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# Improving Engineering Performance through Leadership, CE and Teamwork in a Malaysian Semiconductor Firm

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## ABSTRACT

The rapid change in technology among organizations motivates the need for researchers and practitioners to form new practices by understanding, re-examining and integrating the key determinants of obsolete practices. In the same way, this study aims to compositely examine the role of leadership, concurrent engineering (CE) and teamwork in a Malaysian semiconductor manufacturing firm. A total of 226 survey responses were collected back from the 2100 surveys distributed and analysed using correlation and multiple linear regression analyses. The results showed that the relationship between leadership-CE-teamwork and engineering performance was stronger than that of the other individually-tested relationships. Though best practices in leadership are important for achieving a team's goal, a more flexible and cooperative leadership may be formed with the integration of CE, teamwork and leadership. Top management should consider exploring more opportunities in all these components for improved engineering performance and synergy among engineering teams. Tactical strategies based on various leadership styles, team member competencies and CE approaches should also be formulated to strengthen the flexibility of current leadership styles. The results can be potentially used as general guidelines for the engineering management practice and research in engineering firms.

*Keywords:* Leadership, Concurrent engineering, Teamwork, Engineering performance

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## INTRODUCTION

There are many different definitions of leadership. However, the three major components of leadership applied in firms are perhaps team leadership, influential leadership and goal-based leadership. Leadership is the process in which an individual influences team members towards the attainment of team or organizational goals (Sethi, Smith & Park, 2001).

The success of a team can depend on the leadership style that suits the team. Different teams may consist of members with different capabilities working on various tasks under multiple circumstances. From a theoretical viewpoint, Fiedler's contingency model shows that in high and low favourable situations, task-oriented leadership is linked with high performance and team success (Chong, 2006; Sethi, 2000). Besides that, in moderately favourable situations, relationship-oriented leadership styles are most effective for teams to succeed (Chong, 2006; Sethi, 2000; Valle & Avella, 2003).

Despite the aforementioned evidence on the capabilities of various leadership styles, many engineering firms today fall short in the management and leadership of their engineering project resources (Cleland, 1995; Cleland & Ireland, 2007; Qureshi, Warraich & Hijazi, 2009). More often than not, engineering firms disregard the importance in evaluating engineering performance and merely focus on meeting the cost and time requirements of manufacturing projects (Qureshi *et al*., 2009).

The preceding assertion points out that there is an evident and dire need for firms to continuously evaluate engineering performance and the factors that are linked to it. Literature has shown that the components selected for study here are important basis for organizational and technological success (Abrunhosa & Sa, 2008; Chang, 2009; Ebert & Man, 2008; Valle & Avella, 2003; Valle & Vazquez-Bustelo, 2009). Thus, the aim of this study is to determine the effects of leadership, concurrent engineering (CE) and teamwork on engineering performance in a Malaysian engineering firm.

## LEADERSHIP

Leadership is the behaviour associated with the activity of leading and represents one of the great problem areas both for the student of management and for the practising manager (Kanji, 2008). It is not only a key enabler for research, but also a practical skill used by managers to adapt in various functions (Lo & Osman, 2008).

In management theory, there generally a few classifications of leadership theories which include theories on classic leadership (autocratic, democratic and laissez-faire) and theories on leadership for change (transformational leadership) (Lakshman, 2006). The responsibility of a leader can be segregated in various ways throughout a firm (Galbraith, 1973).

Leadership often appears to be the key component for a firm's success as their roles influence, motivate and direct employees to achieve company performance. According to Obholzer (1997), a good leadership practice in a firm allows work to be completed effectively and efficiently through positive teamwork.

In addition, capable leaders can generate a strong shared mission and vision for a company that relates to its workers overall effectiveness (Ancona & Caldwell, 1992; Boyle, Kumar and Kumar, 2006; Mohrman, Cohen and Mohrman, 1995). Also, leaders who are practicing various traits, principles, attitudes and behaviours may give rise to successful long-term organizational performance (Lakshman, 2006).

In addition, Kolb (1995) believes that leadership is significantly related with organizational performance and also plays a main role in enhancing engineering performance. However, serious commitment on the part of engineering leaders to quality can be sometimes inconsistent, weak or in worst cases, missing. Complaints about engineering management's lack of support and refusal to change appear to be increasingly common among employees (Kaynak, 2003). The aforementioned predicaments make it difficult to nurture the hidden talents or potentials of younger and aspiring engineering leaders. Therefore, the first hypothesis is proposed as:

H1: Leadership correlates with engineering performance in a Malaysian manufacturing firm

## TEAMWORK

Teamwork is defined as the collaboration of co-located individuals from various knowledge and skill areas grouped in one or more problem-solving projects (Jassawalla & Sashittal, 2000). Effective teamwork requires team members to possess not only people management skills, but also skills such as the ability to manage pressure, emotions, red tapes and heated debates (Wang, Chou & Jiang, 2005).

Greaves (2000) suggests that teamwork requires an appropriate organizational environment and full cooperation from both the leader and members to meet or exceed team objectives. One of the key determinants in teamwork is the power to synergize, where if applied appropriately, may result in positive outcomes that exceeds the input to the teamwork (Keller, 2001; Larson & Gobeli, 1989).

Team leadership which is critical in all team environments appears to be highly collaborative and peer-like (Drath, McCauley, Palus, Velsor, O'Connor & McGuire, 2008; Wang *et al*., 2005). It appears that in engineering companies, the project managers delegate tasks to team leaders who will then motivate and coach the performance of their respective members. This action allows leaders to build strong trusts among employees and promotes their impetus to perform (Shea & Howell, 1999).

Teamwork, however, does not always bring forth positive effects to a firm. According to Nurmi *et al*. (1989), although teamwork sounds simple, but it requires high acknowledgment among peers, active leadership, active listening, acceptance of different views and effective communication. Lack of assertiveness and action from team players and conflicting performance may bring about negative outcomes as far as teamwork performance is concerned (Jassawalla & Sashittal, 2000). Hence, the second hypothesis is proposed as:

H2: Teamwork correlates with engineering performance in a Malaysian manufacturing firm

## CONCURRENT ENGINEERING (CE)

CE is a systematic approach to the integrated, simultaneous design of products and their related processes, including manufacture and support (Jassawalla & Sashittal, 2000). It also refers to interdisciplinary collaborations and corresponding efforts to achieve universal targets in NPD, production, marketing and sales (Kusar, Duhovnik, Grum & Starbek, 2004).

A major initiative in putting CE into practice is the effective concurrent teams, which implement development through organizational and information management processes (Abdalla, 1999). Concurrent teams are teams that deal with hi-tech processes and sustain teamwork throughout development phases (Ma, Chen & Thimm, 2008).

On the other hand, Chen and Li (2002) argue that problems arising from CE approaches are very complex due to the uncertainties from design to process stages. This finding shows that it is sometimes difficult to adopt CE in processes that have previously been treated separately.

Zheng, Wang and Yan (2005) also stress that if downstream design workflow launches prematurely, it is doubtful to obtain absolute design outcomes from the upstream design workflow. Consequently, they hypothesize that there is a likelihood of higher design mistake rates and more design rework. Thus, the third hypothesis is proposed as:

H3: CE correlates with engineering performance in a Malaysian manufacturing firm

## ENGINEERING PERFORMANCE

Engineering Performance is the overall achievement of preset targets of engineering projects/tasks. The exceptionality that impinges on engineering performance is of a simple form, whereby the epigrammatic link between engineering performance and some characteristics that influences it is often demonstrated in a research (Cho, Hong & Hyun, 2009). Engineering performance includes the monitoring and management of components such as time, cost, superiority, creativity and product development performance.

***Time.*** Once a decision on a project is made, the execution time should be kept as brief as it could, as time is an aspect of success in engineering performance that provides additional timelines for the dealings leading to the decision (Thiry, 2002).

***Cost.*** Projects that are delayed will cost more money and dissatisfy customers, causing difficulties in financial support and further slippages in project timelines to transpire (Kaliba, Muya & Mumba, 2009; Kamrul Ahsan & Gunawan, 2009).

***Superiority.*** In manufacturing, product superiority signifies distributing distinguished products that provides exceptional benefits and quality features to customers (Cooper, 1996).

***Creativity.*** Creativity is an essential aspect of engineering performance as it involves creative idea generation and innovation that is exceptionally useful for the conceptual stages in manufacturing projects (Garcia & Calantone, 2002; Leenders, Engelen & Kratzer, 2002).

***Product development performance.*** Many firms also need to effectively understand and manage risks associated with developing new products since there is a persistently high probability of new product failure and large financial loss (Schmidt, Sarangee & Montoya, 2009).

In this study, engineering performance is considered on the whole as a dependant variable. From the combination of the previous sections, the fourth and final hypothesis is proposed as:

H4: Leadership, CE and teamwork influence engineering performance in a Malaysian manufacturing firm

Fig.1 presents the research framework of this study. In this framework, the roles of leadership, CE and teamwork in the firm will act as the independent variables tested against engineering performance in a quantitative manner.

## RESEARCH METHOD

The firm chosen for this study was founded in 1999 in Malacca, Malaysia. There are approximately 5600 workers employed in this firm. This firm also has about 43,000 employees worldwide, with 6000 of them involved in research and development. Other than in Malaysia, this firm also operates in Germany, Austria, France, Taiwan, Singapore and China.

Eight out of the world top 20 semiconductor manufacturers are known to operate in Malaysia and the company discussed in this study is one of them (Ford, 2011). The others are Intel, Texas Instruments (TI), Toshiba, Renesas Electronics, STMicroelectronics (STM), Advanced Micro Devices (AMD) and Freescale Semiconductor. The particular company chosen for this study reflects the leadership, CE and teamwork practices in the other seven, namely through their TQM practices. By extension then this study could be seen as a study on the eight semiconductor manufacturers in Malaysia.

Based on figures provided by this firm on projects in the last 2 years (since

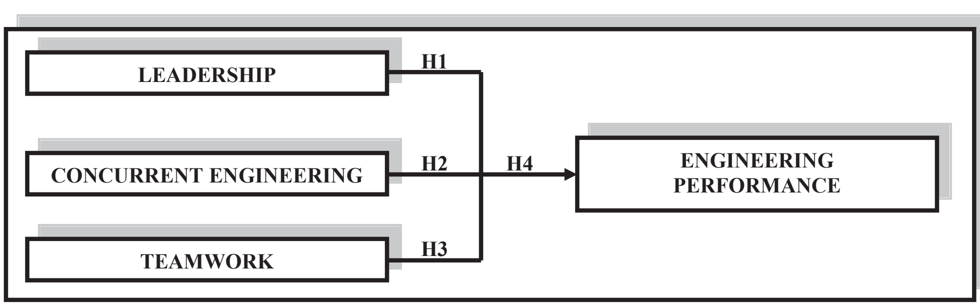


Fig.1: The Research Framework

2009), the firm had 3000 projects in total. Due to high turnover rates, transfers and resignation of managers, some projects were discontinued. The survey items of the questionnaire are tabulated in Table A of the Appendix in this paper. The items were adopted from the research of Jung and Wang (2006), Prajogo and Sohal (2006), Valle and Vazquez-Bustelo (2009), Tan and Vonderembse (2006) and (Fuentes-Fuentes, Albacete-Saez, & Llorens-Montes, 2004). A total of 2100 survey forms were handed out to all the engineering managers and engineers in the Malaysian firm.

As such, the unit of analysis for this study was the respective projects of these managers and engineers in the firm. Within 6 weeks, the data were gathered. A total of 226 survey responses were collected back out of the 2100 surveys that were handed out, which produced a response rate of 11%. The data was analyzed using SPSS 18, a statistical software application used for multivariate analyses, data reduction and data management. The statistical methods employed were Pearson's correlations analysis and multiple linear regression.

## RESULTS

Pearson's correlation analysis is used to evaluate ***H1***, ***H2*** and ***H3***. The following tables present the results on the relationships among leadership, CE, teamwork and engineering performance. Table 1 presents the correlation analysis used to evaluate ***'H1: Leadership correlates with engineering performance in a Malaysian manufacturing firm'***. The Pearson's correlation between leadership and engineering performance is 0.632 with a $p$ value of 0.000. Therefore, the relationship between leadership and engineering performance is positive and significant. Hence, ***H1*** is not rejected.

TABLE 1
Leadership – Engineering Performance Correlation

| Test | Output | Interpretation |
|---|---|---|
| Pearson's Correlation | 0.632*** | Positive Correlation |
| Sig. (2-tailed) | 0.000 | Significant |

*significant at $p < 0.05$ level,
**significant at $p < 0.01$ level,
***significant at $p < 0.001$ level

Table 2 presents the correlation analysis used to evaluate ***'H2: Teamwork correlates with engineering performance in a Malaysian manufacturing firm'***. The Pearson's correlation between teamwork and engineering performance is 0.632 with a $p$ value of 0.000. Therefore, the relationship between teamwork and engineering performance is positive and significant. Hence, ***H2*** is not rejected.

TABLE 2
Teamwork – Engineering Performance Correlation

| Test | Output | Interpretation |
|---|---|---|
| Pearson's Correlation | 0.632*** | Positive Correlation |
| Sig. (2-tailed) | 0.000 | Significant |

*significant at $p < 0.05$ level,
**significant at $p < 0.01$ level,
***significant at $p < 0.001$ level

Table 3 presents the correlation analysis used to evaluate ***'H3: CE correlates with engineering performance in a Malaysian***

***manufacturing firm'***. The Pearson's correlation between CE and engineering performance is 0.662 with a $p$ value of 0.000. Therefore, the relationship between CE and engineering performance is positive and significant. Hence, ***H3*** is not rejected.

TABLE 3
CE – Engineering Performance Correlation

| Test | Output | Interpretation |
|---|---|---|
| Pearson's Correlation | 0.662*** | Positive Correlation |
| Sig. (2-tailed) | 0.000 | Significant |

*significant at $p$< 0.05 level, **significant at $p$ < 0.01 level, ***significant at $p$ < 0.001 level

A multiple linear regression using the stepwise method was conducted to evaluate **'*H4: Leadership, CE and teamwork influence engineering performance in a Malaysian manufacturing firm*'**. The total amount of independent variables tested was three (Leadership, CE and teamwork) for ***H4***. Using the formula provided by Tabachnick and Fidell (2001), the minimum sample size required in this study was 50 + (8 × 3) or 74 respondents. As such, the sample size criterion was met for this study.

Regression formulae are based on the assumption that residuals are normally distributed around the predicted dependent variable scores. For this study, normal probability plots were generated to test this. In the normal probability plots in Fig.2, since the points were in a reasonably straight diagonal line from bottom left to top right, it can be confirmed that there were no major deviations from normality (Pallant, 2005; Tabachnick & Fidell, 1996).

For the normality test, the measure of kurtosis and skewness values for the variables tested was within the prescribed |1.0| range (Tabachnick & Fidell,

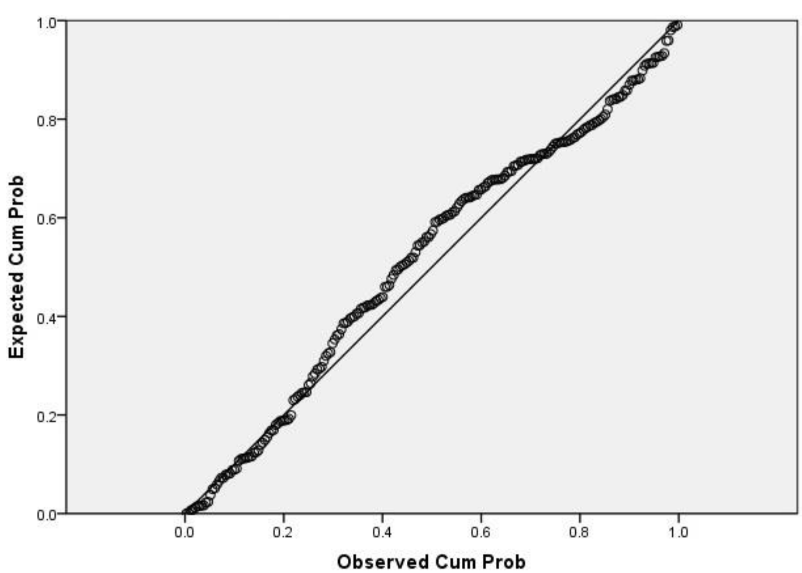


Fig.2: Normal Probability Plots of Regression Standardized Residual

1996). Having satisfied the assumptions for regression analysis, all of the four independent variables were regressed against creative product development and the results are summarized in Table 4.

The results in Table 4 indicate that up to 49.6% of the variance in engineering performance is explained by leadership, CE and teamwork. A correlation coefficient ($R$=0.704) was also obtained for this relationship. In addition to that, the model is significant as indicated by the ANOVA results of $F$ (3, 222) = 72.775, $p$<0.001. Thus, the fourth and final hypothesis, ***H4***, is supported.

## DISCUSSION

From the results of ***H1***, ***H2***, ***H3*** and ***H4***, it is evident that leadership, CE and teamwork positively and significantly influence engineering performance. When ***H4*** was evaluated, an even stronger relationship ($R$=0.704) was obtained as compared to that of ***H1***, ***H2*** and ***H3***'s relationships.

For the individual tests on ***H1***, ***H2*** and ***H3***, it was found that leadership correlates with engineering performance at the same strength with that of teamwork and engineering performance ($R$=0.632). These relationships occur possibly because leadership and teamwork initiatives often go hand-in-hand in engineering projects.

Leaders have to be actively involved in the management of engineering processes and members are also required to demonstrate a certain degree of leadership and coordination skills in their team. Furthermore, leaders with high levels of self-esteem and enthusiasm can often gain their team members' respect, thus enabling better cooperation in the team (Chong, 2006; Sethi, 2000; Sethi *et al*., 2001).

Both components of leadership and teamwork are of equal importance in a team. Teams strive on cohesiveness and synergy to tap on its member's abilities. A leader will normally be nominated to delegate tasks, monitor work performance and provide the right direction to the team members. Therefore, both teamwork and leadership can result in improved engineering performance. Moreover, according to Kolb (1995), both leaders and members should actively play the role of a leader and be open to new ideas in their team.

Furthermore, the leadership component in this study is not only referring to the leadership ability of the team leader, but also each team member's leadership ability. Since the leader is mostly a working

TABLE 4
Multiple Linear Regression for the Effects of Leadership, CE and Teamwork on Engineering Performance

| Predictor | $\beta$ | Std. Error | $t$ | Kurtosis | Skewness | $F$ | $R$ | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| (Constant) | 1.472 | 0.193 | 7.633*** | | | | | |
| Leadership | 0.121 | 0.059 | 2.040* | 0.172 | 0.855 | 72.775*** | 0.704 | 0.496 |
| CE | 0.261 | 0.063 | 3.344*** | 0.035 | 0.797 | | | |
| Teamwork | 0.245 | 0.073 | 5.287** | 0.020 | 0.644 | | | |

(Notes: *$p$<0.05; **$p$<0.01; ***$p$<0.001; $N$=226; Durbin Watson = 1.493) member of the team as well, his/her role is to generally initiate and sustain the team's momentum. After the major tasks have been allocated, the team leader may take on a more dormant role as a team member.

The team members would also perform their assigned tasks individually but more often through discussions and knowledge sharing with other team members. Basically, in almost any discussion that involves a minimum number of 2 individuals, there would surely be a dominator that leads the discussion. Hence the leadership component still co-exists within team discussions and brainstorming sessions.

CE on the other hand, has the highest correlation with engineering performance ($R$=0.662). This is because CE involves initiatives to shorten lead time to manufacture and market, which eventually affects the overall cost, duration and product development performance of the project. It also involves cross-functional teamwork and the use of computer-aided design tools for better designing and information sharing. These aspects in CE enhance product superiority and team creativity in projects. Therefore, it directly affects engineering performance as a whole.

CE also involves regular knowledge sharing activities among cross-functional teams. Compared to the leadership and teamwork components, knowledge sharing practices would give an added advantage to a team over traditional methods. Although a team may produce good results with effective leadership and teamwork, a team that practices the knowledge sharing principles may have the extra competitive edge that elevates the team's performance to a whole new level.

In the analysis of ***H4*** which involved all three variables (Leadership, Teamwork, CE) and engineering performance, the correlation coefficient was found to be even higher compared to that of all the individually tested relationships ($R$=0.704). Principally, each of the 3 variables will exist at some degree in each team. For example, CE and knowledge sharing exists in a small role, which is through group discussions or brain storming sessions during the team meetings. However, the combined effect of all 3 variables would relatively be more significant than their individual evaluations.

According to Galbraith (1973), there is no best, near-to-best or uniformly effective way to manage an organization. From the regression model developed, it is therefore proven that engineering performance can be improved when not just one, but all the key determinants (Leadership, CE and teamwork) interact as a whole in developing engineering performance. Through this form of transformational leadership, leaders can be less or more directive in their leadership style depending on the competency of their teams (Chong, 2006; Sethi, 2000).

## CONCLUSION

In summary, although good leadership is important for coaching and achieving a team's goal, a more flexible and cooperative leadership may be formed with the integration of CE, teamwork and leadership.

Although this study supports the theories discussed in the previous section, this study does contain some limitations.

The main limitation is the sampling method employed which limits the generalisability of this study beyond the context of this firm. Due to time as well as budgetary constraints, this study was conducted in only one Malaysian semiconductor manufacturing firm.

Apart from that, a concurrent modelling analysis in this study may not possible since the framework was developed in a way where the variables cannot be simultaneously tested against each other. This limits the possibility of discovering more relationships and effects among the dependent and independent variables.

Despite the main sampling limitation, this study stresses on the applied mechanism of leadership, CE and teamwork in a semiconductor manufacturing firm with an emphasis on engineering performance. This study would still be useful for other semiconductor firms since the findings can be generally used as guidelines in their efforts to recognize the integration of leadership, CE and teamwork as a new and enhanced practice in the marketplace. In a practical viewpoint, for example, this study can guide effective leadership on deciding when to coach team members and when to be directive. This decision may depend on the team's ability or competency and the task structure level.

A few suggestions are proposed to further improve the study and findings. The first suggestion is related to the survey method of conducting the study within a single firm. It is proposed that this study can be further extended to other manufacturing firms in Malaysia to evaluate the practice of leadership, CE and teamwork. This would allow for greater generalisability of the findings.

Another suggestion is to conduct in-depth qualitative studies in every technology cluster or business unit of this studied firm to further understand its organizational context to explain in more depth the role of leadership, CE and teamwork in various firms. Also, observational techniques could be employed to shed more light on this phenomenon. In addition, instead of using respondent-reported leadership, CE, teamwork and engineering performance scales, it would be better if researchers are able to use empirical data from the firm's records e.g. sales performance, customer satisfaction, development cost etc.

Also, a structural equation modelling (SEM) approach using a combination of statistical data and qualitative causal assumptions can be used in order to test and estimate causal relationships. One of the available software that can be utilized for this analysis is called AMOS. Using this approach, the variables for this study are capable of being tested simultaneously altogether instead of the conventional method where they are linearly tested with only one variable against another. At the same time, an addition of several leadership styles such as transformational leadership and charismatic leadership can also be included as part of the study in order to discover more relationships in the model that can possibly induce team productivity and engineering performance.

Due to the support of theories and research together with possible practical implications, it is evident that leadership, CE and teamwork are indeed not only important for team functioning, but also as drivers for improved engineering performance. Though leadership may fundamentally be about doing the right things, it is still important for engineering leaders to take into account the various functions, situations and members in their team. With different competencies and personalities among team members, there is a necessity to have leaders who have a variety of skills and styles so that they can choose the best leadership style to a variety of situational factors.

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## APPENDIX

Table A
Survey Items of Questionnaire

| Component | Survey Items | Sources |
|---|---|---|
| Leadership | ***Lead_1.*** Our top management is committed to quality.<br>***Lead_2.*** There is a clear existence of vision and strategy.<br>***Lead_3.*** Organization-wide quality culture is practiced.<br>***Lead_4.*** We have objectives for quality performance. | (Jung & Wang, 2006) |
| | ***Lead_5.*** Seniors share same beliefs on firm's future direction.<br>***Lead_6.*** Managers encourage change and implement a culture of improvement, learning and innovation towards 'excellence'.<br>***Lead_7.*** Employees have the opportunity to share in.<br>***Lead_8.*** Employees encouraged to help implement changes.<br>***Lead_9.***There is unity of purpose in our company.<br>***Lead_10.***Barriers among people and sections are eliminated. | (Prajogo & Sohal, 2006) |
| Concurrent Engineering | ***CE_1.*** Product designs and production process are developed simultaneously by a group of employees.<br>***CE_2.*** Product development employees work as a team.<br>***CE_3.*** Product development group members represent a variety of disciplines.<br>***CE_4.*** Product development group members share information.<br>***CE_5.*** Much of process designs are done concurrently with product designs.<br>***CE_6.*** Product and process development designs are developed concurrently by a group of employees from various disciplines.<br>***CE_7.*** Manufacturing is involved in the early stages of product development.<br>***CE_8.*** Process engineers are involved from the early stages of product development.<br>***CE_9.*** Various disciplines are involved from the early stages of product development. | (Valle & Vazquez-Bustelo, 2009; Tan & Vonderembse, 2006) |
| Teamwork | ***Teamwork_1.*** Managers emphasize activities that lead to lack of cooperation between the firm and suppliers.<br>***Teamwork_2.*** Management encourage use of few suppliers based on quality rather than price.<br>***Teamwork_3.*** Managers and employees from different departments work independently to achieve own goals.<br>***Teamwork_4.*** Teamwork is a commonplace.<br>***Teamwork_5.*** Everyone participates in improvement.<br>***Teamwork_6.*** Staff see 'whole picture' in decisions.<br>***Teamwork_7.*** Employees are hesitant to voice their opinions, make suggestions or inquire about firm activities.<br>***Teamwork_8.*** Senior executives insist on accuracy and reliability of all information and communications in firm. | (Fuentes-Fuentes, Albacete-Saez & Llorens-Montes, 2004) |