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THE IMPACT OF REVERSE LOGISTICS ON ENVIRONMENTAL SUSTAINABILITY PERFORMANCE

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Abstract - Environmental sustainability has been obtaining a lot of spotlight since the world has undergone resource pressure, air and waste pollution. Under such circumstances, legislation for environment protection has been issued; from economic perspective of company, make their product recyclable will give them an economical edge in face of competition in the market. Due to these concerns, Logistics is no exception in the business world. Some environment friendly oriented concepts or functions have been added to logistics, such as green logistics and reverse logistics. Reverse logisticsas a new business concept was developed for recapturing values from end of supply chain, which involves activities from recycle, remanufacture to final disposal such as landfill. The purpose of this research is to understand reverse logistics processes in automotive industry, the drivers and barriers implementing the reverse logistics, and then analyze impact of the indicators in reverse logistics such as time, cost, technology and green consciousness on the environmental sustainability. To conduct this research, hypotheses are proposed based on previous studies and findings, then a quantitative approach (PLS-SEM) is applied with web-based survey; primary data is collected from social media LinkedIn and Tencent. The analysis of indicators' impact on environmental sustainability was accomplished by formulating hypotheses and path model in SmartPLS, as well as result assessment. This research is also limited by some conditions, which will also be mentioned together with further research work.

Keywords - Automotive Industry, Reverse Logistics, Recycling, Environmental Sustainability, Quantitative Approach, PLS-SEM (Partial Least Square-Structural Equation Modeling)

I. INTRODUCTION

In a world of finite resources and disposal capacities, recovery of used products and materials is by default a considerable way to support a growing population at an increasing level of consumption. At the disposal side, waste reduction already became a major concern for the human society, and recycling products or materials seems inevitable to replace the common one-way perception of economy and customers are expecting companies to minimize the environmental impact through their whole production process. Companies realized that they have to combine both the environment consideration and their growing economical insight[1].

Compared to traditional logistics operation, the reverse logistics could be simply described as the movement of materials/products/service backward from downstream to the upstream including the handling of the goods along the supply chain[2].In comparison with forward supply chain, the forward inventory is consistent and uniform, while on the other hand, backward supply chain seems dynamic and unpredictable. In general, Products come backward to the origin manufacturer, where it is produced, in a different condition like new, open box, used (damaged/good) and there is very limited information for manufacturer to forecast which items will be returned[3].

As nowadays' forward logistics of automobile industry has been developed to certain extent, In Germany, more than 40 million passenger cars and light-commercial vehicles were registered, this number is being in a roll of change as new cars and used cars are registered or deregistered. Around 8 million passenger cars and light-commercial vehicles are decommissioned each year, among 3 million motor vehicles are permanently deregistered every year. However, not all of these cars are ELVs but used cars that a large share of them were exported to other EU member states and registered there, and the rest share exported to non-EU countries. The number of ELVs permanently deregistered annually in 2009 was approximate 500000 of those 3 million motor vehicles[4]. According to different car manufacturers, 3PL companies are getting more concerned about the car forward logistics. However, with the mature of automotive consumer market competition, innovation and the rise of global environmental awareness, the car reverse logistics must be given due attention as well[5].

II. LITERATURE REVIEW

A. Reverse logistics

"Logistics *is the part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption in order to meet customers* 'requirement"[6]. By the evolution of logistics and demand for sustainable environment ,Reverse logistics comes into sight as a "*The process of planning, implementing, and controlling the efficient, cost*

effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal."[7].Based on this definition, Reverse logistics can begin with distributors and retailers as well as within the organization where production waste or side material of products can be recollected and reused. Therefore, reverse logistics can be seen as the process where materials are collected within the organization, either from retailers and distributors as well as customers with the purpose of regaining value and proper disposal to improve economic advantages, corporate image and reduce negative environment impacts[8].

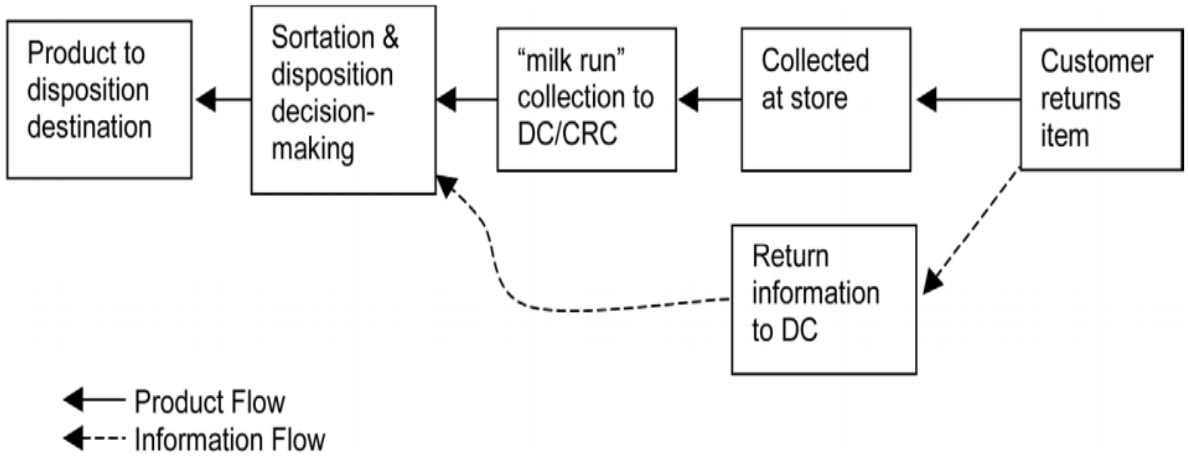

Fig.1Reverse logistics process[7].

B. Drivers behind reverse logistics

Factors such as economics, environmental legislation and environmental consciousness of consumers that drives the reverse logistics have been pointed out by many authors[9].The typology driving forces can be categorized.

- *Economics reasons*
- Direct gains
- (Input materials, cost reduction, value-added recovery)
- Indirect gains
- (Green image, improved relation with customer/supplier)
- *Legislation*
- Consumer rights
- Pro-environmental
- *Corporate citizenship*
- Extended responsibility to society

C. Reverse logistics activities

Material	Reverse Logistics Activities
Products	Return to supplier
	Resell
	Sell via outlet
	Salvage
	Recondition
	Refurbish
	Remanufacture
	Reclaim Materials
	Recycle
	Donate
	Landfill
Packaging	Reuse
	Refurbish
	Reclaim Materials
	Recycling
	Salvage
	Landfill

Table I. Reverse logistics activities[10].

D. Component of reverse logistics system

- *Customer*
  - Expectation from customer, what are specific features (quality, reliability) they want to have on the recycled or remanufactured product.
  - Customer's awareness regarding the potential economic / noneconomic benefits[11].
- *Cost/benefit analysis*
  - Through company's financial report and its costing system, company should figure out how the balance within its reverse activities [11].
- *Transportation*
  - Transportation is the key component limits the performance of a logistics system in aspects, such as returned locations and network, intermodal transport.
- *Warehousing*
  - In the consideration of warehousing the returned products/parts/materials, company

needs to figure out the required space for returns and handling process relatively, whether rent or self-owned.

- *Supply management*
  - Reuse of the returned products/materials/parts will reduce the use and cost of raw material, and eventually change the bill of material in the supply chain.
- *Remanufacturing /recycling*
  - Current manufacturing process of capability and technology will largely influence returned products' time, quantity and quality after remanufacturing.
- *Packaging*
  - Packaging is initially a market tool to enhance the product image and provide certain product information, it also consists of the cost of a product and the customer's perception about product. Packaging in RL would provide more than such characters and also serve the transport requirement and able to return purpose[11].

E. Reverse "green "logistics

"Green logistics" connects the environmental concern with logistic activities. This concept ties environmental and economic efficiency to logistics by trying to reduce the impact of the sector on the environment. Due to such purpose, institutions attempt to be more eco-conscious while companies undergoing their activities at the lowest cost possible. International legislation has already been introduced to some extent, in order to reduce pollution[12]. The reverse logistics is considered to be one component of the definition "green logistics"

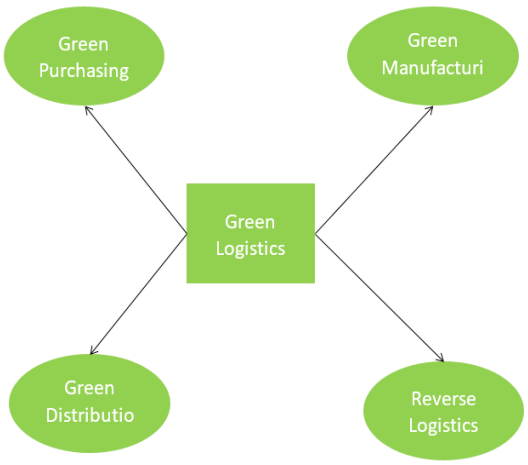

Fig.2 Components of Green logistics*(12)*

F. Environment sustainability

- *Natural resources*

Each year humans are using 30% more natural resources than the planet can replenish. This leads to deforestation, degraded soils, polluted air and water, and dramatic declines in numbers of fish and other species. Also, resources that are not renewable and cannot be replenished are being exhausted rapidly.

The exploitation of resources is concentrated upstream in the Supply Chain. To be sustainable more emphasis is being laid on using natural resources less and more efficient and shifting focus to (more) renewable resources where possible. This will, however, not always be possible without an increase in monetary costs[13].

- *Energy consumption*

Energy consumption can be defined as the net fuel-energy that is needed to provide the heat and power requirements for a process. The inputs of these processes include natural gas, fuel oil, steam and electricity[13].

- *Gas emissions*

Emissions can be divided in two parts: Toxic emissions and pollutant emissions. Toxic emissions come from chemicals that are listed by governmental institutions and should be reported to state authorities. The other part is pollutant emissions. These are emissions that in some way influence the environment, but are not toxic by definition. They lead to, for example: air acidification, water eutrophication, ozone depletion, acidification of fresh water, and salinity in freshwater. One of the pollutant emissions can be further narrowed into greenhouse gas emissions. They result from the generation of electricity or stream. The primary greenhouse gases are carbon dioxide, methane, nitrous oxide and ozone [13].

- *Waste generation*

The European union's approach to waste management is based on "waste hierarchy" which puts priority order on shaping waste policy and managing waste at operational level: prevention, reuse, recycling, recovery and disposal which includes landfill and incineration without energy recovery. Priorities for the waste policy in the EU are as followed:

- Minimum waste amount;
- Make the best use of recycling and reuse;
- Limitation on non-recyclable materials;
- Landfill to non-recyclable and non-recoverable waste[14].

G. Reverse logistics in automotive industry

Automotive reverse logistics refers to the logistics operation taken for auto, resources and information from the downstream (customer) to upstream (recycle enterprise or manufacturer) in order to fulfill the need of waste disposal and environment protection[14].The recycling process for end of life vehicle (ELV) goes in automotive reverse logistics though main four steps:

1. Draining

Before starting any recovery process, all vehicles need to go through a draining process in order to remove fluids like oil, fuel, coolants etc. this draining process aims to avoid the danger of harmful or toxic substances spilling in the dismantling process and protect the shredder material from being contaminated

and thus lose the latter sales value and a rise of disposal expense[15].

2. Component disassembly

ELV parts are expected to serve as spare parts and have a significant resale value, which will be disassembled first, most of parts come from accident vehicles or middle-aged ELV[15].

3. Material disassembly

After the profitable disassembly process, it is followed by valuable material recovery. Component parts which lose their reselling value, but remains with material value will be dissembled, such as PVC from wiring harness or platinum from converters[15].

4. Shredding

The last procedure for recovering the value of an ELV is shredding in order to get metal fraction. The cannibalized ELV with the remaining material, which is basically fluff has no recovering value left from plastics, glasses will be sent to landfill[15].

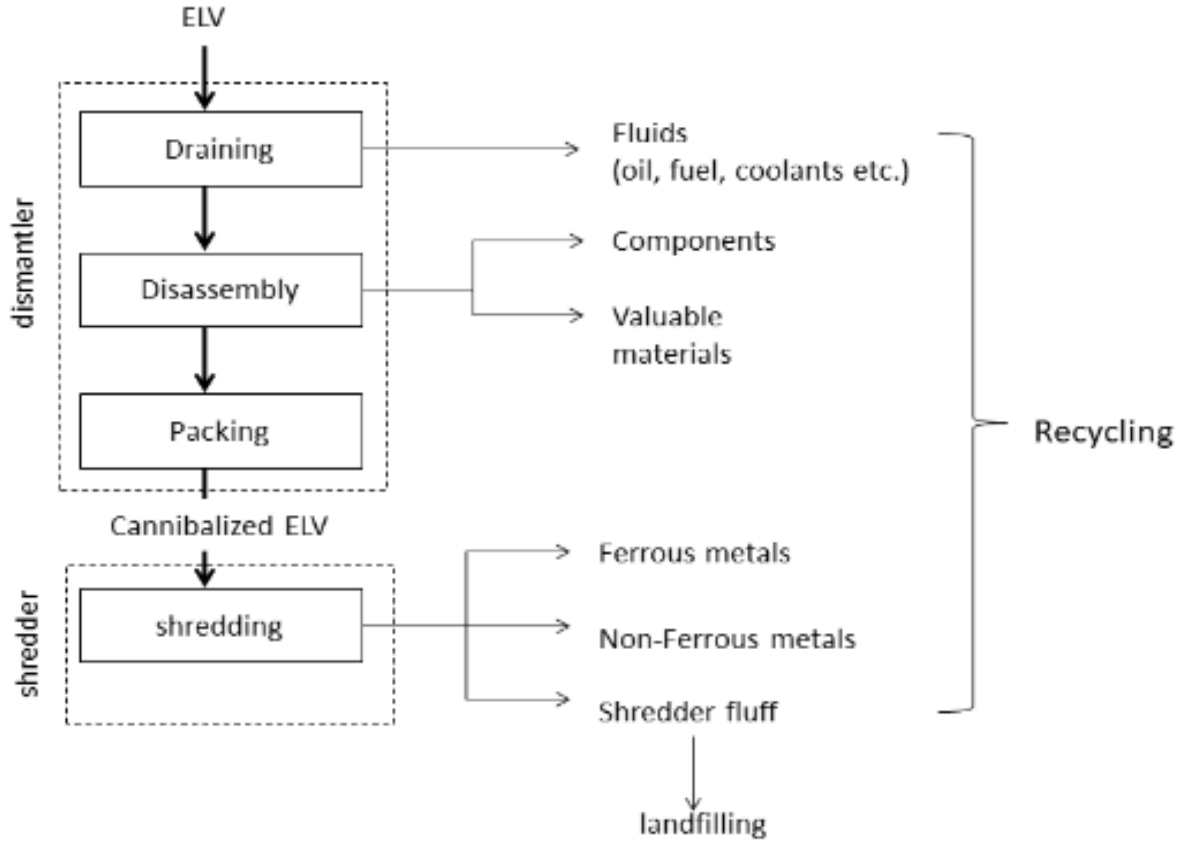

Fig.3 Recycling process for ELV in automotive industry[15].

H. Challenges of reverse logistics in automobile industry

Implementing the reverse logistics in automobile industry has been facing many challenges in many ways.

- *Lack of control in the collection phase*

Lack of control over quantity, quality and timing of the returned products generates the uncertainties, Reflection of the uncertain life of a product, Product life cycle stage and the rate of technological change, the dispose behavior, which results in a stochastic return pattern. Regarding quantity, quality and timing of the returned products are the main challenges for the collection phase of the remanufacturing system. The uncertainty in timing and quantity of the returned products also make the remanufacturing process less predictable than an ordinary manufacturing process. All companies do not try to balance the supply with demand since the uncertainties in supply and demand makes inventory management and control functions more complicated[16].

- *Willingness to Pay*

One of the most important challenges highlighting the use of reverse logistics is the minimum willingness to pay for remanufactured products. Consumers generally have a hypothesis or prejudice that remanufactured products are not as effective and useful as newly manufactured products[16].

- *Cannibalization*

Remanufacturing of old products basically means cannibalize the sales of new products, if the customers are convinced to purchase the remanufactured products. This situation is likely to lead to the companies unable to sell their new products[16].

III. RESEARCH METHODOLOGY

Research methodology is defined as a scientific and systematic process for searching answers on a certain topic. The research result is well built on setting up the research hypotheses and applying suitable research approach.

A. Research model and hypotheses

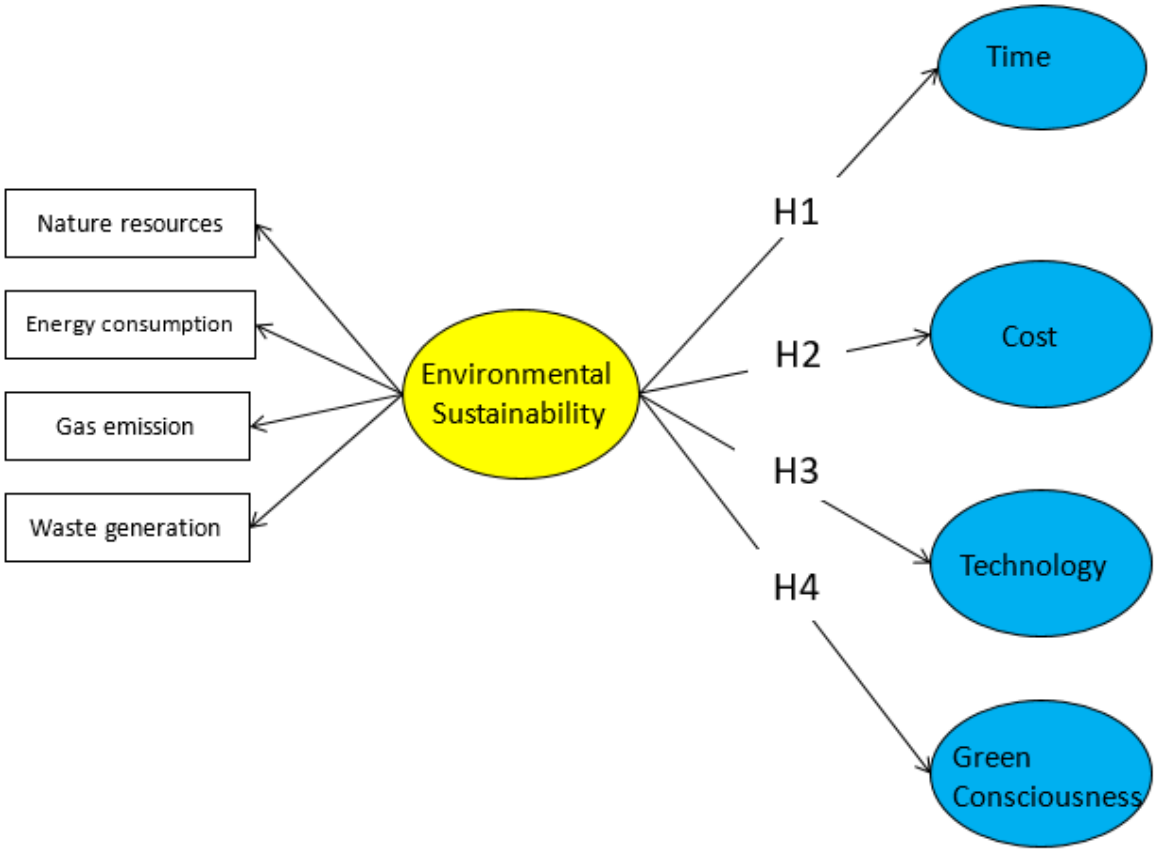

Fig.4 Research model (Self-illustration)

In Fig.4 presented research model that is interrelations of environmental sustainability performance with reverse logistics indicators i.e. time, cost, technology and green consciousness used for hypotheses testing and statistical analysis.

- *Time indicators*
  - Storage period.
  - Remanufacturing time.
  - Delivery time.
  - Disposal time[17].
- *Cost indicators*
  - Greening cost.
  - Storage cost.
  - Delivery cost.
  - Disposal cost.
  - Remanufacturing cost[17].
- *Technology indicators*
  - Information tech/management level.
  - Greening equipment/technique.
  - Packaging[17].
- *Green consciousness indicators*
  - Green culture.
  - Green innovation.
  - Customer green awareness [17].

So, hypotheses are:

1. H1: Time plays a positive role impacting the environmental sustainability performance.
2. H2: Cost plays a positive role impacting the environmental sustainability performance.
3. H3: Technology plays a positive role impacting the environmental sustainability performance.
4. H4: Green consciousness plays a positive role impacting the environmental sustainability performance

B. Quantitative approach

"*Quantitative research is an approach for testing objective theories by examining the relationship among variables*."[18].Quantitative research is derived from previous theory, and then establishes model with dependent variables, and then find out the effects on the independent variables. Quantitative approach also has other features compared to qualitative approach more suitable to this research for developing hypotheses, and conducting research to

test the hypotheses, such as applying deductive approach, high level of measurement, allowing researcher in distance with respondents.

Since this study needs to employ specific data to test the theory that already exists and to gain enough amount of feedback from the respondents in distance, quantitative seems a more suitable method. So, after comparing the research features with content of the study; a quantitative research will be applied to my research.

C. Data collection

There are two kinds of data source could be used for research purpose, primary data and secondary data. After comparison between two data sources in Table , it is known that primary data is time consuming, but applicable for a relative more accurate reliable research result.

Aspects	Primary data	Secondary data
Data aging	Real time	Past
Source	Surveys ,experiments, observations, questionnaire, interviews ,etc.	Publications,articles, websites,internal records,etc
Time consumption	Long	Short
Accuracy and reliability	More	Relative less
Access to data	Hard	Easy

Table II Comparison between primary data and secondary data[19].

- **Survey and questionnaire**

As in Table II, in general, primary data can be obtained from survey and experiment. In this research, a web-based survey is conducted, due to the widely respondents' group and easy to access advantages. The data collection is conveyed by a questionnaire which is commonly applied to conduct descriptive research. To design a qualified questionnaire, Google form is a free and open platform and the designed questionnaire can be sent to respondent media such as LinkedIn and Tencent for respondents via a generated link. And the respondents must be qualified from automotive or logistics industry. Some disadvantages are also need to be considered, which is time consuming and poor response rate.

For the questionnaire, it consists of 3 sections 11 questions in total, first of the question is a confidentiality claim so that respondents know that the answers they give will be only used for this research purpose. And 1-section: basic questions regarding the respondents themselves, such company size and business area.2-section: literature review questions such as reasons and barriers to adopt the reverse logistics in your company. 3-section: a question regarding the hypothesis's indicators. The measurement method for these constructs is 5-point Likert-scale as in III.

Likert		Points
Very relevant	Strongly agree	5
Relevant	Agree	4
Neutral	Neutral	3
Irrelevant	Disagree	2
Completely irrelevant	Strongly disagree	1

Table III Likert-scale (self-illustration)

D. Structural equation modeling (SEM)

Structural Equation Modeling (SEM) allows researchers to assess the overall fit of a model as well as test the research model all together. Using SEM, it does not only evaluate the hypothesized structural linkages among variables but also the linkages that exist between a variable and its respective measures[20].Common techniques are Partial least square SEM (PLS-SEM) and covariance-based SEM (CB-SEM), PLS-SEM's main objective is to maximize the covariance between the predictor latent variable and dependent latent variable, while to minimize the differences between the sample covariance and those predicted by the theoretical model. This research focuses on links between latent variables and the impact these variables have on the environmental sustainability performance. So PLS-SEM is selected technique to analyze the research model.

A PLS-SEM model consists of measurement model and the structural model. Measurement model connects the entire observed variable with the latent variables as the outer model measuring the outer relations and the structural model links the variables together as the inner model testing the hypotheses of this research[20].

- ***Model assessment***

The research model is analyzed in SmartPLSof 3rd generation. and according to the sample size requirement for running the PLS-SEM is "10 times rule " which require a sample size larger than maximal links number pointing at the latent variable[20],in this research ,the maximum number is 5 at the cost indictor, so actually 56 feedbacks in total are collected for running SmartPLS.

The criterion for assessing the measurement model is shown in Table IV

Model type	Assessment type	Criteria	Guidlines
measurement model	Internal Consistency Reliability (ICR	Cronbach's alpha /composite reliability	CA>0.7,CR>0.7,
	convergent Validity	Average variance extracted (AVE)	AVE>0.5
		liability indicators	outer loadings>0.7
	Discriminant Validity	heterotrait-monotrait tratio (HTMT)	should not contain the value 1 for any constructs combined in the model and an HTMT value above 0.9 also indicated a lack of discriminant validity
structural model	model validity	Path coefficients	Values between -1 and +1,more close to +1 means more positive relations and vice versa
		Coefficient of determination	The level of R^2 values, measures relationship of latent variables in term of explained variance to its total variance, set between 0 and 1

Table IV model assessment criteria [20].

The measurement model is evaluated by internal consistency reliability, convergent validity and discriminant validity. The structural model assessment must follow the measurement model and the test result of path coefficients and value of R^2 can reflect the results for the hypotheses testing.

IV. RESULTS DISCUSSION

A. Observation results

The basic information regarding the respondents, among 56 responds, as they have already been firstly categorized by certain criteria, the company scale and business role,

Basic information from Questionnaire		Quantity	Percentage
Business role	Logistics service provider	22	39%
	Manufacturer	21	38%
	Retailer	11	20%
	Others	2	4%
Company scale	1-100	18	32%
	101-500	15	27%
	501-1000	7	13%
	more than 1000	16	29%

Table V respondents' category (self-illustration)

- *Reasons implementing reverse logistics*

From the feedback of 56 respondents, they mostly agree that company will adopt the reverse logistics because of customer satisfaction, while the Policy/regulatory have a rather lower score of 3.3 in likert-scale, indicates the company is less driven out of this concern.

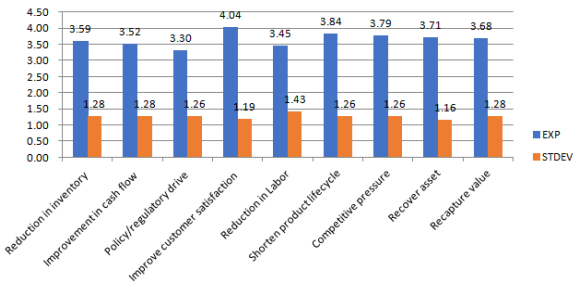

Fig.5 reasons from survey result

- *Barriers from implementing reverse logistics*

From the survey result shown in Fig.6 , we can see that Lack of information system and management together with lack of experience or knowledge reflects the same importance (3.93-agree by Likert scale) as barriers from implementing RL for a company. Lack of information system and management together with lack of experience or knowledge reflects the same importance (3.93-agree by Likert scale) as barriers from implementing RL for a company.

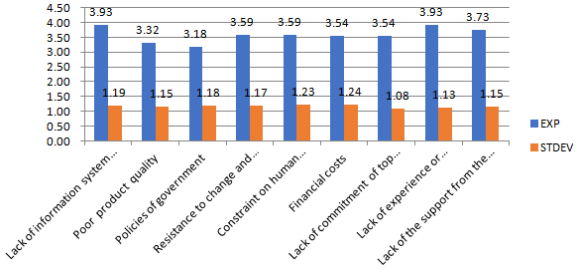

Fig.6 Barriers from survey result

B. Model assessment and hypotheses testing

- *Measurement model assessment*

The results of Cronbach's alpha, composite reliability, Average Variance Extracted (AVE) and outer loadings are shown in **Error! Reference source not found.**V. The composite reliability of each construct for this study ranges from 0.754 to 0.934which is more than the recommended threshold 0.7. Thus, the results indicate that the variables used to represent the construct have satisfactory internal consistency reliability. AVE value ranges from 0.515 to 0.786, which is also more than the threshold 0.5. The outer loadings in the results table shows that delivery cost, packaging, storage period and delivery time have lower value under the threshold 0.7.and since the CR and AVE are both above their respective field, so deleting this 4 indicators will not cause any increase in internal consistency reliability, and these 4 indicators are valid for this research, so these 4 indicators will be retained in the research. This result shows that the

study's measurement model has demonstrated an adequate convergent validity[20].

constructs	variables	outer loadings	CR	CA	Average Variance Extracted (AVE)
Environmental sustainability	Improve Raw material usage	0.775	0.934	0.917	0. 669
	Improve Energy usage	0.815			
	Improve Resource recycling efficiency	0.849			
	Reduction in energy/water consumption	0.819			
	Reduction in air emission	0.828			
	Reduction in waste generation	0.877			
	Reduction in packaging	0.757			
Cost	Greening cost	0.791	0. 863	0. 803	0. 56
	Storage cost	0.789			
	Delivery cost	0.577			
	Disposal cost	0.753			
	Remanufacturing cost	0.806			
Green consciousness	Green culture	0.91	0. 917	0. 864	0.786
	Green innovation	0.887			
	Customer green awareness	0.862			
Technology	Information Tech/management level	0.763	0. 754	0. 506	0. 515
	Greening equipment/technique	0.838			
	Packaging	0.509			
Time	Storage period	0.652	0. 811	0. 695	0. 519
	Remanufacturing time	0.782			
	Delivery time	0.677			
	Disposal time	0.764			

Table VI measurement model assessment (generated in SmartPLS)

To determine the assessment of measurement model's discriminant validity, in this research, Discriminant validity will be assessed by heterotrait-monotrait tratio (HTMT), when the confidence interval of HTMT does not contain 1 for any constructs, then the discriminant validity is satisfied.

	Cost	Environmental sustainability	Green consciousness	Technology
Environmental sustainability	0.664			
Green consciousness	0.635	0.439		
Technology	1.092	0.931	1.024	
Time	1.013	0.864	0.788	1.124

Table VII Discriminant validity (generated in SmartPLS)

From

VI, we can see that for constructs technology and time ,they have contained value 1 in their confidence interval, which indicates they could be explained by other constructs, so a detailed check over the constructs technology and time ,we can see, that variables "packaging" could be possible combined with the green equipment/technique, and for the construct "time", the delivery time and storage period are well explained by the cost variables "delivery cost "and "storage cost", so these 3 variables can be deleted , so that the constructs are distinct from each other.

	Cost	Environmental sustainability	Green consciousnes	Technology
Environmental sustainability	0.664			
Green consciousness	0.635	0.439		
Technology	0.818	0.733	0.703	
Time	0.712	0.766	0.459	0.716

Table VIII discriminant validity after modification (generated in SmartPLS)

After the modification, the discriminant validity is satisfied according to the previous threshold. Overall, the reliability and validity tests conducted on the measurement model are satisfactory, the indicators can fit in the model. And it can be used for the structural model assessment.

- *Structural model assessment*

The validity of the structural model is assessed by the coefficient of determination (R^2) and path coefficients.

The coefficient of Determination represents the combined effects of exogenous latent variables on the endogenous latent variables, R^2 ranges from 0 to 1, and the higher levels indicating higher levels of predictive accuracy.[20]In this study, the value of R^2 is obtained from SmartPLS algorithm function, path coefficients are generated from SmartPLS bootstrapping function. For this study, the bootstrapping generated 5000 samples from 56feedbacks. The result of the structural model with R^2 values of indicators like time, cost, technology, time, green consciousness is presented in

	R Square	R Square Adjusted
Cost	0.368	0.356
Green consciousness	0.157	0.141
Technology	0.344	0.332
Time	0.404	0.393

Table VIII.

	R Square	R Square Adjusted
Cost	0.368	0.356
Green consciousness	0.157	0.141
Technology	0.344	0.332
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Table IX the coefficient of determination (generated in SmartPLS)

From

	R Square	R Square Adjusted
Cost	0.368	0.356
Green consciousness	0.157	0.141
Technology	0.344	0.332
Time	0.404	0.393

Table VIII, the time, cost, technology and green consciousness can explain the environmental sustainability in percentage as 35.6%, 14.1%,33.2% and 39.3%.

The path coefficients represent the proposed hypotheses, with the T statistics, 1.65 at significance level 10%, 1.96 at significance level 5%, 2.57 at 1%.from **Error! Reference source not found.**IX, we can see that all T statistics are more than 2.57, so all indicators are at significant level of 1%.

	T Statistics	path coefficients
Environmental sustainability -> Cost	8.536	0.606
Environmental sustainability -> Green consciousness	2.595	0.396
Environmental sustainability -> Technology	6.128	0.587
Environmental sustainability -> Time	8.85	0.635

Table X Path coefficients (generated in SmartPLS)

The path coefficient result allows researcher to confirm or reject hypotheses and understand the strength of relations between the latent variables as presented in Fig.7.

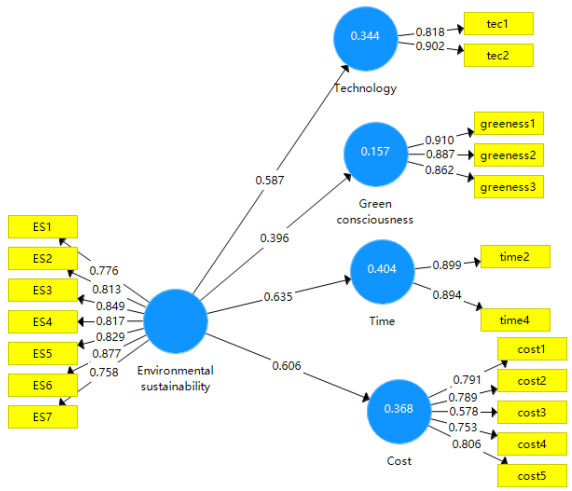

Fig.7 Result of structural model (generated in SmartPLS)

- *Hypothesis testing*

Based on **Error! Reference source not found.**IX the assessment result of path coefficients, we can see that all path coefficients are between -1 and +1, have a significant level of 1%, according to previous studies, in

	Hypotheses	Path coefficients	Results
H1	Time plays a positive role impacting the environmental sustainability performance	0.635	supported
H2	Cost plays a positive role impacting the environmental sustainability performance	0.606	supported
H3	Technology plays a positive role impacting the environmental sustainability performance	0.587	supported
H4	Green consciousness plays a positive role impacting the environmental sustainability performance	0.396	supported

Table X, the environment sustainability performance is significant and positively impacted by the indicators ,thus the hypotheses are supported by the result.

	Hypotheses	Path coefficients	Results
H1	Time plays a positive role impacting the environmental sustainability performance	0.635	supported
H2	Cost plays a positive role impacting the environmental sustainability performance	0.606	supported
H3	Technology plays a positive role impacting the environmental sustainability performance	0.587	supported
H4	Green consciousness plays a positive role impacting the environmental sustainability performance	0.396	supported

Table XI hypotheses testing (self-illustration)

And in comparison, within the hypotheses, green consciousness plays a rather weaker impact on the environmental sustainability with the lowest Path coefficient value (0.396). While time is still considered to be the most important factor (0.635) among these four factors impacting the environment performance.

V. CONCLUSION

The purpose of the research is to analyze the impact of the reverse logistics on the environmental sustainability. To realize this purpose, literature review on the previous study was firstly conducted in the field of reverse logistics, environmental sustainability and the practice in the automotive industry.

A research model and hypotheses were established based on the literature review.4 factors: time, cost, technology and green consciousness of reverse logistics were proposed to evaluate its impact on environmental sustainability. Then a quantitative method was applied to test the model and hypotheses .In this process, the primary data was selected and collected by a questionnaire, designated based on previous studies in Google form and was then posted online to social media: LinkedIn and Tencent, where respondents in area of logistics and automotive industry were asked questions in Likert scale: 1 – completely irrelevant/strongly disagree to 5 – very relevant/ strongly agree. The technique adopted to analyze the model was PLS-SEM, the sample size required at a minimum of 10 times of max number of links to the latent variable ,so the sample size must be over 50 .After 2 weeks collection, 56 pieces of questionnaire were collected and then analyzed by SmartPLS, to improve the customer satisfactory was by no surprise most convincing reason for a company to adopt the reverse logistics in the automotive industry, while lack of experience and information system among the respondents were widely considered to keep back the company to adopt the reverse logistics.

The rest data acquired from questionnaire were assessed in SmartPLS, in two parts: measurement model and structural model, in the measurement model assessment, internal consistency reliability (ICR) was assessed by composite reliability and Cronbach's alpha; convergent validity was assessed by average variance extracted(AVE) and indicator liability, which were all matched with the criterions. But according to the test result of discriminant validity, the indicator Packaging was moved to the category of green equipment/technique, and in factor, time, the

indicator storage period and delivery time were deleted because they can be correlated with the indicator storage cost and delivery cost in the cost category. After the modification in the measurement model, Path coefficients and T statistics were collected for assessing the structural model and draw the testing result of the hypotheses.

All the four hypotheses were supported by the Path coefficients at the significant level of 1%. Time plays the most important role in impacting the environmental sustainability performance while the green consciousness is considered the less important factor.

FUTURE WORK AND LIMITATIONS

There are several limitations in the research. First, the indicators in this research were limited to 4 factors, but certainly there will be more indicators a researcher can find in more studies to analyze the impact of reverse logistics on the environmental sustainability; another limitation was due to the time consuming of collecting the questionnaire and the respondents professional feedback, it would be perfect to collect as many feedback as possible among the experts or professionals face to face. Nowadays the environment issues are discussed in many industries, to make the environment more sustainable seems to be a universal agreement, and since this research focused on the reverse logistics, but along the big picture such as supply chain, there must be some intriguing area for the future study.

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