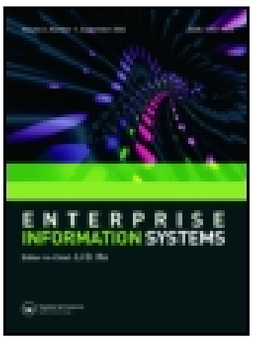

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Investigation of critical success factors for improving supply chain quality management in manufacturing

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ABSTRACT

This study aimed to identify and prioritise critical success factors (CSFs) for improving supply chain quality management (SCQM) under the context of Industry 4.0. We identified five potential factors from the literature and through semi-structured interviews of five individuals in different company positions and departments. 132 valid questionnaires were used to measure the factors with the results showing that the five CSFs play an essential part in SCQM. Customer focus was the most significant factor positively influencing improvements in supply chain quality management. The quality of the information technology system was also important, as well as increased collaboration among supply chain members. Process integration and leadership also had an impact, but supplier quality management showed no significant effect.

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Critical success factors; supply chain quality management; customer focus; information systems; Industry 4.0

1. Introduction

The traditional manufacturing industry had suffered an increasing number of challenges under the development of Industry 4.0, mainly caused by the poor communication between manufacturer and purchaser (Feng 2020), and the lack of precise information (Pattanayak and Punyatoya 2019), and the lack of information adequate technology (Perico et al. 2019). Therefore, to implement cost control and enhance flexibility, it is important to re-investigate the supply chain for the manufacturing industry in the context of information technology.

Supply chain management (SCM) involves merging strategic initiatives to achieve excellent management of upstream and downstream processes (Wong et al. 2018). Competition happens across the whole supply chain and quality management is a key strategic issue for most manufacturing companies (Zaidin et al. 2018). The integration of quality management and the supply chain ensures that all related partner organisations can be measured and improved. SCQM is central to integrated supply chains (Marinagia

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2015), and the companies with better quality management usually had a better organisational performance.

SCQM is an extension of SCM that involves Quality Management (supplier support, customer focus & orientation, strategic planning and leadership, continuous improvement & learning, empowerment and teamwork, human resource focus, management structure, quality tools) and Supply Chain Management. (transportation & logistics, marketing, continuous improvement & learning organisational behaviour, best practices, supply base integration, relationships & partnerships, strategic management) (Robinson & Malhotra, 2005).

Organisations try to integrate quality into the supply chain, and one effective way to enhance the quality of SCM is to recognise the critical success factors (CSFs) (Vargas and Comuzzi 2020). CSFs are considered to optimise material flow, improve quality systems and maximise data sharing by applying enterprise resource planning systems. However, they are often not the same in different circumstances (Vargas and Comuzzi 2020). Dezdar and Ainin (2012) pointed out that the economic changes, the type of firm, and the culture in different countries would cause the differences. Therefore, discovering the CSFs under the development of information technology is of great importance.

In order to understand the problems of traditional manufacturing enterprises under the new circumstances, the study explores the CSFs to improve SCQM via a case study in an organisation in Chongqing, China. The company is a traditional state-owned enterprise that provides components for the national shipbuilding company and is facing major problems such as defective products and late delivery due to the ineffective use of technology. Hence, this study aimed to identify and prioritise the CSFs for the Company.

From a theoretical standpoint, the study considers the context of Industry 4.0 and develops a research model based on a literature review that can influence the quality management of the supply chain. From a practical view, the study determines the valid CSFs and makes recommendations to the company. These could inspire other traditional manufacturing firms to adopt suggestions and explore their CSFs in facing the challenge of information technology.

The paper is organised as follows: part 2 presents an overview of the research on supply chain quality management (SCQM) and the critical success factors (CSFs) and the development of hypotheses. Part 3 illustrates the methodology, which includes both qualitative and quantitative methods. The results are given in Part 4, followed by discussion and recommendations in Part 5, followed by the conclusions.

2. Literature review & hypotheses

2.1 Improvement of SCQM

Supply chains are experiencing a transformation from SCM to supply chain quality management (SCQM). SCM can encourage companies to build supply chain competence that focuses on reducing cost (Vanichchinchai and Igel 2009). Quality management concentrates on activities like product design and process control. Suppliers and customers are also critical to quality (Thomas, Wallin, and Ogden 2011). Consequently, SCQM extends this by adding quality management practices (Goecks, Santos, and Korzenowski 2020).

There exist extensive literature focusing on the SCQM theory. According to the research of Robinson and Malhotra (2005), SCQM is a 'formal coordination and integration of business process involving all partner organisations in the supply channel to measure, analyse and continually improve products, services, and processes in order to create value and achieve the satisfaction of intermediate and final customers in the marketplace'. Thomas (2008) stated that SCQM is an approach used to enhance system performance between suppliers and customers. The quality of SCQM is influenced by the supply chain and quality management system (Robinson and Malhotra 2005). Kuei, Madu, and Lin (2008) described the requirements for SCQM: the ability to stimulate the competitive advantages of the supply chain; the ability to stimulate the competitive advantages perceived by local firms' leaders, planning and implementation of SCQM.

There are a variety of research concerned with the performance measurement of SCQM. Opengart (2015) opined that the No. 1 topic on SCAM implementation is the studies on the integration of the supply chain quality management. Powell and Rødseth (2013) developed a conceptual framework of Integrated Planning (IPL) to maintain the manufacturing planning and control stages systematically. Erkayman (2019) suggested building up a JIT (Just-in-time) production system in the automotive industry through ERP implementation via a case study. Karamouz, Kahnali, and Ghafournia (2020) summarised empirical models for evaluating the SCQM, such as Balanced Scorecard (BSC), Activity Based Costing (ABC), Supply Chain Operation Reference Model (SCOR), etc.

However, only a few researchers have investigated the factors affecting the implementation of SCQM (Kuei, Madu, and Lin 2008). Furthermore, according to the performance evaluation by Pattanayak and Roy (2019), no research has built up the connection between the enhancement of business performance and supply chain performance parameters. On the other hand, there is no conclusive evidence such as empirical analysis or qualitative case study can prove the relationship.

2.2 Critical success factors

Rockart (1979) originally propose CSFs to define the information needs of the executives. CSFs are used to assign to the in-charges in pursuit of achieving the ultimate organisational vision, while CSFs are those vital issues, 'things must go right' to ensure success for an organisation or a managerial individual (Anderson 1984). Slevin & Pinto (1987) applied the concept of CSFs project management, claiming that managers can put limited resources into key parts of the organisation by identifying the CSFs, and they can also monitor the CSFs to guide the project.

Therefore, some studies focused on how to identify CSFs. CSF methodology is a strategic technique or a procedure conceptually designed for dictating the key areas that determine the success or the survival of an organisation (Boynton and Zmud 1984; Tan, 1999). Boynton and Zmud (1986) suggested generating CSFs via structured dialogues among top management, resulting in statements of CSFs. Bullen and Rockart (1981) advocated when to use CSFs, and all levels of in-charges have to be interviewed. The final CSFs should be integrated into a collective set for the organisation as a whole.

Consequently, there are different works for providing deep investigations on CSFs. Project cost, project quality, project time and client satisfaction are considered as the measures of supply chain performance based on e-procurement and supply chain technology internalisation (Pattanayak and Punyatoya 2019). In addition, several authors emphasise that the Impact

of Industry 4.0 has significantly affected the CSFs, and technology should be a key factor for the development of supply chains (Ivanov, Dolgui, and Sokolov 2019; Pfohl, Yahsi, and Kurnaz 2015). Raut, Narkhede, and Gardas (2017) identified 32 CSFs from the academic literature and emphasised 'Global Climatic Pressure and Ecological Scarcity of Resources' to be the most crucial factors. Overall, the literature suggests that the dominant factors are customer focus, superior supplier quality, quality of the IT system, process integration and leadership (Chen, Daugherty, and Landry 2009; Kaynak and Hartley 2008; Madhani 2009; Ravichandran and Rai 2000). Vision and goals, software configuration and software selection affect the CSF of SMEs (Kurnia, Linden, and Huang 2019). The classification, analysis and synthesis of CSF through the unified variance and process method are a major announcement for future researchers (Romero and Vernadat 2016). Vargas and Comuzzi (2020) propose to measure CSFs in terms of size, the degree of economic development the company has lived in, culture, department and type.

2.3 Similar studies

There was been extensive discussion on CSFs, with distinct results. Table 1 summarises similar studies of CSFs:

Table 1. The comparison of similar studies.

Similar literature	Methodology	Findings
A multidimensional model of Enterprise Resource Planning critical success factors, EIS, 2020.	(1) Literature review (2) Case study (3) Interviews	(1) Identify the context dimensions (size, economic status, culture, sector, type) (2) Present the CSFs (Table 2 to Table 10) for each dimension (3) Evaluate the CSFs by case studies and experts survey
A hermeneutic analysis of critical success factors for Enterprise Systems implementation by SMEs, EIS, 2019.	(1) hermeneutic analysis	(1) Illustrate 3 knowledge gaps (2) Identify 5 CSFs categories (change management, functional fit, project management, top management, external) (3) Present CSFs in Table 6 and identify them between "distinct" and "frequently cited"
Critical success factors for mutual collaboration with suppliers in the IT outsourcing industry: a case study of a top IT outsourcing company in Korea, EIS, 2018.	(1) Literature research (2) Case study (3) Interviews	(1) Present the SRM level 1,2,3 (2) Six CSFs for the trust-based long-term partnership (Supplier management strategy reflecting corporate business goal, Process innovation, Norm sharing and open communication for partnership, Supplier involvement, Standardisation of the formal evaluation system, Feedback of performance evaluation) (3) Evaluate by case study

Table 2. Interviewee profiles.

Age	Gender	Department	Position
53	Male	General Office	Vice President
36	Male	Technology Centre	Manager
41	Female	Procurement	Vice Manager
47	Female	Marketing	Manager
48	Male	IT Department	Manager

However, this paper is different from the articles referenced above. First of all, this study conducts a mixed research method which includes interviews of experts in the company to explore the CSFs in the organisation; and exploratory research to verify the CSFs. Moreover, the case study of a Chinese state-owned manufacturing company is suitable for exploring the change of CSFs under the economic context of Industry 4.0.

2.4 Hypotheses

This study aimed to identify and prioritise the CSFs that can improve the efficiency and effectiveness of SCQM in a Company. Based on the literature review, the study used the framework proposed by Kuei, Madu, and Lin (2008) and identifies five CSFs: customer focus, supplier quality management, quality of IT system, process integration and leadership.

2.4.1 Customer focus

Customer satisfaction is an important part of customer focus. The ultimate aim of SCQM is achieving customer satisfaction (Kuei and Madu 2001). Organisations must make a continuous effort and commit to SCQM to sustain customer satisfaction. Organisations also need to gather timely and reliable customer information. They use various approaches to enable them to collect customer information that can stimulate product design and production (Azar et al., 2010). Obtaining customer focus also requires greater attention to downstream relations with customers. Customers may be involved in quality improvement programmes (Forza and Filippini 1998).

A manufacturing supply chain is a series of activities from the acquisition of raw materials to customer delivery (Beamon and Ware 1998). Previous studies have found that customer focus is one of the strongest predictors of organisational performance (Samson and Terziovski 1999). Supply chain effectiveness has a close relationship with the alignment of the supply chain value proposition with customers' needs (Keivan and Simons 2006). Kuei and Madu (2001) claimed that customer focus is the CSF for quality management. In 2015, its first principle of quality management was the customer focus of the study company. The company aimed to satisfy the needs and expectations of customers for quality, price, on-time delivery and product life cycle. This study therefore hypothesised:

H1. There is a positive relationship between customer focus and improvement of SCQM in the Company.

2.4.2 Supplier quality management

Masnita, Triyowati, and Rasyawal (2017) revealed that the management of supplier quality through the whole supply chain directly led to better performance. Supplier quality management refers to management efforts to improve overall quality, as well as performing effective management in product or service quality from the supplier (Zhang, Hu, and Zhao 2020). It emphasises supply quality rather than price (Kuei and Madu 2001). There are several approaches to improve supply quality, including:

(1) Supplier selection (Choi, Thomas, and Hartley 1996; Kuei and Madu 2001).
(2) Supplier relationship (Azar, et al., 2010; Kuei and Madu 2001).

(3) Supplier evaluation (Thomas, Wallin, and Ogden 2011).

Supplier quality management requires a long-term business partnership (Lintukangas, Kähkönen, and Hallikas 2019). The case study Company uses different suppliers for raw materials, parts, accessories, tools and office supplies, so we therefore hypothesis:

H2: There is a positive relationship between supplier quality management and improvement of SCQM in the Company.

2.4.3 Quality of IT system

Studies have identified the quality of the information technology (IT) system as a potential CSF. IT is an enabler in building and maintaining a supply chain to meet organisational requirements (Kuei and Madu 2001). IT systems are often used to assess both productivity and quality (Jurison 1998), but few companies consider the quality of the IT system itself (Bagrova, Kruchinin, and Nazarenko 2019; Xu 2011). A good IT system facilitates efficiency and effectiveness across the whole supply chain, supporting enterprise resource planning and product life cycle management. All supply chain members can align themselves with the digital format and transform themselves into an IT-based SCQM enterprise. A good IT system therefore improves consistency, responsiveness and collaboration in the supply chain.

Organisations commonly adopt blocks of IT, including computers, software and telecommunications. However, the quality of the IT system is not always high (Kuei and Madu 2001). It may be difficult to use SCQM to control quality factors if there is no accurate information (Li and Collier 2000; Wang, Lida, and Peng 2007). Accurate information technology and timely data collection can facilitate improved organisational performance. It was found that medium- and high-performance organisations differ from low-performance ones in their emphasis on high levels of IT-driven organisational integration (Kuruwitaarachchi et al. 2020). This study therefore hypothesised:

H3: There is a positive relationship between the quality of the IT system and the improvement of SCQM in the Company.

2.4.4 Process integration

Process integration is the integration of the production requirement and delivery issues when design and introducing a product or service in a company (Evans and Lindsay 1995; Schroeder et al. 2008). In order to establish a quality-driven supply chain, Madu and Kuei (2004) emphasised that optimising the capabilities in process integration is important. The cooperation of different supply chain parties is important in providing a smooth and synchronised connection between various processes for improving the efficiencies of an operative supply chain (Wankmüller and Reiner 2020). Organisations therefore need to integrate processes so that all the necessary resources can be collected so as to deliver smoothly. Beamon and Ware (1998) introduced a model for assessing, improving and controlling the quality of the supply chain called the Process Quality Model (PQM). It has seven modules to enhance process integration:

(1) Identify process, technology and tasks to be performed;
(2) Identify customer expectations;
(3) Define quality;
(4) Identify current quality performance measures;
(5) Evaluate current processes;
(6) Improve processes; and
(7) Control and monitor processes.

The supply chain involves a set of activities from procurement to ultimate customer delivery (Beamon and Ware 1998), which may be disrupted by an unsmooth supply chain process. SCQM requires external and internal business process integration across the whole supply chain (Fernandes et al. 2017). The key business processes integration by providing products and services information not only to enhance efficiency but also to add value to the trading partners. Process integration decreases process variation resulting in continuous quality improvement (Azar, et al., 2010). The degree of process integration decides the degree of efficiency and effectiveness of the supply chain (Chin et al. 2004). Improving the quality of all supply chain processes can result in lower costs and in maximising resource use (Beamon and Ware 1998). The case study Company is a typical manufacturing company that involves various activities and processes. This study therefore hypothesised:

H4: There is a positive relationship between process integration and improvement of SCQM in the Company.

2.4.5 Leadership

Leadership drives supply chain quality, which can ensure business excellence. The quality management programme is usually dependent on the decisions of the top management in a company (Robinson and Malhotra 2005; Yeung, Lee, and Chan 2003). Managers in different parts of the supply chain need to set directions for the operation of the supply chain and create a customer orientation (Kanji and Wong 1999). In summary, the responsibilities of leaders are to:

(1) Commit themselves to the development of the supply chain and encourage participation, learning, innovation and creativity.
(2) Maintain and sustain relationships with supply chain partners. Organisations should realise that they no longer exist independently, but are connected to other supply chain members.
(3) Develop a quality culture to provide outputs that will satisfy customers.

According to Kuei, Madu, and Lin (2011), supply chain managers and designers should make extraordinary leadership efforts to improve the SCQM system. Kuei and Madu (2001) claimed that managers need to offer leadership in enabling the conditions and facilitating trust for supply chain quality. Strong leadership can optimise activity implementation and build competitive advantages (Kuei, Madu, and Lin 2001). Leadership can therefore directly result in improved organisational performance. Supply chain managers need to have a better understanding of the current operating principles and strategic choices available. This study therefore hypothesised:

H5: There is a positive relationship between leadership and improvement of SCQM in the Company.

3. Methodology

In general, this research is a descriptive study that combines quantitative analysis and qualitative analysis, collecting primary data through questionnaire surveys and analysing the data with the help of SPSS software. The proposed conceptual framework is shown in Figure 1.

3.1 Qualitative method

To figure out the SCFs in this company, the researchers conducted a semi-structured interview which directly talks with managers of the Hydraumatic Mechanism-Electricity Co. The interviewees included three male employees and two female employees from different departments, holding different positions (see Table 2).

The study used individual in-depth interviews with the above managers of the Company. These were semi-structured and organised around a set of predetermined open-ended questions, with other questions emerging from the conversations between interviewer and interviewee (DiCicco-Bloom and Crabtree 2006). Five face-to-face interviews were conducted in Mandarin and each interview lasted about 30 minutes.

The first interview question was the basic research question, to provide information about SCQM in the Company, and followed by several specific questions to dig more deeply into various aspects of the research. We used specific questions on the proposed CSFs, customer focus, supplier quality management, quality of IT system, process integration and leadership. A sample of individual open-ended questions is listed in Appendix A.

The interview was used to connect the conceptual framework to the level of corporate practice, in order to revise or adjust these theoretical critical success factors based on the experiences of the managers in the company. Furthermore, specific critical success factors can precisely focus on the target company.

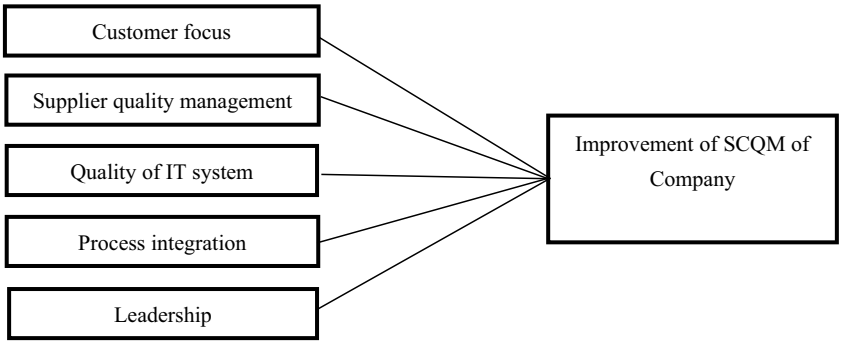

Figure 1. Conceptual framework.

3.2 Quantitative method

3.2.1 Questionnaire design

The questionnaire was designed in English, but a Chinese version was also available because all respondents were Chinese. Both paper-based questionnaires and web-based questionnaires were provided. The content covered the five independent variables proposed as CSFs for improving SCQM in the Company. We used previous research scales with slight modifications to match the study context. Simple attitude scales were used in the questionnaire, and scores were allocated from 1 to 5 to show answers from 'strongly disagree' to 'strongly agree'. The data were collected from the scores for each measurement item in the valid questionnaires.

The questionnaire was divided into two parts, one part to gather information about the variables and the other to provide basic information about the respondents. The questions for each variable and the corresponding item indices used in the questionnaire are listed in Appendix B.

To identify the current condition of SCQM of the Company, four questions about the quality of products, delivery reliability, operational efficiency and innovation power were asked. Respondents answered from 1 to 5 for 'strongly disagree' to 'strongly agree'.

3.2.2 Research model

We used SPSS 17.0 to analyse data from the 132 questionnaires. A regression model was developed with one dependent variable (DV) and five independent variables (IV):

$$I = \beta_0 + \beta_1 CF_i + \beta_2 SQM_i + \beta_3 QITS_i + \beta_4 PI_i + \beta_5 L_i \quad (1)$$

CF_i = Customer focus, SQM_i = Supplier quality management, $QITS_i$ = Quality of IT system, PI_i = Process integration, L_i = Leadership, β_0 = differential impacts on factors other than customer focus, supplier quality management, quality of IT system, process integration and leadership, β_1 = differential impacts on customer focus, β_2 = differential impacts on supplier quality management, β_3 = differential impacts on quality of IT system, β_4 = differential impacts on process integration, and β_5 = differential impacts on leadership.

A hypothesis was developed to test the overall importance of the regression model:

H0: $\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 = 0$

H1: At least one coefficient is non-zero.

4. Results

4.1 Qualitative research

As mentioned above, semi-structured interviews were conducted in order to find out more diversified information and opinion. In this study, five interviewers who are the employees of the case study company took part in the interview in their office. The case study company is located in Chongqing, China. The interviewees who have extensive industry experience and worked for more than 5 years were selected to participate in the

interview. They come from different departments with different positions, in which three male and female employees were participated in this study. The first one is the vice-president suggested that lean production management is a CSF for the improvement of SCQM. The second one is the manager of the technology centre is responsible for the product design. It was mentioned that the focus of the company is always customers, and adoption of technology is important to support the focus of customers to the company. The third one is the vice manager of the procurement department has lots of connections and communication with suppliers. She suggested that the department should build a close relationship with suppliers and establish a management system to ensure the materials would be delivered on time. The fourth one is the manager of the marketing department, who thinks the SCQM of the company operates well and the expansion of the department is required especially in the marketing processes. The fifth one is the manager of the IT department, who thinks the SCQM of the company operates in general, especially the IT system, but the system adoption is still low. Through interviews with five people selected from different positions and departments, we can analyse the CSFs of SCQM comprehensively.

To achieve advanced SCQM, the Company has focused on four gaps: supply chain competence, CSFs, strategic competence and supply chain quality (SCQ) practices, as shown in Table 3. There are four steps to reduce the implementation gaps. Step 1 was to develop advantages over competitors to eliminate the first gap. Step 2 was to use CSFs to stimulate the development of supply chain competencies. Step 3 was to focus on the strategic enablers, including infrastructure and the climate across the whole supply chain. Step 4 was to eliminate the fourth gap through continuous learning from supply chain practices.

This study identified CSFs that the Company considered could enhance the competencies of the supply chain in the marketplace. Three factors have previously been identified as crucial for initiating SCQM: customer focus, superior supplier quality and IT system quality (Kuei and Madu 2001). One of the biggest challenges for managers was responding to different stakeholders, including employees, customers and suppliers.

4.2 Quantitative research

4.2.1 Respondent profile

Both web-based questionnaires and paper-based questionnaires were distributed to employees of the Company. In total, 200 questionnaires were distributed and 158 were collected from the respondents, with 132 suitable for analysis. The respondents' demographic information is summarised in Table 4.

Table 3. Four steps to reduce the implementation gaps.

SC competence (gap 1)	CSFs (gap 2)	Strategic competence (gap 3)	SCQ practices (gap 4)
Quality products	Customer focus	Quality management	Supplier/customer quality meeting
Delivery reliability	Supplier quality management	Technology	Quality reporting
Supplier trust	Quality of IT system	Supplier participation	Supply chain quality office
Operational efficiency	Process integration	Configuration design	Supply chain optimisation
Innovation power	Leadership	Strategic planning	Policy development

Table 4. Study respondents' demographic information.

Background	Details	Frequency	Percent
Age	25–35 years old	32	24.2
	35–45 years old	36	27.3
	45–55 years old	64	48.5
Department	Procurement	13	9.8
	Manufacturing	52	39.4
	Marketing	17	12.9
	Technical centre	20	15.2
	Others	30	22.7
Position	Vice managers	15	11.4
	Managers	16	12.1
	Vice president	3	2.3
	Employees	98	74.2
	Vice managers	15	11.4
Length of service	5–10 years	21	15.9
	10–15 years	17	12.9
	15–20 years	35	26.5
	More than 20 years	59	44.7
Education level	High school	14	10.6
	Bachelor	112	84.8
	Master	6	4.5

Table 5. Correlation analysis.

Correlations							
		Overview of SCQM	Customer focus	Quality of IT system	Leadership	Process integration	Supplier quality Mgt
Overview of SCQM	Pearson correlation	1	.525**	.514**	.477**	.231**	.091
	Sig. (2-tailed)		.000	.000	.000	.008	.297
	N	132	132	132	132	132	132

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

Table 6. Summary of model fitting and regression analysis.

Model	*R*	*R*-square	Adjusted R-square	Std. error of the estimate	Durbin–Watson
1	.910[a]	.828	.821	.47153	2.177

a. Predictors: (constant), supplier quality management, process integration, leadership, quality of it system, customer focus.

b. Dependent variable: Overview of SCQM

In the regression analysis, the *F*-test of the regression model shows that the value of *F* is 121.326 (Table 7) and the significant factor is 0.000. This is less than 0.05, showing that the independent variable is statistically significant.

4.2.2 Correlation analysis

We used correlation coefficients to identify the relationships between five independent variables and one dependent variable (see Table 5).

H1 was therefore supported in that customer focus was positively associated with improved SCQM in the Company. However, H2 was not supported because supplier quality management was not associated with improved SCQM. Similarly, H3, H4 and H5 were all supported because the quality of the IT system, process integration and leadership were all positively associated with improved SCQM.

Table 7. ANOVA analysis of the proposed model.

Model		Sum of squares	df	Mean square	*F*	Sig.
1	Regression	134.877	5	26.975	121.326	.000[a]
	Residual	28.015	126	.222		
	Total	162.892	131			

[a]Predictors: (Constant), supplier quality management, process integration, leadership, quality of IT system, customer focus.
Dependent variable: overview of SCQM.

4.2.3 Regression analysis

Table 6 shows that the degree of model-fitting was good (R-square = 0.828) and these five determinants explained 82.8% of the result. If the Durbin–Watson Statistic equals 2, there is no serial correlation (Turner 2019). The value of the Durbin–Watson statistic in this study was 2.177, which is close to 2, showing that there was no autocorrelation.

The hypotheses were tested using regression analysis, as shown in Table 8. The independent variable is considered to significantly influence the dependent variable when the p-value is <0.05. If not, there is considered to be no relationship between the independent and dependent variables.

These results strongly support H1, and suggest that customer focus will positively influence the improvement of SCQM of the Company. Similarly, H2, H3 and H4 were also strongly supported, suggesting that supplier quality management, quality of IT system and process integration will also affect SCQM. There was also a significant and positive relationship between leadership and improved SCQM in the Company. The regression coefficient was 0.531, and the significance level was 0.000 (<0.05).

All five variables are therefore likely to support improved SCQM in the Company. To investigate how these five variables affect improvements in SCQM, we used this model:

$$I = 3.172 + 0.585CF + 0.102SQM + 0.573QITS + 0.257PI + 0.531L \quad (2)$$

4.2.4 Factor analysis

Table 9 shows that the χ^2 of Bartlett's test of sphericity was 3003.178, with 120 degrees of freedom and a significance level of 0.000. This suggests that the information indicators overlap, and it was therefore necessary to conduct factor analysis. The Kaiser–Meyer–Olkin value was 0.787, which also shows the need for factor analysis.

To conduct accurate factor analysis, we used principal component analysis. After extracting the common factor from the five variables, the cumulative variance reached 89.419%, which satisfies the standard of 70%. To develop a clear understanding of the

Table 8. Coefficients.

		Unstandardised coefficients		Standardised coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.172	.041		77.297	.000
	Customer focus	.585	.041	.525	14.199	.000
	Quality of IT system	.573	.041	.514	13.909	.000
	Leadership	.531	.041	.477	12.900	.000
	Process integration	.257	.041	.231	6.246	.000
	Supplier quality management	.102	.041	.091	2.476	.015

[a]Dependent variable: overview of SCQM.

Table 9. Results of the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's test of sphericity.

Kaiser–Meyer–Olkin measure		.787
Bartlett's test of sphericity	Approx. chi-square	3003.178
	df	120
	Sig.	.000

Table 10. Commonalities of the Indicators

Communalities	Initial	Extraction
Q5	1.000	.926
Q6	1.000	.905
Q7	1.000	.941
Q8	1.000	.874
Q9	1.000	.819
Q10	1.000	.949
Q11	1.000	.834
Q12	1.000	.920
Q13	1.000	.918
Q14	1.000	.895
Q15	1.000	.809
Q16	1.000	.938
Q17	1.000	.919
Q18	1.000	.901
Q19	1.000	.856
Q20	1.000	.902

structure of the factors, we used the biggest variance to conduct orthogonal rotation. The result shows that:

(1) The interpretation ratio of customer focus was 65.652%.
Therefore, customer focus is the most important variable.
(2) The interpretation ratio of quality of IT system was 7.522%.
Therefore, the quality of IT system is the second most important variable.
(3) The interpretation ratio of leadership was 6.729%.
Therefore, leadership is the third most important variable.
(4) The interpretation ratio of process integration was 6.030%.
Therefore, process integration is the fourth most important variable.
(5) The interpretation ratio of supplier quality management was 3.487%.
Therefore, supplier quality management is the least important variable.

5. Discussion

Although many authors have recognised the importance of supply chain management, supply chain quality management's critical factors under the development of Industry 4.0 remain unclear (Vargas and Comuzzi 2020). Based on the previous literature, this study reports the significant links between the CSFs and improvement of SCQM of the company, including customer focus, supplier quality management, quality of IT system, process integration and leadership. The results of this study have profound implications for the managers of the case study company. According to data analysis, customer focus is

strongly and positively influencing the improvement of SCQM of the company and it is the most significant factor. Quality of IT system is another key to the SCQM because an advanced IT system will increase collaboration among all the supply chain members from design to marketing (Pattanayak and Punyatoya 2019). In addition, process integration and leadership also have a significant influence on the improvement of SCQM of the company. Unlike the hypothesis, supplier quality management has a non-significant influence on the SCQM of the company. It is caused by the poor management of suppliers on the quality and volume.

We have therefore made some recommendations to help managers to improve the SCQM in the Company to face the changing environment of Industry 4.0:

(1) Establish an IT-based platform for customers and suppliers. Customer focus is the strongest factor for the improvement of SCQM. Forms of trust include contractual trust, goodwill trust and competence trust (Liu 2015). Managers should make sure that products can be delivered in accordance with the contract. Good relationships with customers can facilitate cooperation and ensure customer satisfaction. As Industry 4.0 has addressed, the technology-based factors should not be neglected. For instance, Oh, Ryu, and Yang (2019) suggest establishing an open system as a brand new transformation of the e-procurement system. They emphasise the open system could offer transparent information for purchasers to find the suppliers. Furthermore, it is convenient for enterprises to find their partners.
(2) Implement supply chain technology. Manufacturing industries should take information technology seriously and implement it into the supply chain management process to enhance firm performance (Pattanayak and Punyatoya 2019). In order to enhance the efficiency and effectiveness of supply chain management, there are various kinds of SCM technologies (Kosansky and Schaefer 2009). For example, the warehouse management system, the transportation management system, strategic level technologies, long-term planning systems, etc. (Pattanayak and Punyatoya 2019). For managers who prefer to supervise the process of the supply chain, smart logistics combined with smartphone Apps have crucial impacts on procurement and distribution. A better IT system can provide timely insights into quality aspects across the whole supply chain and end-to-end business processes. It enhances communication and cooperation among supply chain members, including the company, which also improves organisational performance.
(3) Transform to IT-based JIT and lean manufacturing. JIT (Just-in-time) management is a strategy that can focus on efficiency by considering the process integration and cost reduction. While lean manufacturing focuses on customer values by supply precise production (Erkayman 2019). There are many IT-based strategies to change JIT management and lean manufacturing. Wang, Gong, and Wang (2017) illustrate the information processing organisation in JIT. They emphasised that it is an effective way to reduce decision-making delays by applying the production control system through an information system. Furthermore, it is also possible to introduce IoT (Internet of Things) based methods to develop the JIT management system (Xu and Chen 2016). Feng (2020) developed the SCOR (supply chain operations reference) model in the process of lean manufacturing, and emphasised that 'planning'

is the first and most significant step in the supply chain process, and could be a strong connection in procurement and production.

From the results of the previous literature and the practical experience of the managers, small IoT size and fast-changing market enterprises (such as the company in the case study) can use JIT to enhance efficiency. And the product structure can be redesigned according to the information processing organisation view (Erkayman 2019). Finally, it is worth enhancing lean production via transparent procurement provided by information technology.

(1) Provide training and encourage innovation. According to the research result, leadership is important. Both training and innovation can improve quality management in design, production and inspection. Supply chain management practices can therefore provide operational benefits, such as decreased production lead time, faster product development and improved quality.
(2) Strengthen the supplier quality management by decentralisation of purchasing and supplier evaluation. The company should reduce the risk of delays in delivery and quality problems by establishing cooperation with more suppliers instead of purchasing from only 14 suppliers who provide the raw materials. Besides, supplier evaluation is necessary for the company to choose outstanding suppliers with a good reputation and performance. Then, the relationship between suppliers and the company should shift from purchasing to co-making quality products.

6. Conclusions and further research

This study identified CSFs for improving SCQM under the influence of the development of Industry 4.0. Customer focus is the strongest positive factor for the improvement of SCQM in the case study Company. Customer satisfaction, customer involvement and customer communication can support effective quality management because they are the ultimate goals of the Company. The quality of the IT system, process integration and leadership can also enhance the SCQM of the company. However, supplier quality management does not significantly influence the SCQM, which is not in line with the previous studies and hypotheses. Without sufficient reliable suppliers, the Company may risk quality problems and late delivery.

This study had some limitations, for instance, though the response rate was good, the sample size was still small. The respondents may also not fully understand SCQM. Some respondents working upstream may not know the operational conditions downstream in the supply chain.

Future studies should explore other potential CSFs not examined in this study and identify the reason(s) why some factors previously found to be significant were not significant in this study. CSFs for the improvement of SCQM in other companies or industries should also be examined.

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Appendix A. Sample questions for individual interviews

Number	Questions
1.	What are your views on the condition and development of SCQM in your company?
2.	What are the strengths and weaknesses of the SCQM?
3.	What are the important CSFs which influence the SCQM in your company? Why do you think so?
4.	Which areas does the company focus on? Such as customers, suppliers and products, etc. Why does the company focus on these areas?
5.	Are there any improvements the company should achieve on SCQM? Why do you think so?

Appendix B. The scale of the five CSFs for improvement of SCQM

Variables	Item Index	Question
SCQM	SCQM1	I think that the quality of the company's products is good.
	SCQM2	The company's products are always delivered on time.
	SCQM3	The operational process of the whole supply chain is always efficient.
	SCQM4	The company has the ability to innovate.
Customer Focus (CF)	CF1	Customers are always satisfied with the company's products.
	CF2	The company can gather timely and reliable customer information (for example, on customer expectations) using various methods.
	CF3	Customers can be involved in design and production across the whole supply chain.
Supplier Quality Management (SQM)	SQM1	The company has strict quality, capability and reputation standards when selecting suppliers.
	SQM2	The company always builds long-term relationships with suppliers based on trust, adaption and communication.
	SQM3	The company assesses the performance of suppliers and deals with low performance.
Quality of IT System (QITS)	QITS1	The information needed during the supply chain can be delivered dependably, consistently and accurately.
	QITS2	The IT system of the company can respond to requests in a timely way.
	QITS3	The IT system can enhance cooperation and establish trust among supply chain members.
Process Integration (PI)	PI1	Processes and tasks are clearly identified when implementing supply chain processes.
	PI2	Quality measures are clear to employees can follow a standard and ensure the quality of processes.
	PI3	The company identifies and prioritises improvement areas by time and cost.
	PI4	The company strictly monitors processes over the whole supply chain.
Leadership (L)	L1	Managers have committed to the development of the supply chain and encourage participation, learning, innovation and creativity.
	L2	Managers always maintain and sustain the relationship with supply chain partners.
	L3	The company has developed a quality culture to provide a qualified output to satisfy customers.