The Relationship of TQM and Lean Production Towards Integrated Application

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Abstract

Total Quality Management (TQM) and Lean Production (LP) have been considered as emerging world-class manufacturing strategies to meet the increasing demands of customers for product quality at competitive price. However, their overall and detailed association has not been fully explored by earlier studies. The objective of this study is to describe the overall and detailed relationship of TQM and LP. The result is envisioned to give meaningful insights for academicians on the inter-relatedness of TQM and LP as well as for industry practitioners on the potential implementation synergy of TQM and LP towards an integrated application, as one system or program. The study was conducted using the Philippine Electronics and Semiconductor Industry as the locale, and employee respondents as the unit of analysis. Pearson test of correlation was used to test the relationship between TQM and LP. Result showed that the overall relationship of TQM and LP is strongly positive and significant. However, when the relationships are compared at detailed levels, the extent of relationship varies. Continuous improvement and striving for perfection strongly bind TQM and LP while Benchmarking, Supplier Quality management and Pull Production do not strongly support the association of TQM with LP.

Keywords:
Lean Production, Total Quality Management, Systems Thinking, Survey Research

1. Introduction

1.1 Background of the Study

Lean Production (LP) and Total Quality Management (TQM) are popular process improvement methodologies, which are incremental and continuous (Caffyn, 1999). The integration is also considered as a world class manufacturing practice (Forza, 1995; Singh & Ahuja, 2013). As complementary methodologies, this integration can provide gains and competitive advantage to organizations if both are fully applied in practice (Andersson, Eriksson & Torstensson, 2006; Singh & Ahuja, 2013; Mosadeghard, 2013). The integration can improve customer satisfaction through a culture of continuous improvement and employee participation (as cited in Dahlgaard & Dahlgaard-Park (2006). The integrated model is also anticipated to give more benefits through synergy, thus, minimizing time and effort (Salleh, Kasolang, & Jaafar, 2012). Hence, these practices should be considered together as a system for a joint benefit of the practices (as cited in Shah & Ward, 2007).

Literature has identified integration issues as barriers to TQM and LP simultaneous implementations. However, these issues have not been described and addressed in detail in an implementation perspective. One of the integration issues identified is the lack of synergy (Reddy, 2013) further described by Singh & Ahuja (2013) as a result of top management ineffectiveness on holistic implementation, lack of clarity in a joint implementation plan, and the organization's inability to change the mindset towards total involvement and systematic thinking. Lack of synergy also occurs when TQM is treated as a separate initiative (Bhat & Rajashekhar, 2009). Ricondo & Viles (2005) also cited top management problems in implementation such as no clear implementation strategy and conflict of priorities. Such issues also stem from dynamic complexity which is related to the high interrelationship and feedback among variables like problems that involve processes, products services and people (Ricondo & Viles, 2005). Dahlgaard & Dahlgaard-Park (2006) also emphasized that the boundaries of practices like TQM and LP are not clearly defined due to high similarities among the concepts. Furlan, et al. (2011) also emphasized that the concept of synergy between these practices is vague since it lacks rigorous empirical methods to be tested. Chiarini (2011) also cited that there is

a lack of guidelines for integrating lean and TQM, hence a point of view on what are their common characteristics and differences should be considered for future research.

To shed light on the implementation of simultaneous process improvements is the systems thinking perspective elaborated by Jambekar, 2000 as summarized below:

> *One of the goal of systems thinking is to structure the interrelationships of involved concepts and variables, thus, leveraging on the significant connections between process improvements. Systems thinking has the capability to explain the dynamics of improvement efforts in a process perspective, rather than the usual function perspective. Hence, there is a need to draw a picture of the whole system to focus on high leverage interventions.*

This research is rooted on the above concepts of simultaneous engineering and systems thinking to determine the synergy on the simultaneous implementation of TQM and LP. The aim of the researcher is to describe the relationship of TQM and LP as potential input in the development of simultaneous implementation, as one system or program. Thus, having an insight on the synergies between these two process improvement strategies can provide implications in their efficient and effective implementations towards full realization of operational benefits such as greater flexibility, faster delivery and increased profits (Dubey & Singh, 2015).

1.2 Lean and TQM: Management Domain, Comparative Concepts and their Interrelatedness

TQM and Lean are one of the broad-based philosophies of Operations Management (OM) philosophies that require cross-functional implementation and decision-making processes to enhance effectiveness and productivity (Gupta & Boyd, 2008; Jambekar, 2000). The OM domain, which is focused on managing processes to transform inputs into outputs has increased emphasis at organizational level as a chain or network of interdependent systems incorporating organization structure, business processes and management direction (Gupta & Boyd). TQM and Lean are part of the business processes which are considered World Class Manufacturing practices (Singh, & Ahuja, 2013). Several OM books also included TQM and Lean as part of the OM strategy, such as those authored by Greasley (2008), Porter (2009), and Slack, Chambers & Johnston (2010).

Lean is a process improvement methodology and one of the best manufacturing practices focused on simplification through "relentless pursuit of eliminating waste" (Trent, 2008, p. 4) which direct impact are faster lead time and lesser inventory (Bradley, 2012). From the citations of Sharma, Dixit & Qadri (2016), Lean means more value creation for customers in a highly economical manner. Lean is also associated with speed, efficiency and acceleration of the process (Taghizadegan, 2006, par.2). As such, the main objectives of Lean are to increase productivity, reduce waste and optimize available resources (Gomes, Lopes, & de Carvalho, 2013) while creating more value to customers (Ayabakan & Eken, 2014). Lean is also considered an integrated socio-technical system (Anvari, et al., 2011; cited by Furlan, et al., 2011).

Lean originated from the Toyota Production System, further developed with the concepts of Taiichi Ohno on Just-in-time (JIT) and the term Lean Production has become internationally known through the major publication of The Machine that Changed the World from Womack, et al. in 1990 (Holman, 2005; Alves, Dinis-Carvalho, & Sousa, 2012). Womack and Jones (1996) also forwarded the five principles of lean thinking as follows: (1) Value, (2) Value Stream, (3) Flow, (4) Pull, and (5) Perfection (as cited by Weigel, 2000 and Anvari, et al., 2011).

Laurie Mullins (Management and Organizational Behaviour) defined TQM as a 'way of life for an organization as a whole, committed to total customer satisfaction through a continuous process of improvement, and the contribution and involvement of people (as cited in CIPS, 2012, para. 4.1, p. 80). This concept demonstrates that TQM is also a socio-technical approach, containing soft and hard aspects. The social or soft aspects are centered on people management which emphasis is on leadership, teamwork, and training and employee involvement. The technical or hard aspects, on the other hand is focused on improving production methods and procedures (Anvari, et al., 2011).

TQM is based on the collective theories of quality gurus such as Deming, Juran, Crosby and Feigenbaum (Ricondo & Viles, 2005). The term TQM originated from US Naval Air Systems, which principles and practices are drawn from the behavioral sciences, management science, economic theories and process analysis (American Society for Quality [ASQ], n.d.). TQM improves and sustains quality of the products and processes in order to meet or exceed customer

expectation (cited by Furlan, et al., 2011). As a management approach, TQM considers six pillars which include: (1) Product, (2) Processes, (3) System, (4) People, (5) Leadership (Charantimath, 2011) and, (6) Customer (Ho, 1999).

Several researchers have forwarded the interrelatedness of TQM and Lean. Singh & Ahuja (2013), for example listed the synergy effects of TQM and Total Productive Maintenance (TPM), which is a component of Lean. The JIT-TQM synergy is also emphasized by Furlan, et al. (2011) which considered JIT and TQM as Lean bundles. Furlan, et al. (2011) also cited the connection of TQM to Lean considering that TQM has been enriched by Lean practices geared at reducing manufacturing variances. TQM and Lean also share concepts of people and senior management involvement, customer satisfaction and continuous improvement, customer satisfaction and continuous improvement (as cited by Chiarini & Baccarani, 2016).

Khalili, Ismail, Karim, & Daud (2018) also emphasized that TQM is considered as a pre-requisite of Lean. In this context, TQM can be tools and techniques of Lean considering that TQM comprises hard aspects including the different tools and techniques is designed to implement Lean principles. Andersson, Eriksson, & Torstensson (2006) and Dahlgaard & Dahlgaard-Park (2006), however, have a differnet view from Khalili, et al. (2018) where TQM is the umbrella concept. According to them, TQM is a management philosophy which contents continuously change when new theories and results such as Lean show that there are better roadmaps.

1.3 Problem Statement & Hypothesis

This study attempted to analyze the relationship of TQM and LP. The analysis was in light of drawing implications that may relate to the management of simultaneous program implementations of TQM and LP in a manufacturing setting. Specifically, this study sought to answer the following questions as they are applied to the locale of this research, which is the Philippine electronics and semiconductor industry:

How does Total Quality Management relate to Lean Production?

(1) How does each Total Quality Management practices relate to each Lean Production practices?
(2) How does each Total Quality Management practices relate to overall Lean Production practices?
(3) How does overall Total Quality Management practices relate to overall Lean Production practices?

In connection with this, the following Hypotheses were developed:

(1) There is no significant relationship between each Total Quality Management practices and each Lean Production practices.
(2) There is no significant relationship between each Total Quality Management practices and overall Lean Production practices.
(3) There is no significant relationship between overall Total Quality Management practices and overall Lean Production practices.

1.4 Related Studies

A similar study on Lean-TQM relationship was conducted by Khalili, et al. (2018) using the manufacturing industry of Malaysia as research locale. This study investigated the linkages among elements of "soft" TQM (STQM) and Lean Manufacturing (LM). A structured questionnaire was designed to validate the model and test the hypothesis. Structural equation model (SEM) was utilized to empirically investigate the model. Result obtained implied that there is a significant relationship between soft TQM and LM. Khalili, et al. emphasized that the similar aspects between both practices imply that these have to be integrated together in the same enterprise. However, there are gaps that can be pointed out in this study such as: (1) the study is focused on the overall relationship, without taking into account the relationships of each constructs of TQM & Lean which could lead which aspects have stronger linkages for integration implementation references, (2) the TQM instrument used considers only the "soft" aspects, and (3) the Lean instrument used are practice-based which may not cover all the principles of lean. These gaps need to be considered in future researches to have a more comprehensive and holistic view on the relationship of TQM and Lean. Dubey & Singh (2015) also conducted an interpretive structural modelling to understand the possible linkage between variables that constitute a Lean enterprise which include TQM. The study emphasized a different view, where Lean behavior drives TQM considering that Lean behavior is one of the tools that can be deployed to achieve TQM.

In their case study on TQM-Lean implementation in Italian hospitals, Chiarini and Baccarani (2016) analyzed the deployment path for integrated implementation as well as the possible benefits that be achieved and pitfalls that can be encountered. They found out that there is a specific deployment path for implementing TQM-Lean strategy which starts with a strong commitment and involvement of top and senior managers and an external political endorsement. This deployment path is supported by the literature review study of Salleh, Kasolang, & Jaafar (2012), where an integrated approach combining the two practices has not been fully explored. They further argued that the main reason for lacking TQM and Lean implementation is due to the absence of a uniform framework model. They emphasized that the proposed integrated model can take the best of both worlds to fully benefit the synergy of both models which may lead to optimization of resourced and reduction of costs and wastage.

Furlan, et al. (2011) conducted an empirical analysis of Lean bundles in manufacturing plants of different industries in nine countries. In this study, TQM is regarded as one of the Lean bundles, along with JIT and Human Resource Management (HRM). Result showed that JIT and TQM are complementary. A similar study was conducted by Shah & Ward (2007) with related result where TQM and JIT as Lean bundles are complementary. This complementarity implies similar concept on the hypothesis that TQM and Pull, a construct of Lean have a significant relationship; considering that JIT is a requisite to establish Pull. Jayaram, Tan and Laosirihongthong (2014) further supported this complementarity as a result of their study that overall TQM and Lean have significant association with performance. Similar to Khalili, et al., these studies did not investigate the coordination mechanisms that need to be put in place in order to manage the inter-dependencies between practices of the two complementary bundles.

Another similar study is conducted by Singh and Ahuja (2014) which revealed that TQM and Total Productive Maintenance (TPM) are also complementary. TPM is a part of the Flow principle of Lean, considering that TPM ensures continuous operation by preventing equipment breakdowns.

Pettersen (2009) conducted a contemporary literature review and argued that Lean is significantly different from its closest relative TQM and that Lean is a management concept of its own. This is in contradiction with other studies where TQM is part of Lean bundles. Pettersen further argued that TQM and Lean may have similarities at philosophical level, the two practices differ significantly at operational level.

Researchers also conducted implementation-related studies on TQM and LP. Dubey, Singh, & Ali, (2015) proved that human resources mediates completely through leadership practice and successful TQM implementation.

1.5 Synthesis

Based on the review of related literature and studies, there has been no study yet conducted on the overall relationship of TQM and LP. A similar study was conducted by Khalili, et al. (2018) but it did not consider the overall aspects of TQM. The study only considered the relationship of TQM "soft aspects" with Lean Manufacturing. Other related studies were focused on the complementarity of Lean bundles such as TQM, TPM and TQM where combined effects of these bundles found out to increase operational performance.

The literature also presented a contradiction whether LP depends on TQM or vice versa is also clear in the literature. For this study, LP being the dependent variable is considered, similar to what is used by Khalili, et al. (2018) in their study. LP depends on TQM as some TQM aspects drive LP implementation as an embedded quality in the operation can help to eliminate waste and to promote continuous flow.

There have been different measures of TQM and LP used in different empirical studies. However, the five principles of Lean thinking as the forefront in Lean implementation framework have not been wholly validated in empirical studies. This is the originality of this study where the five principles of Lean thinking is used to develop the instrument for LP.

1.6 Conceptual Framework

A conceptual model for this study is developed to visualize the relationship between TQM and LP. The assumption in this paper is that both practices are implemented simultaneously in each manufacturing companies at different extent, which would reflect the implication of this study in actual practice. Figure 1 shows the schematic presentation of the proposed model as synthesized from the review of related literature and studies.

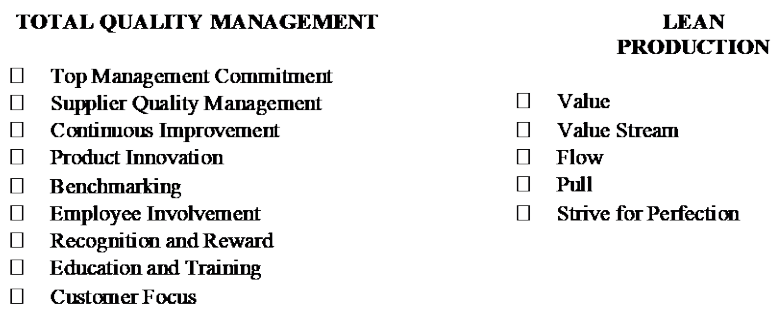

Figure 1. The conceptual framework

2. Methodology

2.1 Sampling Procedure

The population frame where the convenience sampling drawn is the list of Philippine Economic Zone Authority (PEZA) registered electronics and semiconductor companies as of January 31, 2017. There were 465 companies considered in the list as population reference.

2.2 Respondents

The field survey was conducted to the Philippine electronics and semiconductor manufacturing industry as the locale of the study. Employee respondents were the unit of analysis. The criteria to be an eligible respondent of the study were: (1) at least three years working in the company, (2) engineer and above position, and (3) belongs to the Operations/Production, Quality Assurance/Quality Control and Process Engineering departments. The field survey was conducted in one month.

Overall, 110 employee respondents from 62 companies participated the field survey. Employees from Operations have the most participation (42%), followed by Engineering (34%) and QA (24%). The 110-sample size is within one of the rule of thumb in Structural Equations Modelling (SEM) which should have a minimum of 100 cases and 5 cases per variable (as cited in Wolf, Harrington, Clark, & Miller, 2013).

As to the position of respondents, more than half of participants are engineers (55%), followed by managers (34%) and supervisors (11%). Fifty percent of respondents worked 3 to 5 years in their current companies, while 16% of them are 6 to 10 years and 34% of them are more than 10 years.

2.3 Methods of Gathering Data

Self-administered questionnaires were distributed through email and printed copies. Figure 2 shows the two preliminary steps conducuted before the actual survey: (1) content validity of the developed LP instrument and (2) factor analysis and reliability testing of the questionnaire.

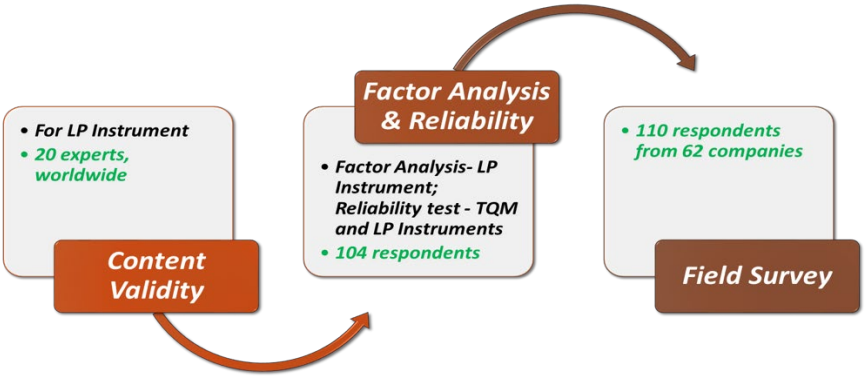

Figure 2. The survey journey

2.4 Instrument

The researcher developed and validated the Lean Production questionnaire based on the five principles of Womack and Jones (Womack and Jones, 2010; Weigel, 2000), which is used to measure the respondents' implementation of Lean Production. On the other hand, the TQM questionnaire for this study is adapted from Das, et al., (2008), considering its relevance to the manufacturing industry and it is one of the latest study that is focused on the development of TQM instrument in a manufacturing industry at Asia-Pacific setting.

Using the developed questionnaires as synthesized from the review of literature, the study conducted validity and reliability testing prior to field survey. The questionnaire used a 5-Likert Scale to assess the level of agreement of each company respondents about the implementation of TQM and LP in their respective companies. The 5-Likert scales used were: (1) Strongly disagree, (2) Disagree, (3) Neither agree or disagree, (4) Agree, and (5) Strongly agree (Vagias, 2006; Boone Jr. & Boone, 2012). Respondents were asked to indicate their level of agreement with the statement in each items using this likert scale.

2.5 Data Processing and Statistical Treatment

The researcher used the Pearson Correlation through SPSS in determining the correlation and testing the relationship between TQM and LP. The sample correlation coefficient between two variables, say TQM as x and LP as y is denoted r or r_{xy} and the formula reference is:

$$r_{xy} = \frac{\operatorname{cov}(x, y)}{\sqrt{\operatorname{var}(x)} \cdot \sqrt{\operatorname{var}(y)}}$$

In this formula, cov(x, y) is the sample covariance of x and y; var(x) is the sample variance of x; and var(y) is the sample variance of y.

The researcher used the interpretation of Pearson Correlation values as to the following as suggested by Rumsey, D.J. (n.d.): Exactly –1.0 a perfect negative linear relationship; –0.70. a strong negative linear relationship; –0.50; a moderate negative relationship; –0.30. a weak negative linear relationship; 0. No linear relationship; +0.30. a weak positive linear relationship; +0.50. a moderate positive relationship; +0.70. a strong positive linear relationship; and, Exactly +1. a perfect positive linear relationship.

3. Results and Discussion

3.1 Each TQM Construct and Each Lean Production Construct

Overall, each aspects of TQM and each aspects of Lean Production showed positive and significant relationship among each other as shown in Table 1.

Table 1. Pearson correlation *heat map of TQM constructs and Lean Production constructs

TQM/LP	Value	Value Stream	Flow	Pull	Strive for Perfection
Top Management Commitment	.540**	.603**	.582**	.437**	.665**
Supplier Quality Management	.345**	.399**	.515**	.389**	.527**
Continuous Improvement	.708**	.687**	.577**	.618**	.751**
Product Innovation	.603**	.580**	.655**	.621**	.711**
Benchmarking	.498**	.448**	.408**	.445**	.506**
Employee Involvement	.639**	.693**	.651**	.589**	.771**
Reward and Recognition	.465**	.476**	.617**	.368**	.539**
Education and Training	.522**	.524**	.624**	.432**	.671**
Customer Focus	.514**	.524**	.662**	.485**	.604**

**Correlation is significant at the 0.01 level (2-tailed).

*Heat Map is a representation of data in which data values are represented as colors.

Legend:

- Strong positive relationship;
- Moderate positive relationship; and,
- Weak positive relationship

Strong positive relationships are evident in Strive for Perfection aspect of Lean Production such as its association with TQM's Top Management Commitment (r=0.665), Continuous Improvement (r=0.751), Product Innovation (r=0.711), Employee Involvement (r=0.771), and Education & Training (r=0.671). The strong positive relationship between Continuous Improvement and Strive for Perfection is a practical implication that for a company to strive towards excellence, it has to embrace continuous improvement. Another insight from the result is that Employee Involvement and Education & Training may steer the companies towards continuous improvement and operational excellence. On the other hand, a strong Top Management Commitment may yield to a strong culture of continuous improvement and operational excellence.

A strong positive relationship between Product Innovation and Strive for Perfection (r=0.711) would also indicate that a strong cross-functional participation in the review of customer requirements and product realization at the design stage may facilitate Strive for Perfection in various ways. For example, updating operations procedures and work instructions at the mass production stage would be easier since the involvement of the process owners at the design stage enables them to translate the design requirements in a continuous improvement perspective.

A strong positive relationship is also observed between Continuous Improvement and Value Stream (r=0.687) as well as Employee Involvement and Value Stream (r=0.693). This would imply that to understand and improve the Value Stream in a Lean Production setting, managers may need to incorporate this in continuous improvement activities while involving employees. This result could also lead to an insight that Value Stream should not be done in a top-down perspective, rather in a more participative continuous improvement environment.

Surprisingly, Product Innovation and Flow (r=0.655) also manifested a strong positive relationship. Contextually, this would imply that when customer requirements, cross-functional participation and quality considerations are diligently implemented at product innovation stage, the transition to production would be smooth and thus, the requirements for a continuous flow would be considered as well.

While some aspects of TQM demonstrated a strong positive relationship with some aspects of Lean Production, some aspects also demonstrated a weak positive relationship. Weak positive relationship is demonstrated by the Supplier Quality Management aspect of TQM with LP's Value (r=0.345), Value Stream (r=0.399) and Pull (r=0.389) aspects of Lean Production. The weak positive relationship between Supplier Quality Management and Value would imply a challenge that management need to consider how customer value can be more directly linked in managing suppliers. This weak positive relationship would call the need for managers to look at end-to-end linkage of customer requirement and product or service realization from suppliers in a TQM and Lean Production environment. In a value stream and pull production perspective, this result would manifest a weak linkage of key suppliers to add value to the organization in terms of quality, cost and delivery. This may be accounted to the weak relationship of the companies with key suppliers, which may result to cooperation and coordination issues in implementing just-in-time (JIT) system and quality improvement with suppliers. Rewards and Recognition and Pull also demonstrated a weak positive relationship (r=0.368). This weak linkage would imply that employees may not be motivated well to prove efficiency in their tasks because they may not be rewarded and recognized accordingly.

Looking at the heat map presented in table 1, weak positive relationships are mainly demonstrated by three aspects: Supplier Quality Management, Benchmarking and Pull. This would imply that managers may need to focus more on these three aspects when simultaneously implementing TQM and LP as one integrated program. In the case of Supplier Quality Management, for example, its weak relationship with most of the Lean aspects may be attributed to lack of coordination and information sharing on how key suppliers can contribute to customer value and efficiency of the company's internal processes. One reason may be attributed to the greater preference of companies to reduce prices from supplier purchases than establishing a long-term relationship with suppliers. This situation would perceive by suppliers as "adversarial". As such, they may not initiate or cooperate towards a collaborative and mutually beneficial activities such as just-in-time systems and joint improvement programs.

In the case of Benchmarking, the weak relationship with most of the LP aspects would be due to low level of implementation compared to other TQM aspects. To strongly associate Benchmarking with Value Stream, Flow and Pull, managers may need to benchmark TQM and LP practices externally and demonstrate the benefits of benchmarking both strategies as the best practices are customized and applied internally. After which, internal sharing of TQM and LP best practices may be reinforced to strengthen the benchmarking culture of the company.

Pull is the aspect in LP with the majority of weak positive relationship with TQM aspects. Weak association is observed with its relationship with TQM the following TQM aspects: Top Management Commitment, Supplier Quality Management, Benchmarking, Reward and Recognition and Education and Training. The weak positive relationship of Pull with these TQM aspects may be due to tool- and efficiency-specific nature of Pull which may not be directly covered by the said TQM aspects. For example, Pull is specific to just-in-time systems, use of Kanban tools and inventory control mechanisms where the items of the mentioned TQM aspects may not be directly linked to these Pull implementations. Another reason may be attributed to low extent of Pull implementation compared to other LP aspects. This would manifest that LP aspect implementation may need to be improved by looking at how it should be "specifically" integrated with other TQM aspects. This may be started by leveraging on the moderate positive relationship of Pull with other TQM aspects such as Continuous Improvement, Product Innovation, Employee Involvement and Customer Focus.

Looking at the heat map in a strong positive relationship perspective, it is evident that TQM's Continuous Improvement and LP's Strive for Perfection demonstrated the most numbers of strongest association compared with other aspects. This would imply that strongly implementing Continuous Improvement and Strive for Perfection items would sustain the implementation of overall TQM and LP. Companies may also use these two aspects as venue to improve the other aspects.

Overall, majority of the relationship of each TQM aspects with each LP aspects demonstrated a moderate positive relationship. This result is also relative to the overall implementation of TQM and LP which is moderate extent of implementation. This would imply that companies may still need strive on improving the implementation of TQM and LP towards a more integrated program.

3.2 Each TQM Construct and Overall Lean Production

Generally, the aspects of TQM showed a moderate positive and significant correlation with overall Lean Production as shown in Table 2.

Table 2. Pearson correlation of TQM constructs and overall Lean Production

TQM Construct	Pearson Correlation with Lean Overall
Top Management Commitment	.669**
Supplier Quality Management	.525**
Continuous Improvement	.780**
Product Innovation	.748**
Benchmarking	.535**
Employee Involvement	.789**
Reward and Recognition	.585**
Education and Training	.659**
Customer Focus	.662**
**. Correlation is significant at the 0.01 level (2-tailed).	

Legend:
- Strong positive relationship;
- Moderate positive relationship; and,
- Weak positive relationship

Majority of the "soft aspects" such as Top Management Commitment, Employee Involvement, Reward and Recognition, and Education and Training showed a positive significant relationship with Lean Production which is supported the findings of Khalili, et al. (2018). Employee Involvement (r=0.789), Continuous Improvement (r=0.780) and Product Innovation (r=0.748) are the top TQM aspects with strong positive relationship to overall Lean Production. This would imply that strong implementation of these three aspects may be used as company leverage in a successful implementation of Lean Production.

Supplier Quality Management (r=0.525) demonstrated a moderate positive relationship with overall Lean Production. This would imply that the improvement efforts of the company in managing suppliers may not directly improve Lean Production implementation as much as other TQM aspects. As suggested by Kim (2015), the integration of Lean Production to supplier can be enhanced through a focused implementation on what Lean aspects can be implemented to suppliers and intertwined onsite. In order to improve this, as previously evident on the studies of Friedli, et al. (2010) manufacturing companies should ensure the end-to-end consideration of the value chain through the management of the downstream interface to customers. This finding would be an improvement in the electronics and semiconductor industry as it is widely recognized that supplier relationships provide a vital link in the implementation of successful Just-in-time (JIT) systems through a win-win outcome. This can be achieved through appropriate supplier selection and effective supplier relationship management (Aksoy & Ozturk, 2011).

Benchmarking and Rewards and Recognition also showed a moderate positive relationship with overal LP. This weaker relationship is also aligned with the lower extent of implemenation of both TQM aspects as explained in the previous sections of this chapter.

Looking at the heat map, majority of the TQM aspects (6 out 9) have a strong positive relationship with overall LP, while the rest of the items have a moderate positive relationship. This would imply that TQM aspects can be strongly aligned with overall LP. As such, there should be a minimum conflict when implementing both operational strategies simultaneously.

3.3 Overall TQM and Overall Lean Production

Overall, TQM and Lean Production have a strong positive linear and significant relationship as shown in Table 3.

Table 3. Pearson correlation of TQM and Lean Production

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TQM Overall	Pearson Correlation	.838**
	Sig. (2-tailed)	.000
	N	110

This strong and significant relationship implies that the association of the two operational practices is evident. As such, in an implementation perspective, the improved implementation of TQM can reflect a corresponding improvement in Lean Production implementation. Also, this would imply that companies that are already implementing a robust TQM may implement Lean Production easily.

4. Summary of Findings and Conclusion

Overall, the relationship of TQM and LP is significant and strong positive. However, when the relationships are compared at TQM aspect level to overall LP and LP aspect level, the extent of relationship varies from one aspect to another. At the aspect level, TQM aspects with the strongest relationship with LP aspects are: Continuous Improvement, Product Innovation and Employee Involvement. On the other hand, TQM aspects with the weakest relationship with LP are: Supplier Quality Management and Benchmarking. Strive for Perfection aspect of LP demonstrated the strongest relationship with TQM aspects. Value Stream and Pull demonstrated the weakest relationship with TQM aspects.

Continuous improvement and striving for perfection strongly bind TQM and LP when they are simultaneously implemented. This is further reinforced through cross-functional teams, quality circles and facilitation of a suggestion system. Thus, improving employee involvement and commitment to further steer continuous improvement activities.

Benchmarking, supplier quality management and pull production do not strongly support the association of TQM and LP. This can be attributed to the lower extent of their implementation, indirect linkage with other aspects and the specific nature of the aspects. The dependence of pull production and JIT system to supplier quality management strongly supports this finding. The lower extent of implementing and prioritizing long-term supplier relationships would have impacted the implementation of JIT system in the companies.

5. Implication of the Study

The results of this study have implications for the potential integration of TQM and LP as one program in manufacturing environments. By having an insight on the detailed and holistic extent of relationship between TQM and LP, a comprehensive simultaneous implementation program can be developed with embedded continuous improvement techniques. Thus, a minimized effort and resources with a higher managerial success may be demonstrated while managing two operational strategies at the same time.

The results of this study also indicate that describing the relationship between two variables using specific to general analysis is beneficial to understand the association. In a methodology perspective, this study has forwarded that looking the relationship at the aspect or construct level can provide insight on how the elements of a concept being analyzed "behave" towards a systematic and holistic relationship. Focusing not only on the absolute description of an element or a dimension but also on relative description can also provide insight on the comparative impact towards a systematic conclusion and recommendation.

The results of this study also have empirical implications. The validity and reliability of the developed LP instrument in this study proved that Womack and Jones's framework (the 5 principles of Lean) is empirically valid and that this can be used as instrument for Lean measures in survey studies. This proof may also provide further confidence to industrial consultants and practitioners on the applicability of the Lean framework as the forefront in developing, implementing and sustaining Lean practices. Another implication is the establishment of the significant relationship between TQM and LP which empirically validated the interrelatedness of TQM and LP.

This study also forwarded information on the gaps (weak items and aspects), constraints (weak relationships) and difference in the implementation of TQM and LP. As an implication, companies may need to focus on these aspects in a continuous improvement perspective. On the other hand, this study also forwarded on which aspects companies may need to use as leverage (strong items, aspects and relationships) to successfully implement TQM and LP.

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