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RESEARCH ARTICLE **Open Access**

Determining the Evolution Level of Logistics Systems in Large Industries

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Abstract
To improve the operation level of the companies tailored to industry 4.0 it is necessary to develop logistics system. In order to develop the logistics level, the first step is to measure the growth and evolution of all logistics process. For measuring the evolution and growth of the logistics system (LS), the processes and components of the logistics system and then the evolution level should be determined, at the end their level of evolution should be measured for each firms. The purpose of this paper is to determine the evolution level of the LS in the large industries of Iran. The research method is descriptive - applied and Data were gathered in two steps. First utilizing interviews with logistics experts for identifying the logistics process and components. Second step was data collection by check list in local visits and direct observation in firms. Checklist was completed in group sessions with the help of managers and experts in each firm. Using the mean of the logistics components and degree of adoptive (DOA) technique, evolution of LS was measured in industries. Results shown that firms with heavy products have little progress in the evolution of logistics compared to other firms and also the firms that have automatic production system will growth in logistic evolution better than others especially in intra-logistics and material handling. The method and result of this paper can be seen as a roadmap for managers and organizations and they will plan development and evolution of logistics processes.
Keywords: Logistics, Evolution, Process, Component, level

Introduction

The logistics in organizations is one of the most important competitive advantage (Yadas, 2020). The major logistics activities include transportation, storage, inventory management, packaging and other administrative activities. The logistics system integrate these activities (Van der Laan, etal, 2007). So many organizations are looking for the evolution of this system (Becker, etal, 2009). With the growth of industry generations to the 4.0 and 5.0 levels it is necessary to develop the logistics processes and activities to these levels (Werner-Lewandowska, 2019). The main features of industry 4.0 are the automation and virtualization, the logistics system must develop in processes for industry 4.0 alignment (Bag, etal, 2020). For this objective, evolution level in all the logistics process must be measured and analyzed based on their status. According their status will take action in their proper advancement (Battista, etal, 2012).

The development and evolution of the system has been identified as system maturity (Domingues, etal, 2016). A maturity model consist techniques of measuring the growth rate of a system at different stages of life with recommendations for the evolution and development of that system (Proença and Borbinha (2016). Measurement of the growth rate or state of the system may include each of

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the dimensions, aspects, processes, or sum of them. Maturity models are helpful tools to assess the actual situation of an organization. The maturity model consists of a series of growth levels. The lowest level shows the initial state of the system or process and the highest level, indicating maturity (Willner, etal, 2016). Progress on the evolution path between these two levels involves a gradual development with respect to the capabilities of the organization. The maturity model serves as a measure to assess the position on the evolution path (Matrane, etal, 2015).

Large companies to develop the logistics system should determine the level of logistics processes (Vieira, etal, 2017). If the industrial organizations fail to determine the status quo of their systems, it is impossible to develop and implement their strategies for growth and development (Carvalho, etal, 2016). There are three main issues to measure the maturity of LS. First, the components and indicators in the LS were able to detect. Second, each of the components or indicators may have specific effects on the growth and maturation of LS. The third issue is the calculation of the evolution level. Nevertheless, the research problem is divided into three questions:

1. What are the LS processes, component and indicators for determining the LS evolution? 2. What are levels for the LS evolution? 3. How can measure the evolution level in industries?

The remainder of the paper proceeds as follows. In the next section, literature review presented and the research method section presents data collection procedures and instrument validation procedures. This is followed by the data analysis and results section. The paper then concludes with the discussion of findings and implications for research and practices.

Theoretical background

The theoretical bases of the study include: 1. Logistics processes, 2. Logistics evolution, 3. Logistics maturity models.

Logistics Processes

Appropriate logistics involves proper capturing, right product, quality and proper quantity, in the right place and time, for the right customer and at the right cost (Van der Laan, etal, 2007). The logistics process focuses on the efficient transfer of material and goods from the source of supply and construction to the consumption point in an efficient cost, time, quantity, and quality to be accepted by customers (Glistau, Machado, 2018). Logistics in the course of multiple processes involves the procurement of materials, transportation, displacement, storage, information and communications flow, distribution and delivery, packaging and etc (Giutsi, etal, 2019).

Logistics is the integrated flow of materials and information in the supply chain. Supply chain supply chain comprises, producer, distributors and retailers (Shakeri, etal, 2020). If an industry expects efficiency and effectiveness, it is necessary to complete all the logistics processes on the desired level. The evolution or maturation of the logistics system can be achieved by completing the logistics process(Lin, etal, 2019).

Many parts of the processes and logistics components introduced by Reay, et al. (2006), they introduced the processes include information and communication, materials and parts supply, inventory management, storage and distribution. Battista, etal, 2012 presented the logistic maturity model as a guide for continuous development of logistics processes in clothing manufacturing industries. In their research, they identified the logistics processes in the garment industry. Batista and shirarld (2013) developed a logistic maturity model based on SCOR and divided logistics process as: planning, supply, distribution and ultimately recycling.

Logistics processes include storage and management, transportation, handling, inventory management and control, packaging and distribution management (Richards, Grinsted, 2013). Oleśków-Szłapka, etal, (2019), introduced three logistics processes 1. Materials and products flow 2. Information flow and 3.Administration flow. Sanae, etal, (2019) divided the logistics processes as planning and supply of materials , procurement and transportation, storage, data flow, handling , packaging and distribution. Yavas, etal (2020) In their study by the name logistics services in the new industrial environment, identified four processes for logistics based on the analyzing research from 2005 to 2020. Four process include transportation management, information management, Inventory management, and distribution management. Sakai, etal (2020), are introduced the logistics processes in four main tasks with a process approach. These four tasks are carrying and entering, receiving, holding and inventory control, distributing and transmitting and also Logistics Information System (Home-ortiza, etal, 2019).

Logistics process in supply chain as a system approach include five integrated process. These process consist Inbound Logistics, Warehouse Management, Intra-logistics, Logistics Routing and also outbound logistics (Werner-Lewandowska & Olejnik, 2020).

Logistics Evolution

The logistics process emphasizes on routine and standardization of inputs and outputs, particularly through the analysis and development of a logical sequence of meticulously designed activities (Bag, 2020). Traditional model for a logistics is considered a forward movement. This focuses on the transfer of materials from suppliers to consumers (Jahn, etal, 2018). The evolution of logistics can improve and develop many of these processes, such as to automate and mechanize of processes (Speranza, 2018).

The three industrial revolutions came as a result of the introduction of mechanization, electricity and IT (Barreto, etal, 2017). Internet of Things and Services into the industrial environment has triggered the fourth industrial revolution with the vision of “everything connected with everything else (Galindo, 2016). Logistics have been changed proportional on each industrial revolution as shown in fig 1.

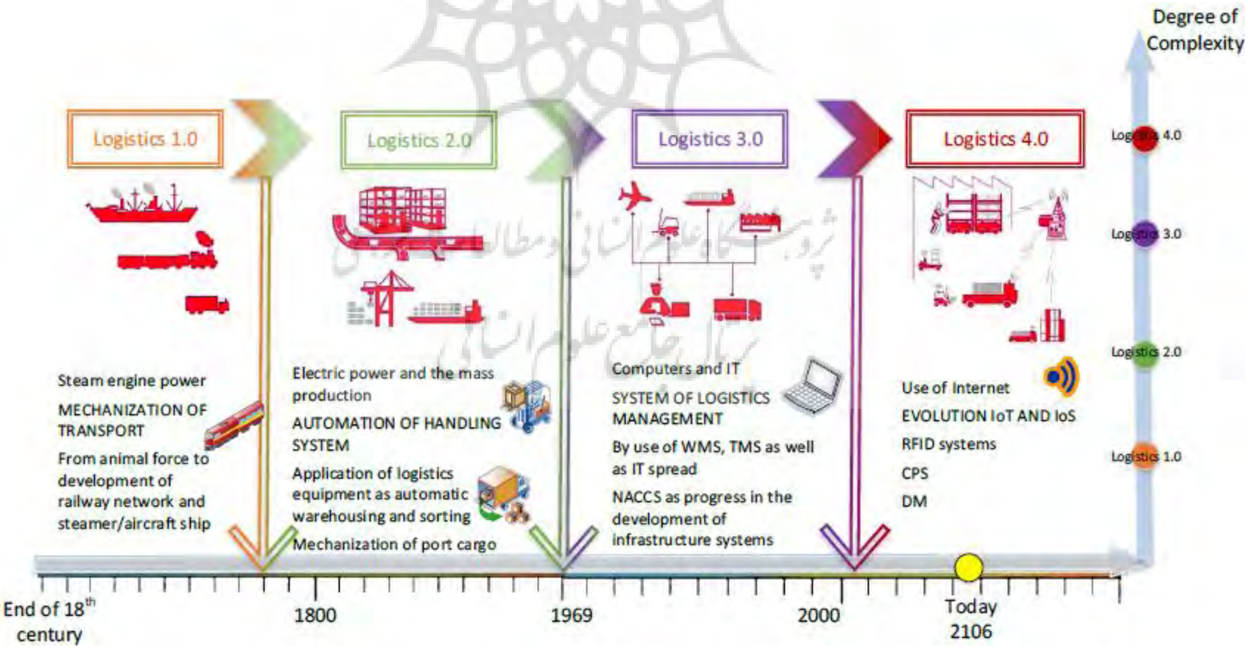

Figure 1. *Evolution of Logistics (Galindo, 2016)*

Recently, the term Logistics 4.0 has emerged because of the application of Industry 4.0 technologies and technological concepts to logistics processes (Woschank, etal, 2021). In each of the logistics generations, properties have emerged. These properties can be as sign of logistics generation and the existence of each attribute can show the evolution of the logistics in each firm (Sane, 2019). Figure 2 shows the properties and characteristics of each generation of logistics.

Table 1.
The properties and characteristics of each generation of logistics (Galindo, 2016)

Logistics processes	properties / characteristics in Logistics generations			
	Logistics 1.0	Logistics 2.0	Logistics 3.0	Logistics 4.0
Inbound Logistics	Push delivery process Manual operations	Pull Delivery Process/ Vendor Managed Inventory	Autonomous Inventory Management (Computerized)	Predictive Inbound Logistics (Big Data)
Warehouse Management	Manual operations Mechanization	Automatic Warehouse System	Automatic Warehouse Network	Supply Chain Warehouse Network/Non Warehouse Expenses
Intra-logistics	Manually Trolley Lift Truck	Manually Train Forklift	Autonomous forklift on open area	Autonomous forklift on open area steered by production machine
Logistics Routing	Manually Routing / Discharge and loading	Centralized Vehicle	Pre-planned and Centralized Fleet	Real-time routing connected/ Autonomous Transportation
Outbound Logistics	Push delivery process Manual operations	Order Based Delivery Management	Order Based Delivery Management by ICT	Autonomous Delivery Management/Predictive Delivery Management

Logistics Maturity / Evolution Models

Maturity Model (MM) is a technique to measure several aspects of processes in an organization for determining the systems evolution levels ((Mittal,etal, 2018). According to current literature, there are three main areas of applicability in which MMs could be adopted such purposes identified are reported: Descriptive purpose: assessing the AS-IS situation of the organization/process. Prescriptive purpose: indicating how to approach maturity improvement in order to positively affect business value. Comparative purpose: enabling to cross-benchmark. A model of this nature would be able to compare similar practices across organizations in order to benchmark maturity within different industries (Spaltini, etal, 2022).

Related to logistics process there are several terms used in the literature referring to MM, for instance, readiness assessment model, roadmap, framework, and maturity index (Angreani, etal, 2020). Logistics maturity models have a same purpose. That is measurement of the current state of process and comparison with complete situation (Mittal, etal, 2018). MM has a leveling model from the lowest to the highest and is usually a set of evolution indicators. It also has dimensions to express the scope of the model itself to evolutionary dimensions (Proenca, etal. 2016).

Reay et al. (2006) used the first logistic maturity model as the logistic maturity pyramid in service agencies affiliated to the American administration. They showed that the logistic maturity model same as other model requires three basic factors: 1) to determine the number maturity levels that are usually distributed in research between three to six stages. 2) Levels and Characteristics at each stage of maturity. 3) The way they develop and increase maturity level of each process into evolution. Ballou (2007) identified the logistics and supply chain management evolution model by assessing six phases: forming, discrete components, integration, continuity, value chain and networking to achieve evolution. Battista, Schirald, (2013) develop a model for Development of the Logistics process by the name "the logistics maturity stages Model". In order to identify the logistics processes in the garment industry, they study the status of each process, and they have presented solutions for continual improvement based on the process strengths and weaknesses.

Oleśków-Szłapka, etal, (2019) presented the model of the logistic phases maturity model based on six stages Model of Reay etal. They introduced the steps of the logistic maturity with the use of gray model and artificial intelligence. Sanae, etal, (2019) investigated maturity of auto industry supply chain in Morocco. They first introduce the supply chain processes and list the barriers to growth and implementation of each of them, they developed a three - stage growth model as the supply chain maturity model. Lizarralde etal, (2020), presented the maturity model of the operations components by defining five steps according to a Likert scale ranging from very weak to very well. Ramos, etal. (2021) introduced an assessment model for organization status in development of industry 4.0 by determining four stages: lack, existence, growth and excellence. And the last the maturity model of the 4 industry has presented by Caiado, etal. (2021) they have been designed and measured operation levels within the supply chain process by defining five stages as non - existence, conceptual, developed , and optimal, for operation levels within the supply chain.

The logistics 4.0 maturity model has introduced by Werner-Lewandowska and Kosacka-Olejnik (2019). They have defined six stages for logistics development in the maturity model and have introduced the measurement tool to measure the stages. This model have six stage from L0 to L5. Concept of L4.0 maturity model is shown in the Fig. 2.

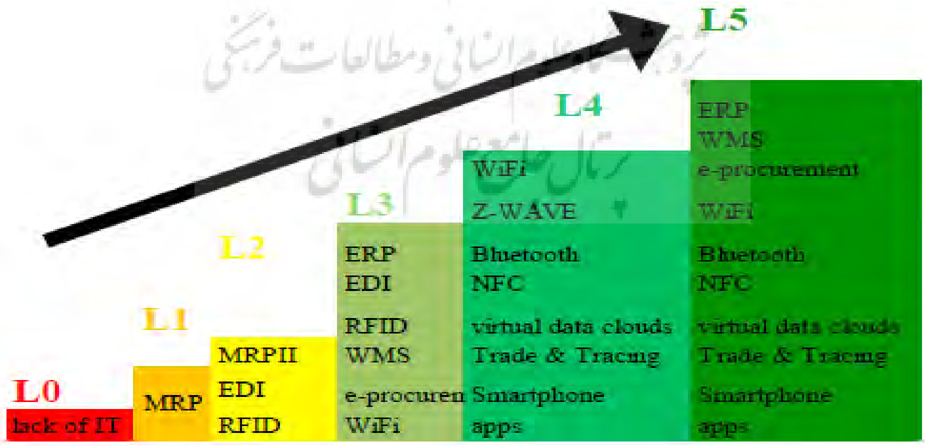

Figure 2. *Logistics 4.0 maturity model (Werner-Lewandowska and Kosacka-Olejnik, 2019)*

Methodology

The method of study is descriptive and practical in terms of purpose. The samples consists of two groups. The first group was ten experts in the logistics and supply chain management. They had expertise in the supply chain and were members of board in universities and all had enough of the criteria of expertise expected. Their comments and ideas are used to identify and confirm the logistics processes and components and also determination of evolution levels in logistics systems and stages level for processes. The second group was senior executives and operation managers in the supply chain of large industries. These managers have involved in departments of: materials planning, orders management, parts supply, transporting materials and parts, storages, inventory control, packing and distribution. Their knowledge and experiences are used to determine the logistics process and components status in their firms.

Interviews were used for data collection from the experts and checklist are used for data collection from second samples. Sampling was performed purposefully and continued until the theoretical saturation of the data. In this study, 11 semi-structured face-to-face interviews were conducted with experts, and after 10 interviews, repetition was observed in the received information. But to be sure, continued until interview 10. Given the time and resources available, 15±10 samples are enough to conduct the interview (Jaffari, etal, 2021).

In order to determine the real situation of the logistics components, the logistics equipment and the logistics operation should be observed and to be complete with the experience of the managers in specialized meetings. Managers for specialized meetings has been selected from all logistics processes in the firms. Checklist has design based on logistics component in table 3.

Empirical studies on LS evolution in large industries was carried out in the third quarter of the 2021. The studied population was big industries. Research was conducted on a sample of 4 big company in four industry in Iran country. Table 2. Show the firms and type of industry. We assigned codes for each firms and used them in continue.

Table 2.
Name and type of industry

Company Name	Code	Type of Industry
SAIPA Logistics	SP	Auto Industry Logistics
HESCO Logistics	HC	Heavy machinery Logistics
Solico Logistics	SL	Food industry
Goldiran Logistics	GL	Appliance Industry

Data analysis and Finding

In order to data analyze, four steps have been carried out.

Identify the Processes and Their Components in the Logistics System

The results of the research literature were provided to the experts and they were reviewed. By doing interviews with experts, first the list of logistics processes and components were provided. They analyzed eight model in literature review. Those model are: a)Reay, 2007, b)Batista and shirarld (2013), c)Richards, Grinsted, (2013), d)Galindo, 2016, e)Sanae, etal, (2019), f)Yavas, etal (2020), g)Sakai, etal (2020), h)Werner-Lewandowska & Olejnik, 2020). After analysis based on system approach, they agreed in a group meeting with the five processes for logistics system: 1) Inbound Logistics, 2) Inventory and warehouses Management, 3) Intra-logistics (Materials handling), 4) Logistics Routing, 5) Outbound Logistics. For measuring the selected processes need to some components in each process. The expert group have identified twelve components for logistics processes by surveying the logistics activity in big industries and requirements for perform the mission of the logistics system. The processes and components for logistics system shown in Table 3. We assigned codes for each component and used them in continue.

Table 3.
Logistics process & components

Logistics Process	Component	Code
Inbound Logistics	Material and parts transportation from suppliers	IL1
	Loading	IL2
	MRP	IL3
	Inventory Management	IL4
Warehouse Management	Unloading	WM1
	Inventory receiving	WM2
	Keeping and holding	WM3
Intra-logistics (Material Handling)	Material handling to production line side	MH1
	Material handling between assembly stations	MH2
	Products and goods handling to CBU warehouses	MH3
Logistics Routing	Packaging	LR1
	Delivery	LR2
Outbound Logistics	Loading and unloading	OL1
	Products and goods transportation to market	OL2

Determining the Indicators of Components for Checklist Design

To measure the logistics situation in firms, need to checklist. The checklist should contain indicators for measurement. Therefore, it is necessary to identify the indicators for each logistics components. Related to each logistics generation. Based on literature review and experts interview for the logistics components in each generation, indicators are considered in the table 4.

Table 4.
Indicators for Each Logistics Components

Components	Code	indicators
Material and parts transportation from suppliers	IL1	Kind of delivery system (Push, Pull, Computerized, VMI, Big data)
Loading	IL2	Manual, Mechanization1, Mechanization2[2], Automatic
MRP	IL3	Manual, MRP, MRPII, MRPIII
Inventory management	IL4	Manual, Computerized, VMI, Big data
Unloading	WM1	Unloading system(Manual, Mechanization, Automatic)
Inventory receiving	WM2	Manual, Mechanization, Automatic, ASRS
Keeping and holding	WM3	Manual operations, Mechanization, Automatic, Automatic network
Material handling to production line side	MH1	Manually Trolley, Manually Forklift, Automatic forklift, Autonomous forklift or other equipment
Material handling between production stations	MH2	Manually Trolley, Manually Forklift, Automatic forklift, Autonomous forklift or other equipment
Products and goods handling to CBU warehouses	MH3	Manually Trolley, Manually Forklift, Automatic forklift, Autonomous forklift or other equipment
Packaging	LR1	Manual, Mechanization1, Mechanization 2, Automatic
Delivery	LR2	Manual, Mechanization1, Mechanization2, Automatic
Loading and unloading	OL1	Manual, Mechanization1, Mechanization2, Automatic
Products transportation to market	OL2	Kind of delivery system (Push, Pull, DRP, Big data)

[2] Mechanization 1= Human- Machine, and Mechanization 2= Machine- Human.

Determining the Degree and Stages for Evolution Levels

For determining the evolution levels, the results of the literature were provided to the experts in summary, they emphasized four level for Logistics System Evolution (LSE) (Logistics 1.0 to 4.0 levels), Experts identified three stages for each level (Low, Medium, and High) and defined as below:

Low: This process has problem in performing its functions.

Medium: The process performs its functions, but it does not cover all the logistics purposes.

High: The process performs its functions, and cover the logistics purposes

Table 5 show the levels, Degree of level (DOL), Stages and degree of stages (DOS).

Table 5.
Point for levels and degree for their stages

Levels	L1			L2			L3			L4		
DOL	0 - 1			1.001 - 2			2.001 - 3			3.001 - 4		
Stages	L	M	H	L	M	H	L	M	H	L	M	H
DOS from	0	0.33	0.67	0	0.33	0.67	0	0.33	0.67	0	0.33	0.67
DOS To	0.33	0.66	1	0.33	0.66	1	0.33	0.66	1	0.33	0.66	1

Measurement Technique for the LSE

According to experts, in order to measure the logistics level, three steps have been considered. First, determining the existence of each logistics components in the firms. Second, determining the stages of the specified components. Third, measuring the component level and stage degree.

First Step: determining the existence of each logistics components in the firms

The state of existence or absence of each logistics components investigate by observing processes and performing specialized meetings with managers of the logistics process in firms.

Second step: determining the stages of the specified components

Component stages determine by L-M-H, in the Checklists.

Third step: Measuring the level of LSE

Logistics System Evolution (LSE) obtained by Eq.1 and Components evolution levels (CE) calculate by arithmetic mean (Eq.1). For each level has determined a value from 1 to 4.

$$LSE = \frac{\sum_{i=1}^{n} CS_{ij} V_j}{\sum_{j=1}^{n} V_j} \qquad \text{Eq.1}$$

$$CS_{ij} = \sum_i DOS_i \quad , \quad j = 1,2,3,4 \qquad \text{Eq.2}$$

LSE : Logistics System Evolution
CS: Components Situation
DOS= Degree of stages (Li or Mi or Hi)
Li: Low stages for component i
Mi: Medium stages for component i
Hi: High stages for component i
L=0.33, M=0.66, H=1
V_j: Evolution level Value ($V_1 = 1, V_2 = 2, V_3 = 3, V_4 = 4$)
n = Number of components
i = 1, 2 … .14 , j = 1,2,3,4 (Evolution levels)

Determining the Level of LSE for Cases

LS evolution level was measured for the four cases in three steps.

First Step: determining the status of logistics component in each firms

By observing processes and performing specialized meetings with managers of the logistics process in each firm, the state of existence or absence of each logistics components and also components stages was investigated. Results has shown in tables 6, 7.

Table 6.
Status of logistics component in each firms

Firms Components	SAIPA Logistics	HESCO Logistics	Solico Logistics	Goldiran Logistics
IL1	VMI	Pull Process	Pull Process	Pull Process
IL2	Mechanization 2	Mechanization 1	Mechanization 1	Mechanization 1
IL3	MRPII	MRP	MRP	MRP
IL4	VMI	Computerized	Computerized	Computerized
WM1	Mechanization1	Mechanization1	Mechanization1	Manual
WM2	Automatic	Mechanization2	Mechanization2	Mechanization1
WM3	Automatic	Mechanization1	Mechanization1	Mechanization1
MH1	Automatic forklift	Manually Forklift	Manually Forklift	Manually Forklift
MH2	Autonomous forklift or other equipment	Manually Forklift	Manually Forklift	Manually Forklift
MH3	Automatic forklift	Manually Forklift	Manually Forklift	Manually Forklift
LR1	Mechanization2	Mechanization1	Mechanization1	Mechanization2
LR2	Mechanization1	Mechanization1	Mechanization1	Mechanization1
OL1	Mechanization 2	Mechanization 1	Manual	Manual
OL2	Push	Pull	Push	Push

Second step: determining the stages of the specified components

By complete checklist in specialized meetings with managers of the logistics process in each firm, the state of existence or absence of each logistics components and also components stages was investigated. Results has shown for SAIPA Logistics (for example) in tables 6.

Table 7.
Status of component stages for SAIPA Logistics

Levels	L1			L2			L3			L4		
Stages	L	M	H	L	M	H	L	M	H	L	M	H
IL1								✓				
IL2							✓					
IL3								✓				
IL4								✓				
WM1					✓							
WM2							✓					
WM3							✓					
MH1								✓				
MH2										✓		
MH3									✓			
LR1								✓				
LR2								✓				
OL1						✓						
OL2	✓											

As shown in the table 7 for SP Co. the components: MH2 is in the L 4.0 level and OL1 is in the L1.0 level. WM1 and OL1 are in the L 2.0 level. Other component are in the L3.0. Its mean logistics system in SP is not integrated and have an unbalance growth. The average of the logistics evolution for the SP is at Level 3.

Third step: Measuring the LSE level

Logistics System Evolution (LSE) and Components evolution levels (CE) calculated for four cases. We show calculates for SAIPA logistics and for another firms we show the results only. The logistics evolution level for the SAIPA Logistics is calculated as below:

$$CS_{i1} = 0.33 \quad , \quad i = 9$$
$$CS_{i3} = 0.66 + 0.33 + 0.66 + 0.66 + 0.66 + 0.33 + 0.33 + 0.66 + 1 + 0.66 = 5.95, i = 1,2,3,4,6,7,8,10,11,12$$
$$CS_{i2} = 0.66 + 0.66 = 1.32 \quad , i = 5,13$$
$$CS_{i1} = 0.33 \quad , \quad i = 14$$

$$LSE = \frac{0.33(1) + 1.32(2) + 5.95(3) + 0.33(4)}{10} = 2.21$$

The LSE for the SAIPA Logistics is at L3.0 in L stage. Fig. 3 show the LSE level for the SP, HC, SL and GL.

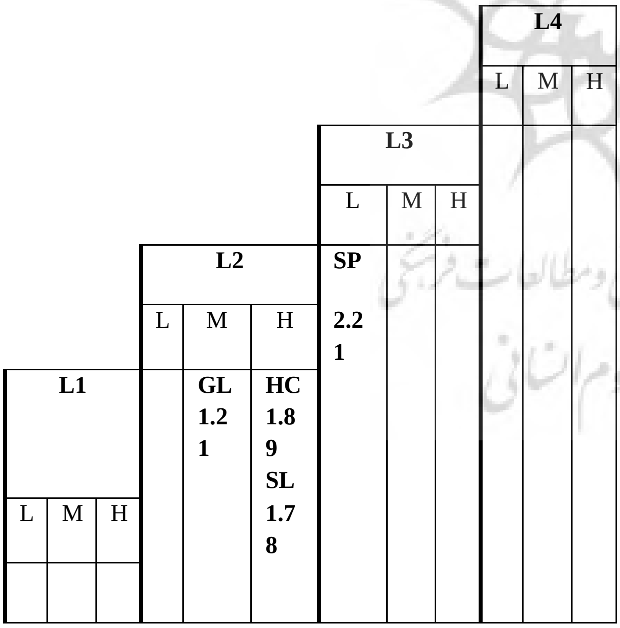

Figure. 3. *LS evolution levels for firms*

Results

Three steps are required to measure evolution of LS. The first step is to identify components. The second step is determining the maturity steps, and the third step is measurement and comparison (Ramos, etal, 2021). For the first step, logistics components has identified. By reviewing the literature and researches in the logistics, processes and executive components were identified for the logistics system and analyzed by experts in logistics and supply chain and based on the logistics and management conditions in Iran, processes and executive components were proposed for the logistics system. The number of processes required for the large Industries in Iran, such as the majority of the research done, was determined in five processes. By doing interviews with experts, components of logistics processes were provided. They agreed with the 14 components as: four components for inbound logistics, three component for Warehouse Management, three for intra-logistics (materials handling), three components for logistics routing, two components for outbound logistics.

In second step, the results of literature review showed that most of the logistics maturity models are considered 4 and 6 levels for maturity. By experts interview 4 levels has determined for LSE. In third for measuring the LSE by checklist for data collection in current situation in firms. Results shown the LSE for all firms have not balance growth. LSE level for the SP is at L3.0 in L stage, for HC and SL is at L2.0 in H stage, this level for GL is L2 in M stage.

Conclusions

According the results, in all firms the outbound logistics process, has minimum evolution. The reason is that the products delivery process in the Iranian industry follows the pressure system. The economic embargo and reducing the supply of products made companies fail to implement the pull system and order Based delivery. Large industrial firms must consider customer need and their orders in supply chain with pull and order base process because Retailers are at the bottom of the supply chain. Constructive marketers view the retail process as an essential part of the overall distribution strategy (Ebrahimi, etal, 2021). The low growth level in both inbound and outbound logistics processes relates to these two processes to external systems. In compared some components that are depend on information technology, have good situation for to be automatic, and this is reason for better situation in evolution levels.

Based on the results, SP have better situation in LS evolution and GL have lowest level. Achieving the logistics automation in industries with higher levels automation in production system is simpler than other firms with low automation in production and services. By analyzing the level of processes and their strength and weakness Decision - makers will plan development and evolution of processes. Therefore, the method and result of this paper can be seen as a roadmap for managers and organizations. Unbalance growth of logistics processes and their components were observed in all firms. It is necessity that managers and authorities to focus their efforts for integrated development of the components and indicators of LS.

Future research can collect all factors and indicators mentioned in the literature, for other industries, and try to identify and determine appropriate LS components and indicators and then measure the maturity status of LS. Given that the indicators identified with the impact and importance specified should be used in a model or system of maturity of LS, it is recommended that the approach or measurement system of LS maturity design according to the terms of each organization.

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