53

Table 3 An idea on the structure of TQM

Goals, aims		
<u>Management systems</u> • Management by policy deployment • Cross functional management • Quality diagnosis • Quality assurance through whole process • ISO 9000s • QC circle activities • etc.	<u>Tools</u> • 7 QC tools • SPC • QFD • etc.	<u>Operational arts</u> • Hows for introducing TQM • Hows for promoting TQM • Hows for facilitating • etc.
<u>Concepts</u> • Customer satisfaction • Teamwork • Participation of every department and everyone • Prevention • Continuous improvement • Education & training in QC/QM • Customer-supplier relationship (internal customer) • Organizational culture for quality		
<u>Principles</u> • Leadership by CEO • Customer focus • Management by facts • People-centered management		

3.4 TQM and firm's performance

Many studies on the relationship between TQM and firms' performance were conducted (Powell, 1995; Tamimi, 1995; Reed, Lemak and Montgomery, 1996; Adam Jr. *et al.*, 1997; Hendricks and Singhal, 1997, 2000; Ho, Duffy and Shih, 2001). The general consensus of these studies

Table 4 TQM and performance: partial correlations

	Total performance
• Organizational commitment to TQM	0.30
• The degree of advancement of implementing TQM	0.31

Source: Powell (1995)

Table 5 Performance of UK companies in recent years

	TQM companies	Non-TQM companies
	Much better	Much better
Cost of product	27 %	10 %
Quality of product**	27	0
Delivery of product**	39	5
Competitiveness**	27	0

** : $p < 0.01$

was that implementing TQM brought better performance, but the rate of contribution (R^2) was not so large. Powell (1995), for instance, collected data from 166 American firms in his survey. Table 4 illustrates a part of his findings. It shows that the overall performance of firms correlated positively and significantly with both implementing TQM and its degree of advancement. In the survey mentioned in Section 3.2, we compared the performance of TQM and non-TQM companies in the UK in order to analyze the effectiveness of TQM. It suggested that the former had significantly better performance than the latter (Table 5).

Although there was some evidence as mentioned above that implementing TQM contributes significantly to improve firm's performance, the level of contribution attributed to TQM alone was not so large. This indicates that there are other factors than TQM at play. They could be the differences in the processes of implementing TQM, economic trends, the type of industry, the business environment including technology, competitiveness and market, corporate strategy, resources of firm, etc. The rest of the paper focuses on one of the key factors that positively impacts on firm's performance regarding TQM implementation.

4. Relationship between TQM and JIT production system

Both TQM and JIT production system can be considered as important for achieving the required quality, low cost, flexibility and dependability. In this section we consider JIT production system and the importance of the relationship between TQM and JIT production system in implementing TQM.

4.1 JIT production system

JIT production system is also referred to as the lean production system or Japanese-style production system. It was formed in the development process of production management in Japan after the Second World War. Therefore, first of all, it is reasonable to review this process briefly.

It can be divided into the following five stages (Yui, 1997):

- (1) Import and introduction of modern production management from abroad (1945-1959)

Both quality and productivity stayed at low-levels.

- (2) Development and diffusion at home (1960-1974)

The prototype of Japanese-style TQC was formed between 1961 and 1965 as mentioned earlier. The manual of Toyota production system was completed in 1973. Quality, productivity and dependability were improved.

- (3) Progress in high-variety small batch production, and the beginning of internationalization of production management (1975-1984)

JIT production system spread to many companies at home (in Japan) after the late 1970s and began to be introduced abroad.

- (4) Diffusion of Computer Integrated Manufacturing (CIM) and progress of internationalization of production management (1985-1990)

Manufacturing strategy started to be discussed. CIM was one feature of the embodiment of manufacturing strategy³⁾. TQC was transferred to overseas companies during the 1980s and renamed as TQM in the late 1980s as discussed in Section 2.3.

- (5) Long-term economic recession and the rebuilding of production management systems (1991-)

In order to cope with the long-term decline from the early 1990s, Japanese firms have tried to adapt management tools such as ISO 9000s, business process re-engineering, quality award criteria etc. They will continue to struggle for their own survivals.

Almost all researches on Japanese-style production system (JSPS) based on management-study in Japan were conducted after the end of the 1980s. Those authors respectively developed their own view. One researcher, for instance, insisted that it comprised JIT production system and Japanese-style working system (Suzuki, 1994). Another idea was that JSPS in a narrow sense comprised JIT and TQC as techniques (Schonberger, 1982). A third took a broader view and asserted that it encompassed aspects of technology, labor and management (Sakamoto, 1999). The present author identified the major characteristics of so-called JSPS as shown in Table 6. In my view, the very essence of JSPS is to realize small-lot-size operations with a line layout which reduce the production lead-time. The premise of achieving a JIT production system is to establish 'single set-up' (set-up within ten minutes). It was after the mid-1970s when the single set-up was achieved that JIT production system began to reap big rewards. The author analyzed some cases regarding implementation of JIT production system after the mid-1970s in Japanese factories. A summary of some typical examples is shown in Table 7. The benefits gained in three cases presented were:

- a reduction of work-in-process by 90%
- an improvement in productivity by 145%
- a reduction in operators from 40 to 3

JIT production system began to be adapted in overseas factories since the late 1980s. According

3) For a more thorough understanding, see Hitomi, 1996, 355 and 459-63.

Table 6 Characteristics of Japanes-style production system

Category of Activities	Items
Manufacturing Strategy	• Establishing a flexible management system, • Linking labour and technology flexibility, • Just-in-time concept which means to produce goods when needed, • Reducing lead time, • Reducing inventory drastically, • Achieving high quality, low cost and high variety of products
Design	• Line layout, • Synchronization of each stage in high variety operation process = Mixed model production, • Multi-functional operators, • Flexibile staffing = Less workforce, • Flexibility of production system using micro-electronics technology
Planning and Control	• Market oriented production planning based on every ten days and daily order • Leveled scheduling = smoothing production • Small lot size operations • Pulling system by the last stage • <i>JIDOKA</i> which means, in the event of problem occurrence, (1) operators have authority to stop line (2) machine stops automatically • <i>POKA-YOKE</i> (eliminating defects automatically) • Minor technical invention • Computer-aided control of production
Improvement	• Set-up time reduction, • improvement of technology, • Reduction of defectives • Quality circles (QC circle activities)

Table 7 Typical examples of JIT implementation in Japanese factories

Company	Period of Activity	Type of process	Implemented Activities	Results
KU	1976-79	Assembly line	Smoothing, Synchronizing, Single set-up	Decreasing work-in-process by 90%
NI	1980-85	Jobbbing, Make-to-order	Line layout, Small lot size operations, Visible control	Improving productivity by 145%, Reducing throughput time by 50%
KA	1985-89	Line layout with multi-variety production	Linkage of POS system and FMS	Reducing operators from 40 to 3, Quick response of manufacturing function

to Gilbert (1990), quite a few American companies acquired competitiveness in terms of productivity and quality by applying JIT production system.

4.2 Synergy of TQM and JIT

We investigated the relationship between TQM and JIT production system in our survey mentioned in section 3.2 above. Respondents to the survey were asked whether they thought that JIT

Table 8 Synergy of TQM and JIT production system

Category	TQM	Linkage	JIT
Scope	Company-wide, Customer, Subcontractor	A →	Mainly manufacturing, Customer Subcontractor
Organizational emphasis of activities	Strategic ◎ Managerial ◎ Operational ○	← A →	Strategic ○ Managerial ◎ Operational ◎
Goals or Aims	Performance Retention and acquisition of customer Total quality (Q, C, D, E*) *E: Environment	← A →	Cost reduction & Improvement of productivity by eliminating seven wastes Flexibility Speed
Principles or Concepts	Leadership, Customer focus Customer-supplier relationship Organizational culture for Q. Management by facts Continuous improvement, Prevention People-centered management Participation, teamwork	← A →	JIT (necessary goods when needed) <i>Jidoka</i> = automation
Elements	Top mgt. support/commitment Management by policy deployment Participation of every department. Participation of everyone TQM facilitating organization Cross functional management Management of daily operations QA from R&D to after sales QC education & training Benchmarking SPC, seven QC tools QC circles, teamwork Quality cost system Standardization Quality diagnosis by top management		<i>Kanban</i> (card) control Production smoothing Small lot size (one piece) production with flow lines Reduction of set-up time Multi-functional operators Flexible staffing = Less operators Standard operations Visual control <i>Poka-yoke</i> = fool proof Automatic line stop Line stop authority of operators = Autonomy to intervene

strong positive influence

ordinary positive influence

A : All or most of the items within the category relate to all within the category of the other system

was regarded as a part of TQM. In UK, 48% (22/46) of the respondents answered "yes" to this question and the other 48% (22/46) in negative. In Japan, the corresponding responses were 56% (25/45) and 36% (16/45) respectively. The next question was as followed:

If the answer to the above question is "No", then what do you think of the priority between TQM and JIT?

The result in UK was 64% (14/22), and 83% (15/18) in Japan. It is evident from this survey that the majority of respondents, 78% (36/46) in UK and 84% (38/45) in Japan, thought TQM includes JIT or must be implemented earlier than JIT in both countries. Table 8 which was formed based

on the above survey and the discussion so far, represents the relationship between TQM and JIT production system. It should be emphasized that it is extremely important for companies to review their management systems of quality and manufacturing in order to gain a noticeable improvement by tapping the natural synergy in linkages between TQM and JIT. As seen in Table 8, first, most items in principles or concepts, and elements of TQM, such as leadership, customer focus, organizational culture for quality, participation, teamwork, etc. are intangible and behavioral factors. The rest of them are mainly management systems, including management by policy, cross-functional management, and quality assurance from R&D to after sales, etc. which are soft ones too. On the other, almost all items of JIT are hard and tangible factors, such as control by *kanban* (card), reduction of set-up time, fool-proof, etc. Then, goal or aims, and scope of TQM are broader than those of JIT production system. Finally, in many organizations, top management (CEOs) lead introduction and implementation of TQM as corporate strategy with a deep commitment. But, almost all projects of JIT production systems had been promoted by directors or senior managers of operations function as a support for corporate strategy, or as manufacturing strategy. Based on these findings above, it obviously takes long time for companies to introduce and implement TQM, and as seen in Table 8 most items in elements of TQM affect the implementation of activities of JIT production system. This means that the former should be a premise of the latter.

In conclusion, therefore, companies must introduce and implement TQM earlier than JIT production system, and they are required to facilitate the project carefully considering the priority of application of those principle and elements. It is also necessary for them to introduce and implement as many items as possible systematically, not partly. It goes without saying that every linkage between TQM and JIT production system must be examined in both the introduction and the implementation stages⁴⁾.

5. Conclusion

In this paper the author described the four stages of developing process of QC and QM. He then discussed not only the concept and the elements of TQM in order to clarify its ambiguity, but proposed an idea on the structure of TQM. He referred to the relationship between TQM implementation and firm's performance, too. He suggested that in order to achieve further benefits, it was essential that organizations considered how to exploit the synergy that existed between TQM and JIT production system. The proposed diagram shown in Table 8 can be used as a framework for achieving effective linkages between them.

Further study regarding the current progress in TQM including ISO quality management systems and quality awards etc. are needed (Jabnoun and Sedrani, 2005; Parast, *et al.*, 2006; Costa and Lorente, 2007).

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