INCORPORATING QUALITY ASSESSMENT IN REVERSE LOGISTICS- FIRM PERFORMANCE AND SUSTAINABILITY PERSPECTIVE.

[1]Abdul Salam Khan, [2]Khawar Naeem, [2]Abdul Fattah
[1]LCFC, Ecole Nationale Suerieure d'Arts et Metiers, 4 Rue Augustin Frensel, Metz, 57078, France. abdul_salam.khan@ensam.eu
+33674140051
[2]University of Engineering & Technology, Peshawar, KPK, Pakistan.
Khawar89@gmail.com, mechengr2801@gmail.com.

ABSTRACT: *Manufacturing enterprises are opting for new strategies and technologies to accommodate the client-base requirement. A typical modern day manufacturing unit deals with multiple requirements from different stakeholders regarding the usability of the product. Customer demands appropriate quality while there is an ever-increasing pressure from governments to mitigate the negative environmental footprints of production especially when the product completes its useful life. In this study, an understanding of the recovery mode of salvaged items through reverse logistics is outlined and impact analysis of quality assessment in reverse logistics is performed on sustainable production and firm performance. We use structure equation modeling for the analysis and direct, indirect and total effects of independent variables are examined on dependent variables. We conclude the study by providing key directions for future research.*

Keywords: Quality, Reverse Logistics, Sustainable Production, Firm Performance

INTRODUCTION

In a production system environment, due to increased competition and customer's obligations, enterprises are held responsible for entire product life cycle. A product enters into End-Of-Life (EOL) stage once it completes its intended tasks for stipulated tenure. Reverse Logistics (RL) is concerned with the retrieval of EOL products. Reverse Logistics (RL) is defined as "movement of goods from a consumer towards a producer in a channel of distribution" [1]. Previously, the emphasis on RL originated as a result of awareness in the customers regarding green production environment [2] followed by an active stewardship role of government such as in the case of Waste Electrical and Electronic Equipment [3] and other demonstrated examples from Canada, Japan and the US [4][5]. A RL supply chain is marked differently from a Forward supply chain in the sense that in a forward supply chain, material moves from a common junction (raw materials acquisition from supplier) where the material is treated in the same process flow while in RL, material is collected from customers, at different points & in different life cycle stages [6]. At times, both supply chain works in parallel while at other times, there are dedicated supply chains for either Forward Loop or a Reverse Loop. One example of a combined (both forward & reverse) supply chain is given below in Figure 1 [7].

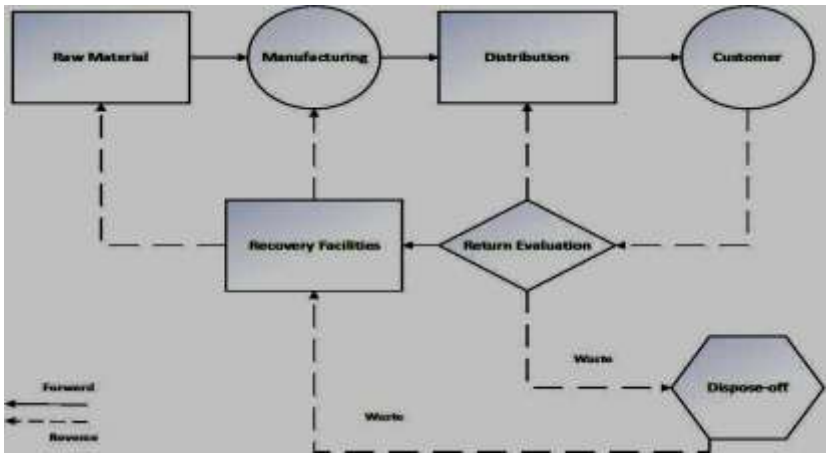

Figure 1. Combined Forward and Reverse Logistics [7].

Raw material is acquired from two sources; one being supplier while another is the returned items through reverse logistics. Return evaluation is performed to assess the usability of the return product and one of three decisions is made. Product is sent to recovery facilities where maximum value/energy is extracted, after minor adjustment it is sent to distribution channel and/or it is disposed-off without considering any of the above options. In literature, focus is more diverted to importance of quality assessment in a Forward supply chain. However, there is a growing emphasis on quality assessment in a reverse loop supply chain [6]. Time based quality assessment is important in a reverse supply chain as it can help in reducing the amount of waste produced and sequentially can impact on the performance of an enterprise [8]. In this research study, we discuss the impact of quality assessment in the context of reverse logistics and its impact on firm performance and sustainable production. We also empirically investigate the impact of sustainable

production on firm performance. In the next section, we describe theoretical foundation for each study hypothesis.

Reverse Logistics and Quality Assessment

In reverse logistics also known as closed loop supply chain, quality is more problematic as there are multiple categories and uncertainties associated with quality in reverse logistics [6]. It needs to be a business practice to develop value of information in enterprises regarding quality [9]. A reverse logistics supply chain would be more robust and effective if quality assessment criteria are employed. It is through networks and association within an enterprise and with outside partners to employ quality evaluation criteria for reverse logistics [10]. In this study, we are positing that quality assessment criteria, once adopted in reverse logistics would enhance the efficiency of the system. According to the measurement scheme, efficiency of the RL system is described as asset recovery, handling of processes and integrating information. We hypothesize that;

H_0: Quality Assessment does not impact Reverse Logistics

H_1: Quality Assessment has a positive on Reverse Logistics

Quality Assessment and Sustainable Production

In contemporary businesses, there is a huge responsibility on the part of an enterprise to be more socially responsible and engage in green, lean and clean production [11]. Sustainable production entails a Triple Bottom Line (TBL) approach which outlines a strategy for Profit, People and Planet. According to research, if products are not reversed in a close loop supply chain, they can add to environmental degradation and decrease in profitability. Enterprises need to produce not only new products for sustainability but also need to employ a reverse logistics strategy such as in Automotive Industry [12]. In a research study in Brazil, small industries are focused for application of sustainable reverse logistics and the findings are generalized to multiple contexts [13]. However, there is no study that considers the relationship (reverse logistics and quality assessment) impact on sustainable practices. We hypothesize that considering reverse logistics, a quality assessment strategy would enhance the sustainable production. Accordingly,

H_0: Quality Assessment does not impact Sustainable Production in the context of Reverse Logistics

H_2: Quality Assessment has a positive impact on Sustainable Production in the context of Reverse Logistics

Quality Assessment and Firm performance

Application of quality assessment criteria can help controlling waste, re-work, tool wear and labor cost. If quality of repair is improved then it would help increasing trustworthiness in the eye of customer. Also, there would be improvement in product recovery; dispatching and profitability would increase [14]. We hypothesize that;

H_0: Quality Assessment does not impact Firm Performance in the context of Reverse Logistics

H_3: Quality Assessment has a positive impact on Firm Performance in the context of Reverse Logistics

Sustainable Production and Firm Performance

Sustainable production means a facility employed to optimize the use of resources. From enterprise viewpoint, resources are manpower, raw material, energy, tools, machines and their optimal assignment and usage can save enterprise money. Also, doing things right in the first attempt enhances enterprise reputation in the market. A re-defined supply chain and social monitoring in reverse logistics can improve firm performance [10][13]. We posit that in reverse logistic supply chain, sustainable production impacts firm performance positively. Accordingly;

H_0: Sustainable Production does not impact Firm Performance in the context of Reverse Logistics

H_4: Sustainable Production has a positive impact on Firm Performance in the context of Reverse Logistics

MATERIAL AND METHODS

In this study, quantitative empirical analysis is performed for assessing the impact of quality on reverse logistics. A sample of 100 respondents was drawn from European countries (Sweden & France) and from Pakistan. The nature of business from where the sample was drawn pertained to manufacturing, fabrics, automotive and chemical. Table 1 below exhibits hierarchical position and specialization of the respondents. In order to have holistic perspectives, we drew sample from all tiers of organizational hierarchy. Similarly, diversity was maintained in the specialization of the respondents as the research framework was.

Table1. Respondents Profile (n=100)

Characteristic	**Count**
Nature of Business	
Manufacturing	40
Fabrics	15
Automotive	15
Chemical	30
Position	
CEO	20
Manager	43
Shop-Floor employee	37
Specialization	
Quality	25
Engineering	40
Marketing	15
Business	20

touching upon multiple congruent of the business environment

A five (5) point Likert scale questionnaire was devised for measuring the constructs. Measurement scheme for all constructs is provided in Table 2. Scales for measures were borrowed from established literature and an expert study was performed for validation of the constructs. Two logistics experts and two academicians were consulted for this purpose and the measurement scheme was verified for "all scales of variables are converging and they are measuring what they are intending to measure" [9] with a positive consent of the experts.

Measurement Scheme

In our research framework, reverse logistics was an independent variable while firm performance was a dependent variable. However, both quality assessment and sustainable production served as independent as well as dependent variables. Reverse logistics measure was borrowed from the study[15] and it is measured as the efficiency of the employed system in recovering value from salvaged items, process design (handling) of the rework and remanufacturing of the recovered items and integrating information regarding quality and condition of the products returned. Similarly, quality assessment tool measures the quality of repair, level of returns to be accommodated for repair and compliance by partners with the agreed condition of quality. Sustainable practices are defined as developments that meet needs of today without a compromise on the resources of tomorrow [16] and they are measured in compliance with Triple Bottom Line (TBL) approach [17]. Triple Bottom Line approach is a supply chain phenomenon that not only served well in the traditional era of manufacturing and distribution but also, it is proving equally helpful in current vision of Industry 4.0. Lastly, firm performance in this context is measured in terms of improvement in affiliation with customer base, recovering products, profitability and reduction in inventory costs. Thus, firm performance largely covers non-monetary aspects which are long term objectives of any successful business but also, in firm performance measures, costs considerations encompasses firm near sighted and short term performance objectives.

Table2. Measurement Scheme for the Theoretical Framework

Factor	Measurement Scheme	Reference
Reverse Logistics (RL)	Recovery of Assets Handling Re-manufacturing Routing Integrating Return Information	[15]
Quality Assessment (QA)	Quality of Repair Level of returns allowed Vendor's compliance with buying agreement	[15]
Sustainable Production (SP)	Environmental Monitoring Product & Process development Social Monitoring Supply Chain Re-definition	[18]
Firm Performance (FP)	Improved Customer Relations Improvement in Recovery of Products Improved Profitability Reduced Investment in Inventory	[15]

Non-Response

As the survey results were acquired, an analysis was performed by comparing the results of early responses with the latest responses to understand if any differences existed between the two extreme responses [19]. The results of non-response t-test revealed that there was no statistical difference between early and late responses with a p-value of 0.134. Overall 100 questionnaires were distributed and 87 were returned in which there were some missing cases and incomplete survey. After removal of the problematic responses, total of 78 questionnaires were considered for the analysis with a response rate of 78%.

RESULTS

In order to justify inclusion of scales and contextual importance of questions being asked, a pilot study was conducted by distributing the questionnaire to 20 post-graduate students. In order for a scale to be reliable, the Chronbach alpha value needs to be above the threshold of 0.7 [20]. We ran through internal consistency tests for the pilot study data as well as for real time data. Chronbach's values for pilot study are mentioned in brackets in Table 3. We can identify that all factors had an internal consistency measure above the limit of 0.7. Table below shows number of items (questions) in each factor as well as the range of correlation.

Table3. Internal Consistency Results

Factors	Items	Chronbach Alpha	Range of correlation
RL	5	0.76 (0.72)	0.42-0.61
QA	4	0.79 (0.75)	0.43-0.68
SP	4	0.71 (0.76)	0.41-0.58
FP	3	0.86 (0.78)	0.60-0.74

Next, we analyzed the model fit statistics for the latent constructs using structure equation modeling in AMOS. The chi-square ratio is 2.467, while values of CFI, NNFI and RMSEA are 0.932, 0.948 and 0.042, respectively which are above the threshold values [21]. RMSEA is a fit index that tells us about the fit of the chosen parameters with the population covariance [22]. Cut-off value for RMSEA is 0.06 and any value below it would represent good fitness of the model data [23]. Comparative Fit Index (CFI) is a fit index that considers the sample size and a value of CFI above 0.95 is considered to be a good indicator of model fit [24]. Values of SRMR and GFI needs to be less than 0.05 [24] and greater than 0.90 [25], respectively. All the measurement indices are in the suggested control limits which mean that measurement model is valid and it exhibits good fit.

Table4. Fit Statistic for Measurement Model of the latent constructs

Parameter	Estimate	Reference Value
χ^2 (degree of freedom)	214.65(87)	----------
χ^2/degree of freedom)	2.467	<= 3
CFI	0.932	>=0.9
Bonnett's NNFI	0.948	>=0.9
RMSEA	0.042	<=0.08
SRMR	0.02	<=0.05
GFI	0.03	<=0.05

In order to have more robust measurement framework, last check was performed on discriminant validity assessment by incorporating two approaches which are cross-loading and Fornell Larcker method [26]. Cross loading test suggested that the loadings did-not exceed the indicators loading. Secondly, Fornell Larcker requires that square root of AVE for individual construct should be larger than its highest correlation with rest of the constructs [27]. Both tests suggested that data on hand qualifies for discriminant validity assessment.

Table5. Discriminant Validity (Fornell Larcker Criteria)

	RL	QA	SP	FP
RL	**0.768**			
QA	0.714	**0.854**		
SP	0.638	0.752	**0.772**	
FP	0.702	0.689	0.742	**0.901**

Table 6 below contains results of the hypotheses. Hypothesis 1 was to establish relationship between reverse logistics and quality assessment for which the co-efficient of relationship is 0.496 and is significant at 5 percent (t-value= 8.261, $p<0.05$). Also, hypothesis 2 carried a relationship between quality assessment and sustainable production for which the strength of relationship co-efficient is 0.478 significant at 1 percent (t-value = 9.416, $p<0.001$). Similarly, co-efficient of relationship is 0.328 for hypothesis 3 which prescribed a relationship between quality assessment and firm performance and it is significant at 5 percent (t-value= 2.954, $p<0.05$). Lastly, in hypothesis 4 we established that there is a significant impact of sustainable production on firm performance which is significant at 5 percent with relationship co-efficient equals 0.385 (t-value= 3.312, $p<0.05$)

Table6. Findings of the research study

Hypothesis	Original Sample	Sample Mean	Standard Error	T-Value	Outcome
H_1 RL → QA	0.496**	0.492	0.065	8.261	Supported
H_2 QA → SP	0.478***	0.479	0.087	9.416	Supported
H_3 QA → FP	0.328**	0.316	0.133	2.954	Supported
H_4 SP → FP	0.385**	0.381	0.092	3.312	Supported

** $p< 0.05$, *** $p<0.01$

Figure 2 below exhibits the SEM (Structure Equation Modeling) results of individual hypothesis. Here we can observe that all of the effects are direct in nature. For instance, direct effect of reverse logistics on quality assessment is 0.496. However, we need to estimate the in-direct effects of all independent variables. Reverse logistics has an in-direct effect on sustainable production and firm performance. Similarly, quality assessment has an in-direct effect on firm performance via sustainable production. We can conclude that the in-direct effect of reverse logistics on sustainable production is 0.2370, in-direct effect on firm performance via sustainable practices is 0.0912 while in-direct effect on firm performance via quality assessment is 0.1626. Lastly, in-direct effect of quality assessment on firm performance via sustainable production is 0.184.

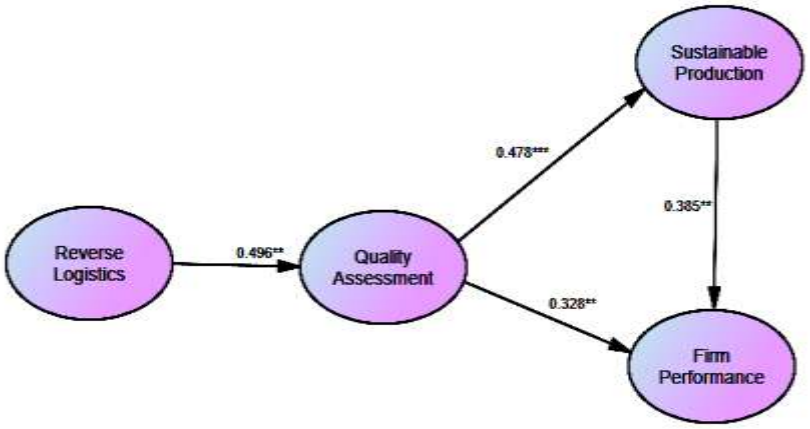

Figure2. Structure Equation Modeling (SEM) result of the framework

DISCUSSION

In this study, we established a hypothetical relationship between quality assessment in revere logistics and firm-performance. A notion of sustainable production was brought to have more rigor and meaningful insights from the study. In reverse logistics context, understanding the importance of quality assessment has always been a bottleneck for managers. This study is first of its kind that takes upon the conceptual framework and validates it through empirical quantitative techniques. As can be seen in Figure 2, there are two kinds of relationships between variables, direct as well as in-direct relationships. Table 7 below contains all the direct, in-direct and total effects of the study variables. Of all, reverse logistics has a strong co-efficient of relationship with quality assessment (0.496) which means that inclusion of the quality assessment parameter in this context is important and relevant. Similarly, we can see that quality assessment has an impact and relationship with both sustainable production and firm performance and the strongest co-efficient of determination in this study is between quality assessment and firm performance (0.512). Lastly, sustainable production has a good in-direct role between quality assessment and firm performance. Overall, we met all study hypotheses and it can be concluded that reverse logistics in the presence of quality assessment has a positive and significant impact on sustainable production and firm performance.

Table7. Overall study results

Variable	Target Variable	Direct Effect	In-Direct Effect	Total Effect
Reverse Logistics	Quality Assessment	0.496	--------	0.496
	Sustainable Production	-------	0.237	0.237
	Firm Performance	-------	0.163	0.163
Quality Assessment	Sustainable Production	0.478	-------	0.478
	Firm Performance	0.328	0.184	0.512
Sustainable Production	Firm Performance	0.385	-------	0.385

RECOMMENDATIONS

This study can serve as an empirical guide for managers and a new research stream for researchers. We have following recommendations for future investigation.

First, data was collected from both Europe and Pakistan and it was analyzed together. Future research can establish a comparison study between both regions to understand contextual differences in the reverse logistics environment. Second, this study is performed in single snapshot of time (cross-sectional).In order to generalize through induction; data at multiple points in time can be analyzed for more robust results. Third, in this research framework, quality assessment served as a perfect mediator between reverse logistics on one end and sustainable production and firm performance on another. It would be interesting to consider the role of quality assessment as a moderator and then result indices can be compared for more prominent role of quality. Lastly, results of this study can be replicated in a different study area to understand contextual differences. This might help including further variables such as government role, quality culture and some control variables such as business size, investment in quality and business reputation.

REFERENCES

1. Murphy, Paul R. and Richard P. Poist (1989), "Management of Logistical Retro-movements: An Empirical Analysis of Literature Suggestions," Transportation Research Forum, Vol. 29, No. 1, pp. 177-84
2. Dowlatshahi, S. H. A. D. (2010). A cost-benefit analysis for the design and implementation of reverse logistics systems: case studies approach. *International Journal of Production Research*, *48*(5), 1361-1380.
3. Georgiadis, P., & Athanasiou, E. (2010). The impact of two-product joint lifecycles on capacity planning of

remanufacturing networks. *European Journal of Operational Research*, *202*(2), 420-433.

4. Quariguasi Frota Neto, J., Walther, G., Bloemhof, J. A. E. E., Van Nunen, J. A. E. E., & Spengler, T. (2010). From closed-loop to sustainable supply chains: the WEEE case. *International Journal of Production Research*, *48*(15), 4463-4481.
5. Ferguson, M., Fleischmann, M., & Souza, G. (2008). Applying revenue management to the reverse supply chain.
6. Zikopoulos, C., & Tagaras, G. (2015). Reverse supply chains: Effects of collection network and returns classification on profitability. *European Journal of Operational Research*, *246*(2), 435-449.
7. Tonanont, A., Yimsiri, S., Jitpitaklert, W., & Rogers, K. J. (2008, January). Performance evaluation in reverse logistics with data envelopment analysis. In *IIE Annual Conference. Proceedings* (p. 764). Institute of Industrial and Systems Engineers (IISE).
8. Guide Jr, V. D. R., Souza, G. C., Van Wassenhove, L. N., & Blackburn, J. D. (2006). Time value of commercial product returns. *Management Science*, *52*(8), 1200-1214.
9. DeVellis, R. F. (2016). *Scale development: Theory and applications* (Vol. 26). Sage publications.
10. Souza, G. C. (2013). Closed-loop supply chains: a critical review, and future research. *Decision Sciences*, *44*(1), 7-38.
11. Jayaraman, V. (2006). Production planning for closed-loop supply chains with product recovery and reuse: an analytical approach. *International Journal of Production Research*, *44*(5), 981-998.
12. [Subramoniam, R., Huisingh, D., Chinnam, R. B., & Subramoniam, S. (2013). Remanufacturing Decision-Making Framework (RDMF): research validation using the analytical hierarchical process. *Journal of Cleaner Production*, *40*, 212-220.
13. Seitz, M. A. (2007). A critical assessment of motives for product recovery: the case of engine remanufacturing. *Journal of Cleaner Production*, *15*(11-12), 1147-1157.
14. Baenas, J. M. H., De Castro, R., Battistelle, R. A. G., & Junior, J. A. G. (2011). A study of reverse logistics flow management in vehicle battery industries in the midwest of the state of São Paulo (Brazil). *Journal of Cleaner Production*, *19*(2-3), 168-172.
15. Autry, C. W., Daugherty, P. J., & Glenn Richey, R. (2001). The challenge of reverse logistics in catalog retailing. *International Journal of Physical Distribution & Logistics Management*, *31*(1), 26-37.
16. Glover, J. L., Champion, D., Daniels, K. J., & Dainty, A. J. D. (2014). An Institutional Theory perspective on sustainable practices across the dairy supply chain. *International Journal of Production Economics*, *152*, 102-111.
17. Hussain, N., Rigoni, U., & Orij, R. P. (2018). Corporate governance and sustainability performance: Analysis of triple bottom line performance. *Journal of Business Ethics*, *149*(2), 411-432.
18. Marshall, D., McCarthy, L., Heavey, C., & McGrath, P. (2015). Environmental and social supply chain management sustainability practices: construct development and measurement. *Production Planning & Control*, *26*(8), 673-690.
19. Armstrong, J. S., & Overton, T. S. (1977). Estimating nonresponse bias in mail surveys. *Journal of marketing research*, 396-402.
20. Culliton, S. E., Bryant, D. M., MacDonald, S. J., Hibbert, K. M., & Chesworth, B. M. (2018). Validity and Internal Consistency of the New Knee Society Knee Scoring System. *Clinical Orthopaedics and Related Research®*, *476*(1), 77-84.
21. Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological bulletin*, *107*(2), 238.
22. Byrne, B.M. (1998), Structural Equation Modeling with LISREL, PRELIS and SIMPLIS: Basic Concepts, Applications and Programming. Mahwah, New Jersey: Lawrence Erlbaum Associates.
23. Steiger, J.H. (2007), "Understanding the limitations of global fit assessment in structural equation modeling," Personality and Individual Differences, 42 (5), 893-98.
24. Hu, L.T. and Bentler, P.M. (1999), "Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives," Structural Equation Modeling, 6 (1), 1-55.
25. Tabachnick, B.G. and Fidell, L.S. (2007), Using Multivariate Statistics (5th ed.). New York: Allyn and Bacon.
26. Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. *Journal of marketing research*, 382-388.
27. Henseler, J., Dijkstra, T. K., Sarstedt, M., Ringle, C. M., Diamantopoulos, A., Straub, D. W., ... & Calantone, R. J. (2014). Common beliefs and reality about PLS: Comments on Rönkkö and Evermann (2013). *Organizational Research Methods*, *17*(2), 182-209.