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Developing a transformation readiness index for Industry 4.0: a case study of food logistics in the rice commodity sector

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ABSTRACT

In 2021, it was recorded that Indonesia had a population of 272,682.50 million people, which then underwent an increase of 1.12% from the previous year to 275,773.80 million people in 2022. The rapid growth of the population will affect the food supply in Indonesia. It is known that many provinces in Indonesia still have a percentage deficit in food distribution, especially in the rice commodity, which needs to be improved to meet projected annual needs. This research tries to develop a transformation index by combining the Industry 4.0 concept model with the logistics operating in the food sector. To improve food security in Indonesia by transforming towards Industry 4.0. Research with a qualitative descriptive approach produces several factors that can influence the transformation index of food logistics companies in Indonesia towards Industry 4.0. The results of the use of technology, especially in encouraging transparent and real-time data transfer (horizontal and vertical) and decision-making in the logistics sector, are critical to pay attention to. However, organizational management, culture, and human resources are also essential things to pay attention to in transformation.

1. Introduction

Population growth in Indonesia increases every year. Based on the results of the Population Census over the last five years (2018-2022), Indonesia experienced an increase in population. In 2021, it was recorded that Indonesia had a population of 272,682.50 million people, which then underwent an increase of 1.12% from the previous year to 275,773.80 million people in 2022 (Badan Pusat Statistik, 2022b). The rapid growth, of course, affects the food supply in Indonesia.

According to report data, Indonesia's food security index is currently at 60.2, which ranks 63rd out of 113 countries and 10th out of 23 countries in the Asia Pacific region. However, Indonesia's index value is below the average global index value of 62.2 (Global Food Security Index, 2022).

This measurement index value is based on 4 indicators: Affordability, Availability, Quality and Safety, and Sustainability and Adaptation. Scores of the (Global Food Security Index, 2022) Indonesia, Indonesia has a score of on the Affordability indicator 81.4, which is an indicator for measuring consumers' ability to buy food, vulnerability to price changes, and related programs and policies when changes in food prices occur. The score on the availability indicator is 50.9, which indicates the size of agricultural production and on-farm capabilities, as well as the risk of disruption to the food supply chain and food distribution. The Quality and Safety Indicator score is 56.3, which measures the variety and nutritional quality of food and food safety. Sustainability and Adaptation is 46.3, which is an indicator for measuring the vulnerability of natural resource risks and how to deal with these risks.

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Regarding Indonesia's food security index score, several indicators still get low scores, one of which is the availability indicator, which has a score of 50.9. Based on the results of the analysis carried out, in the availability indicator, there are several assessment parameters, including pain points and areas of improvement needed, namely the supply chain infrastructure parameters, which are considered to be still 'low' and the sufficiency of supply is 'very low' (Global Food Security Index, 2022).

This is also reinforced by research that has been conducted, which shows that several things cause low food security in Indonesia (Suryana, 2014), Including obstacles to food distribution and an unorganized food logistics system. Based on report data (Badan Pusat Statistik, 2022a), it is known that there are still many provinces in Indonesia that have a percentage deficit in food distribution, especially in the rice commodity, which needs to be improved to meet projected annual needs. As a food company that is trusted to run a logistics business that ensures the affordability and stability of rice commodities, of course, this is an important point to pay attention to, including unequal distribution, the amount is reduced in the distribution process, lack of supplies, uncertainty in planning warehouse use, unpredictable demand for rice distribution, and also uncertain in the supply chain (Bantacut & Fadhil, 2018; Sartika, 2014).

Industry 4.0 was introduced by Germany in 2011 at the Hannover Fair (Jagtap et al., 2020; Schuh et al., 2016) and was assessed as being able to increase the efficiency and effectiveness of control of the flow storage of goods, services, and information between consumption points to meet customer needs. The application of Industry 4.0 in the logistics industry is currently widely known as Logistics 4.0 (Amr et al., 2019; Galindo & Wang, 2016; Sternad & Lerher, 2018). the results of previous research conducted by (Jagtap et al., 2020) concluded that the connection between Industry 4.0 and food logistics is essential for developing food logistics in the future. The application of technology such as the Internet of Things, system integration, automation, use of big data, and AI will be needed. So, the importance of companies is in transforming towards Industry 4.0.

The Indonesian Ministry of Industry is currently working on an Industry 4.0 transformation program through Making Indonesia 4.0: A Roadmap for Indonesia's Strategies in the Era of Industry 4.0 and said that in adopting Industry 4.0, the Transportations and Logistics sector is currently still in the lowest position, namely 28% when compared with other sectors (Kementerian Perindustrian, 2018).

As a follow-up to the commitment to transform towards Industry 4.0 in Indonesia, the Ministry of Industry in 2018 launched the Indonesia Industry 4.0 Readiness Index or INDI 4.0 tool. This tool was created within the framework of the Ministry of Industry to determine the extent of readiness of Manufacturing Companies in Indonesia for transformation. According to the measurement results that have been carried out, the INDI 4.0 value for one of the Food Logistics Companies is currently still at Level 2. Namely, the Company, in its transformation towards Industry 4.0, is still in Initial Readiness and still needs much improvement in the Company Management and Organization, People and Culture, Products and Services, Technology and Company Operations. However, measurements carried out on companies using the Indonesia Industry 4.0 Readiness Index (INDI 4.0) tools are considered less comprehensive because the parameter preparation in the INDI 4.0 tools is intended to measure companies in the manufacturing sector. According to (Hasbullah & Bareduan, 2023; Monshizadeh et al., 2022) it is also explained that it is necessary to consider the perspective of each industry player in measuring transformation readiness because the obstacles and challenges faced by companies in transforming are different.

So, based on the background of the problems above, this research tries to develop an index for measuring readiness for transformation 4.0 by combining the Industry 4.0 concept model with the case of logistics operating in the food sector as an effort to improve food security in Indonesia by transforming towards Industry 4.0.

2. Methods

This research uses a qualitative descriptive method that aims to understand the phenomena experienced by research subjects, such as behavior, perception, motivation, and actions, holistically and utilizing descriptions in the form of words (Moleong, 2012; Ratnaningtyas et al., 2023) to produce data. Descriptive originating from the subject. This research uses two types of data: Primary and Secondary Data. Primary data is obtained directly by organizations, institutions, agencies, or individuals from objects. In this research, primary data was obtained by conducting interviews and

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surveys from experts, practitioners, or academics who understand the principles of industrial transformation 4.0 and food logistics business processes. Secondary data is collected by collecting information from book literature theory and previous research from sources, including organizations, institutions, bodies, and institutions available for use (Abdullah et al., 2022).

Primary Data

Techniques for collecting primary data include surveys, interviews, and discussions with three experts, one lecturer, one supply chain management practitioner, and one food logistics practitioner, regarding variables, indicators, and index levelling.

Table 1 Experts respondent

Experts	Experiences
A	Fifteen years as an Expert and practitioner in manufacturing and Supply Chain Management.
B	Twenty-nine years as an expert and practitioner in Information Technology and cyber security
C	Twenty-seven years as an expert and practitioner in Corporate Strategy and Human Capital.
D	Twenty-five years as a practitioner and lecturer in Supply Chain Management.
E	Fifteen years as a manufacturing factory in Engineering and Supply Chain Management practitioner.
F	7,5 years as a practitioner in Transformation Management of a Food Logistic Company.

Secondary Data

Literature study data collection techniques by searching for sources from reports of organizations or institutions, books, and journals related to Industry 4.0, logistics and food logistics, and research methods related to research. Table 2 References Journal and Existing Index.

Table 2 References journal and existing index

Journals References	
Manufacturers	(Jodlbauer & Schagerl, 2016), (Schumacher et al., 2016), (Ichsan et al., 2019), (Schumacher et al., 2019), (Tan et al., 2019), (Almamalik, 2020), (Maria et al., 2020), (Nick et al., 2020), (Çınar et al., 2021), (Hasbullah et al., 2021), (Hajoary, 2023).
Logistic	(Sternad & Lerher, 2018) (Felch et al., 2018) (Oleśków-Szłapka & Stachowiak, 2019) (Elibal et al., 2020) (Zoubek & Simon, 2021) (Dallasega et al., 2022) (Khan et al., 2022) (Sun et al., 2022)
General Company	(Sony & Naik, 2020)
References Existing Index	
IMPULS: Industry 4.0 Readiness	(Lichtblau et al., 2015)
DREAMY: Digital Readiness Assessment Maturity Model	(De Carolis et al., 2017)
SIMMI 4.0: System Integration Maturity Model Industry 4.1	(Leyh et al., 2016)
RAMI 4.0	(Schweichhart, 2016)
INDI 4.0: Indonesia Industry 4.0 Index	(Kementerian Perindustrian, 2018)
SIRI: Smart Industry Readiness Index	(EDB Singapore, 2020)

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3. Results and Discussion

The results of the data and information that have been obtained are then grouped into indicators from several references. Based on the results of grouping initial data originating from journal sources or previous research, 52 variables or indicators used in previous research were obtained to determine the transformation measurement model towards Industry 4.0. The following is Table 3.

Table 3 Initial indicators

No	Indicators	No	Indicators	No	Indicators
1	Organization	19	Data	37	Internal Logistic
2	Material Flow	20	After Sales	38	Business
3	Automation	21	Digital Transformation	39	Warehouse
4	Management	22	Strategy	40	Procurement
5	Information	23	Leadership	41	Inventory
6	Technology	24	Customer	42	Forecasting
7	Analytic	25	Culture	43	Packaging
8	People	26	Product	44	Handling
9	Investment	27	Governance	45	Maintenance
10	Knowledge	28	I4.0 Principles	46	Transportation
11	Environment	29	Vertical Integration	47	Distribution
12	Innovation	30	Horizontal Integration	48	Monitoring
13	Research	31	Economy	49	Functional
14	Operation	32	Social	50	Communication
15	Service	33	Physical World	51	Integration
16	Sustainable	34	Virtual World	52	Aset
17	Logistics	35	Value Chain		
18	Factory	36	Purchasing		

After obtaining secondary data, interviews were conducted with several experts and practitioners involved in this research with three Industry 4.0 Transformation Experts, one Academician, one Supply Chain Management Practitioner, and one Food Logistics Transformation Practitioner. The interview stages were divided into several different times based on the readiness of the interviewee. However, using the same question template in the interview session includes:

1. What factors influence Food Logistics Companies to transform?
2. What variables or indicators need to be adopted in Transformation 4.0 for the Food Logistics Sector in Indonesia from the 52 indicators obtained from existing journals and Transformation 4.0 measurement models?

This interview stage was carried out for 30 - 45 minutes, and based on the interview results, several views were obtained on the factors that influenced the transformation:

Table 4 Factors influenced and references.

Factors Influenced	Experts						Existing Index
	A	B	C	D	E	F	
Implementing transformation 4.0 or digital transformation requires commitment and support from company management.	v	v	v	v	v	v	(Lichtblau et al., 2015), (Schweichhart, 2016), (Kementerian Perindustrian, 2018), (EDB Singapore, 2020) (Ichsan et al., 2019) (Schumacher et al., 2019), (Almamalik, 2020), (Sony & Naik, 2020), (Dallasega et al., 2022), (Khan et al., 2022), (Hajoary, 2023), (Oleśków-Szłapka & Stachowiak, 2019), (Sony & Naik, 2020), (Çınar et al., 2021), (Khan et al., 2022).

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Factors Influenced	Experts						Existing Index
	A	B	C	D	E	F	
Implementing Transformation 4.0 requires a targeted strategy to become the Company's reference in transformation (long-term, medium-term or short-term).	v	v	v	v	v	v	(Lichtblau et al., 2015), (Kementerian Perindustrian, 2018), (EDB Singapore, 2020). (Schumacher et al., 2016), (Schumacher et al., 2019), (Tan et al., 2019), (Almamalik, 2020), (Nick et al., 2020).
Companies must be willing to invest in IT and human resources to support Transformation 4.0.	v	v	v			v	(Lichtblau et al., 2015), (Kementerian Perindustrian, 2018), (Khan et al., 2022)
Companies need a transformation team, special department, or division to oversee transformation in the Company and monitor ongoing projects.	v	v	v			v	(Kementerian Perindustrian, 2018)
Knowledge and understanding of the Company's human resources are essential factors to pay attention to, so it is necessary to develop competencies (Such as training, workshops, and others to support transformation 4.0.).	v	v	v	v	v	v	(Tan et al., 2019), (Khan et al., 2022), (Lichtblau et al., 2015), (Kementerian Perindustrian, 2018), (EDB Singapore, 2020).
There is a need to instill a culture of discipline and a high work ethic to improve quality and create a good work environment.			v	v			(Schumacher et al., 2016), (Tan et al., 2019), (Maria et al., 2020), (Nick et al., 2020), (Kementerian Perindustrian, 2018).
Companies need to implement a culture of innovation so that all human resources can contribute to continuous improvements and support a better work system.			v				(Kementerian Perindustrian, 2018), (Khan et al., 2022), (Nick et al., 2020)
The Company's HR needs to be open to supporting the transformation carried out so that there is no resistance to a new system way of working, or technology.	v	v	v	v	v	v	(Kementerian Perindustrian, 2018), (EDB Singapore, 2020), (Schumacher et al., 2016), (Schumacher et al., 2019), (Tan et al., 2019), (Almamalik, 2020), (Nick et al., 2020), (Sony & Naik, 2020), (Çınar et al., 2021), (Khan et al., 2022).
Companies need to implement a system or data integration that is connected horizontally from upstream to downstream, which can connect the Company with external parties to the Company.	v	v	v	v	v	v	(Lichtblau et al., 2015), (Leyh et al., 2016), (Schweichhart, 2016), (De Carolis et al., 2017), (Kementerian Perindustrian, 2018), (EDB Singapore, 2020), (Oleśków-Szłapka & Stachowiak, 2019), (Sternad & Lerher, 2018), (Hasbullah et al., 2021).
Companies must implement a system or vertically connected data integration that links soft floor conditions to management and allows for real-time monitoring.	v	v	v	v	v	v	(Lichtblau et al., 2015), (Leyh et al., 2016), (Schweichhart, 2016), (De Carolis et al., 2017), (Kementerian Perindustrian, 2018), (EDB Singapore, 2020), (Oleśków-Szłapka & Stachowiak, 2019), (Sternad & Lerher, 2018), (Hasbullah et al., 2021).

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Factors Influenced	Experts						Existing Index
	A	B	C	D	E	F	
Companies need a database and analytical data system to record customer, supplier, distributor, vendor or other data and enable improvements or the production of new service products.	v	v		v	v	v	(Jodlbauer & Schagerl, 2016), (Schumacher et al., 2019), (Hasbullah et al., 2021), (Lichtblau et al., 2015), (Leyh et al., 2016), (Kementerian Perindustrian, 2018), (EDB Singapore, 2020).
Companies need to implement systems or technology to control warehouse locations, the flow of receiving supplies of incoming goods to outgoing goods, and information related to warehouse conditions in real time.	v	v	v	v	v	v	(De Carolis et al., 2017), (Oleśków-Szłapka & Stachowiak, 2019), (Sternad & Lerher, 2018), (Hasbullah et al., 2021).
It is necessary to have a system or technology to monitor information on the amount of product data coming in and out of the warehouse in real time.	v	v	v	v	v	v	(De Carolis et al., 2017), (Kementerian Perindustrian, 2018), (Oleśków-Szłapka & Stachowiak, 2019), (Sternad & Lerher, 2018), (Hasbullah et al., 2021)
Companies need to apply technology (RFID, GPS, Barcode, and others) to transportation modes in the real-time movement of goods to monitor location, transportation conditions (temperature, shaking, and others), and more.	v		v			v	(Leyh et al., 2016), (Schumacher et al., 2016), (Ichsan et al., 2019), (Schumacher et al., 2019), (Tan et al., 2019), (Werner-Lewandowska & Kosacka-Olejnik, 2019), (Almamalik, 2020), (Maria et al., 2020), (Hasbullah et al., 2021), (Zoubek & Simon, 2021), (Khan et al., 2022), (Sun et al., 2022).
The Company has implemented a system that can make decisions about transportation routes based on cost efficiency, transportation vendors, and routes.	v			v		v	
Implementing a cyber security system in IT and OT in the Company is needed.	v	v		v		v	(Lichtblau et al., 2015), (Kementerian Perindustrian, 2018)
It is necessary to implement a maintenance system for machines or systems that can be monitored and communicated in real-time via the Internet.	v			v	v		(De Carolis et al., 2017), (Kementerian Perindustrian, 2018)

The results of the interviews obtained 17 summaries of factors that could influence index transformation in the Food Logistics sector. Based on exploring 39 journal variables, existing measurement models, and interviews conducted, a transformation index selected indicator obtained 17 indicators.

Food logistics transformation does not only focus on technology adoption but is related to management of organization, people, and culture, which are essential factors in transforming towards Industry 4.0. This factor is vital to support transformation in the Company to ensure that the strategy to be targeted is apparent and becomes a reference. Moreover, employee involvement is also a driver of organizational change by building a culture that can adapt to change, disciplined and innovate.

Implementing a data transfer system that is integrated vertically and horizontally also very important in logistics companies, especially for the food commodity rice. This is to determine the supply, distribution, and prices of rice in various regions in Indonesia. Apart from that, the use of analytical data

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systems can also make it easier for companies to forecast the supply and demand for rice in Indonesia to avoid rice shortages.

The use of systems or technology (IOT, RFID, Barcode, and others.) in controlling the number of goods, flow, layout, and warehouse conditions can help companies ensure the availability of rice so as to avoid loss or damage to the quality of the rice. Apart from that, the use of systems or technology such as (RFID, GPS, and others.) in the transportation mode of moving goods is also needed to make it easier to know the location and condition of the vehicle when moving.

Implementing a decision-making system is important to assist in providing decisions or recommendations in rice commodity food logistics companies. This will make it easier for the Company to make decisions when determining transportation routes for distributing rice and selecting the transportation or transportation vendor that will be used in accordance with the conditions and available budget costs.

4. Conclusion

Research with a qualitative descriptive approach produces several factors that can influence the transformation index of food logistics companies in Indonesia towards Industry 4.0. The use of technology, especially in encouraging transparent and real-time data transfer (horizontal and vertical) and decision-making in the logistics sector, is critical to pay attention to. However, organizational management, culture, and human resources are also essential things to pay attention to in transformation. It shows that in transforming towards Industry 4.0, food logistics companies need to make improvements in determining the Transformation Strategy, Allocation of Investment in the company, forming a Transformation Team to monitor the transformation that will be carried out, improving and building Culture in the company, Employee Development, and Employee Acceptance of the company. It is improving system integration through Horizontal Integration and Vertical Integration, paying attention to Customer Needs in the food sector. Apart from that, implementing Smart Warehouses, Smart Inventory, Smart Transportation, Smart Decisions, Cyber Security and Smart Maintenance also needs to be done in order to increase food security in Indonesia.

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