The impact of total quality management on supply chain management and firm’s supply performance

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This research investigates the relationships among total quality management practices (TQMP), supply chain management practices (SCMP) and firm’s supply performance (FSP) in the automotive industry in Thailand. The measurement instruments for SCMP, TQMP and FSP were developed based on an extensive literature review and verified by experts, pilot test and various statistical techniques to ensure reliability and validity in structural equation modeling constructs. The hypothesized model was tested through a path analysis. Qualitative case studies of two large first-tier automotive suppliers were conducted to obtain more in-depth information. We found that the set of SCMP, TQMP and FSP measures are reliable and valid for Thailand’s automotive industry. TQMP not only has a significant direct positive impact on SCMP and on FSP but also a significant indirect positive impact on FSP through SCMP.

Keywords: TQM; supply chain management; supply performance; supply chain quality management; automotive; Thailand

1. Introduction

In a dynamic international market, quality is not enough. Supply at the right time, place and cost is also critical for competitive advantage (Chin et al. 2004, Robinson and Malhotra 2005). The global business competition is no longer between the organisations but between their supply chains (Kuei et al. 2001, Li et al. 2006). Therefore, leading companies have adopted supply chain management (SCM) and total quality management (TQM) to strengthen their organisational performance. However, a simultaneous implementation of both systems is challenging and consumes a considerable amount of resources due to the extended scope that covers not only internal functions but also the operations of external business partners. If the simultaneous implementation can be accomplished, the organisation should reap great benefits. If it fails, the impact on the business performance would be serious.

Although, both SCM and TQM are critical for organisational competitiveness, the subjects have been, most of the time, studied separately (Kuei et al. 2001, Gunasekaran and McGaughey 2003, Casadesus and Castro 2005, Robinson and Malhotra 2005). This research aims to investigate the relationships among total quality management practices (TQMP), supply chain management practices (SCMP), and firm’s supply

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performance (FSP) with respect to the internal supply performance of the automotive part suppliers, a critical component of the whole supply chain. The automotive industry in Thailand was employed as a case study; because, the automotive supply chain is very complex and the Thai automotive industry is very active in both SCM and TQM. Also, it is one of the major globally competitive industries of Thailand.

2. Relationship between SCM and TQM in the automotive industry

Quality management (QM) especially performance management and SCM have been predominantly discussed in operations management journals (Taylor and Taylor 2009). Ideally, QM should be a critical success factor for SCM to deliver quality products to the customer(s) in time and at competitive cost. Without providing empirical evidence, Gunasekaran and McGaughey (2003) suggested that TQM could play a key role in improving SCM. Similarly, Bandyopadhyay and Sprague (2003) stated that TQM could be implemented in a supply chain to enhance competitiveness, especially in complex supply networks, such as the automotive supply chain. Although an average automobile consists of over 15,000 components, only a few are manufactured by the final assemblers (Perez and Sanchez 2001), while most are manufactured and supplied by a network of specialised vendors. Therefore, price, quality and delivery of an automobile depend significantly on those of its components, which in turn are influenced by quality and efficiency of all partners along the supply chain. As a result, the automotive industry is one of the most active industries in the development of supply networks. Most companies in this industry have implemented just in time (JIT) purchasing and operations which share many principles with SCM (Scannell et al. 2000, Tan 2001, Gimenez 2004, Narasimhan et al. 2008). JIT aims to achieve on-time delivery and to minimise unnecessary inventory cost. To achieve JIT delivery, quality of the whole internal operations as well as that of the external partners must be assured. Gonzalez-Benito and Spring (2000) studied the implementation of JIT purchasing in the Spanish automotive component industry and concluded that the automotive assemblers tended to develop a partnership with most suppliers, but applied JIT logistics to only some of them. In the U.S. automotive industry supply chain, Scannell et al. (2000) found that JIT purchasing significantly associated with flexibility, conformance to specification and low production cost performance.

Empirical research explored the relationship between SCM and QM in different aspects (Kuei et al. 2001, Gunasekaran and McGaughey 2003, Casadesus and Castro 2005, Robinson and Malhotra 2005) but there was no consensus about the findings. Casadesus and Castro (2005) could not confirm that ISO 9000 practices fully support SCM. Romano and Vinelli (2001), in a case in the textile and apparel industry in traditional and coordinated supply chains, found that the coordinated supply chain had better ability to meet customers’ quality expectations than the traditional supply chain. Choi and Rungtusanatham (1999) compared QM at three supply chain levels, i.e., final assemblers, top-tier suppliers and tertiary-tier suppliers, in the automotive, electronics and other industry groups. They could not identify any statistically different quality levels across the supply chains in their samples. Conceptually, Vanichchinchai and Igel (2009) in a review of SCM and TQM literature found that SCM and TQM share similarities regarding philosophical perspective, ultimate goal (customer satisfaction) and ultimate integration (from internal functions and external business partners); but, have differences in primary goal (quality for TQM and delivery for SCM) and primary integration
(from internal functions for TQM and from external business partners for SCM). These similarities and differences can provide synergy or conflict in a simultaneous implementation. Therefore, it is important to explore and confirm what impact TQM can have on SCM (Gunasekaran and McGaughey 2003). The following research questions address this need. (1) Does TQMP have a direct positive effect on SCMP? (2) Does TQMP have a direct positive effect on FSP? (3) Does TQMP have an indirect positive effect on FSP through SCMP that address issues targeted by TQMP?

3. Relationships among the practices of SCM, TQM and firm’s supply performance

3.1 TQM practices and SCM practices

SCM and TQM are more than simple tools or techniques. They are management philosophies (Sun 2000, Tan 2001, Tan et al. 2002, Chan and Qi 2003, Khan 2003, Vanichchinchai and Igel 2009) implemented as large-scale management systems that consist of various sets of practices (Waldman 1994, Hellsten and Klefsjo 2000, Khanna et al. 2003). There are similarities and differences between TQMP and SCMP which could support or obstruct each other. For example, customer relationship management as defined by the Global Supply Chain Forum (GSCF) framework (Croxton et al. 2001), customer relationship proposed by Li et al. (2005) and Li et al. (2006), long term relationship and cooperation (Min and Mentzer 2004) are similar to customer and market focus measured by the Malcolm Baldrige National Quality Award (MBNQA) criteria (NIST 2007), Brah et al. (2002) and Hoang et al. (2006). Internal lean practices proposed by Li et al. (2005), process integration by Min and Mentzer (2004) and manufacturing flow management in the GSCF framework are similar to process management measured by the MBNQA (NIST 2007), the EFQM excellence model (EFQM 2010), the Thailand quality award criteria (Thailand Productivity Institute 2009) and Hoang et al. (2006).

For differences, Gowen and Tallon (2003) concluded that few researchers have studied human resource management in the context of SCM. Many SCM frameworks do not include internal human resource practices, for instance, the SCM framework of GSCF (Croxton et al. 2001), Tan et al. (2002) and Li et al. (2005). Conversely, human resource management related practices are emphasized and included in most TQM frameworks (Hoang et al. 2006, Perdomo-Ortiz et al. 2009, Vanichchinchai and Igel 2009) such as MBNQA (NIST 2007), EFQM excellence model (EFQM 2010), Khan (2003), Pun (2002). Jiménez-Jiménez and Martínez-Costa (2009) also found a positive relationship between TQM implementation and human resource management practices of empowerment, teamwork, staffing, training, appraisal and compensation. In conclusion, the similarities and differences of management practices among SCM and TQM could either synergise or conflict and this should be explored further and confirmed empirically. Thus, the hypothesis is as follows.

H1: A firm’s TQM practices have a significant positive direct effect on its SCM practices

3.2 TQM practices and firm’s supply performance (FSP)

Both SCM and TQM aim to achieve customer satisfaction as the ultimate goal (Gunasekaran et al. 2001, Gunasekaran and McGaughey 2003). Basically, customers require better product quality, faster delivery and lower cost. However, traditional QM focuses on specification-based performance or “small-q” (Vanichchinchai and Igel 2009).

The more immediate goal of SCM is satisfying customers through delivery or time-based performance (Vanichchinchai and Igel 2009). This may be because traditional SCM focused on physical distribution (Gilmour 1999, Croom et al. 2000). A comprehensive study of the SCM literature by Chin et al. (2004) and Kuei et al. (2001) based on Jayaram et al. (2000) concluded that the issue of timing receives special attention in SCM research. SCM aims to respond to customers as quickly as possible, at the right time, place and cost. Samaranayake (2005) also noted that SCM aims to achieve speed-to-market, agility and the flexibility to respond quickly to customer requirements at minimum cost. Moreover, several SCM researchers (Lummus and Vokurka 1999, Lummus et al. 2003, Chase et al. 2007, Simchi et al. 2008) found that SCM emphasises the flow of materials and information throughout the entire supply chain. Consequently, a conflict may arise between delivery and quality goals. Conversely, there may be a synergy in the ultimate goal, customer satisfaction. The following hypothesis tries to investigate the relation.

H2: A firm’s TQM practices have a significant positive effect on FSP

3.3 TQM practices and firm’s supply performance (FSP) through SCM practices

Both SCM and TQM require involvement from all internal functions and collaboration with all external partners. Oakland (1989) suggested that the word “total” in TQM refers to every department and every person at every level in the organisation. In the TQM environment, all employees are treated as internal customers. If the internal customers are not satisfied, value creation for the external customer is difficult. Therefore, TQM emphasises employee involvement (Khan 2003). Accordingly, the criteria of most TQM frameworks such as MBNQA and EFQM excellence model include a measure for human resources. Hoang et al. (2006) also found that human resource management issues had the highest coverage in TQM. However, too much focus on internal participation may lead to difficulty in real TQM implementation. Yeung and Amstrong (2003) reported that a main barrier of TQM implementation was lack of external focus, as quality improvement effort were made only in internal issues.

SCM requires internal and external business process integration across the whole supply chain (Gimenez 2004) and its effectiveness and efficiency depend significantly on the degree of integration (Chin et al. 2004). The external focus of SCM may be due to the fact that the organisation itself must work with its customers and the suppliers within the same SCM system. Most SCM frameworks emphasise the relationship with external business partners and almost ignore the human resource component (Vanichchinchai and Igel 2009). Although SCM emphasises integration of external business partners, the actual implementation must begin by integrating internal functions and then moving on to external integration. From an extensive literature review, Vanichchinchai and Igel (2009) concluded that SCM targets external business partnerships and TQM emphasises mainly internal functions to participate. Therefore, an ultimate integration and the difference in primary focus can be a source for both, synergy and barriers in improving FSP when implementing a combined set of SCM and TQM systems. Further research is needed to explore this implication. Therefore, the third hypothesis is as follows:

H3: A firm’s TQM practices have a significant positive indirect effect on FSP through SCM practices
4. Measures

In this study, a SCMP measurement for the automotive industry in Thailand was developed based on the research of Li et al. (2006), Min and Mentzer (2004), Tan et al. (2002), Lee and Kincade (2003), Sahay and Mohan (2003), Chin et al. (2004), GSCF in Lambert et al. (2005) and Kim (2006). The TQM framework developed for Vietnam by Hoang et al. (2006) was the basis for TQMP measures. Given that this TQM framework constituted both hard and soft practices of TQM, covered most prestigious quality award criteria widely accepted by TQM experts such as MBNQA and EFQM excellence model and was designed for industries in developing countries and then tested in the Vietnamese industries. Supply chain performance measures proposed by Min and Mentzer (2004), Li et al. (2006) and Gunasekaran et al. (2001) were applied to develop the measurement instrument for the firm’s supply performance (FSP). To improve the content validity, these measurement items were assessed by four academic experts in SCM and TQM and three industry experts in the automotive industry in Thailand. As a result, SCMP measures included four sub-constructs, namely information management, lean system, supply chain organisation and partnership management. While, TQMP measures comprised customer focus, commitment and strategy, human resource management and information analysis. FSP measures were composed of cost, flexibility, relationship and responsiveness.

A six-point Likert scale was applied to validate the existence of the SCMP, TQMP and FSP in the companies surveyed.

Back translation of the questionnaire from English to Thai and back to English was conducted to avoid linguistic differences in Thai and English technical vocabulary. Then, a pilot survey was conducted to ensure that the respondents had no difficulties in completing the questionnaire. Twelve companies were selected from the database of Thailand Automotive Part Manufacturer Association (TAPMA) and the directory of Thai Automotive Business. The key informants were executives in SCM and TQM systems in their companies. Since, both the paper-based questionnaire and electronic questionnaire were for the large-scale survey, the pilot questionnaire was prepared in electronic form to be delivered via email in order to test the applicability of the electronic questionnaire. After receiving the returned questionnaires, the researcher contacted the respondents for further comments. Some suggested to provide a definition of SCM in the questionnaire, because SCM was new in Thailand even in the automotive industry. Therefore, its meaning, scope and application may not be clearly understood and could be viewed differently by different managers and companies. In response to this comment, the SCM definition of the GSCF which is “the integration of key business processes from end user through original suppliers that provide products, services and information that add value to all trade partners” (Lambert et al. 2005, p. 28) was added. Overall, there was no further comment about length, format, content and clarity of the questionnaire.

5. Research method

5.1 Data collection and sample

Multiple responses from each company were encouraged by asking at least two respondents per company to answer the questionnaire to improve reliability of the information obtained. Carr et al. (2000) experienced that many Asian firms would be reluctant to cooperate in research surveys without first developing a relationship with the researchers. To overcome such potential obstacles, various methods such as personal
requests via telephone, supportive requests from professional organisations and incentives and rewards for respondents were used to obtain a high response rate.

For the electronic questionnaire distribution, target companies were identified through a directory of Thai Automotive Business and the database from TAPMA, Thailand Automotive Institute (TAI), Federation of Thai Industries and Industrial Estate Authority of Thailand (IEAT). Several professional organisations in the automotive industry in Thailand including TAPMA, TAI, Human Resource Club of Amata Industrial Estate, Human Resource Club of Laem Chabang Industrial Estate and Human Resource Club of Eastern Seaboard Industrial Estate, helped distribute electronic questionnaire to their members. The paper-based questionnaire was manually distributed during three public seminars about the automotive industry organised by TAI and Thailand Productivity Institute.

The total number of returned questionnaires was 415; 146 questionnaires were excluded due to missing data or inappropriate respondent profile. Almost all of them were paper-based questionnaires distributed during public seminars. Single and multiple responses were obtained from 171 and 40 companies, respectively. Including multiple responses, the final number of valid samples by company was 211. Organisational characteristics of the sample firms are shown in Table 1.

<table>
<thead>
<tr>
<th>Characteristics and description</th>
<th>Company</th>
<th>Percentage (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Position</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing Director/President/CEO</td>
<td>13</td>
<td>6.2%</td>
</tr>
<tr>
<td>Director/Deputy Managing Director/Vice President</td>
<td>93</td>
<td>44.1%</td>
</tr>
<tr>
<td>Manager</td>
<td>105</td>
<td>49.8%</td>
</tr>
<tr>
<td><strong>Ownership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thai</td>
<td>75</td>
<td>35.9%</td>
</tr>
<tr>
<td>Japanese</td>
<td>104</td>
<td>49.8%</td>
</tr>
<tr>
<td>Other Nationality</td>
<td>30</td>
<td>14.3%</td>
</tr>
<tr>
<td>Missing</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Company Size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small to Medium &lt;= 200</td>
<td>54</td>
<td>25.6%</td>
</tr>
<tr>
<td>Large &gt; 200</td>
<td>157</td>
<td>74.4%</td>
</tr>
<tr>
<td><strong>Tier in the Supply Chain</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Tier Suppliers</td>
<td>177</td>
<td>87.2%</td>
</tr>
<tr>
<td>Other Tier Suppliers</td>
<td>26</td>
<td>12.8%</td>
</tr>
<tr>
<td>Missing</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Management System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO 9000</td>
<td>92</td>
<td>43.6%</td>
</tr>
<tr>
<td>ISO/TS 16949</td>
<td>155</td>
<td>73.5%</td>
</tr>
<tr>
<td>JIT or lean manufacturing or Toyota production system</td>
<td>45</td>
<td>21.3%</td>
</tr>
</tbody>
</table>

*Not including missing responses.

Table 1. Organisational characteristics.
samples for every organisational characteristic was found, given the Chi-square value of 
company ownership at 3.11 for two degrees of freedom, Chi-square value of company size 
and tier in the supply chain were 0.71 and 0.48 at one degree of freedom. All $P$ values were 
higher than 0.05 confirming the similarity between respondent and non-respondent 
samples. Besides, $t$-test of the mean score of all items between single and multiple 
responding companies showed a $P$ value of 0.663 at 0.05 significant level confirming no 
significant difference between single and multiple responding companies.

5.2 Qualitative case study

We also conducted qualitative case studies of two large first-tier automotive suppliers to 
obtain more in-depth information about the linkages between SCM and TQM. The first 
company was a French majority owned company (taken over from a Japanese company) 
specialised in engineering parts. It represented firms with more mature SCM and QM 
systems. The other was a Thai-owned firm producing decorative parts and representing 
management style with less developed SCM and QM systems. Both companies were 
committed to SCM and QM having departments directly responsible for SCM and QM. 
They were also leaders in manufacturing and management systems in their market 
segments and had received a number of awards and certificates. The informants were SCM 
managers who had key roles in SCM implementation and were knowledgeable about SCM 
and QM of their companies. Information about the background and objectives of the 
research were explained to the individual informant via telephone to have a clear 
understanding about the purpose of this case study and to develop a good relationship. 
The informants were assured that all information collected will be used solely for academic 
purposes. The list of questions and necessary information was sent to them about 1 week 
 prior to the interview. Most of the questions were open-ended questions in order to gain 
a wide range of responses and frank opinions.

5.3 Reliability and validity

Item-total correlations and Cronbach’s $\alpha$ to examine the reliability of the measurement 
items should exceed 0.3 and 0.7, respectively (Nunnally and Burnstein 1994, Hair et al. 
1998). With careful consideration, for SCMP, five items of lean system and one items 
of partnership management (LS01, LS04, LS13, LS14, LS15 and PM04) were dropped 
because of low item-total correlation values. It was observed that these six items deal with
specific operational issues rather than the general management issues of the sample companies. These items were unique for the individual organisation and products produced. After the removal, the remaining items had item-total correlation score above 0.3 and their Cronbach’s α values were above 0.7. All TQMP items had item-total correlation scores well above 0.5 and Cronbach’s α well exceeded 0.8 as shown in Table 3. Also, all FSP items had item-total correlation score well above 0.5 and their Cronbach’s α well exceeded 0.7. Consequently, all TQMP and FSP item were kept.

The validity of each sub-construct was tested by first-order confirmatory factory analysis (CFA) with maximum likelihood estimate to remove the items with weak loading coefficients, below 0.5. Two items of information management, two items of lean system and one item of strategy and organisation (IM01, IM02, LS05, LS07 and SO03) were eliminated because of low loading coefficient. This was because the sample companies were mostly the first-tier part suppliers that sell products to the automotive assemblers rather than to the automotive users. The automotive assemblers assess the end users’ requirements and then convert those requirements to product specifications. Therefore, the automotive part suppliers merely respond to the automotive assemblers’ requirements and pay less attention to end user requirements. No TQMP and FSP item was dropped. The multiple goodness of fit index, namely \( \chi^2/df \), GFI, CFI, NNFI and SRMR were applied to assess the overall goodness of fit of each sub-construct. Generally, \( \chi^2/df \) ratio should be less than 3. GFI, CFI and NNFI should be at least 0.9 and SRMR should be less and 0.1 (Hair et al. 1998). As shown in Table 3, every sub-construct of SCMP, TQMP and FSP well met these requirements.

Reassessment of Cronbach’s α of SCMP after eliminating items with low loading coefficients, composite reliability and average variance extracted confirmed reliability of the measurement models (Netemeyer et al. 1990) as shown in Table 3. Composite reliability of every sub-construct was well above the required value of 0.60 and average variance extracted exceeded 0.50 except for information management, lean system and partnership management. Considering Cronbach’s α, composite reliability and average variance extracted together, all sub-constructs were sufficiently reliable.

The second-order CFA was conducted to confirm that these sub-constructs were sub-constructs of broader constructs (Hair et al. 1998). During the second-order constructs validation process, no item was dropped, given that the loading coefficients between the second factors and their sub-constructs in every second-order construct were well above 0.5 as shown in Table 4. All \( t \) values were higher than 1.96 for 0.05 significance level. The overall fit of every second-order construct was good as shown in Table 5. In conclusion, SCMP, TQMP and FSP construct comprised the proposed sub-constructs and items in accordance with their supportive theories.

Moreover, all measurement models were tested for convergent, discriminant, and nomological validity as shown in Table 3. Nine of 12 models had average variance extracted value exceeded 0.50, suggesting acceptable convergent validity (Shock et al. 2004). Discriminant validity was assessed by examining correlations between pairs of latent variable (Anderson and Gerbing 1988). Their correlation coefficients were much below one confirming that the sub-constructs were distinct. Therefore, discriminant validity could be assumed. Besides the GFI, CFI and NNFI which had been measured and confirmed, AGFI, IFI and RMSEA were added to assess nomological validity (Steiger 1990). They confirmed that the measurement models were well nomologically valid. Based on the overall results, these measurement models were found fit and valid.
Table 3. Reliability and multiple fit indexes of sub-construct.

<table>
<thead>
<tr>
<th>Sub-construct</th>
<th>No. of items</th>
<th>Cronbach’s $\alpha$</th>
<th>Composite reliability</th>
<th>Average variance extracted</th>
<th>$\chi^2/df$</th>
<th>P value</th>
<th>GFI</th>
<th>CFI</th>
<th>NNFI</th>
<th>SRMR</th>
<th>SRMEA</th>
<th>IFI</th>
<th>AGFI</th>
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</thead>
<tbody>
<tr>
<td><strong>Supply chain management practice</strong></td>
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<tr>
<td>Information management</td>
<td>5</td>
<td>0.7573</td>
<td>0.78</td>
<td>0.42</td>
<td>0.656</td>
<td>0.5755</td>
<td>0.99</td>
<td>1.00</td>
<td>0.0310</td>
<td>0.000</td>
<td>1.00</td>
<td>0.98</td>
<td></td>
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<tr>
<td>Lean system</td>
<td>9</td>
<td>0.8529</td>
<td>0.84</td>
<td>0.37</td>
<td>1.631</td>
<td>0.0631</td>
<td>0.98</td>
<td>0.99</td>
<td>0.0490</td>
<td>0.055</td>
<td>0.99</td>
<td>0.92</td>
<td></td>
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<tr>
<td>Partnership management</td>
<td>6</td>
<td>0.7541</td>
<td>0.77</td>
<td>0.36</td>
<td>1.358</td>
<td>0.2014</td>
<td>0.98</td>
<td>0.99</td>
<td>0.0350</td>
<td>0.041</td>
<td>0.99</td>
<td>0.96</td>
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<tr>
<td>Strategy and organization</td>
<td>6</td>
<td>0.8706</td>
<td>0.87</td>
<td>0.54</td>
<td>1.552</td>
<td>0.1566</td>
<td>0.99</td>
<td>1.00</td>
<td>0.0220</td>
<td>0.051</td>
<td>1.00</td>
<td>0.95</td>
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<tr>
<td><strong>Total quality management practice</strong></td>
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<tr>
<td>Customer focus</td>
<td>3</td>
<td>0.8228</td>
<td>0.83</td>
<td>0.62</td>
<td>0.030</td>
<td>0.8638</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0048</td>
<td>0.000</td>
<td>1.00</td>
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<td>Commitment and strategy</td>
<td>4</td>
<td>0.8526</td>
<td>0.85</td>
<td>0.58</td>
<td>0.570</td>
<td>0.4513</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0056</td>
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<td>1.00</td>
<td>0.99</td>
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<td>Human resource management</td>
<td>7</td>
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<td>0.90</td>
<td>0.57</td>
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<td>0.98</td>
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<td>0.0220</td>
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<td>Information analysis</td>
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<td>0.70</td>
<td>1.020</td>
<td>0.3119</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0310</td>
<td>0.010</td>
<td>1.00</td>
<td>0.98</td>
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<td><strong>Firm’s supply performance</strong></td>
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<td>Cost</td>
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<td>0.81</td>
<td>0.59</td>
<td>2.180</td>
<td>0.1398</td>
<td>0.99</td>
<td>0.99</td>
<td>0.0450</td>
<td>0.076</td>
<td>0.99</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td>Flexibility</td>
<td>3</td>
<td>0.7996</td>
<td>0.80</td>
<td>0.58</td>
<td>0.080</td>
<td>0.7772</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0082</td>
<td>0.000</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Relationship</td>
<td>4</td>
<td>0.8460</td>
<td>0.84</td>
<td>0.57</td>
<td>0.860</td>
<td>0.3546</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0079</td>
<td>0.000</td>
<td>1.00</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Responsiveness</td>
<td>3</td>
<td>0.8510</td>
<td>0.87</td>
<td>0.69</td>
<td>0.090</td>
<td>0.7613</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0097</td>
<td>0.000</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
6. Findings and discussion
The structural model of this study is shown in Figure 1. The overall fit of the model, $\chi^2/df$ ratio = 1.329 was well below 3 with a $P$ value 0.082. GFI = 0.96, CFI = 1.00, NFI = 0.99, NNFI = 1.00 were above the recommended critical value at 0.9 and SRMR = 0.023 was much lower than the cut-off point at 0.1.

For path analysis, all $t$ values were well above 1.96 and significant at 0.05 level as shown in Table 6. TQM practices had strong relationship with SCM practices as illustrated by the high standardised estimate 0.79 and $t$ value of 9.56, thus H1 was supported. This can be explained by similar practices such as customer relationship in SCM and customer focus in TQM. In recent years, TQM has been broadened to include all best practices (Vanichchinchai and Igel 2009) even the SCM-related one (Martinez-Lorente et al. 1998). Thus, TQM practices facilitate SCM practices implementation. Similar findings by Flynn and Flynn (2005) of the synergies between QM and SCM in the machinery, electronics and transportation components industries in the US, Germany, Italy, Japan and England showed that QM and SCM can be implemented together. Kannan and Tan (2005) also found that TQM, SCM, and JIT reinforced each other. However, the result of our study was different from some other studies. Hsu et al. (2009) investigated the relationship between operations capability including TQM, SCM and JIT and business performance and could not confirm a significant relationship between TQM capability and SCM. They explained this surprising finding by the measures employed to assess TQM capability that focused mainly on internal quality initiatives and

### Table 4. Second-order confirmatory factor analysis.

<table>
<thead>
<tr>
<th>Second-order construct</th>
<th>Sub-construct</th>
<th>Standardised estimate</th>
<th>$t$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain management practice</td>
<td>Information management (IM)</td>
<td>0.788</td>
<td>8.15</td>
</tr>
<tr>
<td></td>
<td>Lean system (LS)</td>
<td>0.898</td>
<td>8.42</td>
</tr>
<tr>
<td></td>
<td>Partnership management (PM)</td>
<td>0.808</td>
<td>8.63</td>
</tr>
<tr>
<td></td>
<td>Strategy and organization (SO)</td>
<td>1.000</td>
<td>11.30</td>
</tr>
<tr>
<td>Total quality management practice</td>
<td>Customer focus (CF)</td>
<td>0.786</td>
<td>9.15</td>
</tr>
<tr>
<td></td>
<td>Commitment and strategy (CS)</td>
<td>1.000</td>
<td>12.10</td>
</tr>
<tr>
<td></td>
<td>Human resource management (HR)</td>
<td>0.982</td>
<td>11.92</td>
</tr>
<tr>
<td></td>
<td>Information analysis (IA)</td>
<td>1.000</td>
<td>14.52</td>
</tr>
<tr>
<td>Firm’s supply performance</td>
<td>Cost (CT)</td>
<td>0.805</td>
<td>11.15</td>
</tr>
<tr>
<td></td>
<td>Flexibility (FL)</td>
<td>0.690</td>
<td>7.65</td>
</tr>
<tr>
<td></td>
<td>Relationship (RL)</td>
<td>0.960</td>
<td>10.91</td>
</tr>
<tr>
<td></td>
<td>Responsiveness (RS)</td>
<td>1.000</td>
<td>12.07</td>
</tr>
</tbody>
</table>

### Table 5. Multiple fit indexes of the second-order construct.

<table>
<thead>
<tr>
<th>Construct</th>
<th>$\chi^2/df$</th>
<th>$P$ value</th>
<th>GFI</th>
<th>CFI</th>
<th>NNFI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCMP</td>
<td>0.820</td>
<td>0.9776</td>
<td>0.94</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0379</td>
</tr>
<tr>
<td>TQMP</td>
<td>1.223</td>
<td>0.0704</td>
<td>0.94</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0302</td>
</tr>
<tr>
<td>FSP</td>
<td>0.647</td>
<td>0.9627</td>
<td>0.98</td>
<td>1.00</td>
<td>1.00</td>
<td>0.0223</td>
</tr>
</tbody>
</table>
did not explicitly address boundary spanning quality issues such as supplier quality. Casadesus and Castro (2005) surveyed firms certified by ISO 9000 standard in Spain and could not confirm that ISO 9000 implementation fully supported SCM. The conflict between Casadesus and Castro’s finding (2005) and ours can be explained by differences in the measurement frameworks applied in both studies. Our TQM framework covers a more comprehensive superior QM system; while, Casadesus and Castro (2005) applied the ISO 9000 framework which contains only a subset of overall TQM requirement (Kartha 2004). Similarly, Yeung (2008) found that strategic supply management that focuses on the dyadic supply relationship between a manufacturer and its key suppliers significantly supports QM implementation but not the adoption of ISO 9000.

A firm’s TQMP significantly and positively impacts its firm’s supply performance (FSP). The standardised estimate of their relationship was 0.51 with a $t$ value of 5.46, thus $H_2$ was supported. TQM targets customer satisfaction as the ultimate goal (Vanichchinchai and Igel 2009) which also covers FSP such as responsiveness. Moreover, former empirical researches, for instance, Rahman (2001), Sun (2000),

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Table 6. Relationships among TQMP, SCMP and FSP.

<table>
<thead>
<tr>
<th>Path</th>
<th>Total effect</th>
<th>Direct effect</th>
<th>Indirect effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>TQMP $\rightarrow$ SCMP</td>
<td>0.79 (9.56)</td>
<td>0.79 (9.56)</td>
<td>–</td>
</tr>
<tr>
<td>TQMP $\rightarrow$ FSP</td>
<td>0.85 (11.98)</td>
<td>0.51 (5.46)</td>
<td>0.34 (4.15)</td>
</tr>
<tr>
<td>SCM $\rightarrow$ FSP</td>
<td>0.42 (4.55)</td>
<td>0.42 (4.55)</td>
<td>–</td>
</tr>
</tbody>
</table>
George and Sherry (1998), Danny and Mile (1999), Khan (2003), Hendricks and Singhal (1997), Prabhu et al. (2000) and Hsu et al. (2009) confirmed that QM/TQM can improve not only quality performance but also the organisational performance as a whole. FSP is a subset of the business performance. Besides, MBNQA criteria which are acclaimed as the most accepted TQM framework (Black and Porter 1996) are referred to as criteria for performance excellence (NIST 2007). The TQM framework in this research also adopted principles of MBNQA criteria and EFQM excellence model.

In addition, TQMP had a significant indirect positive effect on FSP through SCMP. The standardised estimate of the indirect effect between TQMP and FSP was 0.34 with a $t$ value 4.15 which supported H3. The total effect between TQMP and FSP was 0.85 with a $t$ value 11.98 clearly indicating shared practices and performance. Although, SCMP emphasises external partnership with customers and suppliers, the SCMP implementation must be strongly supported by internal collaboration among departments because coordination within the organisations is a prerequisite of SCM (Lambert and Cooper 2000). Therefore, TQM which focuses on internal participation of all employees is a critical foundation for SCM. In turn, both contribute to the firm’s supply improvement. Accordingly, Kuei et al. (2001) reported for Taiwan that companies with higher supply chain quality management tended to perform better than companies with lower supply chain quality management in the performance of cost saving. Moreover, Lin et al. (2005) who surveyed the impact of supply chain quality management in Taiwan and in Hong Kong found that QM significantly correlated with the supplier participation and selection strategy in SCM and this influenced business performance. Tan et al. (1998) who studied the linkages between QM, supplier evaluation and supply base management in the US suggested that QM and supply base management should be implemented together to improve corporate performance. Kannan and Tan (2005) concluded that there were linkages between TQM, SCM, and JIT which reinforced each other and then improved business performance. Kaynak and Hartley (2008) confirmed that the implementation of QM within each supply chain member’s organisation is a prerequisite for supply chain quality. Flynn et al. (2010) also found that internal integration was significantly related to not only operational but also business performance. All studies cited above indicate strong support that TQM and SCM can be implemented together to create value.

7. Implications and conclusion

This research was one of the first to study the relationships among SCM practices, TQM practices and firms’ supply performance in a developing country. It can also be used in further research on the new concept of supply chain quality management (Robinson and Malhotra 2005, Sila et al. 2006, Foster 2008). The findings present insights into the debate concerning the impact of TQM practices on SCM practices and on firm’s supply performance. The quantitative results suggest that TQM practices can directly facilitate the implementation of SCM and can directly enhance the firm’s supply performance. Moreover, TQM practices can indirectly improve firm’s supply performance through SCM practices. This is because TQM has been broadened to cover some SCM practices and firm performance dimensions such as cost and responsiveness. Thus, TQM can be used as a foundation for implementing SCM and improving firm’s supply performance. Findings from qualitative case studies of both companies also confirmed these. As a result although TQM and SCM are large-scale management systems, managers should not consider them
as separate. Both could be implemented together to achieve excellent performance in the firm supply-related business process system.

However, the case companies experienced some negative effects of disruptions caused by QM especially when employees were overly strict with applying QM standards and did not clearly understand SCM requirements. For instance, when there were contingency events such as quality problems, some employees were adhering too strictly to working instructions. They made no effort to resolve these immediate problems up front and neglected supportive tasks not specified in job descriptions which lead to delivery delays and higher cost. However, the French company reacted to these problems better than the Thai company because of stronger QM system and awareness. Both companies tried to solve these problems with stronger awareness building through more training, better communication between QM and SCM staff and goal alignment. The case companies also recommended that industry-specific QM systems such as ISO/TS 16949 should be introduced before implementing SCM. Thus, differences in scope and maturity of QM and SCM implemented or in firm characteristics can affect the results. If the QM foundation is not comprehensive enough, the firm may not be able to use QM to support SCM implementation. Thus, training in quality awareness, communication, goal alignment or adopting industry-specific QM systems such as ISO/TS 16949 are recommended prior to SCM implementation. Managers should be aware of these issues when implementing SCM and TQM together. Lack of suitable measurement instruments was one of the major challenges for this research. Consequently, this study developed measurement instruments for SCM practices, TQM practices and firm’s supply performance for the automotive industry in Thailand. These instruments were comprehensively confirmed to be reliable and valid. With some adjustments, they can be applied in research in other industries or developing countries.

8. Limitations and suggestions for future research

The distribution of the paper-based questionnaires was a convenience sampling. Future research should apply different random samples for more generalisation of the results. Only 19% of the sample companies provided more than one response and the single respondent in an organisation may cause possible response bias. For future research, other data collection methods should be chosen to increase the multiple respondent rates. Although the measurement instruments as well as hypotheses were comprehensively confirmed as reliable and valid with various statistical techniques, further studies based on the adaptation of these instruments in other industries or developing countries could be conducted to confirm its general validity. The samples in this research comprised only the automotive part suppliers. In future research, the automotive assemblers and downstream business partners could be studied together with the upstream suppliers in order to investigate the relationship along the whole supply chain. The effect of individual TQM practices on individual SCM practices and individual firm’s supply performance dimensions may also be researched.

References


Thailand Productivity Institute, 2009. Available at: http://www.tqa.or.th/en/node/702


### Appendix

**1) Supply Chain Management Practice (SCMP)**

**Information Management (IM)**

- **IM01** We contact the end users of our products to get feedback on product performance and service
- **IM02** We work with our trade partners to survey and define customer requirement
- **IM03** We have a common standard for information sharing (e.g. product order, shipment, inventory) for our trade partners to follow
- **IM04** We evaluate formal and informal complaints as well as satisfaction of our trade partners
- **IM05** We effectively share information with our trade partners to facilitate business planning and react to changes
- **IM06** We apply advanced information technology in our supply chain
- **IM07** We have information sharing among functions for the objectives of supply chain management

**Lean System (LS)**

- **LS01** We delay final manufacturing activities until customer orders have actually been confirmed
- **LS02** We reduce inventory levels
- **LS03** We reduce set-up time
- **LS04** We reduce inspection of incoming materials/components/products
- **LS05** We order in small lot sizes
LS06 We streamline business processes (e.g. ordering, shipping, receiving and other paperwork) with our trade partners
LS07* We reduce response time
LS08 We have continuous improvement activity
LS09 We deliver products directly to points of use (e.g. customer’s assembly lines)
LS10 We involve in teams our trade partners to improve our supply chain
LS11 We use a pull production system (pull means producing only when there is demand not to keep high inventory)
LS12 We share supply chain management practices or resources (e.g. manufacturing, warehousing, distribution, marketing, etc.) with our trade partners
LS13* We place our personnel at the business facilities of our trade partners to facilitate cooperation
LS14* We store our goods at appropriate distribution points close to our customers
LS15* We design our products for modular or unit part assembly (e.g. brake systems, wiring harness, air-conditioning systems, steering column, instrument cluster)
LS16 We have contingency management system for unexpected events (e.g. order change or cancellation, computer network down)

Partnership Management (PM)
PM01 We share knowledge about core business processes with our trade partners
PM02 We share improvement benefits as well as other risks and rewards with our trade partners
PM03 We develop a long-term relationship and trust with our trade partners
PM04* We rely on a small number of quality trade partners
PM05 We participate in the sourcing decisions of our suppliers
PM06 We include our trade partners in our product development projects
PM07 We have common goals agreed with our trade partners

Strategy and Organization (SO)
SO01 We have a supply chain performance measurement system
SO02 We certify our suppliers using supply chain performance criteria (e.g. quality, cost, delivery)
SO03* We extend our trade partners to include partners beyond immediate suppliers and customers
SO04 We have organisational structure which facilitates business process integration with our trade partners
SO05 Our top level managers strongly encourage employee (worker) involvement in supply chain management
SO06 Our employees (workers) are actively involved in supply chain management-related activities
SO07 Our organisation has an open, trusting culture with low bureaucracy. Our working environment is very good for supply chain management

(2) Total Quality Management Practice (TQMP)
Commitment and Strategy (CS)
CS01 Our top level managers strongly encourage employee (worker) involvement in quality management
CS02 We have a clear vision, mission, policies, long term objectives and plan for improving quality
CS03 We have a clear quality goal and short-term business performance plans
CS04 Our top managers allocate adequate resources toward efforts to improve quality
Customer Focus (CF)
CF01 We have a system for collecting complaints or suggestions from customers
CF02 We actively seek ways to improve the products in order to achieve greater customer satisfaction
CF03 We have introduced and maintained the “customer focus” philosophy for a long time

Human Resource Management (HR)
HR01 We provide training and training resources to employees (workers) and encourage them to attend these training programs
HR02 We have many active improvement teams
HR03 We actively evaluate and implement employees’ suggestions related to quality and supply chain management, if they are suitable
HR04 Our line employees (workers) are responsible for and inspect the quality of their own work (self inspection)
HR05 We have an assistance mechanism (problem solving network) to help line employees solve quality problems
HR06 Our employees (workers) are actively involved in quality management-related activities
HR07 We provide awards to individuals and groups for excellent suggestions

Information Analysis (IA)
IA01 We have information sharing among functions for the objectives of quality improvement
IA02 We display information on quality performance at most of the work stations and everybody knows it
IA03 We use quality improvement tools and techniques extensively for process management and improvement

(3) Firm’s Supply Performance

Cost (CT)
CT01 We have a good overall inventory management performance (e.g. inventory turnover, obsolete, availability)
CT02 We have a good overall financial performance (e.g. ROA, ROI, ROS)
CT03 We have an effective and efficient production plan

Flexibility (FL)
FL01 We have the ability to produce products with various specification (e.g. features, options, sizes, colors, special specification)
FL02 We have the ability to rapidly adjust production capacity in response to changes in customer demand
FL03 We have the ability to handle rapid introduction of new products

Relationship (RL)
RL01 Our suppliers have a good overall performance (e.g. quality, cost, delivery)
RL02 We have a good overall relationship with trade partners
RL03 We have an accurate demand forecasting
RL04 We have an effective and efficient business process (e.g. less clerical, documentary, inspection jobs)
Responsiveness (RS)

RS01 We have a good overall delivery performance (e.g. on-time, fast)
RS02 We have a good overall quality of products and services
RS03 We have the ability to provide our customers real time information about their orders

Items marked by an asterisk (*) were removed in the final instrument.