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Engagement Model in Reverse Logistics Activities: Drivers of E-Waste Processing Business Performance

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Abstract

Reverse logistics (RL) activities carried out by informal businesspeople are growing very fast. Even though improve the welfare, but they are often labeled as reducing environmental quality. For environmental reasons, they often become targets for extortion by irresponsible government officials. This research aims to determine the most possible engagement model for this business group to implement RL activities, so that business performance, especially environmental factor, increases. In this research, the model is divided into three groups, namely involvement, collaboration, and empowerment. Meanwhile, business performance is measured using six dimensions, namely financial, internal business processes, innovation and growth, stakeholders' value, social and environment. Using the structural equation modeling and applying second order confirmatory analysis, this research succeeded in identifying models to engage in green RL activities. The best indicators that describe each dimension are: for involvement model, first, the purpose of doing business is for profit, save the environment, and positive social impact; second, only carry out safe processing methods; third, minimize direct contact to e-waste. The best collaboration that can be implemented between businesspeople and the government or electronics manufacturers is professional business development; provision of affordable simple technology machines; and profit-sharing system in cooperation. All empowerment indicators meet the loading factor requirements, but the best two illustrate this dimension are investing in component shredders and smoke filter machines. By running SmartPLS software, this research has proven that the engagement models in RL activities formulated in this research has a positive effect in improving the performance of e-waste processing businesses.

Keywords
Engagement model; reverse logistics; business performance; sustainability.

1. Introduction
The electronic waste (e-waste) processing business boomed in 2010 – 2015 and continues to run today (Maheswari et al., 2017). This business growth is in line with the growth in the amount of world e-waste which has reached 53.6 million tons and is predicted to increase by 38% by the end of 2030 (Forti et al., 2020). Indonesia as the highest contributor of e-waste in Southeast Asia, reaching 1,618 kilotons/day, has undoubtedly become a very fertile place for the growth of this business (Rahmanda et al., 2023). Another factor that is driving the rapid growth of this business is the low level of education and limited skills of marginalized community groups, so that it is difficult for them to work in the formal sector and some are forced to choose to work in the informal sector to engage in this business.

As is known, electronic waste still contains a lot of high-value metals such as PCBs from computers, cellphones, processors, RAM, mother boards/main boards, hard disks, computer sockets, ICs, chip cards, memory, electrical panels. , telecommunications equipment and several other electronic devices. Through certain skills using fairly simple equipment, electronic waste can be processed to be sorted and retrieved gold, silver, palladium, or copper metals that are still valuable.

In fact, the local regional government can already see that this e-waste business is quite capable of quickly moving the economy of the lower classes, opening up new job opportunities, and indirectly reducing the high number of criminal cases (Damanhuri & Padmi, 2012; Maheswari, Yudoko, & Adhiutama, 2019). E-waste has the potential as a resource and can also play a role as a mining material in urban areas (urban mining) (Maheswari et al., 2020) (Maheswari, Yudoko, Adhiutama, & Agustina, 2020). The results of the preliminary study found that quite a lot of people who originally worked in other informal sectors or even in the formal sector, then chose to switch to getting involved in the waste processing business. They considered that even though there were things that were harmful to health and disrupted the environment, because this business could generate more money, they continued to run it so that they could continue to live properly.

The existence of risks and threats to public health and environmental means that governments in many developed countries do not provide space for informal business groups to process this electronic waste. The waste to energy program was taken over by their government and the results were channeled back for the communities' benefit. Community involvement is only limited to helping sort waste based on categories and also paying the costs of recovery which are quite a lot. From this policy, it is hoped that people will be wiser in using electronic devices so that they do not quickly become waste that endangers.

The Indonesian government has attempted to prevent and enforce the law for this business group to pay attention to the impact of its operational activities on health and environmental pollution, but it seems to be less than optimal. This business continues to thrive -- becoming even more likely -- after the government encouraged people to switch to using electric cars, while the government itself, with its limited number of human resources (officers), is not ready and able to control and manage its waste. As an illustration, although 'waste banks' have been established in almost all sub-districts, the growth of waste from electronic devices is suspected to be much faster.

In an effort to maximize the utilization of e-waste for a cleaner environment, improve the welfare of marginalized groups, and create a quality social environment, a comprehensive and standardized waste management and processing system is needed through an engagement model (EM). The engagement models for running RL activities are divided into three forms, i.e., involvement, collaboration, and empowerment. The established engagement model is the one that is most likely to be applied according to community conditions. If this engagement model is implemented, the performance of the e-waste processing business will increase (Maheswari & Simangunsong, 2023).

2. Literature Review

The RL concept has been adopted by developed countries and has succeeded in overcoming the growth of e-waste(Rogers & Tibben-Lembke, 1998). Many developed countries have implemented this concept by requiring companies that produce waste from their production activities to resell, recycle, refurbish, recondition, and return to suppliers (Abdissa et al., 2022; Han & Trimi, 2018; Job et al., 2020; Muhammad et al., 2020; Sellitto, 2018). The extended producer responsibility (EPR) program is also implemented by requiring companies producing electronic products to take back their electronic products if they are damaged and cannot be reused according to their function, from the hands of the community. In fact, RL activities that are carried out well by a company can be used as a competitive advantage and as a measure of business and environmental performance (Sangwan, 2017; Sellitto, 2018). It doesn't have to be done alone, the obligation to carry out RL activities can be given to other companies that provide industrial waste recovery services. These companies have permits to utilize waste from the government so that it can be ensured that their business processes do not pollute the environment.

In contrast to developed countries, in Indonesia and other developing countries, e-waste recovery (RL) activities are dominated by informal groups. In general, there are five informal business groups that are active in RL activities in developing countries, namely collector, intermediary business, processors, exporters, and repair services (Maheswari et al., 2019; Maheswari & Simangunsong, 2023). In accordance with the type of business, the main activities of RL activities in developing countries are collecting electronic waste from end users; sorting waste according to type and quality; dismantling; recycling, and exporting (for components that cannot be processed to extract precious metals) (Maheswari et al., 2019). Activities such as remanufacturing and reconditioning are rarely carried out by this informal business group. From these five business processes, the e-waste processing activity to extract precious metals such as gold, silver, palladium, and copper is the activity that is most often claimed to cause environmental pollution and is the focus of this study.

The stakeholder engagement model in green reverse logistics activities must consider several things, namely the nature of the relationship, level of engagement, and types of communication (Carter, 2015). The relationship between government and informal business in realizing environmentally friendly RL activities requires a very long time. For example, to improve the performance of informal businesses, the government needs to provide several facilities and training programs. Training programs also need to be designed very well because people involved in this business have varying levels of education and the majority are low. The way to communicate with them must also use various methods depending on not only the level of education, but also business experience. With these two considerations, a high engagement level must be chosen to be successful in improving business performance. There are three engagement models that match the characteristics above, namely involvement, collaboration, and empowerment. Involvement in RL activities means learning on all sides of collecting, sorting, dismantling, recycling, and exporting process. The form of involvement in RL activities is demonstrated by the business goal not solely for profit, but also to reduce electronic waste by maximizing its use and creating a positive impact on people's social lives. The form of involvement in RL activities is demonstrated by the business goal not solely for profit, but also to reduce electronic waste by maximizing its use and creating a positive impact on people's social lives. Apart from that, it is also demonstrated by complying with the rules, being aware of using personal protective equipment, providing a special place to operate, and using simple machines to reduce direct contact with e-waste. Collaboration models are demonstrated by cooperation between informal e-waste business groups with government, electronic product manufacturers, and larger scale e-waste businesses. Collaboration with the Government is very necessary because there is a limited number of officers to manage waste, including electronic waste, which still has economic value. In order to increase business capabilities and business processes do not pollute the environment, the government needs to provide training, processing machines and air filters. E-waste processing business groups can be empowered by purchasing simple technology machines themselves. They have enough purchased power to buy spindles and air filters machines. The indicators that measure the engagement model are presented in Table 1 below.

Table 1. Engagement Model in Sustainable Reverse Logistics

Construct	Indicator	No. Item
Involvement Model (IM)	Business objectives maximize utilization for profit, protect the environment, and provide positive social impacts	IM1
	Compliance with environmental regulations	IM2
	Awareness of using masks when interacting with electronic waste	IM3
	Awareness of using gloves when interacting with electronic waste	IM4
	Awareness of using booths when interacting with electronic waste	IM5
	Willingness to provide a special place	IM6
	Seriousness to reduce direct contact with waste	IM7
Collaboration Model (CM)	Capacity building training for environmental performance improvement	CM1
	Professional business management & development coaching	CM2
	Provision of simple machines/technology to improve worker and environmental safety	CM3
	Provision of micro-financing facilities to accelerate business growth	CM4
	Pioneering collaboration between electronics manufacturers and business informal	CM5
	Profit sharing system between electronics manufacturers and business informal	CM6
	Collaboration between business informal & large-scale waste processing businesses	CM7
Empowerment Model (EM)	Becoming a partner for licensed electronics manufacturers or large waste processors	EM1
	Investment in component shredders	EM2
	Investment in air filter machines	EM3
	Investment for green business development	EM4
	Sharing knowledge on green electronic waste processing	EM5

The performance of the e-waste processing business is measured using the sustainable reverse logistics scorecard (SLRS) measurement (Maheswari et al., 2020). There are six dimensions of SLRS measurement, namely financial, internal business process, innovation and growth, stakeholders' value, social, and environment. The indicators that measure each of these dimensions are presented in Table 2.

Table 2. E-waste Business Performance

Construct	Indicator	No. Item
Financial (F)	Greater profits compared to other informal businesses	F1
	Cheap raw materials and big margins	F2
	Efficient operational costs	F3
	High business productivity with adequate equipment	F4
	Turnover ensures business continuity	F5
Internal Business Process (IBP)	Low work accident rate	IBP1
	Following the rules by using personal protective equipment	IBP2
	Skilled and experienced workers	IBP3
	Availability of waste disposal sites from sorting and processing	IBP4
	Certainty that raw materials are no longer functional	IBP5
Stakeholders' Values (SV)	Business provides a sense of security for workers and the environment	SV1
	Business successfully reduces the pile of electronic waste	SV2
	Business creates jobs	SV3
	Business provides benefits for investors	SV4
Innovation & Growth (IG)	Business innovates by using simple machines/technology	IG1
	Business is creative in creating efficient and safe operating processes	IG2
	Business grows because of the innovation and creativity carried out	IG3
	Business turnover increases according to targets	IG4
	Money turnover and business turnover are faster than other businesses	IG5
	Workers are facilitated and encouraged to improve their skills	IG6
Social (S)	Business reduces unemployment	S1
	Business reduces crime rates	S2
	Business empowers communities to collect and sort their own waste	S3
	Business successfully manages waste so that it does not cause environmental problems	S4
Environment (E)	Environment around the business is cleaner	E1
	There are no complaints from the surrounding community	E2
	Business does not pollute the air	E3
	Business does not pollute the water	E4
	Business does not pollute the land	E5

Transaction cost economics help e-waste processing businesses to increase their performance, because they can share the cost, for example procurement cost and delivery cost, with other e-waste business (Vlachos, 2016). Environmental impact, green image, health and safety issues, and employment generation opportunities are the key performance indicators for RL decision (Sangwan, 2017). Chaves et al., (2020) RL cycle time and return processing time give positive impact to e-waste processing business. Therefore, the ownership of low-tech machine is needed to improve business performance. RL motivation factors are corporate image, reduced environmental impact, cost reduction, and compliance with legislation (Chaves et al., 2020). Based on the description above, the hypothesis in this research is: models of involvement in RL activities can improve the performance of e-waste processing businesses.

3. Methods

1. Measurement model testing
   In testing the measurement model, it is carried out through three stages, namely:
   a. Convergent Validity, testing is carried out on each indicator of each dimension. Chin (1998) explained that an indicator is declared valid if the factor loading value is greater than 0.70. Chin (1998) also suggested that if this value is less than 0.70, the indicator should be removed.
   b. Construct Reliability and Validity, testing the reliability of the instrument in the research model. An item is reliable if the Cronbach Alpha value is > 0.6 (Bentler & Bonett, 1980). The closer the Cronbach's alpha is to 1, the higher the internal consistency reliability. Composite reliability values of 0.6 – 0.7 are considered to have good reliability (Sarstedt et al., 2021). Testing the average variance extracted (AVE) value which must be greater than 0.50
   c. Discriminant Validity, for testing the discriminant validity, this research uses Fornell Larcker criterion. The Forner Larcker test is a measure that compares the square root of the AVE value with the relationship of latent variables (Fornell & Larcker, 1981). The square root value of each AVE construct must be greater than its correlation value with other constructs.
2. Structural model testing
   There are three steps in structural model testing (Hair Jr et al., 2014), namely:
   a. R-square test, R-square explains how much the endogenous construct can be explained by the exogenous construct. An R square value > 0.75 is included in the strong category, an R square value of 0.50 is included in the moderate category, and an R square value of 0.25 is included in the weak category (Hair et al., 2013).
   b. Goodness of fit, goodness of fit model is determined by the SRMR < 0,08 and NFI > 0,70
   c. P-values and T-test, the final stage is to estimate the path coefficient estimation. T-statistic in the bootstrapping report algorithm > 1,96 and P Value < 0,05 (Hair et al., 2013).

4. Data Collection

With the aim that the research results can be widely used, the data collected is attempted to represent areas indicated for carrying out RL activities on a small and medium scale from previous research plus urban areas with potential for urban mining, such as: South Sulawesi, East Kalimantan, Lampung, Batam and NTB, because it is close to neighboring countries, it is quite prone to becoming a dumping ground for e-waste. The research used 173 samples, all of which were electronic waste processing groups with a turnover of more than 75 million Rupiah (Figure 1).

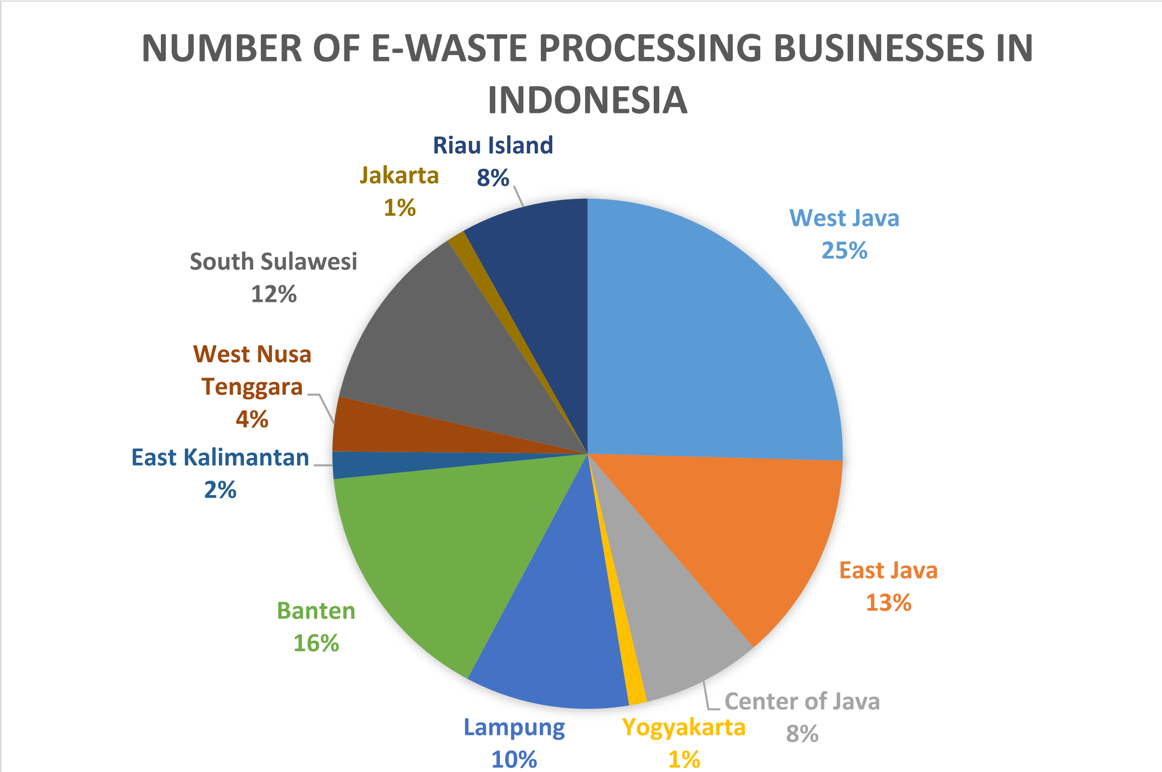

Figure 1. Respondent Data Distribution

5. Results and Discussion

The electronic waste processing business in Indonesia can be categorized into three groups, namely 1) waste collectors from end users, 2) intermediary e-waste business, and 3) electronic waste processors who take valuable materials or metals. The interests and objectives of each business group in carrying out reverse logistics activities are different so that the involvement model that is most likely to be implemented will also differ according to these three business groups. With the reason that the e-waste processing group is the group that is most often claimed to pollute the environment, the researcher chose this group's data for analysis.

5.1 Measurement model testing

5.1.1. Convergent Validity Test

Convergent validity test is conducted by calculating the loading factor each indicator. The loading factor value should more than 0,70 (Hair Jr et al., 2014). In the first running PLS-Algorithm, there is one indicator (E1) with the loading factor value 0,611. Therefore, this indicator was dropped from the model. The final convergent validity test is presented in Figure 2 below.

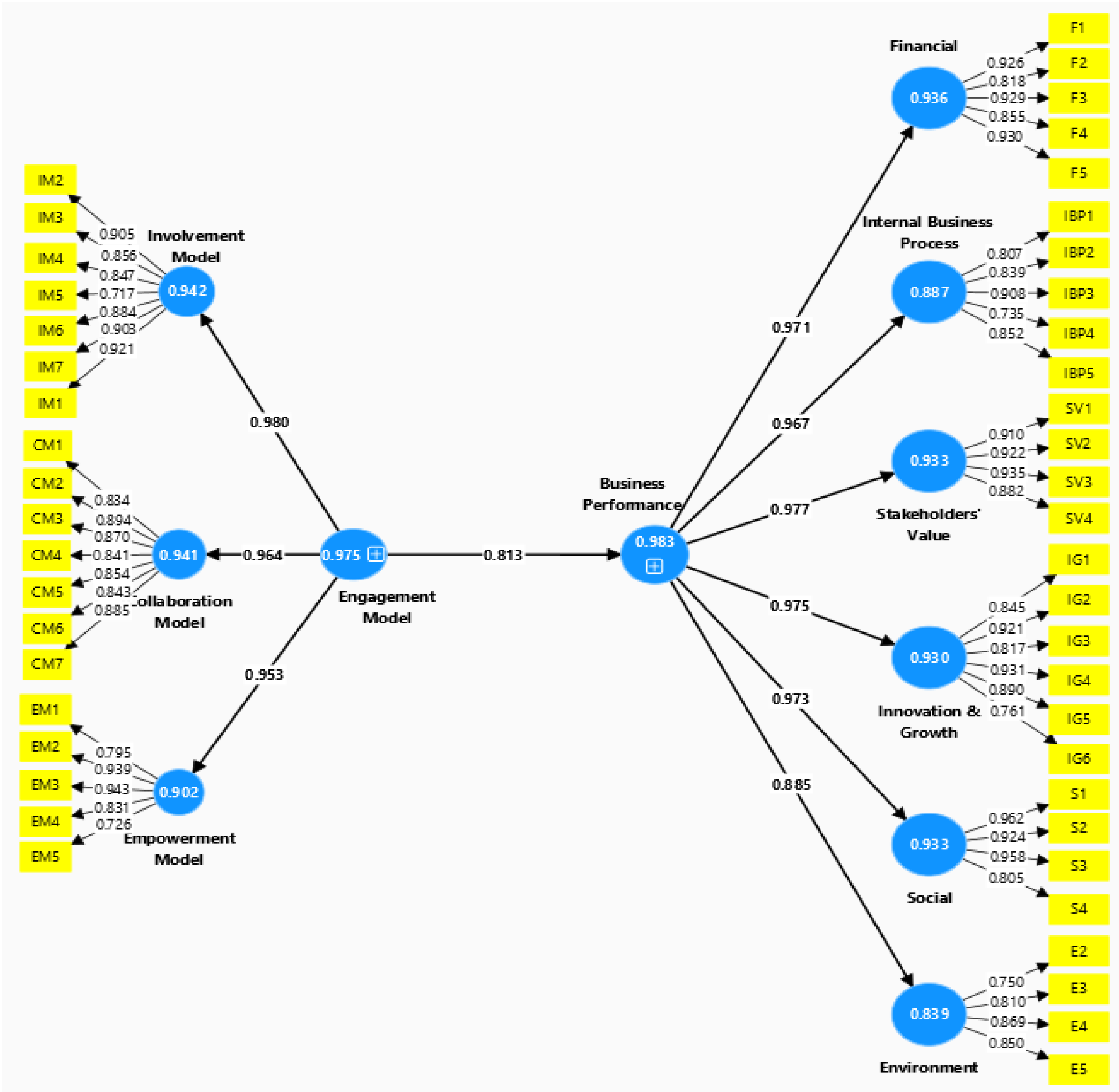

Figure 2. Modified Measurement Model

5.1.2 Construct Reliability and Validity

The reliability testing of the measurement model is done by looking at the Cronbach's Alpha, composite reliability, and AVE values. The Cronbach's alpha and composite reliability values of all dimensions and variables in the study are above 0.60. Likewise, the AVE values of all variables are above 0.50. Thus, all dimensions and variables in this study are reliable as a measurement model (Table 3).

Table 3. Construct Reliability and Validity Test

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)	Results
Business_Performance	0.983	0.986	0.984	0.689	reliable
Collaboration_Model	0.941	0.942	0.952	0.740	reliable
Empowerment_Model	0.902	0.913	0.929	0.724	reliable
Engagement_Model	0.975	0.976	0.977	0.690	reliable
Environment	0.839	0.850	0.892	0.674	reliable
Financial	0.936	0.940	0.951	0.797	reliable
Innovation &_Growth	0.930	0.938	0.946	0.745	reliable
Internal Business _Process	0.887	0.899	0.917	0.690	reliable
Involvement_Model	0.942	0.947	0.954	0.747	reliable
Social	0.933	0.937	0.953	0.836	reliable
Stakeholders'_Value	0.933	0.936	0.952	0.833	reliable

5.1.3 Discriminant Validity Test

Discriminant validity testing was carried out by looking at the results of the Forner Larcker test which are presented in Table 4 below. From Table 4, it is clear that the measurement instrument is valid for use in the next stage. Once it is reliable and valid at the dimensional level, then it is necessary to create a latent variable score which can be done using SmartPLS software. This latent variable score will then be used as a dimension for exogenous and endogenous variables in the second stage.

Table 4. Discriminant Validity - Fornell Larcker

	BP	CM	EM	EgM	E	F	IG	IBP	IM	S	SV
BP	0.830										
CM	0.735	0.910									
EM	0.792	0.759	0.851								
EgM	0.816	0.885	0.752	0.830							
E	0.784	0.608	0.640	0.674	0.821						
F	0.801	0.622	0.737	0.739	0.741	0.911					
IG	0.775	0.751	0.808	0.820	0.808	0.875	0.863				
IBP	0.744	0.690	0.734	0.756	0.716	0.723	0.817	0.868			
IM	0.790	0.822	0.823	0.779	0.653	0.731	0.804	0.733	0.864		
S	0.772	0.670	0.729	0.746	0.763	0.869	0.835	0.752	0.717	0.914	
SV	0.763	0.733	0.771	0.798	0.728	0.785	0.854	0.847	0.766	0.811	0.964

Similar to the loading factor test for indicators, the latent variable score must have a loading value above 0.70. The Cronbach's alpha, composite reliability, and AVE values in the second stage model also meet the requirements (Table 5). To strengthen confidence in the results of the hypothesis testing, the haterotrait monotrait (HTMT) ratio was calculated in the second stage test. The HTMT value in the second stage model meets the requirements (Table 6), which is 0.829 <0.90. Finally, the Forner Larcker test in Table 7 also shows good results. Thus, the model in the second stage meets all the requirements (Figure 3).

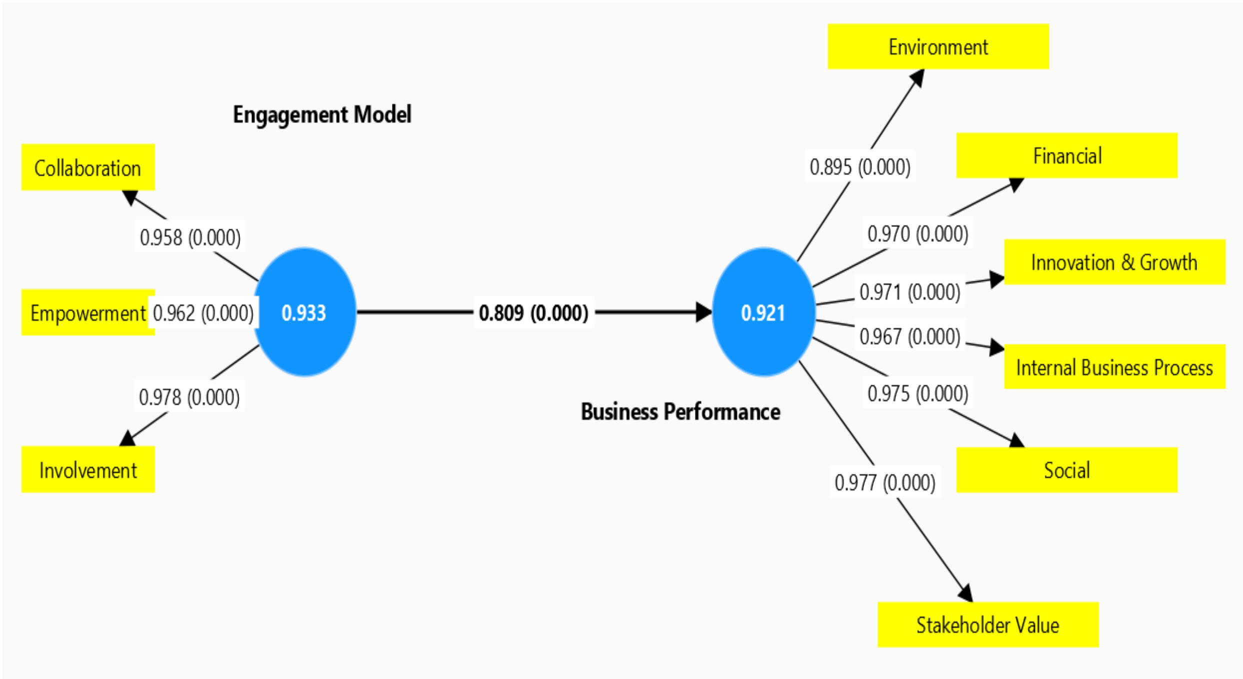

Figure 3. Measurement Model Second Stage

Table 5. Construct Reliability and Validity Second Stage

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Business Performance	0.983	0.986	0.986	0.921
Engagement Model	0.964	0.964	0.977	0.933

Table 6. HTMT Test Second Stage

	Business Performance	Engagement Model
Business Performance		
Engagement Model	0.829	

Table 7. Forner Larcker Test

	Business Performance	Engagement Model
Business Performance	0.959	
Engagement Model	0.809	0.966

5.2 Structural Model Testing

5.2.1 R-Square

The first step in testing the structural model is to calculate the R-square value, which is also a goodness-fit test in the inner model of PLS SEM. R-square assesses how much the endogenous construct can be explained by the exogenous construct. The R-square calculation result in Table 8 show that 65,5% business performance variable is explained by engagement model. The 34.5% of business performance variability remains are explained by other variables not measured in this research. Therefore, additional exogenous variables such as regulatory policies, market competition, and consumer awareness should be considered to enrich the model.

Table 8. R-square dan R-Square Adjusted

	R-square	**R-square adjusted**	**Results**
Business_Performance	0.655	0.651	Moderate

5.2.2 Goodness of Fit

A high R-Square value does not guarantee a fit model to measure the influence of exogenous constructs on endogenous constructs. Therefore, it is still necessary to conduct a goodness of fit test by calculating the SRMR and NFI. Based on the results shown in Table 9, the SRMR value is 0.027 < 0.08 and the NFI is 0.948 > 0.70. Thus, the research model is truly fit and the final stage, path coefficient estimation, can be carried out, by looking at the P-values and T-values.

Table 9. Model Fit Test

	Saturated Model	Estimated Model
SRMR	0.027	0.027
d_ULS	0.034	0.034
d_G	0.145	0.145
Chi-square	77.838	77.838
NFI	0.948	0.948

5.2.3 Path Coefficient Estimation

From Table 10, it can be explained that the engagement model has a positive and significant effect on business performance of 80.9%. This means, if the e-waste processing business applies predetermined engagement models (involvement, collaboration, empowerment), then business performance as measured by financial, internal business processes, innovation and growth, stakeholders' value, social and environmental will increase.

Table 10. Path Coefficient - Second Stage

	Original sample (O)	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	**P values**
Engagement Model -> Business Performance	0.809	0.797	0.076	10.660	0.000

6. Conclusion

This study aims to prove that the engagement of e-waste processing businesses in the form of involvement, collaboration, and empowerment when running reverse logistics activities can improve business performance. The business objectives of seeking profit, protecting the environment, and providing a positive social impact are sought to be balanced by all business actors. Some of them are also trying to reduce direct contact by independently making traditional component e-waste shredding machines. Although there is one indicator of the environmental dimension that must be removed from the model. The existence of a business is identical with a dirty and messy place. However, the results of the structural model second stage testing have proven that the engagement model has a large and significant positive influence on the performance of e-waste processing businesses.

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