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Evaluation of Supply Chain Financial Performance from the Perspective of Balance, Strength, and Resiliency: A Case of Korean Enterprises

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ABSTRACT

Previous approaches have employed the SCOR model for evaluating supply chain management, and in particular, have focused on cash-to-cash cycle time (C2C). This paper reviews the Supply Chain Index (SCI) developed by Supply Chain Insight LLC, which evaluates supply chain performance based on balance, strength, and resiliency. The main aim of this study is to review SCI as a new methodology to measure performance management, as well as to apply C2C for a case study of Korean firms, to compare and present differences for further complementary application.

1. Introduction

Among the various methodologies to evaluate the performance of supply chains composed of the plan-procurement-production-shipment process, the SCOR model is a highly practical evaluation method in that it comprises four components: Plan, Source, Make, and Deliver. The SCOR model is an integrated performance index of supply chains. However, due to difficulty in collecting performance data, studies have been limited to the application of a single performance index, such as cash-to-cash cycle time (C2C). However, evaluating the performance of supply chains only through C2C is not desirable because an intentional extension of days of account payables possibly worsens the integrity of the whole supply chain (Cecere and Mayer, 2014b) according to the C2C measurement system.

Recent studies concerning the Supply Chain Index (SCI) from Supply Chain Insight LCC driven by Cecere and Mayer (2014a) are based on the fact that supply chains are complex non-linear systems, and are becoming increasingly complex. Accordingly, we consider the possibility of disruption to the supply chain as a whole as well as the case that a single performance indicator is used. Consequently, this study includes balance and strength to analyze not only the performance of the time period but also its improvement. Furthermore, SCI is differentiated from existing performance measurement systems by addressing the stability of supply chain performance, fluctuation, and improvements through the measurement of resiliency (Cecere and Mayer, 2014a).

The main aim of this study is to review SCI concepts and present comparison results with C2C through a case study of Korean firms in order to examine their potential complementary application. The remainder of this paper is organized as follows: Section 2 details the literature review, and the third section compares C2C and SCI, as well as provides an explanation of each indicator. In the fourth section, we present the evaluation results of the supply chain financial performance of domestic manufacturing enterprises and wholesale and retail trade enterprises, classified according to the size and type of enterprises. In the last section, we summarize our results and discuss the applicability of this approach.

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Table 1. Literature review

Literature	Sample data	Contents
Richard and Laughlin (1980)		<ul style="list-style-type: none"> Investigated the idea of C2C as a fundamental tool to measure a firm's performance as well as a firm's liquidity. Studied C2C as the net time interval between a firm's cash expenditure and eventual recovery of cash receipts from sales.
Lyroutdi and Lazaridis (2000)	82 major Greek firms in food and beverage industries. (1997)	<ul style="list-style-type: none"> Investigated the implications of the C2C as a liquidity indicator, regarding profitability, indebtedness, and firm sizes. The methodology includes regression and correlation analysis with <i>t</i>-test of sample means. Found positive relationships between the C2C and traditional liquidity measures, return on assets and net profit margins.
Kim et al. (2003)	621 Korean firms (1997-2001)	<ul style="list-style-type: none"> Studied supply chain asset performance with C2C, inventory days and asset turn. Found that large firms' performance is better than small firms' performance and retail industry shows better performance than manufacturing industry does.
Pfohl and Gomm (2009)		<ul style="list-style-type: none"> Analyzed the role of financial flows in supply chain. A mathematical model is developed to explain financing activities of supply chain and C2C is used as the key figure of financial flows.
Akgün and Gürnlü (2010)		<ul style="list-style-type: none"> Investigated a theoretical view of C2C and its factors as a tool for evaluation of supply chain regarding C2C as an integral metric.
Shin and Soenen (1998)	58985 American firms (1975-1994)	<ul style="list-style-type: none"> Studied the relationship between the firm's net trade cycle and its profitability by regression and correlation analysis. Found a strong negative association between C2C and profitability and liquidity of firms.
Deloof (2003)	1009 large Belgian non-financial firms (1992-1996)	<ul style="list-style-type: none"> Investigated the relation between working capital management and profitability, using regression. Variables including C2C is used as measures of working capital management. Results suggest that profitability is inversely related to the number of days of accounts receivable and inventories.
Eljelley (2004)	929 stock companies in Saudi Arabia (1996-2000)	<ul style="list-style-type: none"> The study examined the relation between profitability and liquidity by regression model. Found that C2C is important factor to measure liquidity.
Garcia-Teruel and Martinez-Solano (2007)	8872 Spanish SMEs (1996-2002)	<ul style="list-style-type: none"> Measured effects of working capital on firm profitability. Results demonstrated that value could be created by reducing the number of days of account variables. Found reducing number of days of inventory and account variables as well as C2C is significantly related to profitability.
Anser and Malik (2013)	155 manufacturing companies of Pakistan. (2007-2011)	<ul style="list-style-type: none"> Analyzed how the changes of C2C affects profitability in the sample with regression model. The result showed that shorter C2C leads to increased profitability.
Ebben and Johnson (2011)	879 small U.S. manufacturing firms and 833 small U.S. retail firms (2002-2004)	<ul style="list-style-type: none"> Investigated the relationship between C2C and levels of liquidity, invested capital, and performance. Provided support that C2C is an important measure for a firm's management.
Abuzayed (2012)	52 firms listed in a small and emerging market. (2000-2008)	<ul style="list-style-type: none"> Examined the effect of working capital management measured by C2C on firm's performance. The sample was analyzed by correlation and regression model. Found firm's profitability is positively related to C2C.
Yazdanfar and Öhman (2014)	13,797 Swedish SMEs (2008-2011)	<ul style="list-style-type: none"> The study used a seemingly unrelated regression (SUR) model to find empirical evidence that C2C affects profitability. The result showed that longer C2C are less profitable and variance from the optimal C2C level decreases firm's profitability.
Gill et al. (2010)	88 American manufacturing firms (2005-2007)	<ul style="list-style-type: none"> Investigated the relationship between working capital management and the firm's profitability using regression model. Found positive relationship between C2C and profitability.
Muscettola (2014)	4,226 Italian manufacturing SMEs (2007-2010)	<ul style="list-style-type: none"> Studied how C2C affects a firm's profitability with cluster analysis and regression. Results showed no significant association between C2C and profitability.

2. Literature review

Predominantly, previous research concerning firm performance has employed C2C for financial analysis. Richard and Laughlin (1980) clarified the idea of C2C as a fundamental tool for measuring a firm's performance as well as a firm's liquidity, defining C2C as the net time interval between a firm's cash expenditure and eventual recovery of cash receipts from sales. Other studies have also regarded C2C as an effective indicator for evaluating firm performance (Lyroudi and Lazaridis, 2000; Kim et al. 2003; Pfohl and Gomm 2009). In addition, Akgün and Gürünlü (2010) introduced C2C as a criterion to evaluate the performance of supply chain as a whole.

Studies regarding C2C and firm profitability and performance suggest an inverse relationship (Shin and Soenen 1998; Deloof 2003; Eljelly 2004; Pacachi; Garcia-Teruel and Martinez-Solano 2007; Anser and Malik 2013). Some studies have used a regression model as the main method to analyze the relationship between C2C and performance (Deloof 2003; Eljelly 2004; Padachi 2006; Ebben and Johnson 2011; Abuzayed 2012; Yazdanfar and Öhman 2014). Yazdanfar and Öhman (2014) emphasized that a firm's C2C is not necessarily required to be short in order to realize great profitability, identifying that too short or too long C2C reduces a firm's performance. However, several studies have found the opposite results, including a positive relationship between long C2C and firm performance, as well as no strong correlation between C2C and firm performance (Gill et al. 2010; Abuzayed 2012; Muscettola 2014). In particularly, Abuzayed (2012) argued that more profitable firms might have less motivation of working capital management.

As indicated above, many prior studies utilize C2C for a firm performance evaluation methodology, and results have varied. In this paper, we will analyze Korean manufacturing and wholesale and retail firm performance employing C2C as well as SCI.

3. Review of supply chain financial performance measures: C2C and SCI

3.1 C2C

The cash to cash cycle time is the length of time that it takes for an enterprise to purchase raw materials, complete the manufacturing process, and convert these products into income. C2C is the main index to measure asset performance, as one of the 12 performance indices from the supply chain operations reference model. Due to its easy data acquisition, C2C has been applied to various domestic and foreign studies.

A detailed calculation procedure for C2C is as follows: We subtract days of payables from the sum of days of inventory and days of receivables. If C2C is relatively long, this implies that the amount of time spent in converting inventory and accounts receivable into cash is relatively long. It causes increases in additional cash infusion costs as a result of interest payments. Eventually, this worsens cost issues and competitiveness of enterprises, and it is necessary for enterprises to improve their C2C through rapid delivery of goods to customers, faster collection of payment, efficient inventory management, and rapid raw materials acquisition (Kim et al., 2003).

$$\begin{aligned} C2C &= (Days\ of\ Inventory + Days\ of\ Receivables) - Days\ of\ Payables \\ Days\ of\ Inventory &= Inventory \div (Cost\ of\ Sales \div 365(days)) \\ Days\ of\ Receivables &= 365(days) \div Receivable\ Turnover \\ Days\ of\ Payables &= 365(days) \div Payable\ Turnover \end{aligned}$$

3.2 SCI

As mentioned prior, relying only on a particular indicator is likely to cause confusion in the overall supply chain management. Accordingly, Supply Chain Insight LCC considers a more complex financial performance indicator, and divides categories into growth, profitability, cycle, and complexity factor, and extracts financial factors representing performance for each category. In later studies of Cecere and Mayer (e.g., 2014a), balance, strength, and resiliency were selected as main indicators of SCI. Balance is based on the analysis of revenue growth and return on invested capital for a specific enterprise. Strength is based on the analysis of operating margin and inventory turns. Resiliency is based on a scatter plot of strength, indicating the ability of a supply chain to maintain consistency in response to environmental changes and improvements. Cecere and Mayer (2014a) set the contribution of balance, strength, and resiliency as 30% each toward the final score, and the remaining 10% derives from a peer vote contributed by a professional panel. Among these four components, three quantitative components are measured by the following methodology

First, balance focuses on maintaining an adequate inventory level. Reduced inventory levels weaken customer service levels, and excess inventory leads to higher costs. Balance is comprised of revenue growth and return on invested capital. High balance scores represent a well-balanced performance of the supply chain.

$$Balance = \frac{1}{n-1} \left(\frac{REV_n - REV_1}{REV_1} + \frac{ROIC_n - ROIC_1}{ROIC_1} \right)$$

where Rev_i : revenue growth of i th period, $ROIC_i$: return on investment capital of i th period, and n : period used in research, 2010 ($i = 1$) ~ 2016 ($i = 7$).

Second, the strength component analyzes inventory turns and operating margins of supply chains. A higher score signifies higher performance of supply chains from the perspective of strength.

$$Strength = \frac{1}{n-1} \left(\frac{OM_n - OM_1}{OM_1} + \frac{IT_n - IT_1}{IT_1} \right)$$

where OM_i : operating margin of i th period and IT_i : inventory turns of i th period.

Third, resiliency is based on the intersection of operating margins and inventory turns. The lower value indicates a high ability to sustain consistency in response to environmental shifts and other changes.

$$Resiliency = \frac{1}{m} \sum_i \sum_{j>i} d_{ij}$$

where m : total number of pairs and d_{ij} : Euclidean distance between a pair of points i and j ($j > i$).

		Operating margins (x)				
$j \setminus i$	i	1	2	...	6	7
1		0	0	...	0	0
2		d_{12}	0	...	0	0
3		d_{13}	d_{23}	...	0	0
...		...	...	...	0	0
7		d_{17}	d_{27}	...	d_{67}	0

Figure 1. Measurement process of resiliency and its visualized result

As shown in Figure 1, Euclidean distances between a pair of points i and j on the rectangular coordinates of operating margin and inventory turn are measured, and the mean distance of all possible pairs of points at the intersections denotes resiliency. When the graph features its direction toward quadrant 4, this represents an ideal case in that performance is improving every year.

4. Evaluation of supply chain financial performance: Case of Korean companies

4.1 Source of measurement and data collection

To compare SCI and C2C as supply chain performance indicators, balance panel data was collected from the annual report of 2,239 enterprises (1,867 from manufacturing industry, 372 from wholesale and retail trade industry) from 2012-2016 (The analysis period of this study is from 2012 to 2016 but measuring SCI requires data from 2011 as it includes improvements over years.) and whose closing account was settled in December. Data was extracted from the KIS-VALUE (NICE Information Service) and measurement results are as follows:

4.2 Measurement result classified by industry

As shown in Table 2, the C2C of wholesale and retail trade was shorter than the manufacturing industry during the analysis period. Both industries tended to have longer C2C over the last five years, which we assume is the result of stagnation in the domestic economy due to the recent economic downturn. Especially, the days of inventory of the manufacturing industry remained stable, as it slightly changed during the study period from 53.8 days (2012) to 54.2 days (2016) whereas that of wholesale and retail trade greatly increased from 40.4 days to 47.8 days. This is the main factor contributing to the increasing C2C.

Table 2. Measurement result of C2C according to the types of enterprise

(unit : day)

		'12	'13	'14	'15	'16	n
Manufacturing	C2C	86.2	88.1	90.5	91.6	92.2	1,867
	Days of inventory	53.8	54.1	55.4	55.3	54.2	1,867
	Days of receivables	65.5	65.2	66.5	67.0	69.5	1,867
	Days of payables	33.2	31.2	31.4	30.7	31.5	1,867
Wholesale and retail trade	C2C	58.4	56.2	62.4	64.7	70.0	372
	Days of inventory	40.4	39.4	42.0	45.4	47.8	372
	Days of receivables	48.3	46.5	49.1	47.7	50.9	372
	Days of payables	30.4	29.6	28.7	28.4	28.6	372

* Based on median value

As Cerere and Meyer (2014a) have mentioned, balance is the sum of revenue growth and return on invested capital, strength is the sum of inventory turns and operating margins, and resiliency is based on the pattern of the intersection of operating margin and inventory turns. They also detailed that measuring the current performance, how it is improved from previous years, and the stability of its improvement is an important part of SCI measurement.

In this respect, all values of balance and strength of both industries in given periods are negative (-), showing low financial performance level, as shown in Table 3. However, regarding improvement, values are positive, which indicates both industries are improving. In particular, the manufacturing industry shows higher improvement compared with the wholesale and retail trade industry. Resiliency scores of 0.202 for manufacturing and 0.262 for wholesale and retail trade industry were found, which shows that the manufacturing industry is performing better than the wholesale and retail trade industry.

Table 3. The measurement result of balance, strength, and resiliency according to the industry

		'12	'13	'14	'15	'16	n
manufacturing	Balance	-0.641	-0.423	-0.316	-0.272	-0.216	1,867
	Strength	-0.193	-0.134	-0.120	-0.094	-0.059	1,867
	Resiliency			0.202			1,867
wholesale and retail trade	Balance	-0.616	-0.433	-0.294	-0.344	-0.240	372
	Strength	-0.117	-0.113	-0.108	-0.096	-0.070	372
	Resiliency			0.262			372

* Based on median value

Figure 2. The resiliency changes according to industry

However, when visualizing the resiliency changes according to the industry as shown in Figure 2, both are not trending toward quadrant 4. This implies that the manufacturing industry is clearly maintaining its supply chain with the tighter consistency of operating margins and inventory turns than the wholesale and retail trade industry, but both should intensify efforts for improving performance.

4.3 Measurement result classified by industry and size of enterprises.

As shown in Table 4, the C2C of small- and medium-sized enterprises (SMEs) in the manufacturing industry has increased over the last 5 years. The C2C of large manufacturing enterprises has changed from 85.1 days (2012) to 87.3 days (2016) while that of SMEs has increased from 87.1 days to 97.9 days during this period. Especially in the case of SMEs, the C2C gap has enlarged over time. Thus, it is necessary to improve the management strategy of SMEs for continuous improvement.

Also, in the case of the wholesale and retail trade industry, C2C has increased throughout the study period. We assume C2C has been negatively affected by stagnation in the domestic economy and the recent downturn in consumption. The C2C of large wholesale and retail trade enterprises have increased from 42.2 days (2012) to 57.2 (2016) and that of SMEs has changed from 75.2 days to 84.5 during this time.

The main factor of worsening C2C performance is the increase in days of inventory and days of receivables. While days of inventory for large enterprises has increased from 35.5 days (2012) to 42.8 days (2016), that of SMEs has changed from 47.1 days to 47.6 days over this period, which shows a relatively larger increase for large enterprises. Days of receivables of large enterprises have changed from 35.2 days (2012) to 42.3 days (2016) while that of SMEs has changed from 60.1 days to 66.4 days. This suggests that in the wholesale and retail trade industry, the increase in days of receivables is a key factor negatively affecting the C2C.

Table 4. The measurement result of C2C classified by industry and size of enterprises

(unit : day)

		Size of enterprise	'12	'13	'14	'15	'16	<i>n</i>
Manufacturing	C2C	Large enterprise	85.1	85.2	87.6	87.7	87.3	627
		SME	87.1	89.5	92.7	93.7	97.9	1,240
	Days of inventory	Large enterprise	52.4	51.4	53.3	51.1	51.9	627
		SME	55.6	55.7	57.4	57.6	59.1	1,240
	Days of receivables	Large enterprise	64.1	62.9	63.4	65.2	65.1	627
		SME	66.4	67.0	67.6	67.7	71.3	1,240
	Days of payables	Large enterprise	31.4	29.2	29.1	28.6	29.7	627
		SME	34.8	33.1	32.3	31.6	32.5	1,240
Wholesale and retail trade	C2C	Large enterprise	42.2	43.3	49.4	46.8	57.4	121
		SME	75.2	77.9	85.8	84.0	84.5	251
	Days of inventory	Large enterprise	35.5	35.3	38.4	35.0	42.8	121
		SME	47.1	47.1	52.8	48.0	47.6	251
	Days of receivables	Large enterprise	35.2	36.7	37.4	39.0	42.3	121
		SME	60.1	60.2	62.5	64.6	66.4	251
	Days of payables	Large enterprise	28.5	28.8	26.4	27.2	27.7	121
		SME	32.0	29.5	29.4	28.6	29.5	251

* Based on median value

Table 5 shows the SCI analysis results according to the size of enterprise. Regardless of the size of firms, both industries have low performance regarding balance, showing negative values. However, enterprises in both industries are improving their performance. Particularly in the manufacturing industry, large enterprises are performing better, and in the wholesale and retail trade industry, the SMEs are relatively better in performance. Regarding the strength indicator, large enterprises in the manufacturing industry are the only group featuring positive values, and thus, showing improvement. The SMEs are also improving but still contain negative values in both industries.

We additionally conducted *t*-test to check whether the results based on C2C were statistically significant. Two groups were determined as firm size (a group of large enterprises and a group of SMEs) and the *t*-value is -4.418 showing it is statistically significant at the 1% significance level. Between large enterprises of both industries, it is also statistically significant at the level of 1% as the *t*-value is 4.3461. Thus, we have sufficient support that large enterprises have shorter C2C compared with SMEs, and among large enterprises, firms in the wholesale and retail industry have shorter C2C than firms in the manufacturing industry. Regarding resiliency, large enterprises (0.221) scored better than SMEs (0.251) in the manufacturing industry, and SMEs (0.429) performed better than large enterprises (0.596) in the wholesale and retail

trade industry. Greater resiliency means better financial consistency of maintaining supply chain in an unstable environment. As evident from the change in resiliency shown in Figure 3 and Figure 4, the manufacturing industry is more stable than the wholesale and retail trade industry. In addition, the graph of the resiliency of large manufacturing enterprises is approaching quadrant 4, which indicates financial improvement of the supply chain.

Table 5. The measurement result of SCI classified by industry and size of enterprises

		Size of enterprise	'12	'13	'14	'15	'16	<i>n</i>
Manufacturing	Balance	Large enterprise	-0.629	-0.436	-0.362	-0.272	-0.238	627
		SME	-0.571	-0.425	-0.335	-0.278	-0.237	1,240
	Strength	Large enterprise	1.228	1.393	1.469	1.573	1.615	627
		SME	-0.177	-0.130	-0.119	-0.091	-0.068	1,240
	Resiliency	Large enterprise		0.221				627
		SME		0.251				1,240
Wholesale and retail trade	Balance	Large enterprise	-0.479	-0.368	-0.293	-0.368	-0.152	121
		SME	-0.759	-0.236	-0.418	-0.316	-0.228	251
	Strength	Large enterprise	-0.209	-0.171	-0.118	-0.114	-0.101	121
		SME	-0.146	-0.131	-0.101	-0.091	-0.056	251
	Resiliency	Large enterprise		0.596				121
		SME		0.429				251

* Based on the median value

Figure 3. Changing tendency of resiliency of manufacturing industry

Figure 4. Changing tendency of resiliency of wholesale and retail trade industry

4.4 Measurement result classified by industry division

C2C performance of the manufacturing industry and the wholesale and retail trade industry was classified as follows: C2C of manufacture of motor vehicles, trailers, and semitrailers, a representative type of business in Korea, is the shortest within the manufacturing industry, with 36.7 days (2012) and 44.2 days (2016). In addition, industries related to consumer goods such as textile and apparel, (manufacture of textiles, except apparel: 173 days (2012) and 209.1 days (2016), manufacture of wearing apparel, clothing accessories and fur articles 165.4 days (2012), 170.1 days (2016)) and bio-industry (manufacture of pharmaceuticals, medicinal chemical and botanical products 210.0 days (2012) and 201.4 days (2016)) have relatively slow C2C, indicating that these industries feature low financial performance. Regarding the wholesale and retail trade industry, the C2C of the sale of motor vehicles and parts (15.3 days (2012) and 4.5 days (2016)) is the fastest, and that of wholesale trade on own account or on a fee or contract basis (73.0 days (2012), 89.6 days (2016)) is the slowest.

The measurement results of balance, strength, resiliency are shown in Table 7. First, the balance score of the manufacturing industries, excluding manufacture of other non-metallic mineral products and manufacture of pharmaceuticals, medicinal chemical and botanical products, shows negative values, implying low financial performance. Concerning improvement, manufacture of other non-metallic mineral products as well as manufacture of pharmaceuticals,

medicinal chemical and botanical products showed the highest improvement. This is considered a highly positive result since their performance level is high and improving at the same time. In addition, in the wholesale and retail trade industry, sale of motor vehicles and parts as well as wholesale trade on own account or on a fee or contract basis showed high performance improvement. Second, positive strength scores are shown in manufacture of furniture, manufacture of beverages, manufacture of other non-metallic mineral products, manufacture of food products, and manufacture of wood and of products of wood and cork, excluding furniture. These sectors featured positive strength scores and also have high performance improvement. Among the wholesale and retail trade industry, no sector featured a positive score, implying low performance level in general, but improving. Lastly, high scores of resiliency were found in manufacture of pharmaceuticals, medicinal chemical and botanical products, manufacture of electronic components, computer; visual, sounding and communication equipment, as well as manufacture of medical, precision and optical instruments, watches and clocks manufacturing. Conversely, printing and reproduction of recorded media and manufacture of beverages scored low in resiliency in the manufacturing industry. In wholesale and retail trade industry, wholesale trade on own account or on a fee or contract basis has a strong resiliency score, which implies a high financial consistency in its supply chain. However, sale of motor vehicles and parts showed relative low performance regarding the resiliency result.

Table 6. The measurement result of C2C classified by standardized division (unit : day)

		'12	'13	'14	'15	'16	n
Manufacturing	• Manufacture of motor vehicles, trailers and semitrailers	36.7	40.7	43.2	47.3	44.2	210
	• Printing and reproduction of recorded media	46.2	40.7	44.0	54.8	54.9	18
	• Manufacture of furniture	78.2	83.7	76.6	58.7	65.3	15
	• Manufacture of other transport equipment	95.5	93.2	79.5	82.1	84.3	47
	• Manufacture of beverages	102.6	101.3	97.1	77.4	81.7	14
	• Manufacture of other non-metallic mineral products	96.7	99.5	101.3	87.4	86.7	75
	• Manufacture of rubber and plastics products	68.4	70.9	78.7	73.3	75.4	110
	• Manufacture of food products	70.0	72.7	69.8	73.0	66.2	38
	• Manufacture of pulp, paper and paper products	76.7	78.4	73.0	77.1	77.9	55
	• Manufacture of fabricated metal products, except machinery and furniture	85.5	84.0	85.1	97.1	95.4	106
	• Manufacture of electrical equipment	80.1	76.0	83.9	79.6	82.5	96
	• Manufacture of electronic components, computer; visual, sounding and communication equipment	81.4	83.8	88.2	83.8	88.3	247
	• Manufacture of chemicals and chemical products; except pharmaceuticals and medicinal chemicals	98.8	100.5	106.2	105.7	101.3	197
	• Manufacture of other machinery and equipment	101.0	105.4	104.8	102.1	109.2	207
	• Manufacture of coke, briquettes and refined petroleum products	88.8	88.6	88.5	92.7	95.5	8
	• Manufacture of basic metals	110.4	115.5	121.6	104.9	108.0	177
	• Manufacture of wood and of products of wood and cork; except furniture	144.6	135.0	135.2	118.9	109.9	3
	• Manufacture of leather, luggage	92.9	102.4	97.5	109.3	142.7	11
	• Manufacture of textiles, except apparel	173.0	162.4	172.7	189.3	209.1	12
	• Other manufacturing	141.6	126.1	139.4	143.2	146.8	14
Wholesale and Retail trade	• Manufacture of medical, precision and optical instruments, watches and clocks	129.2	128.9	131.4	141.5	158.2	54
	• Manufacture of apparel, clothing accessories and fur articles	165.4	211.7	188.1	178.3	170.1	60
	• Manufacture of tobacco products	401.0	423.4	366.6	405.1	414.6	2
	• Manufacture of pharmaceuticals, medicinal chemical and botanical products	210.0	220.4	219.6	212.7	201.4	91
	• Retail trade, except motor vehicles and motorcycles	26.2	32.7	31.3	25.7	29.7	47
	• Sale of motor vehicles and parts	15.3	30.4	12.2	4.9	4.5	15
	• Wholesale trade on own account or on a fee or contract basis	73.0	78.0	82.2	92.9	89.6	310

* Based on the median value

Figure 5 shows the resiliency graph of manufacture of pharmaceuticals, medicinal chemical and botanical product manufacturing and printing and reproduction of recorded media, which represent the highest and lowest performance of resiliency in the manufacturing industry. In Figure 6, the resiliency graph of wholesale trade on own account or on a fee or contract basis and sale of motor vehicles and parts are shown in order to compare the highest and lowest performance of resiliency in the wholesale trade industry. As shown in Figures 5 and 6, sectors with low resiliency performance experience relatively large changes during the analysis period and the improvement direction is also irregular.

Table 7. The measurement result of SCI classified by standardized division: Improvement over the last 5 years ('12 ~ '16)

		Balance		Strength		Resiliency	n
		'16	Imp.	'16	Imp.	'16	
Manufacturing	• Manufacture of motor vehicles, trailers and semitrailers	-0.217	51%	-0.053	55%	0.599	210
	• Printing and reproduction of recorded media	-0.058	93%	-0.059	-207%	6.602	18
	• Manufacture of furniture	-0.174	79%	0.030	116%	0.546	15
	• Manufacture of other transport equipment	-0.195	50%	-0.153	53%	0.777	47
	• Manufacture of beverages	-0.261	65%	0.101	236%	1.162	14
	• Manufacture of other non-metallic mineral products	0.184	206%	0.073	168%	0.887	75
	• Manufacture of rubber and plastics products	-0.200	45%	-0.019	114%	0.368	110
	• Manufacture of food products	-0.532	61%	0.036	115%	0.413	38
	• Manufacture of pulp, paper and paper products	-0.217	39%	-0.102	27%	0.782	55
	• Manufacture of fabricated metal products, except machinery and furniture	-0.310	33%	-0.022	85%	0.331	106
	• Manufacture of electrical equipment	-0.199	80%	-0.051	73%	0.446	96
	• Manufacture of electronic components, computer; visual, sounding and communication equipment	-0.319	43%	-0.115	23%	0.248	247
	• Manufacture of chemicals and chemical products; except pharmaceuticals and medicinal chemicals	-0.214	65%	-0.019	92%	0.325	197
	• Manufacture of other machinery and equipment	-0.257	67%	-0.115	61%	0.320	207
	• Manufacture of coke, briquettes and refined petroleum products	-0.203	70%	0.061	135%	0.632	8
	• Manufacture of basic metals	-0.188	78%	-0.043	81%	0.317	177
	• Manufacture of wood and of products of wood and cork; except furniture	-0.108	53%	-0.037	121%	0.459	3
	• Manufacture of leather, luggage	-0.324	52%	0.005	-92%	0.483	11
	• Manufacture of textiles, except apparel	-0.426	75%	-0.145	76%	0.398	12
	• Other manufacturing	-0.125	-236%	-0.010	-123%	0.653	14
	• Manufacture of medical, precision and optical instruments, watches and clocks	-0.281	-77%	-0.105	-88%	0.274	54
	• Manufacture of wearing apparel, clothing accessories and fur articles	-0.243	16%	-0.132	55%	0.284	60
	• Manufacture of tobacco products	-0.210	75%	0.018	-68%	0.292	2
	• Manufacture of pharmaceuticals, medicinal chemical and botanical products	0.070	107%	-0.034	72%	0.236	91
Wholesale and Retail trade	• Retail trade, except motor vehicles and motorcycles	-0.230	-147%	-0.086	77%	2.531	47
	• Sale of motor vehicles and parts	-0.187	77%	-0.121	67%	3.622	15
	• Wholesale trade on own account or on a fee or contract basis	-0.160	77%	-0.070	16%	0.554	310

* Based on the median value

Figure 5. Comparison of resiliency among manufacturing industry division **Figure 6.** Comparison of resiliency among wholesale and retail trade industry division

5. Implications and conclusions

This study reviewed SCI as a new methodology to measure performance management, as well as applied C2C to a case study of Korean firms, to compare and present differences for further complementary application. First of all, the C2C for the manufacturing industry increased from 2012-2016. This is particularly true for SMEs, in which the C2C gap increased between SMEs and large enterprises. SCI analysis results show negative values throughout the study period, implying low financial performance in general. Enterprises need to improve the overall soundness of the supply chain through enhancing performance, strengthening cooperation between large and small-and-medium enterprises, and governmental support. Second, since there is no production process included in the wholesale and retail trade industry, it is expected that their C2C would be shorter than that of the manufacturing industry as the analysis results show. However, from 2012-2016, the C2C of both large enterprises and SMEs have increased continuously. Regarding the SCI analysis results, performance is low, regardless of enterprise size. In particular, performance is worse for large wholesale and retail trade enterprises, as larger enterprises show more fluctuation in resiliency, while SMEs are not stable in the manufacturing industry. More fluctuation in resiliency implies more vulnerability to business environment changes, such as stagnant domestic demand. Therefore, it is necessary to increase inventory management efficiency in order to increase resiliency in the case of prolonged domestic stagnation. Third, according to the analysis results for both industries, C2C and SCI analysis results were in disagreement. The gap between C2C and SCI analysis results varies by industry and we assume features of each industry affect the results. For instance, the C2C of the manufacture of pharmaceuticals, medicinal chemical and botanical products is the longest, implying low performance, while this sector exhibits a good score in the SCI analysis results. Our assumption is that this industry sector experienced financial hardship during the study period as it has a long C2C but it was robust under circumstantial changes over time as its resiliency value is low. This addresses the necessity of using both C2C and SCI as complementary measurements. Lastly, it cannot be denied that C2C and SCI which have been compared in this study have limitations in supply chain performance evaluation because they are both based on annual reports. Supply Chain LCC includes qualitative aspects through expert opinions with other quantitative components in the SCI. Inclusion of non-financial indicators, such as customer service, and balance between financial and non-financial indicators should be considered in future studies.

Our analysis considers Korean manufacturing and wholesale and retail firms, as they are representative industry sectors in Korea. In the further studies, we will expand our scope to include service and healthcare industries.

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