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The role of industry 4.0 in sustainable supply chain: Evidence from the textile industry

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The objective of this study was to examine the role of Industry 4.0 in the sustainable supply chain (SSC). The relationship between Industry 4.0, data storage, data assessment, performance evaluation, data inquiry and SSC were examined. To achieve the study objective, the mediation effect of data storage, data assessment, performance evaluation and data inquiry between Industry 4.0 and SSC was examined. Employees of textile companies were selected for data collection in Indonesia. Results of the study highlighted that Industry 4.0 had a significant positive effect on SSC. Better implementation of Industry 4.0 showed a positive effect on SSC. In addition to this, Industry 4.0 had a positive effect on data storage, data assessment, performance evaluation and data inquiry. Finally, data storage, data assessment, performance evaluation and data inquiry had a positive effect on SSC.

1. Introduction

In this era, the role of technology is most important. The rate of technology adoption among different countries is growing day by day. As the technology is the basis of higher performance in operations, procedures, products as well as services. The adoption of better technology in firm operations increases the quality of operations, decreases the cost of operations, and also decreases the time span. By examining all the benefits of technology adoption, now the companies are moving toward the adoption of higher technology. As the increase in technology has a vital role to enhance the overall business performance (Mason & Harrison, 2004; Fernando et al., 2019). The implementation of the latest technology is increasing with the help of the arrival of Industry 4.0. It is increasing among the companies which enhances the overall business operations. Nowadays, the importance of Industry 4.0 is increasing. In this decade, the application of new technology through Industry 4.0 is providing several important outcomes. Arrival of Industry 4.0 increases the quality of the products and increases the quality of the services. It also increases the overall business performance by increasing accuracy in the operations and increases the accuracy of procedures to increase the business performance. The large multinational companies are now adopting the technology of Industry 4.0 with great speed due to the several benefits. Therefore, Industry 4.0 has vital importance among the organizations (Mosallaeipour et al., 2019; Pacaiova et al., 2020). However, the execution of Industry 4.0 is not easy for the companies. Adoption of Industry 4.0 technology is not easy based on several reasons. For instance, this technology is expensive which is not easy for the small companies to adopt. It is also tough for the companies which are in the initial stage. Because this technology is very expensive which is not easy for the companies. Moreover, the use of this technology also

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requires trained employees. The companies which adopt this technology, are also required to conduct training sessions for their employees to enhance the proper usage. Therefore, although, Industry 4.0 has several benefits, however, the implementation or adoption of Industry 4.0 is one of the challenges for the companies (Moktadir et al., 2018; Raj et al., 2020). Various companies of Indonesia are also based on the several issues connected to the Industry 4.0 implementation. Due to different problems, the textile companies are facing several issues in relation to the application of Industry 4.0 applications. Textile companies of Indonesia have significant potential and several resources to adopt this new technology since the textile industry of Indonesia has been growing in the world and performing among the top performers globally. Although these companies have several resources, still these companies are facing issues to adopt Industry 4.0 technology to increase the quality of operations for the sake of enhancing the overall industry performance. Although the performance of Indonesian textile companies is increasing (van der Kamp, 1997; Prasetyani et al., 2020), however, performance can also be increased further with the help of Industry 4.0 application. Various elements of Industry 4.0 are given in Fig. 1.

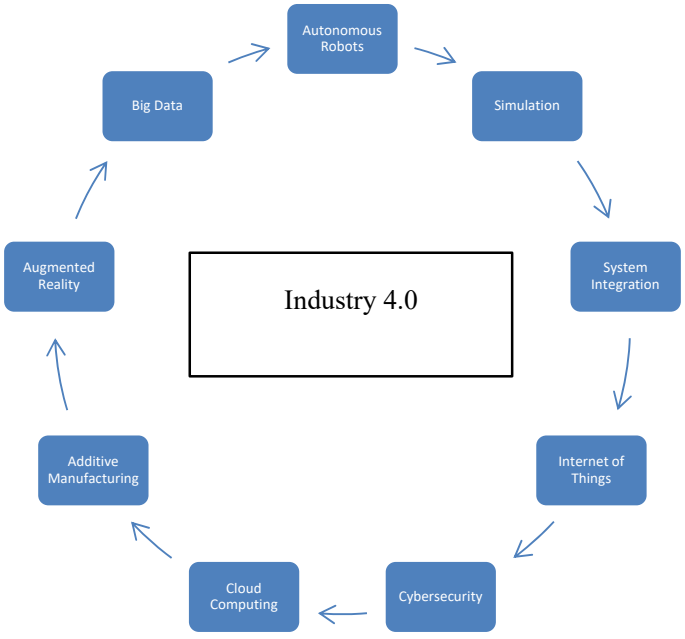

Fig. 1. Elements of Industry 4.0

Better execution of Industry 4.0 has several benefits which causes it to increase the performance (Haseeb, Hussain, Slusarczyk, & Jermsittiparsert, 2019). For instance, application of Industry 4.0 has a significant role in SSC (Jermsittiparsert & Boonratanakittiphumi, 2019; Jermsittiparsert et al., 2019). The latest technology has a positive role in the supply chain. Rise in the operations of the supply chain can increase the sustainability among the supply chain which influences the business performance. Latest technology has a positive role to enhance data management. Industry 4.0 and data storage have important relationships with each other (Fernández-Caramés et al., 2019; Sahal, Breslin, & Ali, 2020). As the big data technology of Industry 4.0 is vital to handle data. Furthermore, data assessment is quite easy with the help of Industry 4.0 technology. Better implementation of Industry 4.0 increases the positive effect of data storage and data assessment. Furthermore, performance evaluation and data inquiry have a vital role in the current study. Both performance evaluation and data inquiry have significant positive influence on sustainable supply chain (SSC). Therefore, the objective of this study is to inspect the role of Industry 4.0 in SSC. The relationship between Industry 4.0, data storage, data assessment, performance evaluation, data inquiry and SSC were examined. Number of studies have carried out the research on Industry 4.0 and textile companies (Jubaedah et al., 2016; Tortorella et al., 2018), however, these studies did not examine the role of Industry 4.0 in supply chain sustainability. Hence, this study has key participation in the literature connected to the industry 4.0 and textile companies.

2. Literature Review

In textile companies of Indonesia, the role of supply chain is vital. As the Indonesian textile companies are growing with great speed and leading globally. The products from the Indonesian textile companies are high quality and produce cheap products of the market. That is the reason, Indonesian industry is exporting various products of textile companies and generating high revenue. The revenue generated by the Indonesian companies is increasing day by day which has vital significance for the country as it contributes to the economic development. The SSC in these textile companies can be enlarged with the help of better technology. The adoption of better technology to the textile operation among the companies can enhance supply chain sustainability. Various previous studies highlighted the connection between Industry 4.0 as well as

supply chain (Fernández-Caramés et al., 2019; Dolgui et al., 2019; Ul-Hameed et al., 2019; Yadav et al., 2020). Industry 4.0 influences on supply chain through data storage, data assessment, performance evaluation and data inquiry. All these factors show a positive role to reflect the positive effect of Industry 4.0 on supply chain sustainability among the textile companies of Indonesia. Fig. 2 shows the relationship between Industry 4.0, data storage, data assessment, performance evaluation, data inquiry and SSC.

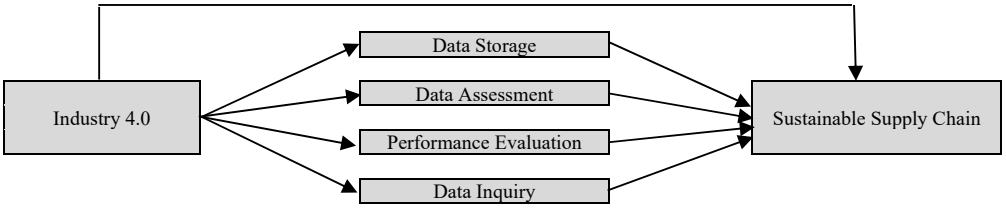

Fig. 2. The relationship between Industry 4.0, data storage, data assessment, performance evaluation, data inquiry and sustainable supply chain

2.1 Industry 4.0 and SSC

Industry 4.0 is one of the digital transformations of production as well as associated industries as well as value creation procedures. Industry 4.0 is utilized interchangeably with the fourth industrial revolution along with this it signifies a new stage in the companies as well as management of the industrial value chain. It is the most important introduction of technology in the current era of Industrialization since it has several benefits for the business to increase the overall performance with the help of implementing latest technology. Several studies were carried out in the literature showing the vital importance of Industry 4.0 in business organizations (Brettel, Friederichsen, Keller, & Rosenberg, 2014; Rane, & Narvel, 2019). Implementation of better technology is likely to contribute to the various actions of supply chain. Better implementation of technology increases the supply chain. Supply chain is the vital part of industries particularly, it has major importance among the textile companies because of the growing importance as the textile companies require fast system of supply chain to produce the products and to deliver to the ultimate customers by maintaining the sufficient quality. However, it is not easy task for the companies to increase the supply chain as it is the key area and linked with the several other operations. Therefore, to increase the supply chain, Industry 4.0 has key importance.

Hypothesis 1. *Industry 4.0 has positive effect on SSC.*

2.2 Industry 4.0, Data Storage and SSC

Industry 4.0 also plays a major role to store the data. It is one of the most important pillars of Industry 4.0 which is vital for the companies. As it is tough to maintain the data in a better way because each company has several customers which require proper data storage which is maintained by the companies. Data storage is the key part of Industry 4.0 which has major importance in various people. To maintain the customer data and any other partners data is most valuable which requires only general discussion. Therefore, Industry 4.0 has a positive role in data storage and data storage has importance for the companies. Data storage is the vital part of organizations which increase the business performance. Better data management has a significant positive role in the business of this institute. Previous studies also show the relationship between Industry 4.0; however, it does not allow for the other opportunities. Industry 4.0 has a vital role in sustainable development of the supply chain since big data is a key feature of various Industry 4.0. It is highlighted by the other sources that big data has a major role in data storage (Jeble et al., 2018; Li et al., 2020).

Hypothesis 2: *Industry 4.0 has a positive effect on data storage.*

Hypothesis 3: *Data storage has a positive effect on SSC.*

2.3 Industry 4.0, Data Assessment and SSC

Along with the various other factors, data assessment is also one of the major parts of textile companies. Increase in the data assessment can increase the performance. In this way, the technology of Industry 4.0 has vital importance. Data assessment is the procedure of scientifically as well as statistically assessing data to control whether they meet the better quality required for different projects or business procedures as well as are of the right type along with the quantity to be able to actually support their envisioned use. Therefore, data assessment among the textile companies has a positive role in Industry which is influenced by Industry 4.0. Industry 4.0 has a positive role in data assessment. Data assessment as shown by the other

studies plays a vital importance for the business which has influence on supply chain activities (Guazzi et al., 2018; Guazzi et al., 2012). Better data assessment has a positive effect on the supply chain.

Hypothesis 4. *Industry 4.0 has a positive effect on data assessment.*

Hypothesis 5. *Data assessment has a positive effect on SSC.*

2.4 Industry 4.0, Performance Evaluation and SSC

Industry 4.0 is also helpful in the performance appraisal system among various companies. Particularly, it is important among the textile companies to increase the performance evaluation. A performance appraisal, also referred to as a performance evaluation among the companies, performance evaluation, development discussion, or employee appraisal is a technique by which the employee job performance of an employee is recognized as well as evaluated. Therefore, Industry 4.0 also has a major influence on performance appraisal. Performance appraisal or performance evaluation plays the most important role in textile companies (Maghsoodi et al., 2018; Dal Corso et al., 2019). With the growing importance of the textile sector, the importance of performance evaluation is increasing. It is also important because performance evaluation has a positive role in the supply chain. The employee working in supply chain operations also requires a positive role in the supply chain and increases in the performance assessment increase the supply chain.

Hypothesis 6. *Industry 4.0 has a positive effect on performance evaluation.*

Hypothesis 7. *Performance evaluation has a positive effect on SSC.*

2.5 Industry 4.0, Data Inquiry and SSC

In the above sections, it is shown that Industry 4.0 plays an important role in the supply chain with the help of data storage. Moreover, it is found that Industry 4.0 will be more helpful to enhance the supply chain. In addition to this it is also discussed that Industry 4.0 has a positive role in data inquiry. Data inquiry is the most important part of the company because if the organization requires the data of any one customer, it is difficult to find the data. Because textile companies always have a huge number of customers, therefore, to get the key data, it is required for the companies to find out through technology such technology introduced among the textile companies. Therefore, Industry 4.0 has a positive role in data inquiry. Increase in Industry 4.0 can decrease the problem of data inquiry as previous studies also show that data inquiry is also an important part of various companies (Asch et al., 2018; Sergis et al., 2019). Furthermore, data inquiry has a major role in the supply chain. Better data inquiry by the specific customer can increase the supply chain. Thus, Industry 4.0 has a positive effect on data inquiry and data inquiry has a positive effect on the supply chain. Furthermore, this study also examined the mediating role of data storage, data assessment, performance evaluation and data inquiry between Industry 4.0 and SSC.

Hypothesis 8. *Industry 4.0 has a positive effect on data inquiry.*

Hypothesis 9. *Data inquiry has a positive effect on SSC.*

Hypothesis 10. *Data storage mediates the relationship between Industry 4.0 and SSC.*

Hypothesis 11. *Data assessment mediates the relationship between Industry 4.0 and SSC.*

Hypothesis 12. *Performance evaluation mediates the relationship between Industry 4.0 and SSC.*

Hypothesis 13. *Data inquiry mediates the relationship between Industry 4.0 and SSC.*

3. Research Methodology

In the current study, non-probability convenience sampling was used to dispense the questionnaire. Therefore, a survey questionnaire was used in this study for data collection (Räisänen, Hedman, Andersson, Stridsman, Lindberg, Lundbäck, Rönmark, & Backman, 2020). For this purpose, 300 sample sizes were selected, which means 300 respondents were selected to collect information for generation of findings. This study focuses on different textile companies in Indonesia. Consequently, for data collection and to examine the relationship between Industry 4.0, data storage, data assessment, data evaluation, data inquiry and SSC, a questionnaire was designed and distributed among the textile companies. Employees of textile companies were selected from Indonesia. Finally, data were analyzed by using Partial Least Square (PLS) which is recommended by different studies (Albassami, Hameed, Naveed, & Moshfegyan, 2019). It is given in Table 1, the missing values as well as outlier in the data (Aydin & Şenoğlu, 2018). Both the missing value and outlier was assessed before data analysis to insure the results originality. Table 1 shows that data is free from any case of error.

Table 1
Data Statistics

	No.	Missing Value	Mean	Median	Min	Max	Standard Deviation	Kurtosis	Skewness
IND1	1	0	3.457	4	1	5	0.208	-0.589	-1.566
IND2	2	0	2.911	4	1	5	1.921	-1.73	-0.425
IND3	3	0	3.566	4	1	5	1.139	-0.165	-1.725
IND4	4	0	3.503	4	1	5	0.917	-0.273	-0.697
IND5	5	0	3.377	4	1	5	1.154	-0.532	-0.529
IND6	6	0	2.971	4	1	5	1.212	-1.446	-0.645
IND7	7	0	3.617	4	1	5	1.099	-0.124	-0.627
DS1	8	0	3.606	4	1	5	1.052	-0.464	-1.49
DS2	9	0	3.794	4	1	5	0.975	-1.343	-0.842
DS3	10	0	3.703	4	1	5	1.138	-1.304	-0.663
DA1	11	0	2.986	4	1	6	1.264	-0.643	-0.587
DA2	12	0	3.566	4	1	5	1.066	-0.366	-0.487
DA3	13	0	3.509	4	1	5	1.264	-0.827	-1.516
PE1	14	0	3.457	4	1	6	0.999	-0.803	-0.425
PE2	15	0	3.554	4	1	5	1.114	-1.553	-0.4
PE3	16	0	2.977	4	1	5	1.123	-0.566	-0.426
DI1	17	0	3.577	4	1	5	1.153	-0.236	-1.697
DI2	18	0	3.589	4	1	5	1.191	-0.366	-0.672
DI3	19	0	3.423	4	1	5	0.992	-1.684	-0.438
SSC1	20	0	3.731	4	1	5	1.152	-0.104	-0.77
SSC2	21	0	3.697	4	1	5	1.093	-0.523	-1.567
SSC3	22	0	2.806	4	1	5	1.273	-0.258	-0.905
SSC4	23	0	3.669	4	1	5	0.973	-0.484	-0.594
SSC5	24	0	3.634	4	1	6	1.23	-0.529	-0.593
SSC6	25	0	3.709	4	1	5	1.127	-1.469	-1.59
SSC7	26	0	3.92	4	2	5	0.884	-0.652	-0.392
SSC8	27	0	3.96	4	2	5	0.903	-0.224	-0.672
SSC9	28	0	3.629	4	1	5	1.077	-0.767	-0.49
SSC10	29	0	3.109	3	1	5	1.207	-1.396	0.281

4. Research Findings

After the collection of data, it was analyzed by using statistical tools. PLS was used for analysis in the current study (Hair, Sarstedt, Pieper, & Ringle, 2012; Hair, Ringle, & Sarstedt, 2013; Hair Jr, Sarstedt, Hopkins, & Kuppelwieser, 2014; Hair Jr, Hult, Ringle, & Sarstedt, 2016; Naveed, Hameed, Albassami, & Moshfegyan, 2019). Fig. 3 given that Industry 4.0 is measured by using seven scale items. Data storage is measured by using three scale items. Performance evaluation is measured by using three scale items. Data assessment is measured by using three scale items. Data inquiry was measured by using three scale items and finally, SSC was measured by using six scale items. It is found that all the scale items for all the variables; Industry 4.0, data storage, data assessment, data evaluation, data inquiry and SSC are above 0.5 which are given in Table 2. Only two items are below 0.7 but above 0.5.

Table 2
Factor Loadings

	Data Assessment	Data Inquiry	Data Storage	Industry 4.0	Performance Evaluation	SSC
DA1	0.901					
DA2	0.855					
DA3	0.602					
DI1		0.905				
DI2		0.865				
DI3		0.885				
DS1			0.78			
DS2			0.817			
DS3			0.826			
IND1				0.598		
IND2				0.503		
IND3				0.868		
IND4				0.819		
IND5				0.84		
IND6				0.832		
IND7				0.777		
PE1					0.817	
PE2					0.931	
PE3					0.929	
SSC1						0.794
SSC2						0.772
SSC3						0.802
SSC4						0.744
SSC5						0.847
SSC6						0.849

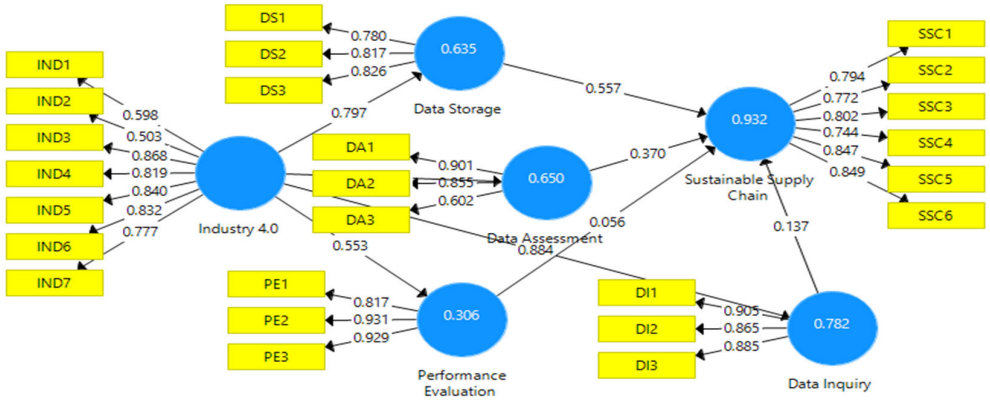

Fig. 3. Measurement Model

Discriminant validity is examined through cross-loadings given in Table 4 (Fornell & Larcker, 1981). Moreover, composite reliability (CR) for all the variables; Industry 4.0, data assessment, data evaluation, data inquiry and SSC found above 0.7. The average variance extracted (AVE) is also above 0.5 which is acceptable (Hair, Hollingsworth, Randolph, & Chong, 2017).

Table 3
Reliability and Convergent Validity

	Alpha	rho_A	CR	AVE
Data Assessment	0.704	0.764	0.836	0.635
Data Inquiry	0.862	0.863	0.916	0.784
Data Storage	0.734	0.737	0.849	0.653
Industry 4.0	0.872	0.891	0.903	0.577
Performance Evaluation	0.872	0.871	0.922	0.799
SSC	0.889	0.891	0.915	0.644

Table 4
Cross-Loadings

	Data Assessment	Data Inquiry	Data Storage	Industry 4.0	Performance Evaluation	SSC
DA1	0.901	0.667	0.732	0.704	0.421	0.833
DA2	0.855	0.676	0.741	0.69	0.355	0.793
DA3	0.602	0.373	0.386	0.521	0.77	0.422
DI1	0.687	0.905	0.661	0.801	0.355	0.743
DI2	0.652	0.865	0.689	0.773	0.357	0.725
DI3	0.621	0.885	0.666	0.774	0.376	0.684
DS1	0.603	0.556	0.78	0.617	0.372	0.697
DS2	0.677	0.627	0.817	0.657	0.421	0.78
DS3	0.666	0.654	0.826	0.656	0.321	0.781
IND1	0.508	0.377	0.392	0.798	0.68	0.424
IND2	0.462	0.293	0.333	0.703	0.609	0.334
IND3	0.685	0.811	0.684	0.868	0.353	0.745
IND4	0.675	0.812	0.714	0.819	0.371	0.751
IND5	0.627	0.811	0.696	0.84	0.359	0.71
IND6	0.671	0.754	0.681	0.832	0.392	0.709
IND7	0.623	0.67	0.622	0.777	0.352	0.707
PE1	0.536	0.406	0.416	0.527	0.817	0.424
PE2	0.533	0.323	0.395	0.468	0.931	0.418
PE3	0.503	0.361	0.416	0.481	0.929	0.425
SSC1	0.671	0.701	0.67	0.772	0.393	0.794
SSC2	0.621	0.55	0.704	0.587	0.4	0.772
SSC3	0.687	0.619	0.801	0.696	0.421	0.802
SSC4	0.595	0.662	0.771	0.623	0.294	0.844
SSC5	0.852	0.675	0.727	0.692	0.409	0.887
SSC6	0.819	0.694	0.738	0.707	0.364	0.849

In this portion of the analysis, the effect of Industry 4.0 was examined on data storage. The direct effect of Industry 4.0 was examined on data assessment and performance evaluation. Furthermore, the direct effect of data storage, data assessment and performance evaluation were examined on SSC. Results are given in Table 5. Figure 4 showing the structural model of PLS (Henseler, Ringle, & Sinkovics, 2009; Henseler & Chin, 2010; Henseler & Fassott, 2010; Hameed, Basheer, Iqbal, Anwar, & Ahmad, 2018). It is found that Industry 4.0 has a positive effect on data storage. Industry 4.0 has a positive effect on data assessment. Moreover, Industry 4.0 has a positive impact on performance evaluation. Furthermore, the results highlighted

that data storage has a positive effect on SSC. Data assessment has a positive effect on SSC. Finally, data inquiry has a positive effect on SSC. Therefore, Industry 4.0 increases the data assessment, data evaluation and data inquiry. Moreover, data assessment, data evaluation and data inquiry have the ability to increase SSC.

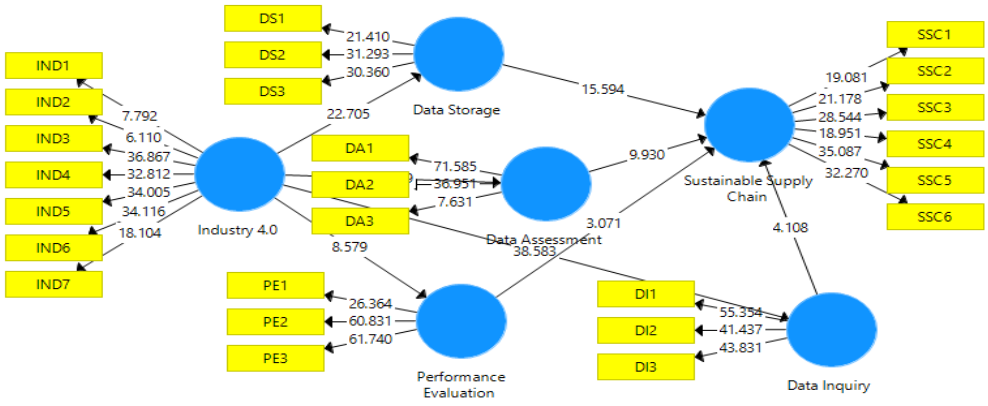

Fig. 4. Structural Model

Table 5
Direct Effect Results

	(O)	(M)	SD	T Value	P Values
Data Assessment → SSC	0.37	0.369	0.037	9.93	0
Data Inquiry → SSC	0.137	0.135	0.033	4.108	0
Data Storage → SSC	0.557	0.558	0.036	15.594	0
Industry 4.0 → Data Assessment	0.806	0.806	0.035	23.209	0
Industry 4.0 → Data Inquiry	0.884	0.884	0.023	38.583	0
Industry 4.0 → Data Storage	0.797	0.798	0.035	22.705	0
Industry 4.0" → Performance Evaluation	0.553	0.552	0.064	8.579	0
Performance Evaluation → SSC	0.056	0.054	0.018	3.071	0.002

Four indirect effects were examined in the current study. The first indirect effect of data assessment was examined between Industry 4.0 and SSC. The second indirect effect of data inquiry was examined between Industry 4.0 and SSC. The third indirect effect of data storage was examined between Industry 4.0 and SSC. The fourth indirect effect of performance evaluation was examined between Industry 4.0 and SSC. The first indirect effect of data assessment between Industry 4.0 and SSC is significant with t-value 9.214. The second indirect effect of data inquiry between Industry 4.0 and SSC is significant with t-value 4.16. The third indirect effect of data storage between Industry 4.0 and SSC is significant with t-value 11.438. The fourth indirect effect of performance evaluation between Industry 4.0 and SSC is significant with t-value 2.868. All these indirect effects were examined by using the instructions of Preacher and Hayes (2008). Additionally, an indirect effect histogram is given in Fig. 5.

Table 6
Indirect Effect Results

	(O)	(M)	SD	T Value	P Values
Industry 4.0 → Data Assessment → SSC	0.298	0.297	0.032	9.214	0.000
Industry 4.0 → Data Inquiry → SSC	0.121	0.12	0.029	4.16	0.000
Industry 4.0 → Data Storage → SSC	0.444	0.446	0.039	11.438	0.000
Industry 4.0 → Performance Evaluation → SSC	-0.031	-0.03	0.011	2.867	0.004

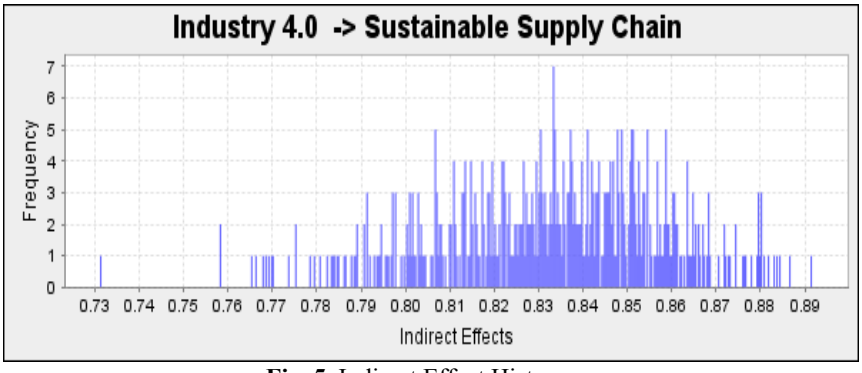

Fig. 5. Indirect Effect Histogram

5. Conclusion

The relationship between Industry 4.0, data storage, data assessment, performance evaluation, data inquiry and SSC were examined in this study. The objective of this study was to examine the role of Industry 4.0 in SSC. The mediation effect of data storage, data assessment, performance evaluation and data inquiry were examined between Industry 4.0 and SSC. For this purpose, employees of textile companies were selected for data collection in Indonesia by using a survey questionnaire. Outcomes of the study highlighted that Industry 4.0 has maintained significant positive effect on SSC. Industry 4.0 technology has also had an influential role to achieve higher performance in the supply chain. Better implementation of Industry 4.0 has shown a positive effect on SSC. Moreover, it is found that Industry 4.0 has had a positive effect on data storage and data assessment. Increase in Industry 4.0 technology increases the improvement in data storage and data assessment. Industry 4.0 also has also had a positive effect on data evaluation and data inquiry. Better implementation of big data technology has also had a positive role to improve data evaluation and data inquiry. Therefore, Industry 4.0 has maintained a positive effect on data storage, data assessment, performance evaluation and data inquiry. Finally, data storage, data assessment, performance evaluation and data inquiry have shown a positive effect on SSC. Hence, increase in data storage, data assessment, performance evaluation and data inquiry technology increase the SSC.

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