01. A development of a framework for evaluation of reverse logistics maturity level

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Abstract: Reverse logistic (RL) and management of unused product, waste as well as limitation of natural resources are growing problems throughout the decade. The RL has been successfully implemented in some companies, however, no clear key performance indicator of a successful RL is provided. The paper proposes a framework for assessing the maturity level of the RL implementation. The framework was designed in order to provide the information as well as a clear key performance indicator. The procedure of assessing the framework was to come to many companies to measure the level of RL implementation. Better integration among supply chain actors can minimise the environmental problems. The finding shows that the maturity level in the implementation of RL for the Indonesian consumer electronics industries is at level 3 (develop level) and 2 (managed level), especially in the local companies.

Keywords: assessment; framework; reverse logistics; consumers' electronics industries; maturity level.

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1 Introduction

Management of unused product, waste, and limitation of natural resources become growing concerns throughout the decade. Good management of reverse logistics (RLs) may improve customer service, environmental concern, economic benefits and sustainability of natural resources (Chouinard et al., 2005; Lee and Dong, 2009; Aras et al., 2011). In addition, regulations and government policy are important factors to meet the environmental standard, set product-specific and green environments (Schultmann et al., 2006; Kumar and Yamaoka, 2007; Ilgin and Gupta, 2010).

The RL has been considered as one strategy to increase environmental concern and company profit and at the same time decrease product return. It can be defined as "a process of company with planning, implementing and controlling rang from inventory, finished goods and supported by e latest information to get a value or disposal" (Rogers and Tibben, 1998; Bernon et al., 2011; Lambert et al., 2011). Many researchers have reported that the RL has played an important role in a number of manufacturing firms because it can be a tool to control the impact of higher costs, improve the value of products, improve business performance, fulfil the increase of number environmental regulations and to fulfil legislative issues (Ramírez, 2012; Silva et al., 2013). Many activities can be classified as RL system (Prahinski and Kocabasoglu, 2006; Kocabasoglu et al., 2007). For example, the returned product is generally collected from the point of the sale, inspected and sorted by employees or to retrieve a product from customers. In Indonesia, the causes of product return are a defective product, malfunctioned product, warranty product, product recall, unsold product, and expired product. deBrito et al. (2005) reported other causes of RL activities, manufacturing return, commercial return, product recall, warranty recall, service return, end-of-use return and end-of-life return.

The RL has been successfully implemented in some companies. The purposes of RL implementation are to waste minimising waste and use of natural resources, increasing product life-cycles, supply chain complexity, customer satisfaction and loyalty. However,

no clear key performance indicators, parameters, or assessment method is provided to measure the successful level of RL implementation. Balan et al. (2006) reported that assessing tools are needed to make new strategies or approach gain competitive advantages. Here, a maturity framework of RL may help the present status of their companies and give the opportunity to increase the performance. RL operations are significantly more complex than traditional manufacturing (Amini et al., 2005). Every process requires a lot of activities, actors, and costs. Therefore, the success of RL implementation comes from many aspects. Maintaining customer satisfaction and maximising speed of production and product lifecycles, reducing expenses, and minimising waste are some examples of the aspects. In addition, the use of secondary material for minimising natural resources is another aspect. Every company that implements the RL should have criteria or parameters to measure the RL level of success.

Maturity concept can be defined as a conceptual model that consists of a sequence of discrete maturity levels for a class of processes in one or more business domains, and represents an anticipat desired, or typical evolutionary path for these processes (Becker et al., 2009). Process maturity concept assumes that the implementation of procedures is carried out in multiple evolutionary and successive stages (Fischer et al., 2016). Maturity concepts have been developed to construct the maturity of RL implementation.

In other hand, a maturity level indicates precisely a level of capabilities that an organisation may have such that it has been obtained through the transformation of one or more sections of organisational processes (Khatibian et al., 2010). Maturity level of RL can be assumes that there are successive stages in the RL implementation and the stages indicate how the process explicitly can described, implemented, assessed and controlled. To fill this gap, the paper proposes the development a framework for evaluation the maturity level of RL implementation. Hence, the maturity level of RL will help to reducing global warming and climate change, minimising of waste and pollution, anticipating the lack of natural resources and fulfilling the environmental obligation.

2 Reverse logistics

RL implementation has been carried out by some companies. Pokharel and Mutha (2009) reported that the development of RL began in the 1980s. Their research mainly focused on strategies and RL model, network to design, production planning and environmental issues. In 1990–2008, the research areas of RL include inventory control, distribution and production planning. Since 2008 until the present, RL research areas focuses on customer satisfaction, loyalty, secondary material, pricing, waste and sustainability environmental. Currently, disposition decision-making process research in RL begins in this decade. Lambert et al. (2011) and Bai and Sarkis (2013) reported RL studies are more capable and flexible of covering the problem from the practical working environment. A recent study conducted by Nikolaou et al. (2013) proposed a corporate social responsibility (CSR) and sustainability issues in RL systems as an integrated model to develop a complete performance framework model.

Studies on RL mainly focus on strategy to minimise cost, profit maximisation, how to fulfil the environmental obligations and customer relations management. The implementation of RL has provided many benefits for the companies, government, and

customer. Moore (2006) reported that the results of a survey of 125 manufacturing companies showed 50%–70% of the total revenue potential is derived from remanufactured products. In addition, Pollock (2007) reported RL systems implementation could improve organisational performance, and increase customer satisfaction and the organisation's position. In a metal recycling company, the implementation of RL systems has given a lot of benefits, namely 74% energy savings, 90% use of natural materials, 97% reduce of mining waste, 88% reduce of air emissions, and 76% reduce of water (Kumar and Putnam, 2008). On the other hand, the existence of strategic issues (technology innovation and IT) can help companies to implement of RL better (Li and Olorunniwo, 2008). By comparing the drivers and the barriers to RL, the barriers are common to most firms and are related mainly to the external environment (Lau and Wang, 2009). According to Wrap (2010) there are some other benefits of implementation of the RL system such as effective waste management, cost, carbon impact and health or safety.

Further, the framework of RL system can be represented by process areas and assessment categories which include the RL area. The framework can be divided into five process areas, i.e., information technology, production planning, distribution, business process and the environment.

3 Methodology

Based on the synthesis of empirical findings and literature review, the goal of this research is to develop a framework for assessing the maturity level of RL implementation. According step used by Heath and Cowley (2004) and Denk et al. (2012) who summarise from Glaser and Strauss (1967), there are four-step guidelines to construct the RL maturity framework. They propose four steps for the designing process of maturity models or framework:

1 data collection phase

2 organising data phase

3 data analysis phase

4 comparative literature phase.

The goal of construct the RL maturity is to improve sustainable environmental, minimise of waste and profit maximise.

The next step is to use the development framework for assessing the maturity of RL implementation. In order to demonstrate the application of the above framework and validate its feasibility, we use the framework in the three consumer electronics industries. We choose consumers electronics household appliances as preliminary investigation because of increasing number of Waste of electric and electronic equipment-WEEE (Khan et al., 2013). Electronic waste, or e-waste, has emerged as a major problem in quite a number of developing countries, as well as an opportunity for development and economic growth (Ejiogu, 2012). In other hand, most of the electronic devices contain plastic and heavy metals such as arsenic, cadmium, chromium, lead, and mercury which are potentially toxic to human and environmental health (Molinari, 2011). According to Widmer et al. (2005), e-waste contains over 1,000 different substances some of which

like gold and copper are valuable while others like lead cadmium, mercury, hexavalent chromium, plastics, selenium and flame retardants can be toxic and can have serious adverse environmental and health effects.

A questionnaire including the list of RL categories was given the RL participants (general manager, operational manager and production manager). The dependent variable and all independent variables are measured using a five point Likert-type scale. Because of the result from Likert's scale in questionnaires are still in the form of the ordinal data type, we implement method of successive interval (MSI) to transform into interval data. MSI is "a procedure for obtaining equal intervals of category data into results of questionnaire". Ordinal data is apparently qualitative data and not an actual figure. Ordinal data use numbers as symbols of qualitative data itself. This was stated by Yuniati (2011) that the data using parametric statistical methods through a questionnaire for data collection are ordinal, so the data need to be changed into the interval data. Statistical procedures such as regression statistic, for example, Pearson's correlation, t-test and so forth require interval scale data. Therefore, if the data are in the form of ordinal scale, then the data should be converted into interval to meet the requirements of these procedures. Unless the Spearman's correlation which allows ordinal scale data, it is not necessary to change the existing data. If the data were still in the form of ordinal data, the effect may occur will shrink the correlation coefficient. This may result in the wrong model and does not meet the requirements under the rules of the model fit. MSI is data quality test phase. In this phase, after the data were collected, there will be test towards the data for validity and reliability.

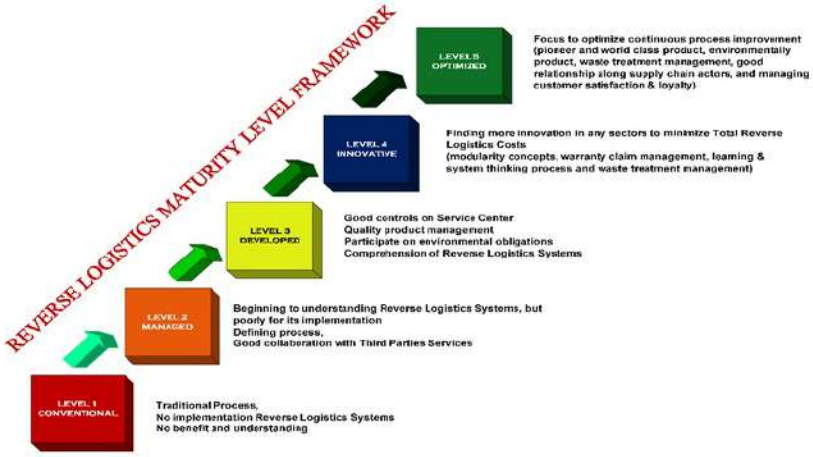
The evaluation process about how robust the RL maturity framework, RL categories, and RL Assessments categories need more clearly and fit with RL problems. If RL maturity is not fit with the RL problems, we redesign until the RL categories fit with RL implementation. Finally, the maturity framework of RL implementation was successfully proposed. The assessment categories subdivided into 21 categories. The RL categories consist of reverse system thinking and information management, reverse production and operations management, reverse distribution, business process and reverse sustainable environmental.

4 Framework of maturity level of RL

After carrying out a series of GT phases, framework of maturity level already equipped with five RL categories. Hadiguna et al. (2011) reported that the proposed system or framework must be verified (statistical analysis and case studies) to confirm the capability of the model or framework. Literature reviews are conducted to support the argument of this work which is designed using the judgmental process and domain knowledge (Anand and Kodali, 2008). Similar to the findings of a study conducted by Wadhwa et al. (2009), the framework also has many entities or process areas for optimisation of control policies and upgrading the company performance.

Further, the framework is designed for assessing the maturity level of RL implementation. This framework is divided into five levels, i.e., level 1 or conventional, level 2 or managed, level 3 or developed, level 4 or innovative and level 5 or optimised. The framework of RL maturity is presented in Figure 1.

Figure 1 Framework of RL maturity level (see online version for colours)



4.1 *Maturity levels*

- *Conventional (level 1):* in the level, there is no implementation of RL systems. The company usually uses traditional process to produce the product and uses 100% natural resources. Company do not understand the benefit if the company implement the RL. The quality and quantity of the product usually fluctuate in the company and no standardisation is adopted due to the application of the traditional production process. Defines no implementation RL.
- *Managed (level 2):* is the product with good quality and specification. The company starts to understand the benefit of the implementation of RL even though RL is still poorly implemented. The decision makers start to learn how to implement RL in their company. To carry out RL in their companies, they have collaboration with the third party services, but, unfortunately, the implementation of RL has yet been successful. The company usually uses 90% natural resources and 10% secondary material.
- *Developed (level 3):* is a maturity level that characterises company has comprehension toward RL concepts even though not too much.
  1. The company has cooperation with third party services to take care customer complaint, services and warranty mechanism. Good product repair and service management.
  2. Produce the environmentally-friendly product and introduce it as a good quality product in the international community. Because company has standardised working systems and perform process control.

3 Conduct the training system for employees to upgrade their system thinking and encourage a bigger and wider management.

4 Waste treatment management to minimise waste and participate in environmental campaign.

The company uses 75% natural resources and 25% secondary material. A good relationship between the company and third party services (1 city > 2 service centre) occurs in order to manage customer satisfaction. The company participates in the environmental campaign and uses primary waste treatment. The company produces high-quality product and leads to ICT/digital product (eco-efficiency).

- *Innovative (level 4):* defines a maturity level where company finding more innovation in any sectors to minimise the total RL costs. It involved comprehension toward RL as well as the system thinking, strong commitment from the company to managing the customer complaint and increasing the satisfaction and loyalty of customer, produce the good quality product to fulfil the market needs, a good relationship with all stakeholders, good management in collecting used product, standardised working system for monitoring and improvement process, and secondary treatment process for waste and participation in environmental regulations. The product uses 50% natural resources and 50% secondary material. The company gives contribution toward the establishment of policy for environmental sustainability by providing creative ideas for the policy. The company produces high-quality product with high durability and specification (based on ICT/digital, eco-friendly and energy efficient product, ISO certified product and other certification). The company works collaboratively with the third parties to solve customer problems and to maintain the customer loyalty and satisfaction.
- *Optimised (level 5):* is the final maturity level, where the company focuses on optimising continuous process improvement. The company serves as the pioneer of the world-class product, produces environmentally product, involves in good waste treatment mechanism, good relationship along RL actors systems, and good management of customer satisfaction and loyalty. The company has had full comprehension of RL concepts that it can obtain many benefits of implementation RL. The company gives 100% warranty for its products and gives best services and product claim from the company. Good networking and integrated systems along with supply chain actors are maintained to guarantee customer's satisfaction and loyalty. It is a pioneer in environmental sustainability policy issues (zero defects and waste, advanced waste treatment, use > 75% secondary material) and its product becomes a world class product (nanotechnology product) with sophisticated management information systems.

Table 1 shows the assessment categories as an indicator to calculate the level of RL Implementation. In developing the RL categories into 21 assessment categories, stakeholders, i.e., decision maker of the consumers' electronics company, government (regulation), customer and Indonesian RL experts are invited to give their ideas/opinion about RL implementation. To see the more detailed information on parameters or indicators of each level of RL maturity, see the Appendix.

Table 1 RL indicators

No.	*Reverse logistics category*		*Assessment categories*
1	Reverse system thinking and information management	1	The comprehension of reverse logistics concepts
		2	Benefit of reverse logistics implementation
		3	The reclaiming product management
2	Reverse production and operations management	1	End of life product recovery and inventory management
		2	ICT/digital systems technology
		3	Quality product
		4	Services mechanism
3	Reverse distribution	1	The comprehensive of relationship and communication along reverse logistics actors
		2	Collecting of used product mechanism
		3	Creating collection centre for returned used product
4	Business process	1	Leadership
		2	Strategic planning
		3	Customer and market focused
		4	Measurement, analysis and knowledge management
		5	Human resources focus
		6	Process management
		7	Business result
5	Reverse sustainable environmental	1	Waste treatment management
		2	Green technology application
		3	Participate on environmental legislation
		4	The utilising of secondary material

4.2 RL categories and assessment categories

In this section, RL categories and assessment categories are explained in details. With the detailed information, that is easy to learn and apply, it will help the companies to understand each level characteristic in the framework.

a Reverse system thinking and information management

In this area are divided into three categories namely the comprehension assessment of RL concepts, benefits of RL implementation and the reclaiming product management. In this section, the comprehension of learning and implementing RL concepts are needed to get some benefit from RL implementation. Moreover, human resources of system thinking should have to always develop and upgraded, the problem of product claim also get special attention. Collaboration with third parties in terms of product service and claims will increase the satisfaction of the consumer.

b Reverse production and operations management

There are four assessment categories, i.e., end of life product recovery and inventory management, ICT/digital systems technology, product quality, and enhanced services

mechanism. Inventory systems are already well-integrated with the market demand; it can avoid the overproduction. The use of nanotechnology is recommended in the process of making a product. As reviewed in some literature, it can be concluded that Nanotechnology could substantially enhance environmental quality and sustainability through pollution prevention, treatment, and remediation (Masciangioli and Zhang, 2003). Wiek et al. (2013) state that Nanotechnology is considered as an important means for addressing urban sustainability challenges ranging from climate change and water contamination. Delgado-Ramos (2014) states that Nanotechnology production of clean energy, to water purification, and important medical advances. Moreover, Hussein (2015) specifically that Nanotechnology is considered as the technology for renewable energy. Renewable energy can be defined as a type energy sources which can provide light, electricity, and heat without polluting the environment. The important of nanotechnology is related to its effects on the environment, health and safety issues (Gao et al., 2016).

Furthermore, repair, service, and claim also require critical attention. Time management of product service will give satisfaction to the consumer. Time management and good service will increase customer loyalty.

c Reverse distribution

The problem of distribution is important to address in RL. Communication, networking and good relationships between actors RL will support reverse distribution implementation. There are three categories, namely, the comprehensive of relationship and communication along RL actors, collecting of used product mechanism and locating collection centre for returned used product. Collaboration and communication among actors RL comprises, among others, distribution centre (DC) including secondary market, collection centre (CC), recycled centre (RC), service centre (SC), third party services, disposal centre (DC), supplier and customer. The good collecting product mechanism will expedite the process of RL. Availability of service centres and services by a third party in each city will make it easier for customers to make a claim and service of products.

d Business process

The area of Business Process is taken from Malcolm Baldrige national quality award (MBNQA). The categories are divided into seven, namely, leadership, strategic planning, customer and market focused, measurement, analysis and knowledge management, human resources focus, process management and business result.

MBC is available for the most comprehensive management framework. MBC significantly works for all types and sizes of organisations. MBC is also equipped with several questi from all high performing organisations. According to Patti et al. (2001), MBC has consistently pointed out to the linkages between adoption of quality programs and performance. Prybutok et al. (2011) also reported that MBC model is a reliable tool for organisations assessing. The MBNQA framework was developed with the input of more than 200 quality experts, and it includes the majority of philosophies and strategies espoused by the most influential quality theorists in North America and Asia. As such, it is claimed to be a comprehensive

framework in terms of the dimensions it incorporates (Winn and Cameron, 1998). Flynn and Saladin (20[illegible]) reported:

- The MBNQA has been developed to more systematically address organisation-wide quality practices, and to assess the level of quality man[illegible]ment implementation.
- The MBNQA has evolved from a means of recognising the best quality management practices to a comprehensive framework for world-class perfi[illegible]ance, where it is widely used as a model for process improvement.
- The MBNQA program was organised to focus intense attention on quality and competitiveness at the firm level, with a long-term goal of institutionalising a [illegible]lture of continuous improvement (Balasubramanian et al., 2005). The universality of the MBNQA and its relationship too many quality management constructs has made the Baldrige model a useful framework for studying quality management practices (Mellat-Parast, 2015).

e Reverse sustainable environmental

The sustainable environmental category is divided into three assessment categories, that is, treatment waste management, green technology application, participate on environmental legislation and the utilising of secondary materials. The waste treatment process is expected not to pollute the environment. The use of technology to minimise the amount of waste generated is highly recommended. In addition, participation in environmental issues and legislation will provide more value for the company itself. The use of secondary material to anticipate the limitation number of natural resources will support environmental sustainability.

5 Implementation and discussions

Indonesia is an agricultural country that has a wide variety of natural resources. More than 237, 6 million people (the result of the May 2010 Census) live in Indonesia; therefore, Indonesia is the 4th most populated country in the world. Huge population, unfortunately, causes many environmental problems. The growth of the industrial sector in 2011 has been the highest one since 2005. Regarding the utilisation side, the rate of GDP in 2011 is driven by 4.7% growth in household consumption. Other utilisation sides are government consumption, gross fixed capital formation (PMTB), exports and imports; the growth percentages are 3.2%, 8.8%, 13.6% and 13.3% respectively. Such condition has brought about the change and challenges for every level of Indonesian society. The rapid growth of economic has also influenced the environment. On the other hand, the Indonesian Central Bureau of Statistics (*Biro Pusat Statistik*) has experienced a higher average of growth rates for the last 20 years. The Indonesian Governmenthas established Non-Departmental Ministry for Environment, and the Environmental Impact Management Agency (*Balai Pengendalian Lingkungan*) as a Non-Departmental Government Agency to take care of the environmental problems.

Even though the regulation for Hazardous Waste Management in Indonesia has been issued, the process of taking care of hazardous waste and implementation of the policy should be supervised continuously. In addition, based on the report 16.7 million tons of waste are not taken care of properly by the municipal services and waste are collected by the municipalities (21.7 million tons per year in total) using mainly small hand carts, and was brought about to small transfer sites, or intermediate collection points (*Tempat Pembuangan Sementara*).

The study focuses on three consumers of electronic industries as a preliminary investigation. The consumers of electronic industries produce the highest percentage of waste and the number is growing significantly. These companies represent consumers of the electronic industries in East Java, Indonesia. As data collection method, the researchers distributed a questionnaire and conducted interview for each company. The questionnaire is very useful and concise to gain specific information about a pertinent topic. A questionnaire is a tool to elicit feelings, perception, experiences, and habits of some individuals or groups. Moreover, the interview is conducted to obtain reliable and valid measures in the form of verbal responses from respondents. The questionnaire is equipped with the Likert scales. Table 2 defines the company profile of three electronics companies, i.e., PCB company, SA company, and GMEI company. Table 3 reveals the results of the questionnaires electronic industries consumers, especially local companies. The definition of local companies is 'a company which provides goods or services to local population/market' which is characterised by 90% of individual capital (business owners), 100% of local workers, and domestic segmentation market among others.

Table 2 Company profile

Company	*Line of business*	*Number of employees*
PCB company	Audio cassette tape, colour TV, AC, washing machine, TV rack, CD replication services, plastic injection services	896
SA company	Fluorescent lamp, various kind of household incandescent light, glass lamp and lighting equipment	800
GMEI company	Electronics items consumers (video)	258

Figure 2 shows RL flow of electronic industries consumers. The first step is customer returns the product to three possible locations, i.e., service centre, distribution centre (store) or third party services. Because the distribution centre doesn't have any authority to repair the product, all of the defected products must be sent to a service centre or third party services. If the product cannot be repaired by technicians in the service centre or by third-party services, the entire product will be collected in the collection centre. The function of recycling centre is the place for disassembling product and separating parts of the product so that they can be processed again or not in manufacture. If the parts cannot be processed again, the part will be sent to a disposal centre. Remanufacturing, recycling, refurbishing, reconditioning are many steps of the production process by the manufacturer to upgrade the value.

Figure 2 RL flow of electronic industries consumers (see online version for colours)

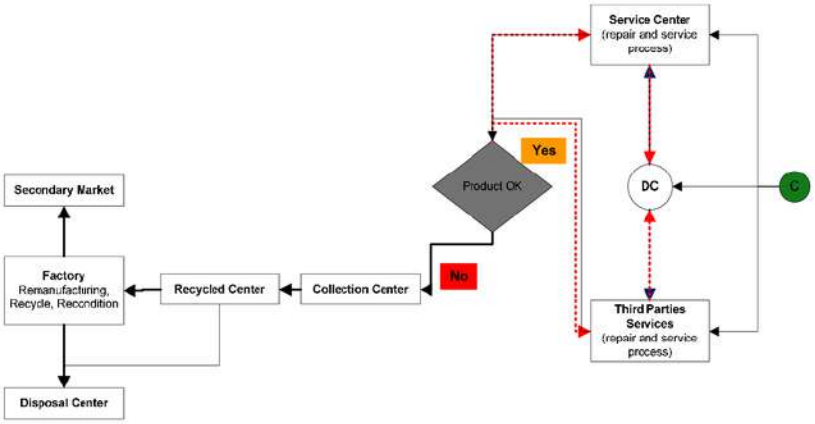


Table 3 Result of the questionnaire

	RL categories	*Indicators*	*PCB company*	*SA company*	*GMEI company*
RL system aspects	Reverse system thinking and information management	A.1	1	1	1
		A.2	1	1	2
		A.3	2	1	1
	Reverse production and operations management	B.1	2	1	2
		B.2	3	1	3
		B.3	2	1	3
			3	1	2
	Reverse distribution	C.1	2	2	1
		C.2	3	1	2
			3	2	1
	Business process	D.1	2	1	1
		D.2	3	1	2
		D.3	2	1	1
		D.4	2	2	2
		D.5	3	1	2
		D.6	3	2	2
		D.7	2	1	2
	Sustainable environmental	E.1	2	2	1
		E.2	2	2	2
		E.3	2	1	2
		E.4	2	2	1

43

The validity and reliability tests justify that the results of the questionnaires are valid and reliable. The value of the Cronbach's alpha is 0,891 and the r calculation is higher than r table (0.4227) with DF = 20 and the level of confidence is 95% (probability 0.05). Since the results of the questionnaire are in the form of ordinal data, the MSI helps to convert the ordinal data into interval data. Table 4 shows the MSI result for PCB company is 2.5763 or at level 3 (develop level). Using the same methods, the result for SA company (Table 5) and GMEI company are 1.4776 and 1.8811 consecutively (Table 6). Based on the value, SA company and GMEI are on the level 2 (managed level).

With the value of the interval of the framework determined, the transformation parameters are described as follows:

- value between 0–≥1 = conventional level
- value between ≥1–≥2 = managed level
- value between ≥2–≥3 = developed level
- value between ≥3–≥4 = innovative level
- value between ≥4–≥5 = optimised level.

Based on Tables 4 to 6 (MSI method result), the researchers can analyse the maturity level of the implementation of RL for consumers of electronic industries (local companies) on the developed level for PCB company and the managed level for SA company and GMEI company.

Table 4 The result of the transformation of ordinal data into interval data (PCB company)

Ordinal scoring scale	*Frequency*	*Proportion*	*Cumulative proportion*	*Z-scale*	*Density F(Z)*	*Scale value (SV)*	*Value of scaling*
1	2	0.0952	0.0952	–1.3074	0.1698	–1.7825	1.0000
2	12	0.5714	0.6667	0.4311	0.3636	–0.3393	2.4432
3	7	0.3333	1.0000	0.0000	0.0000	1.0909	3.8734
4	0	0.0000	1.0000	0.0000	0.0000	0.0000	2.7825
5	0	0.0000	1.0000	0.0000	0.0000	0.0000	2.7825
Σ	21					*Mean*	*2.5763*

Table 5 The result of the transformation of ordinal data into interval data (SA company)

Ordinal scoring scale	*Frequency*	*Proportion*	*Cumulative proportion*	*Z-scale*	*Density F(Z)*	*Scale value (SV)*	*Value of scaling*
1	14	0.6667	0.6667	0.0597	0.3983	–0.5975	1.0000
2	7	0.3333	1.0000	0.0000	0.3990	–0.0021	1.5954
3	0	0.0000	1.0000	0.0000	0.0000	0.0000	1.5975
4	0	0.0000	1.0000	0.0000	0.0000	0.0000	1.5975
5	0	0.0000	1.0000	0.0000	0.0000	0.0000	1.5975
Σ	21					*Mean*	*1.4776*

Table 6 The result of the transformation of ordinal data into interval data (GMEI company)

Ordinal scoring scale	*Frequency*	*Proportion*	*Cumulative proportion*	*Z-scale*	*Density F(Z)*	*Scale value (SV)*	*Value of scaling*
1	8	0.3810	0.3810	–0.3029	0.3812	–1.0005	1.0000
2	11	0.5238	0.9048	1.3074	0.1698	0.4036	2.4041
3	2	0.0952	1.0000	0.0000	0.0000	0.0000	2.0005
4	0	0.0000	1.0000	0.0000	0.0000	0.0000	2.0005
5	0	0.0000	1.0000	0.0000	0.0000	0.0000	2.0005
Σ	21					*Mean*	*1.8811*

It means that all companies start to understand the RL benefit and starts to learn how to carry out the principles of RL in their companies. In terms of quality product, all of the companies produce middle-quality products and will develop them into green, energy savings and efficient products to fulfil the environmental obligation. Distribution aspect shows the companies have a good relation to RL actors, i.e., collection centre, recycled the centre, disposal centre, service centre/third party services, secondary material, and supplier. In terms of business process, they start to build paradox capability management and expect to expand sales overseas. Companies already anticipate customers complain by having cooperation with the third party services to facilitate customer to return the product of the manufacturer. At last in terms of environmental awareness, the three has a traditional waste treatment and growing attention to contribute to the environmental legislation and follow a policy on environmental sustainability that has been issued by the government.

6 Conclusions

The proposed framework has been developed and applied to assess the level of maturity RL implementation in three customers' electronics industries. The result of the implementation as preliminary investigation indicates that the proposed maturity RL is applicable to be used for measure the maturity RL implementation. The implementation in the first company (PCB company) was on the level 3 (develop level). Hence, the result for other companies (SA and GMEI company) was on the level 2 (managed level). To increase their RL maturity level, companies need understanding their strengths and weakness, and for identifying both the opportunities and threats. In addition, to successfully implement the RL, the company needs good relationship between along supply chain actors, i.e., distribution centre (DC) including secondary market, collection centre (CC), recycled centre (RC), service centre (SC), third party services, disposal centre (DC), supplier and customer as end users. Therefore, in order to increase the robustness of the RL maturity, the applicability in many case studies can be conducted in other industries. Finally, there is an opportunity to conduct future research to propose the framework with different RL categories and assessment categories appropriate with the real condition, market needs, and global regulations.

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Appendix

Process area	No	Assessment categories	Reverse logistics (RL) maturity index				
			Level 1 conventional	Level 2 managed	Level 3 develop	Level 4 innovative	Level 5 optimised
Reverse system thinking and information management	1	The comprehension of reverse logistics concepts.	No understanding towards reverse logistics concepts.	Very limited understanding towards reverse logistics concepts; information is obtained from reading, newspapers, magazines or the internet.	Comprehension towards reverse logistics concepts even though not too much.	Comprehension towards reverse logistics concepts as well as the thinking system of reverse logistics systems.	Comprehension towards reverse logistics concepts, starting from its thinking system, the framework, until the benefit of the implementation of reverse logistics systems.
	2	Benefit of reverse logistics implementation	No benefit for implementation of reverse logistics systems.	Comprehension of reverse logistics concepts even though not too much.	Company getting benefit from implementation of reverse logistics systems from the use of secondary material in production.	Getting benefit of remanufacturing, recycle and recondition processes.	Obtain a lot of benefits from remanufacturing, recycling, reconditioning, energy savings, using secondary material, reducing mining wastes, water emission, capital as well as increasing customer satisfaction and loyalty.
	3	The reclaiming product management.	No servicing services from company.	Understanding towards the concept of thinking system about customer's complaint.	The Company has cooperation with the third party services to take care of customer's complaint claim and product warranty.	The company has many service centres/stations and strong commitment to overcome customer's problem.	Company's service centre/station gives100% product warranty and give the best services to maintain customer satisfaction and loyalty.
Reverse production and operations management	1	End of life product recovery and inventory systems.	The company has not integrated PPIC management system.	Traditional PPIC management systems.	There is a balance between demand and production process requirements.	The company produces spare parts/products that meet market demand and fulfil the inventory systems.	No overproduction/zero inventory because the company's production relies solely upon market demand.
	2	ICT/digital systems technology	The company does not produce a product integrating ICT/digital product principle.	Electronic products will be developed based on ICT/digital principles and to fulfil environmental obligations.	The development of consumer electronics products is based on digital/ICT and the products are environmentally friendly/green and energy efficient.	Electronics products are digital/ICT-based, eco-friendly/green and energy efficient. They are developed using the nanotechnology.	Electronics products, medical devices and control equipment as well as electronic components are developed using nanotechnology. The products become the pioneer in the market.
	3	Quality product	Produce poor-quality product	Produce mild-quality product	Produce high quality product being produced with high technology.	Produce high-quality, high-quantity, high specification and durable products.	Produce high quality products that are able to compete with imported products.
	4	Services mechanism	Repair service takes too much time or longer than due date informed to customers.	Repair service is using conventional method and, as the consequence, it takes too much time or longer than due date.	There is a time management being set so that repair service does not take longer than the due date.	The company is able to finish repairing defected products on the due date.	The company is able to finish repairing defected products on the due date and notifies customers that their defected products have been repaired.

Appendix (continued)

Process area	No	Assessment categories	Reverse logistics (RL) maturity index				
			Level 1 conventional	Level 2 managed	Level 3 develop	Level 4 innovative	Level 5 optimised
Reverse distribution	1	The comprehensive of relationship and communication along reverse logistics actors.	No communication systems or the communication systems between actors reverse logistics use the simplest, most convenient means of communication, e.g., telephone.	The relationship among actors of reverse logistics is developed using a better system and various means of communication, e.g., telephone, email and IT devices.	an integrated management information system has been established so that the reverse logistics actors can always monitor the progress and provide the most current information.	Needs and company information can be accessed publicly by the actors reverse logistics systems.; such condition develops stable condition.	Sophisticated management information systems with updated information can be accessed 24 hours. there is gathering between the company with reverse logistics actors continuously.
	2	Collecting of used product mechanism	No collecting product by company.	The ecompany prepares facilities for collecting their damaged product, under warranty or older products.	The company has a simple facility for collecting the damaged products.	The company has a collection centre/station for collecting product from the customer as the end user, warehouse, store and ext.	The company has many collection centres of which location is based on customer's highest demand and has relationship with the third party services.
	3	Locating collection centre for returned used product.	No service centre/station	There is only one service centre/station in each big city.	The company has >2 service centre/station in each city.	The company has an affiliation with the third party services (store).	Good networking and integrated system with update information from the service centre/station and they are easy to find (more than one service centre per city).
Business process	1	Leadership	No responsibility for company	The company started to build paradox capability management by recognising the existence of a wide range of alternative views.	The company encourages a bigger and wider management where people, ideas, resources, processes, markets and other important factors considered in a comprehensive way, not only partially.	The company has already had the ability to recognise the diversity of individuals in the team who have different backgrounds.	There is an opportunity to change, due to the urgent needs that allows the acceptance of ambiguity and risk in a global context. There is transparent organisation and companies can receive and learn new things. The company must have the ability to read global market opportunities, has access to global information, and is capable of being a threat to competitors. The company should also be able to use resources from around the world in any competitive situation.
	2	Strategic planning	The products are sold by the company only to meet the market demand.	The company has a desire to expand overseas sales.	The products are known by the international community especially across Asia.	With the ISO certification and other certifications, the products start to be known not only in Asia but also worldwide.	The product was a pioneer, and gain certification of product quality.

Appendix (continued)

Process area	*No*	*Assessment categories*	*Reverse logistics (RL) maturity index*				
			Level 1 conventional	*Level 2 managed*	*Level 3 develop*	*Level 4 innovative*	*Level 5 optimised*
	3	Customer and market focus	The company only sells products but does not have any customer service to accommodate all kinds of grievances or complaints from consumers.	The company has already had a customer service to accommodate all the complaints, and suggestions from consumers.	Not only have does it have a customer service/station, but the company also has already had a strategy to improve customer satisfaction.	The company has already had 24-hour online IT facilities to accommodate all consumer's needs	The company has a strategy in every product being produced to meet the characteristics of consumers, e.g., price, product specifications, product complexity and customer behaviour to increase customer satisfaction and loyalty.
	4	Measurement, analysis	There is no system of education to the employees about the importance of reverse logistics systems.	Gradually, the company gives the reverse logistics material for training.	The company conducts training about basic concept of the reverse logistics system in the production process.	Periodically, the company conducts training the latest issues in the reverse logistics to employees.	The company facilitates employees to conduct and publish their research about reverse logistics or talk in seminar for great benefits of the company.
	5	Human resources focus	The production process runs according to office hours, employees are paid a salary in accordance with the amount of work they have done.	Companies give rewards to employees who have high performance.	The company has a standardised working system for example standardised time, the time cycle for each production. In addition, there is training to introduce new methods especially reverse logistics systems.	Working system is standardised. A lot of the learning processes are conducted to enhance production performance, a good payroll system with a variety of benefits or rewards.	A variety of working systems, a lot of the learning process to enhance production performance, a good payroll system with a variety of benefits or rewards. The company provides retirement money for the welfare of its employees.

Appendix (continued)

Process area	*No*	*Assessment categories*	*Reverse logistics (RL) maturity index*				
			Level 1 conventional	*Level 2 managed*	*Level 3 develop*	*Level 4 innovative*	*Level 5 optimised*
	6	Process management	In this phase, the company has a traditional management process. The purposes of the company are mainly profit and minimising total costs. It neglects the management process to get better condition.	*Defining process* In this phase, the process's owner will design, analyze and define business processes that will be automated starting from workflow activities, information flow, business rules and policies, required resources and the performance calculation (key performance indicators).	*Execute and perform process control* The results of the modelling and design process are undertaken by the manager and then forwarded to IT for automation. After the implementation, employees and related parties will carry out the process in accordance to the rules that have been established previously as well as supervisors and on-duty managers to control the process.	*Monitoring and improvement process* Business processes that have been implemented monitor the performance by calculating key performance indicators. System monitoring is conducting by using the data in real-time so the finding is in accordance with the real situation in the field. From the results of such monitoring, the management can see and analyze whether the necessary repairs to a business process are necessary or not. Eliminating delays in business processes because delay is essentially a waste. At this stage, the company is implementing business process reengineering that is an activity by reducing the time from another activity to make improvements at a more advanced level, e.g., find double work etc.	*Business process innovation* This process represents the highest level; at this stage the company must understand the soul of the business process. Business process innovation activities are based on the orientation of the goal in the background or why they are carried out. The design of a new process to fully utilise the technology remains the main goal.
	7	Business result	Firms produce goods according to market needs	The company manufactures products according to market needs but also pays attention to the characteristics of Indonesian consumers.	In addition to producing products that meet with the character of Indonesian consumers, the company produce products with good design to ease recycling them.	The resulting product has led to a green product which is the social responsibility of companies. As an addition, the company also runs CSR (corporate social responsibility) program.	Environmentally friendly products, easy to recycle, and CSR are not just the responsibility of the company but also the social organisation, e.g., helping natural disaster victims.

Appendix (continued)

Process area	No	Assessment categories	Reverse logistics (RL) maturity index				
			Level 1 conventional	*Level 2 managed*	*Level 3 develop*	*Level 4 innovative*	*Level 5 optimised*
Reverse sustainable environmental	1	Waste treatment management	Company does not has a waste water treatment system	The company has a traditional waste water treatment system.	*Primary treatment* The company has already had a waste treatment system i.e. level 1/Primary Treatment or wastewater treatment system that ensures that hazardous substances used in the production process has been treated so it is safe for the environment.	*Secondary treatment* Companies have level 2 (secondary treatment) waste water system that aims at eliminating biological contamination from wastewater through aeration process by developing bacteria or other biological organisms. Apart from these two processes, secondary treatment is also equipped with a sludge handling system resulting in digestion, dewatering and disposal of solid.	*Advanced waste treatment* The company has the Advanced Waste Treatment to ensure that there are no sources of pollution such as disease-causing agents, chemicals that dissolve in water-organic, fertilisers, organic chemicals, sediment or suspension materials, radioactive materials, and heat.
	2	Green technology application	There is still a lot of waste that spilled on the floor of the factory.	Waste management has started to be applied to all production processes.	The company has already implemented various methods or approaches for reducing waste.	The company has already had a good waste management.	The company is strongly committed to a zero defect or zero waste in the production process.
	3	Participate on environmental legislation	The company does not have any contribute to the design of environmental legislations.	The company contributes to the environmental legislation though a small one. It obeys the policy that has been issued by the government.	Participates in environmental campaign and supports the government programs.	Provides creative ideas, suggestions and innovations in the design and development of policy issues related to environmental sustainability.	Being a pioneer in environmental sustainability policy issues and is responsible so that its products do not cause any damage to the environment.
	4	The utilising of secondary material	The company uses 100% of natural materials/resources in production process.	The company uses 90% of natural material and 10% of secondary material.	The company uses 75% of natural material and 25% of secondary material.	The company uses 50% of natural material and 50% of secondary material.	The company uses 75% or more of secondary material and is committed to the preservation of natural resources and the environment.

01. A development of a framework for evaluation of reverse logistics maturity level

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