Prioritising the enablers for the successful implementation of Kaizen in China: a Fuzzy AHP study

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Please cite:

Ma, J. Lin, Z. and Lau, C.K. (forthcoming) Prioritising the enablers for the successful implementation of Kaizen in China: a Fuzzy AHP study, *International Journal of Quality & Reliability Management*. In Press. doi: 10.1108/IJQRM-12-2015-0173.

Abstract

Purpose – The main purpose of this study is to develop a better understanding of how Sino-Japanese joint ventures implemented the three Japanese improvement methods, i.e. Kaizen, Kaikaku and Kaizen Blitz. The specific objectives of this study are: (a) to identify the key enablers for the three improvement methods; and (b) to identify the most selected improvement method.

Design/methodology/approach – This study employs fuzzy analytic hierarchy process to pairwise-compare the three improvement methods. The data are collected from 28 industry experts from Sino-Japanese joint ventures. The study then adopts extent analysis approach for pairwise comparisons and extent analysis to obtain synthetic extent values for priority weights.

Findings – The results of the study indicate that Personnel (humanware) factor enablers are the most important factor for Kaizen, whilst Software factor enablers (essential rules, policies and institutional arrangements) weight second and Hardware factor enablers (physical, measurable hard facts or resources) weight last. The study also reviews that Kaizen is the most selected improvement method among the three.

Research limitations/limitations – The sample of this study is limited to Sino-Japanese ventures in Guangzhou, China. This study only identifies the key improvement enablers based on interviews with shop floor managers and improvement experts.

Practical implications –Practical implications are also threefold: (a) the improvement implementations should be based on factors such as regular training, incentives for motivations and shop-floor management; (b) improvement methods are transferable and standard operations may only have small effects on collecting improvement ideas; and (c) Kaizen is the appropriate method to support long-term and process-oriented improvements.

Originality/value –This study is the first to specifically pairwise-compare the three Japanese improvement methods and to identify priorities of their key enablers in Sino-Japanese joint ventures.

Keywords: Kaizen; AHP; Fuzzy; Decision support; China.

Paper type: Research paper

1. Introduction

Kaizen (Imai, 1986) is one of its foundations to support other lean tools and processes (Womack, Jones, & Roos, 1990). However, like other Japanese production management systems, Kaizen is complex, inter-related and context-dependent (García, Maldonado, Alvarado, & Rivera, 2014; Taylor & Taylor, 2008). Many existing studies have agreed that adopting and implementing Kaizen is not always straightforward (Aoki, 2008; Brunet & New, 2003; Caffyn, 1999) and particularly hard to sustain in the long term (Bessant, Caffyn, Gilbert, Harding, & Webb, 1994). In addition, Kaizen is thought to be underpinned by the unique Japanese culture (Hong, Snell, & Easterby-Smith, 2006; Liker & Hoseus, 2008; Recht & Wilderom, 1998), and thus companies outside Japan could face difficulties when selecting the appropriate supporting tools and techniques (Bessant et al., 1994) and would need more time to adopt and implement this improvement method (Hines, Holweg, & Rich, 2004). In addition, two other improvement methods are recently becoming more popular, Kaizen blitz (or Kaizen events) and Kaikaku (Radical changes) (Bicheno, 2001; Browning & Heath, 2009; Done, Voss, & Rytter, 2011; Wiljeana J. Glover, Jennifer A. Farris, & Eileen M. Van Aken, 2014; Glover, Liu, Farris, & Van Aken, 2013; Radnor, Holweg, & Waring, 2012; Santos, Wysk, & Torres, 2014). These methods differ in terms of the time scale for implementation and whether the improvement is continuous or one-off, and have different enablers for their implementation (Fryer, Antony, & Douglas, 2007; García et al., 2014).

Both lean production and these improvement methods were introduced into China in the early 1980s by foreign manufacturing companies (Huang & Liu, 2005; Taj, 2008), particularly those from Japan (Aoki, 2008; Hong, Easterby-Smith, & Snell, 2006; Lee, 1996). Over the following two decades, many Sino-international automotive joint ventures were established. Since the 2000s, China has been the world’s leading automotive producer in term of volume and one of the world’s most popular automotive outsourcing destinations. Many major Japanese car assemblers and their parts suppliers have established joint ventures in China (Calantone & Zhao, 2001) and many of them have successfully transferred the advanced production technology, management knowledge and improvement skills to the Chinese ventures (Aoki, 2008; Shang & Pheng, 2013; Suárez-Barraza & Smith, 2014). Nevertheless, the direct transfer of Japanese Kaizen practice to China may encounter difficulties (Hong, Snell, et al., 2006). The Sino-Japan joint ventures may be affected by the Chinese cultural and constitutional settings (see Zhang & Goffin, 1999) and might have some different priorities for the key enablers of Kaizen or localised enablers to adopt and implement improvements (Aoki, 2008). As stated by Aoki (2008), there is still a large gap in the literature in terms of how Kaizen activities are organised in countries outside Japan.

This study thus aimed to develop a better understanding of how Sino-Japan joint ventures have adopted and implemented the three types of improvement methods, i.e. Kaizen, Kaikaku and Kaizen blitz. The specific objectives of this study are:

a) to identify priorities of the key enablers for successful implementation of the three improvement methods based on the proposed model; and

b) to identify the most selected improvement method.

The study was conducted based upon a series interview of 28 industry experts from four Sino-Japanese automotive joint ventures. The data were collected based on a nine-point pairwise-comparison scale. The priorities of the key enablers were decided by a fuzzy Analytic Hierarchy Process using triangular fuzzy numbers. This study has three theoretical contributions: a) developing a generic hierarchy model for prioritising the key enablers for improvement implementations; b) revealing a set of key enablers unique to Chinese context; and c) indicating that Kaizen is the most selected method among the three improvement alternatives. The findings should fulfil the needs of both academics and practitioners in the existing body of knowledge. They should provide some useful guidelines and methods that can be used by companies based outside of Japan to adopt and implement Kaizen.

The paper is organised as follows: section 2 reviews the literature on the three improvement methods and the key enablers of improvement. Sections 3 presents the research methodologies. Section 4 explains the steps involved in data collection, analysis and results. Finally, in Section 5 the conclusions and recommendations for future research are presented.

2. Literature review

2.1 The three improvement methods: Kaizen, Kaikaku and Kaizen blitz

In recent years, adopting and implementing improvements for long-term and sustainable outcomes have received considerable attention in the literature (Done et al., 2011; Radnor et al., 2012; Shang & Pheng, 2013; Singh & Singh, 2015; Van Aken, Farris, Glover, & Letens, 2010). Improvement method selection is a multi-criteria problem, as there are many different enablers (Fryer et al., 2007; Fryer, Ogden, & Anthony, 2013; García, Rivera, & Iniesta, 2013), enablers (Bateman, 2005; Bessant, Caffyn, & Gallagher, 2001; Caffyn, 1999) or essential criteria (Kaye & Anderson, 1999) to support improvement implementations. Depending on different time scape for implementation and whether the improvement is continuous or one-off, the improvement methods can be categorised into three types: Kaizen, Kaikaku and Kaizen blitz.

Kaizen is a process-oriented improvement method. It focuses on the course of the implementation and aims to produce cumulative results from an incremental change process. It is a "never ending" (Bond, 1999, p320) "on-going improvement" (Imai, 1986, p3) "of a cumulative character" (Marin-Garcia, del Val, & Martin, 2008, p57) and with a "top-down…and…bottom-up" framework (Bessant & Francis, 1999, p1109). It instils in everyone within the organisation (Terziovski & Sohal, 2000) a sense of responsibility for implementing improvements on a continuous basis (Monden, 1983), such as habitually providing both personal suggestions (Imai, 1986) and implementing group-based improvement activities (Handyside, 1997). Therefore, Kaizen is "not of the breakthrough variety, but incremental in nature" (Bessant & Caffyn, 1997, p10). It is "an organisational-wide process of focused and sustained incremental innovation" (Bessant & Francis, 1999, p1106); or "a habitual way of life in the organisation" (Handyside, 1997, p14) to develop and implement all sorts of improvement ideas in a constant manner (Chartered Quality Institute, 2011). Management approval is only needed for large improvement ideas, whilst small changes can be implemented without the prior approval of management (Crocker, Chiu, & Charney, 1984). Intrinsic psychological rewards (e.g., self-motivation) are commonly used to boost participation (Brunet & New, 2003; Máire Kerrin, 1999).

The discontinuous improvement, on the other hand, is called innovation or Kaikaku in Japanese. It is a results-oriented method and characterised by its 'one-off' but innovative results. The implementation of the Kaikaku is different from Kaizen (Imai, 1986). The Kaikaku methods (Bodek, 2004) generally emphasise breakthrough improvement ideas for dramatic alterations (Hines et al., 2004) and radical changes (Bhuiyan & Baghel, 2005). It requires significant investment in capital (Terziovski & Sohal, 2000), new technologies or equipment (Nihon HR Kyōkai, 1995, pp., p8) and can take a long time (Sayer & Williams, 2012) to generate "a large and fundamental change of policy, practice, or awareness" (Bodek, 2004, pix). Handyside (1997, p16) indicated that Kaikaku is "usually characterised by revolutionary new processes, advanced technologies and high capital investment". These non-gradual methods do not necessarily sustain long-term improvements and achieve long-term targets (Imai, 1986).

Kaizen blitz (Laraia, Moody, & Hall, 1999), Kaizen event (Doolen, Worley, Van Aken, & Farris, 2003), or Kaizen burst (Liker & Meier, 2006) are short-term (e.g., 3-5 days) improvement methods (Graban & Swartz, 2012; Natale, Uppal, & Wang, 2014). They are generally based on the ideas or proposals of managers, technicians or consultants (Bodek, 2002; Marin-Garcia et al., 2008) rather than involving all staff members of a company (Terziovski & Sohal, 2000). This cross-functional team usually focuses on large improvements on few targeted areas (Bessant et al., 2001; Farris, Van Aken, Doolen, & Worley, 2009). Most of this types of improvement ideas are not implemented by the proposers (Nihon HR Kyōkai, 1995). Thus, extrinsic rewards (e.g., financial incentives) are necessary to stimulate participation (Yasuda, 1989), but they are commonly associated with the final improvement outcomes (Imai, 1986). Thus, this type of improvement methods could suffer from low participation and low acceptance rates (Hull, Azumi, & Wharton, 1988).

2.2 Key enablers for implementing continuous improvement

Various versions of key enablers or critical successful factors (CSFs) for continuous improvement have been identified (e.g. Fryer et al., 2007; García et al., 2014; Handyside, 1997; Kaye & Anderson, 1999). For instance, Handyside (1997) highlighted the importance of shop floor management, employee involvement, and teamwork. Fryer et al. (2007) identified six key enablers for adopting Kaizen in manufacturing organisations: strong and committed leadership from senior management team; communication; learning and training; quality culture; customer management; and quality data.

According to Lillrank and Kano (1989), the critical factors for improvement implementations can be grouped into three categories: Hardware, Software, and Personnel (Humanware).

2.2.1 The hardware factors

The Hardware factors provide improvement implementations with appropriate and enough measureable hard facts (Lillrank & Kano, 1989). These involve all the physical support (i.e., *technology* and *machinery*), extra labour (i.e., *Kaizen experts*) and financial budgets (i.e., *monetary investment*). Installing high *technology* is always accepted in the workplace to create radical changes in Kaizen event (Brunet & New, 2003; Doolen, Van Aken, Farris, Worley, & Huwe, 2008). This is associated with the use of new *machinery* to offer better production facilities in order to meet higher requirements (Wiljeana J. Glover, Jennifer A Farris, & Eileen M Van Aken, 2014). In addition, hiring project-based improvement *experts* and outside lean *consultants* to coach and intervene the improvement implementations are sometimes promoted at the beginning of the Kaizen journey (Alstrup, 2000; Bateman & Rich, 2003). *Monetary investment* therefore, is needed to provide financial support and use as an important form of extrinsic rewards to motivate and facilitate improvement participations (Maire Kerrin & Oliver, 2002; Ma, 2014).

2.2.2 The software factors

The Software factors embraces a wide range of shop floor rules, routines, procedures, policies and institutional arrangements for improvement implementations (Lillrank & Kano, 1989). Ma (2014) advocates that the shop floor is considered one of the most important areas within an organisation. On the shop floor, *Standard operation procedure* is a key activity for creating effective work flow and improving product quality (Liker, 2004). It also supports many *shop floor management* tools and techniques (e.g.,5S, visual management, waste removal, etc.) to form the foundation of continuous improvement (Bateman, 2005). These tools and techniques are commonly used together to search for shop floor problems, identify the root causes of variations (Hines, Found, Griffiths, & Harrison, 2008) and increase shop floor performance (Letmathe, Schweitzer, & Zielinski, 2012). Once the root causes of the problems are accurately detected, an effective *improvement system* is needed to collect all scales (i.e., either in a group based or individually) improvement suggestions/ideas (Marin-Garcia & Poveda, 2010). The environment to collect group based improvement suggestions/ideas is strengthened by an *open communication network* (Dorfman et al., 1997). This network can benefit the two-way (top-down and bottom-up) information sharing (Choi & Liker, 1995) and promote freedom and originality for suggestions dissemination (Phan, Abdallah, & Matsui, 2011; Takeuchi, Osono, & Shimizu, 2008). In addition, organisations concentrating on training and learning (Fryer et al., 2007), such as the regular *on-/off-the-job training* and *job rotation/relocation* schemes can benefit the development of individual suggestions/ideas (Kumar, Kumar, de Grosbois, & Choisne, 2009; Vinodh & Chintha, 2011).

Employees can constantly acquire new skills and raise awareness of making improvement suggestions (Ariga, Kurosawa, Ohtake, Sasaki, & Yamane, 2013). *Incentive rewards* can also be used to motivate employees to regularly participate in improvement and develop both large and small suggestions (Govindarajulu & Daily, 2004). Review and feedback should be given to the suggestions in a timely manner (Chin, Pun, Xu, & Chan, 2002). It is argued that an effective *benchmarking/feedback system* is a thrust of long-term improvement implementations (Bond, 1999; Çiçek, Köksal, & Özdemirel, 2005). Furthermore, the *improvement culture* is also an essential factor (Marin-Garcia & Poveda, 2010; Shortell et al., 1995; Singh & Singh, 2015). As Fryer et al. (2007) stress, a quality culture with an ambition to accumulate habitual changes can create support for continuous improvement.

2.2.3 The personnel factors

The personnel factors include all human resources (Lillrank & Kano, 1989), as continuous improvement requires a high value on of humanware's involvement and participation (Bessant et al., 1994). *Top managers* have the senior strategic roles of leadership, direction setting and provide appropriate commitments to support improvement implementations (Kaye & Anderson, 1999). *Middle managers* are in a key position in relation to the line managers and shop floor personnel to act as an intermediary for maturation of 'strong worker mentality' and to repopularise and resimplify the quality theory for improvement after the initial contribution made by the top management (Savolainen, 1999). *Line managers* are the auxiliary personnel who play an important role in supervising large improvement processes. They also motivate, collect, review, and small implement ideas (Montabon, 2005). *Shop floor personnel* is responsible for work-related improvement ideas (Aoki, 2008). As suggested by Marin-Garcia et al. (2008), those ideas should be developed based on their hands-on knowledge to resolve local problems within their immediate working area. The participation of the rest of the humanware (i.e., *non-production personnel*) is also critical to support improvement implementations. It is argued that *non-production personnel* can also provide valuable suggestions if they actively involve in improvement activities (Terziovski & Sohal, 2000).

The key enablers for improvement implementations may change over time (e.g. Farris et al., 2009; Fryer et al., 2007; García et al., 2014; Handyside, 1997; Kaye & Anderson, 1999) and may vary for different organisations, countries or cultures (Brotherton & Shaw, 1996). In particular, although some factors (e.g. management commitment and regular training for employees) were universally cited as being critical (Aoki, 2008; García et al., 2014), whilst some other key factors were rather neglected or. For instance, shop floor management has been described as the beginning of Kaizen journey to contain many practices (e.g. 5S practice, visual management, standard operations and waste removal) for improvement (Bateman & Brander, 2000; Handyside, 1997; Hirano, 1996), but less attention has been paid in some studies (Bessant et al., 1994; Caffyn, 1999; Fryer et al., 2007). Moreover, in Japan, there is a strong emphasis on teamwork or groupism for Kaizen, but this building block has not been considered in the studies by Fryer et al. (2007) and Kaye and Anderson (1999).

3. Methodology

3.1 The fuzzy analytical hierarch process

Improvement method selection is complicated and it is multi-criteria decision problem. The fuzzy analytical hierarchy process (FAHP) is an effective procedure to solve complex decision making problems (Buckley, 1985), using experts' experience and tacit knowledge (Saaty, 1994). It is based on Saaty's (1980) original analytical hierarchy process (AHP), but offers better abilities to decompose and evaluate multiple criteria when handling uncertainty due to imprecision or vagueness in decision making process. The FAHP uses fuzzy ratios (Zadeh, 1965), rather than the AHP's crisp nine-point scale (Buckley, 1985), to make pairwise comparisons and reduce bias (Van Laarhoven & Pedrycz, 1983). The fuzzy ratios consist of a set of objects with a continuum of grades of values to represent vague data. Chang's (1992) Triangular Fuzzy Number (TFN) set $\tilde{M}$ (see Figure 1) can be used to respectively indicate the smallest possible value (parameter *l*), the most promising value (parameter *m*), and the largest possible value (parameter *u*) in a fuzzy event (Demirel, Demirel, & Kahraman, 2008; Kahraman, Demirel, Demirel, & Ateş, 2008).

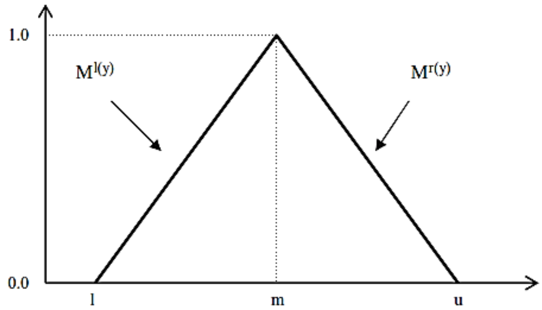

Figure 1 A Triangular Fuzzy Number, $\tilde{M}$ (Kahraman et al., 2008, pp 93)

Each TFN set has the following linear presentations *(1)*:

$$\mu\left(\frac{x}{\widetilde{M}}\right) = \begin{cases} 0, & x < 1 \\ (x-l)/\ (m-l), & 1 < x < m \\ (u-x)/(u-m), & x > 1 \end{cases} \qquad (1)$$

Each TFN set can be given by its corresponding left $l(y)$ and right $r(y)$ representation of each degree of membership as *(2)*:

$$\widetilde{M} = (M^{l(y)}, M^{r(y)} = (l + (m-l)y, u + (m-u)y) \qquad y \in [0,1] \qquad (2)$$

3.2 The extent analysis method of fuzzy analytical hierarch

This study adopts Chang's (1992) extent analysis approach. This approach uses TFN for pairwise comparisons and extent analysis method to obtain synthetic extent values for priority weights. It is one of the most commonly used approaches for FAHP solutions and relatively easier than many other FAHP approaches (e.g., Buckley, 1985; Cheng, 1997; Stam, Sun, & Haines, 1996; Weck, Klocke, Schell, & Rüenauver, 1997). Following Chang (1992, 1996), let $X = \{x_1, x_2, \ldots, x_n\}$ be an object set and $U = \{u_1, u_2, \ldots, u_m\}$ be a goal set. Each object is then taken and extent analysis can be used for each goal respectively. Therefore, the above TFN set $\widetilde{M}$ would be obtained as *(3)* where all $M_{gi}^{j} (j = 1, 2, \ldots, m)$ are TFNs:

$$M_{gi}^{1}, M_{gi}^{2}, \ldots, M_{gi}^{m} \qquad i = 1, 2, \ldots n; \qquad (3)$$

Chang's (1992, 1996) extend analysis approach has 4 steps:

Step 1, let $M_{g_i}^{m}$ be values of extent analysis of the object for m goals, and the value of fuzzy synthetic extent *S* with respect to the i-th object is defined as *(4)*:

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \tag{4}$$

To obtain $\sum_{j=1}^{m} M_{gi}^{j}$ the fuzzy addition operation of *m* extent analysis is performed as *(5)*:

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_i , \sum_{j=1}^{m} m_i , \sum_{j=1}^{m} u_i \right) \tag{5}$$

To obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$, the fuzzy addition operation of $M_{gi}^{j}(j = 1, 2, \dots , m)$ is performed as *(6)* and *(7)*:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{i=1}^{n} l_i , \sum_{i=1}^{n} m_i , \sum_{i=1}^{n} u_i \right) \tag{6}$$

Thus:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{7}$$

Step 2, to compare each of the *S* i-th object. The degree of possibility of $M_2 =$

$(l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as *(8)*.

$$V(M_2 \geq M_1) = sup_{y \geq x} \left[\min \left(\mu_{M_1}(x), \mu_{M_2}(y) \right) \right] \tag{8}$$

It can be equivalently expressed as *(9)*:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d)$$

$$= \begin{cases} 1, & \text{if } m_2 \geq m_1 \\ 0, & \text{if } l_1 \geq u_2 \\ (l_1 - u_2)/(m_2 - u_2) - (m_1 - l_1), & \text{otherwise} \end{cases} \tag{9}$$

Where *d* is the ordinate of the highest intersection point between M_1 and M_2 (see Figure 2). M_1 and M_2 is compared based on the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

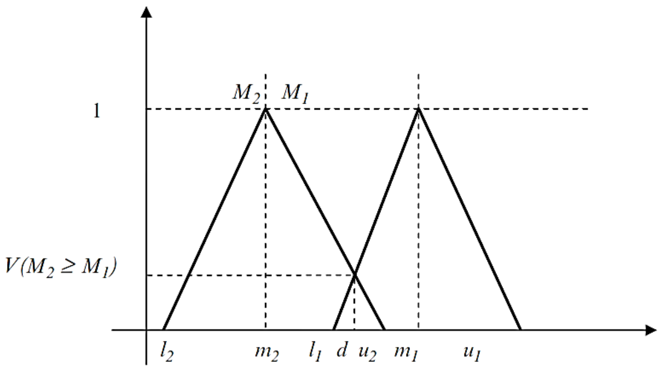

Figure 2 the intersection between M_1 and M_2 (Demirel et al., 2008, pp72)

Step 3, the degree of possibility for a convex fuzzy number to be greater than *k* convex fuzzy numbers $M_i (i = 1, 2, \ldots, k)$ can be defined *(10)*, *(11)* and *(12)*:

$$V(M \geq M_1, M_2, \ldots M_k)$$

$$= V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and} \ldots \text{and } (M \geq M_k)] \tag{10}$$

$$= \min V(M \geq M_i), \quad i = 1, 2, \ldots, k$$

Assume that

$$d'(A_i) = min\, V(S_i \geq S_k) \quad (11)$$

For $k = 1, 2, \ldots, n; k \neq i$. Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2), \ldots d'(A_n))^T \quad (12)$$

where $A_i (i = 1, 2, \ldots, n)$ are n elements.

Step 4, after normalisation, the normalised weight vector is defined as *(13)*:

$$W = (d(A_1), d(A_2), \ldots d(A_n))^T \quad (13)$$

where W is a non-fuzzy number to give priority weights of an attribute or an alternative over other.

3.3 Application of fuzzy AHP on improvement method selection problem

Considering the three types of improvement methods advocated and the critical factors consolidated from literature, the improvement method selection problem is decomposed into a model of hierarchical structure. The model has three levels for the goal (Figure 3). It has three main success factors (1 – 3 in level 1), 17 sub-factors (1.1 – 1.4, 2.1 – 2.8 and 3.1 – 3.5 in level 2) and three improvement methods (A – C in level 3).

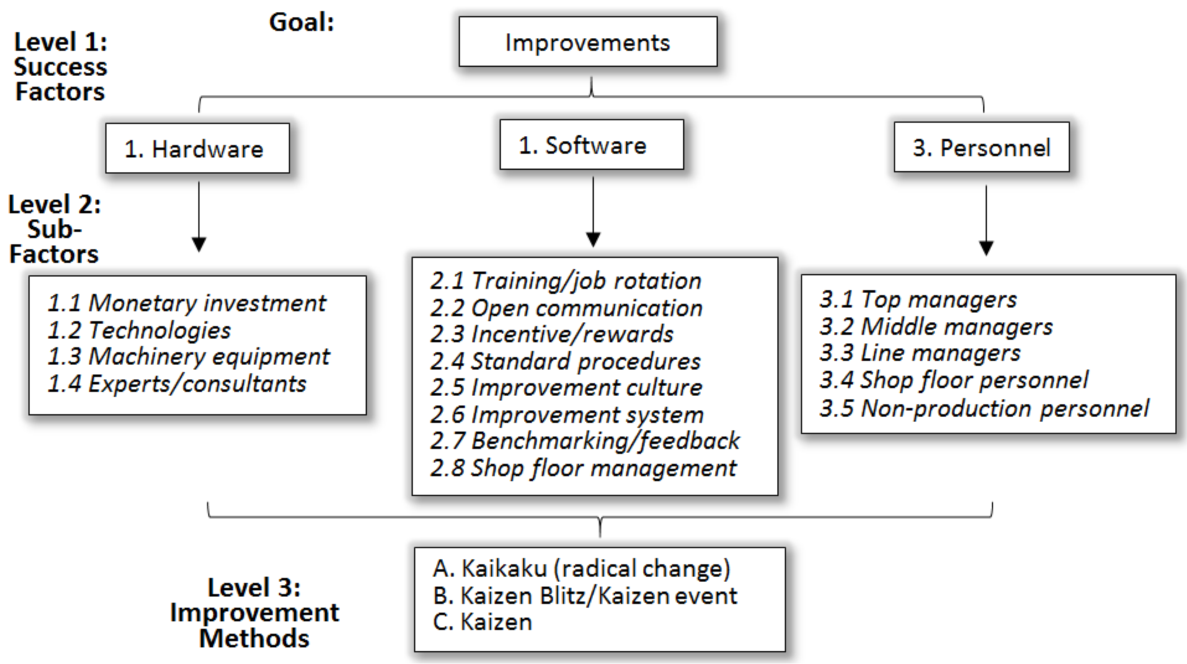

Figure 3 Hierarchy process tree model

In order to suit the study objectives, series of interview meetings were conducted in 2010, 28 shop floor management and improvement experts were selected from four Sino-Japanese automotive complies (car assemblers C1 – C4 with employee number of over 2000) in Guangzhou, China. They were invited to attend personal interview meetings to collect their professional opinions.

Table 1 distribution of expert groups in meetings

Expert groups	C1	C2	C3	C4	*Total No. of participants*
Managerial representatives	1	1	1	0	*3*
Line supervisor representatives	1	2	3	2	*8*
Shop floor representatives	4	4	3	6	*17*
Total					*28*

A set of pretested linguistic variables were used in the meetings for the purpose of pairwise comparisons (Saaty, 2000). The linguistic variables are converted to TFN (Table 2).

Table 2 The triangular fuzzy numbers

Definition	**Fuzzy AHP Scale**
Equally preferred	(1, 1, 1)
Weakly preferred	(2/3, 1, 3/2)
Fairly strongly preferred	(3/2, 2, 5/2)
Very strongly preferred	(5/2, 3, 7/2)
Absolutely preferred	(7/2, 4, 9/2)

Thirdly, the Chang's (1992, 1996) four-step extend analysis approach was followed to 1) calculate the priority weights for all factors and sub-factors; 2) compute the global priority weights to choose the best improvement methods; and finally 3) the priority weights of the improvement methods with respect to the main attributes.

4. Results

The level 1 success factors: hardware, software and personnel on improvement method selections are compared in Table 3.

Table 3 Evaluation of main attributes with respect to improvement

	1. Hardware	**2. Software**	**3. Personnel**
1. Hardware	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
2. Software	(2/3, 1, 3/2)	(1, 1, 1)	(3/2, 2, 5/2)
3. Personnel	(5/2, 3, 7/2)	(2/5, 1/2, 2/3)	(1, 1, 1)

The level 2 sub-factors on improvement are compared in Table 4 - Table 6.

Table 4 Evaluation of sub-factors of hardware factors

	1.1	***1.2***	***1.3***	***1.4***
1.1	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)
1.2	(3/2, 2, 5/2)	(1, 1, 1)	(2/3, 1, 3/2)	(3/2, 2, 5/2)
1.3	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)	(2/3, 1, 3/2)
1.4	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)

Table 5 Evaluation of sub-factors of software factors

	2.1	***2.2***	***2.3***	***2.4***	***2.5***	***2.6***	***2.7***	***2.8***
2.1	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(2/3, 1, 3/2)
2.2	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)	(2/5, 1/2, 2/3)
2.3	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(1, 1, 1)	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2/3, 1, 3/2)
2.4	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)	(1, 1, 1)	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
2.5	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
2.6	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	(2/5, 1/2, 2/3)
2.7	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)	(2/5, 1/2, 2/3)
2.8	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(1, 1, 1)

Table 6 Evaluation of sub-factors of personnel factors

	3.1	***3.2***	***3.3***	***3.4***	***3.5***
3.1	(1, 1, 1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	(1, 1, 1)	(3/2, 2, 5/2)
3.2	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/7, 1/3, 2/5)	(2/3, 1, 3/2)	(1, 1, 1)
3.3	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(1, 1, 1)	(2/3, 1, 3/2)	(3/2, 2, 5/2)
3.4	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)	(2/3, 1, 3/2)
3.5	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)

The level 3 improvement alternatives with respect to relevant sub-factors are compared in Table 7 - Table 23

Table 7 Evaluation of the improvement methods with respect to warehouse/shop floor

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(3/2, 2, 5/2)	(5/2, 3, 7/2)
b. Kaizen Blitz	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(2/7, 1/3, 2/5)	(2/3, 1, 3/2)	(1, 1, 1)

Table 8 Evaluation of the improvement methods with respect to technologies

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)
b. Kaizen Blitz	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 9 Evaluation of the improvement methods with respect to machinery equipment

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(5/2, 3, 7/2)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(3/2, 2, 5/2)
c. Kaizen	(2/7, 1/3, 2/5)	(2/5, 1/2, 2/3)	(1, 1, 1)

Table 10 1.4 Evaluation of the improvement methods with respect to labour

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)
b. Kaizen Blitz	(3/2, 2, 5/2)	(1, 1, 1)	(7/2, 4, 9/2)
c. Kaizen	(2/5, 1/2, 2/3)	(2/9, 1/4, 2/7)	(1, 1, 1)

Table 11 Evaluation of the improvement methods with respect to training/job rotation

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)
c. Kaizen	(2/3, 1, 3/2)	(1, 1, 1)	(1, 1, 1)

Table 12 Evaluation of the improvement methods with respect to open communication

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)
c. Kaizen	(5/2, 3, 7/2)	(3/2, 2, 5/2)	(1, 1, 1)

Table 13 Evaluation of the improvement methods with respect to incentive/rewards

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(3/2, 2, 5/2)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(2/5, 1/2, 2/3)	(2/3, 1, 3/2)	(1, 1, 1)

Table 14 Evaluation of the improvement methods with respect to standard procedures

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(2/7, 1/3, 2/5)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(2/3, 1, 3/2)

c. Kaizen	(5/2, 3, 7/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 15 Evaluation of the improvement methods with respect to improvement culture

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(2/9, 1/4, 2/7)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(2/7, 1/3, 2/5)
c. Kaizen	(7/2, 4, 9/2)	(5/2, 3, 7/2)	(1, 1, 1)

Table 16 Evaluation of the improvement methods with respect to improvement system

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/9, 1/4, 2/7)
b. Kaizen Blitz	(3/2, 2, 5/2)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(7/2, 4, 9/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 17 Evaluation of the improvement methods with respect to benchmarking/feedback

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/9, 1/4, 2/7)
b. Kaizen Blitz	(3/2, 2, 5/2)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(7/2, 4, 9/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 18 Evaluation of the improvement methods with respect to shop floor management

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/9, 1/4, 2/7)
b. Kaizen Blitz	(3/2, 2, 5/2)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(7/2, 4, 9/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 19 Evaluation of the improvement methods with respect to top managers

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)
b. Kaizen Blitz	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 20 Evaluation of the improvement methods with respect to middle managers

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(2/5, 1/2, 2/3)
c. Kaizen	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(1, 1, 1)

Table 21 Evaluation of the improvement methods with respect to line mangers

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(3/2, 2, 5/2)	(2/3, 1, 3/2)
b. Kaizen Blitz	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/7, 1/3, 2/5)
c. Kaizen	(2/3, 1, 3/2)	(5/2, 3, 7/2)	(1, 1, 1)

Table 22 Evaluation of the improvement methods with respect to shop floor personnel

	a. Kaikaku	b. Kaizen Blitz	c. Kaizen
a. Kaikaku	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/9, 1/4, 2/7)
b. Kaizen Blitz	(3/2, 2, 5/2)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(7/2, 4, 9/2)	(2/3, 1, 3/2)	(1, 1, 1)

Table 23 Evaluation of the improvement methods with respect to non-production personnel

	a. Kaikaku	**b. Kaizen Blitz**	**c. Kaizen**
a. Kaikaku	(1, 1, 1)	(2/3, 1, 3/2)	(2/5, 1/2, 2/3)
b. Kaizen Blitz	(2/3, 1, 3/2)	(1, 1, 1)	(2/3, 1, 3/2)
c. Kaizen	(3/2, 2, 5/2)	(2/3, 1, 3/2)	(1, 1, 1)

The priority weights of success factors and sub-factors are calculated. The following equations illustrate the calculations of the fuzzy synthetic extent values of the level 1 factors.

$$S_1 = (1.96, 2.33, 2.9) \otimes (1/13.07, 1/12.33, 1/9.03) = (0.15, 0.19, 0.32)$$
$$S_2 = (3.17, 4, 5) \otimes (1/13.07, 1/12.33, 1/9.03) = (0.24, 0.32, 0.55)$$
$$S_3 = (3.9, 6, 5.17) \otimes (1/13.07, 1/12.33, 1/9.03) = (0.30, 0.49, 0.57)$$

The degree of possibility of the level 1 factors are determined in the following Equations.

$$V(S_1 \geq S_2) = \frac{(0.24 - 0.32)}{(0.19 - 0.32) - (0.32 - 0.24)} = 0.38$$
$$V(S_1 \geq S_3) = \frac{(0.30 - 0.32)}{(0.19 - 0.32) - (0.49 - 0.30)} = 0.06$$
$$V(S_2 \geq S_1) = 1$$
$$V(S_2 \geq S_3) = \frac{(0.30 - 0.55)}{(0.32 - 0.55) - (0.49 - 0.30)} = 0.60$$
$$V(S_3 \geq S_1) = 1$$
$$V(S_3 \geq S_2) = 1$$

The priority weight vector is calculated in the following Equations.

$$d'(A_1) = V(S_1 \geq S_2, S_3) = min(0.38, 0.06) = 0.06$$
$$d'(A_2) = V(S_2 \geq S_1, S_3) = min(1, 0.60) = 0.60$$
$$d'(A_3) = V(S_3 \geq S_1, S_2) = min(1, 1) = 1$$

Therefore,

$$W' = (0.06, 0.60, 1)^T$$

After normalisation, the weight vector of the level 1 factors (L1) is:

$$W' = (0.04, 0.36, 0.60)$$

The same systematic approaches are followed for the level 2 sub-factors and level 3 improvements to calculate their priority weight vectors. The results are list in the follow Table 24.

Table 24 Propriety weights of the hierarchy process tree model

Success factors (L1)	Priorities	Sub-factors (L2)	Priorities	Methods (L3)	Priorities
1. Hardware	0.04	1.1 Warehouse/shop floor	0.16	A. *Kaikaku*	1
				B. *Kaizen blitz*	0
				C. *Kaizen*	0
		1.2 Technologies	0.42	A. *Kaikaku*	0.45
				B. *Kaizen blitz*	0.22
				C. *Kaizen*	0.33
		1.3 Machinery equipment	0.26	A. *Kaikaku*	0.58
				B. *Kaizen blitz*	0.42
				C. *Kaizen*	0
		1.4 Labour	0.16	A. *Kaikaku*	0
				B. *Kaizen blitz*	1
				C. *Kaizen*	0
2. Software	0.36	2.1 Training/job rotation	0.20	A. *Kaikaku*	0.33
				B. *Kaizen blitz*	0.33
				C. *Kaizen*	0.33
		2.2 Open communication	0.05	A. *Kaikaku*	0
				B. *Kaizen blitz*	0
				C. *Kaizen*	1
		2.3 Incentive/rewards	0.30	A. *Kaikaku*	0.62
				B. *Kaizen blitz*	0.27
				C. *Kaizen*	0.11
		2.4 Standard procedures	0.02	A. *Kaikaku*	0.05
				B. *Kaizen blitz*	0.29
				C. *Kaizen*	0.66
		2.5 Improvement culture	0.01	A. *Kaikaku*	0
				B. *Kaizen blitz*	0
				C. *Kaizen*	1
		2.6 Improvement system	0.03	A. *Kaikaku*	0
				B. *Kaizen blitz*	0.30
				C. *Kaizen*	0.70
		2.7 Benchmarking/feed back	0.05	A. *Kaikaku*	0
				B. *Kaizen blitz*	0.30
				C. *Kaizen*	0.70
		2.8 Shop floor management	0.34	A. *Kaikaku*	0
				B. *Kaizen blitz*	0.30
				C. *Kaizen*	0.70
3. Personnel	0.60	3.1 Top managers	0.32	A. *Kaikaku*	0.40
				B. *Kaizen blitz*	0.31
				C. *Kaizen*	0.29
		3.2 Middle managers	0.05	A. *Kaikaku*	0.33
				B. *Kaizen blitz*	0.22
				C. *Kaizen*	0.45
		3.3 Line managers	0.38	A. *Kaikaku*	0.09
				B. *Kaizen blitz*	0
				C. *Kaizen*	0.91
		3.4 Shop floor personnel	0.18	A. *Kaikaku*	0
				B. *Kaizen blitz*	0.30
				C. *Kaizen*	0.70
		3.5 Non-production personnel	0.07	A. *Kaikaku*	0.22
				B. *Kaizen blitz*	0.33
				C. *Kaizen*	0.45

The improvement method is chosen based on the global priority weights. This is determined by the global priority weight of each improvement methods with respect to each of the sub-factors and shown in the following Table 25 - Table 27.

Table 25 Priority weights of alternatives with respect to hardware sub-attributes

	1.1	**1.2**	**1.3**	**1.4**	**Priority weight**
Weight alternative	0.16	0.42	0.26	0.16	
A. *Kaikaku*	1	0.45	0.58	0	0.50
B. *Kaizen* blitz	0	0.22	0.42	1	0.36
C. *Kaizen*	0	0.33	0	0	0.14

Table 26 Priority weights of alternatives with respect to software sub-attributes

	2.1	**2.2**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.8**	**Priority weight**
Weight alternative	0.20	0.05	0.30	0.02	0.01	0.03	0.05	0.34	
A. *Kaikaku*	0.33	0	0.62	0.05	0	0	0	0	0.25
B. *Kaizen* blitz	0.33	0	0.27	0.29	0	0.30	0.30	0.30	0.27
C. *Kaizen*	0.33	1	0.11	0.66	1	0.70	0.70	0.70	0.47

Table 27 Priority weights of alternatives with respect to personnel sub-attributes

	3.1	**3.2**	**3.3**	**3.4**	**3.5**	**Priority weight**
Weight alternative	0.32	0.05	0.38	0.18	0.07	
A. *Kaikaku*	0.40	0.33	0.09	0	0.22	0.19
B. *Kaizen* blitz	0.31	0.22	0	0.30	0.33	0.19
C. *Kaizen*	0.29	0.45	0.91	0.70	0.45	0.62

Finally, the priority weights of the improvement methods with respect to the main success factors are combined and shown in Table 28.

Table 28 Ranking of improvement methods

	1	**2**	**3**	**Priority weight**
Weight alternative	0.04	0.36	0.60	
A. *Kaikaku*	0.50	0.25	0.19	0.22
B. *Kaizen* blitz	0.36	0.27	0.19	0.22
C. *Kaizen*	0.14	0.47	0.62	0.55

The results as shown in Table 24 indicate that: a) *Personnel* is the critical factor for success, specifically, top managers, line managers and shop-floor personnel play a key role for successful improvement implementation; b) several sub-attributes within *Software* are important such as job training, incentives and shop-floor management, whereas other sub-factors such as improvement culture and standard operations are less important; c) *Hardware* is the least important factor.

5. Conclusion and contributions

In attempt to prioritise the key enablers for successfully implementing Kaizen activities in China, this study compared the adoption and implementation of the three types of improvement methods: Kaizen, Kaikaku and Kaizen blitz from 28 experts working in Sino-Japanese joint ventures in China. The results show that the top critical enabler is about *Personnel*, including all levels of staff from top managers, to line managers and shop-floor employees, followed by *Software* which includes job training, incentives and shop-floor management. The factor of *experts/consultants* (1.4) as a *Hardware* sub-factors is not weighted as important. This may also indicate that the number of the employees is not critical for improvement, where the skills and abilities of the employees may be more important. *Culture* (2.5) for improvement is weighted very low. This might imply that improvement methods are transferable from one organisation to another, or between countries. *Job training* (2.1), *incentives* (2.3) and *shop floor management* (2.8) are the three highest score sub-factors under *Software*, where the rest of scored low and less important therefore. Organisations should pay more attentions to these attributes for improvement implementations. Top managers, line managers and shop floor personnel are the three important *Personnel* for improvement implementations. Kaizen is the highest rank improvement method, whilst Kaikaku and Kaizen blitz have the same ranking scores.

The findings of this study have important managerial implications. Given that the critical factors for Kaizen in China are the *Software* (essential rules, routines, procedures, policies and institutional arrangements) and *Personnel* (human sources), improvement implementation should be based on factors such as regular training, incentives for motivations and shop-floor management. Organisations implementing long-term improvement should rely less on *Hardware* (physical, measureable hard facts or resources) than the other two for improvement methods and Kaizen is the appropriate method to support long-term and process-oriented improvements.

This study identified the key enablers for successful Kaizen implementation based on interviews with shop floor managers and improvement experts, future study could examine and compare the statistical links of those factors to either perceptual or actual firm performance outcomes by applying quantitative methods such as survey or secondary longitudinal data. Our sample of Sino-Japan ventures is limited to Guangzhou, China and a larger sample size from a broader area of China would help generalise the results.

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