EVALUATION OF EOL/USED CELL PHONES MANAGEMENT & DISPOSAL ALTERNATIVES: AN ANP AND BALANCED SCORECARD APPROACH

By

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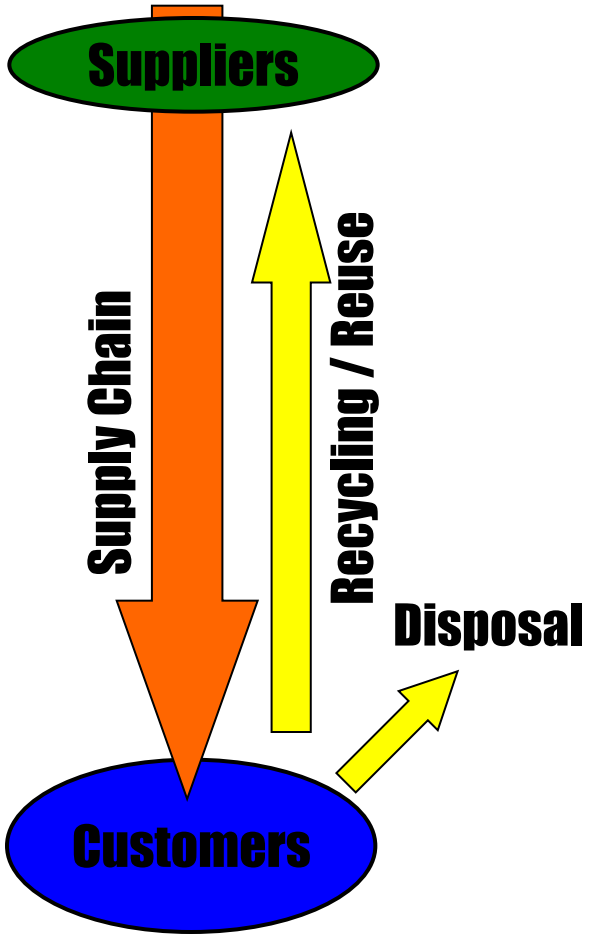
OUTLINES OF PRESENTATION

- Introduction
- Issues in mobile phone remanufacturing
- Mobile phone remanufacturing process chain
- Reverse logistics
- The decision environment
- Application of ANP Methodology
- Balance Score Card
- Discussion and managerial implications
- Conclusions

REVERSE SUPPLY CHAIN MANAGEMENT

Reverse supply chain management (RSCM) is defined as the effective and efficient management of the series of activities required to retrieve a product from a customer and either dispose of it or recover value.

REVERSE LOGISTICS



- Management of reduction and disposal
- Reverse distribution
  - Collection of damaged or unsold products.
  - Recycling of used products.
  - The manufacturer takes responsibility for delivery as well as take-back.
- Two reverse channels
  - Recycling / reuse (back to the suppliers).
  - Disposal (shipment of non-recyclable waste).

REVERSE LOGISTICS……

- A reverse logistics system comprises a series of activities, which form a continuous process to treat return products until they are properly recovered or disposed of.
- These activities include collection, cleaning, disassembly, test and sorting, storages, transport, and recovery operations.
- The latter can also be represented as one or a combination of several main recovery options, like reuse, repair, refurbishing, remanufacturing, cannibalization and recycling[3-5]

REASONS FOR RETURNING USED PRODUCTS

- ***End-of-Life Returns*.** These are returns that are taken back from the market to avoid environmental or commercial damage. These used products are often returned as a result of take back laws.
- ***End-of-Use Returns.*** These are used products or components that have been returned after customer use. These used products are normally traded on an aftermarket or being remanufactured.
- ***Commercial Returns*.** These returns are linked to the sales process. Other reasons for the returns include problems with products under warranty, damage during transport or

  Product recalls.
- ***Re-Usable Components***. These returns are related to consumption, use or distribution of the main product. The common characteristic is that they are not part of the product itself, but contain and/or carry the actual product; an example for this kind of return is remanufactured toner cartridges [14].

REVERSE LOGISTICS DRIVERS

- In the last decades, economic, legislative and social engaging incentives have driven industrial sectors and governments to become active in reverse logistics.
- Economic incentives, because the implementation of reverse logistics represents direct incomes from reduced consumption of raw-materials, from adding value to recovered material and from cost reduction on waste treatment and/or disposal.
- Legislative incentives, because the recent legislation addressing take-back responsibilities, recycling quotas and packaging regulations, that must be accomplished by companies. The engagement of companies with society and environmental issues also can generate incentives to manage return flows in a supply chain.
- Marketing, competitiveness and strategic issues are other incentives for companies to become active in reverse logistics. All incentives are not mutually exclusive and might be present as a mixture in one industrial sector[10].

REVERSE LOGISTICS PRACTICES IN INDIA

- Today, India is the fourth largest country in terms of purchasing power parity (PPP) and constitutes one of the fastest growing markets in the world [5]. However, RL is yet to receive the desired attention and is generally carried out by the unorganized sector for some recyclable materials such as paper and aluminum.
- Some companies in consumer durables and automobile sectors have introduced exchange offers to tap customers who already own such products. The returned products are sold either as it is or after refurbishment by third parties. Ravi et al (2005) opine that reverse logistics, which is the ability to handle customer returns in one of the major challenges faced by the Indian industries.
- The concerns to the environment have increased in the recent times with many Indian companies adopting ISO 14000 practices in their organization.
- Also, legislations (E-Waste, Handling & Disposal Rules, 2012) has been implemented gradually for proper disposal of products for the cause of environmental concern. Thus reverse logistics is an issue which holds a great relevance for India companies.

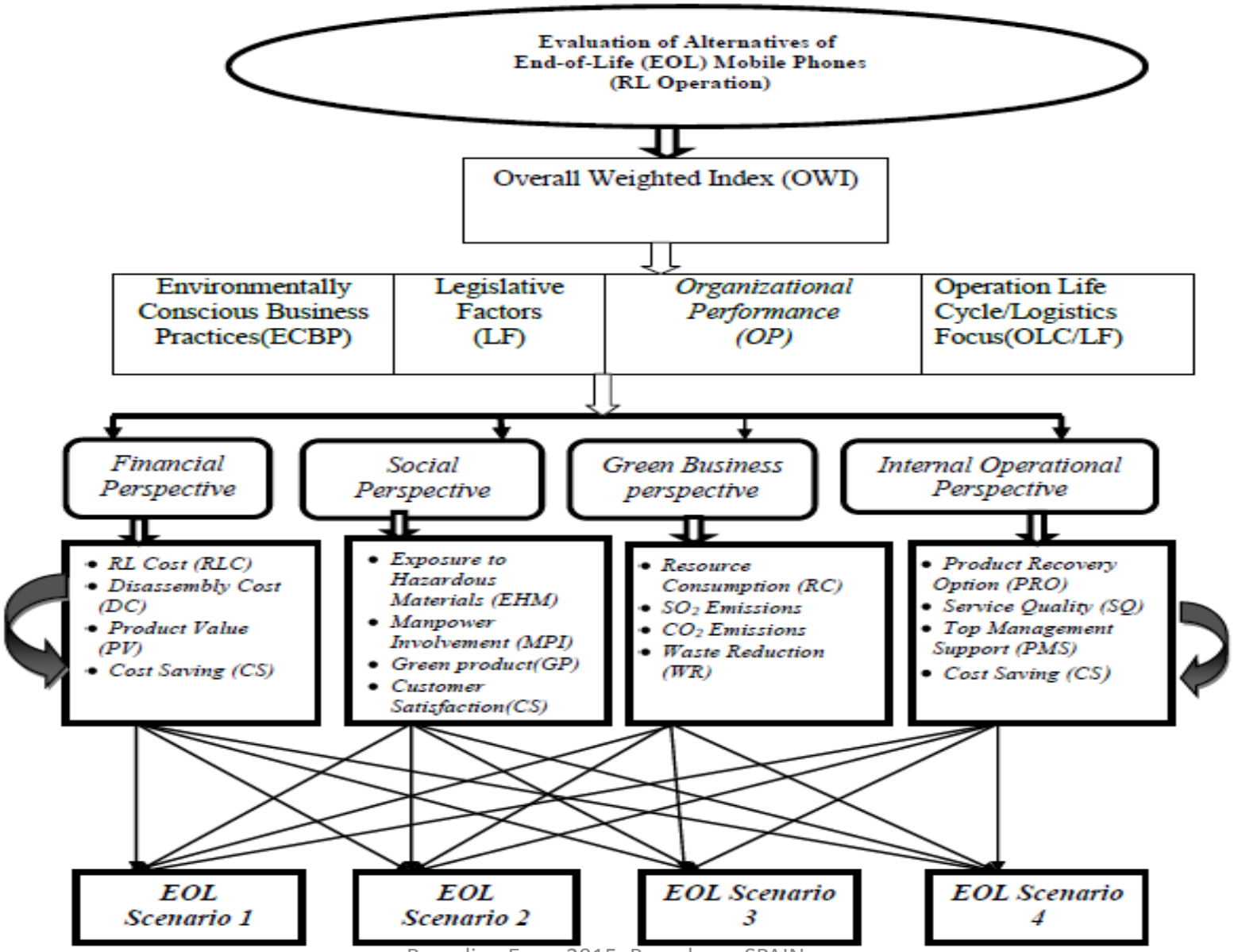
PROBLEM EXPLANATION

- Present work focused on the end-of-life options market for cell phones, and considered Indian legislations as well as global design trends that affect the economic and environmental outcomes of various management schemes.
- The management of electronic waste is emerging as a global environmental problem due to the hazardous materials contained in electronic products and increasing consumption of these products. Cell phones are a unique niche in the e-waste stream not only because of their high rate of displacement by consumers, but also because they have viable reuse and recycling markets.
- The main objective of this work is to recommend an optimal end-of-life (EOL) management strategy/option for cell phones within the Indian business environment.
- In the present work five end-of-life management options for mobile phones has been considered:
- Repair, Refurbishing & Reuse (RRR),
- Cannibalization, Remanufacturing & Reuse (CRR),
- Incineration with energy recovery for most of the elements & disposal to landfill for a few elements (INC),
- Recycling of complete mobile phone for material recovery (REC) and :
- Disposal of Whole Product to Landfill (LND).
- Data was collected and analyzed in order to quantify the environmental and economic outcomes of the current market situation. Based on a literature survey, interview process and mobile phones industries field study, the key variables were determined and used to construct five scenarios which examine the market outcomes under different conditions using analytic network process analysis (ANP).

REVERSE LOGISTICS PRACTICES FOR EOL MOBILE PHONES: A CASE STUDY

- The ANP model that is presented in this research has been evaluated for mobile phones manufacturing/remanufacturing industries, these industries were interested in the implementation of the reverse logistics operations for used mobile phones.
- Due to the limited budget constraints, the industries wanted a systematic way to determine the best possible option for conducting the reverse logistics operations to used mobile phones.
- The case experience helps us to understand in a better way the advantages and disadvantages of the methodology from a practical point of view. The analysis and the implementation of the ANP model are presented in the following nine steps.

ANP Model for Reverse Logistics Operations for EOL Mobile phones



REMANUFACTURING STRATEGIES

- SCENARIO 1: Repair, Refurbishing & Reuse (RRR) of Mobile Phone
- SCENARIO 2: Cannibalization, Remanufacturing & Reuse (CRR) of Mobile Phone
- SCENARIO3: Incineration with energy recovery (INC) for most of the elements & disposal to landfill for a few elements of the mobile phone
- SCENARIO4: Recycling of complete mobile phone for material recovery (REC)
- SCENARIO 5: Disposal of Whole Product to Landfill (LND)

ANALYTIC NETWORK PROCESS (ANP)MODEL

- Analytic network process (ANP) based decision model presented in this work structures the problem related to options in reverse logistics for EOL mobile phones in a hierarchical form and links the determinants, dimensions, and enablers of the reverse logistics with alternatives available to the decision maker.
- In the proposed model, uncertainties regarding quantity and conditions of mobile phones, reliability of capacities, processing times, and demand are considered. The few dimensions of reverse logistics for the EOL mobile phones have been taken from four perspectives derived from balanced scorecard approach, viz. finance, social, green business and internal operational perspective.
- The present approach links the financial and non-financial, tangible and intangible, internal and external factors, thus providing a holistic framework for the selection of an alternative for the reverse logistics operations for EOL cell phones. Many criteria, sub-criteria, determinants, etc. for the selection of reverse manufacturing options are interrelated.
- The ability of ANP to consider interdependencies among and between levels of decision attributes makes it an attractive multi-criteria decision-making tool. Thus, a combination of balanced scorecard and ANP-based approach proposed in this work provides a more realistic and accurate representation of the problem for conducting remanufacturing logistics operations for EOL cell phones.

BALANCE SCORECARD APPROACH

In the present work author inherit the few dimensions of the balanced score card, which allow the managers to look at the business from four important perspectives, namely, financial perspective, social perspectives, green business perspective and internal operation business perspectives (Kaplan & Norton, 1992). Although Kaplan & Norton has been used the concept of balanced scorecard primarily designed for the measurement of the system performance, in present model, we have used these dimensions to evolve a holistic framework towards the conduct of reverse logistics operations for EOL mobile phones

Table Data Collection for the EOL Scenario Evaluation for Mobile Phones

Attributes (For Non-tangible attributes) : on 1-5 scale:1for very high, 5 for very low)	**S1**	**S2**	**S3**	**S4**	**S5** Due to legislation restrictions, this scenario is not possible, hence eliminated.
Reverse Logistics Cost (Rs.)	75	85	65	70	
Disassembly Cost (Rs.)	200	300	300	350	---------
Product Value	1	2	3	1	--------
Product Cost	4	3	4	2	---------
Manpower Involvement	3	2	4	1	----------
Exposure to Hazardous materials	5	4	2	3	----------
CO_2 Emissions	5	4	1	2	----------
SO_2 Emissions	*5*	*4*	*1*	*1*	----------
Waste Reduction (WR)	1	2	3	4	----------
Cost Saving (CS)	1	3	4	2	----------
Product Recovery Option (PRO)	2	3	5	3	---------
Resource Consumption (RC)	4	3	2	1	----------
Customer Satisfaction(CS)	1	2	5	4	----------
Service Quality (SQ)	2	1	4	3	--------

ANP ANALYSIS AND SOLUTION METHODOLOGY

- **Step 1:** Model construction and problem structuring
- **Steps 2:** Pair wise comparisons matrices between component/ levels
- **Steps**-3 Pair wise comparison matrices of interdependencies
- **Step-4** Super matrix formulation and analysis
- **Step-5** Pair wise comparison for different alternatives
- **Step-6**: Selection of best alternative
- **Step –7** Relative importance weight for the relationship
- **Step-8** Calculation of RL performance weighted index

The matrix showing pair-wise comparison of determinants along with the e-vectors of these determinants

DETERMINENTS	ECBP	LF	OP	OLC/LF	E-VECTER
ECBP	1	1/5	1/5	1/4	0.0656
LF	5	1	1	2	0.3638
OP	5	1	1	2	0.3638
OLC/LF	4	1/2	1/2	1	0.2069
CR= 0.011					

PAIRWISE COMPARISION FOR DIMENSIONS

Pair wise Comparison for dimensions under Environmentally Conscious Business Practices (ECBP)					
ECBP	FP	SP	GBP	IOP	E-VECTER
FP	1	2	3	1	0.3507
SP	½	1	2	1/2	0.1892
GBP	1/3	1/2	1	1/3	0.1093
IOP	1	2	3	1	0.3507
CR= 0.0039					

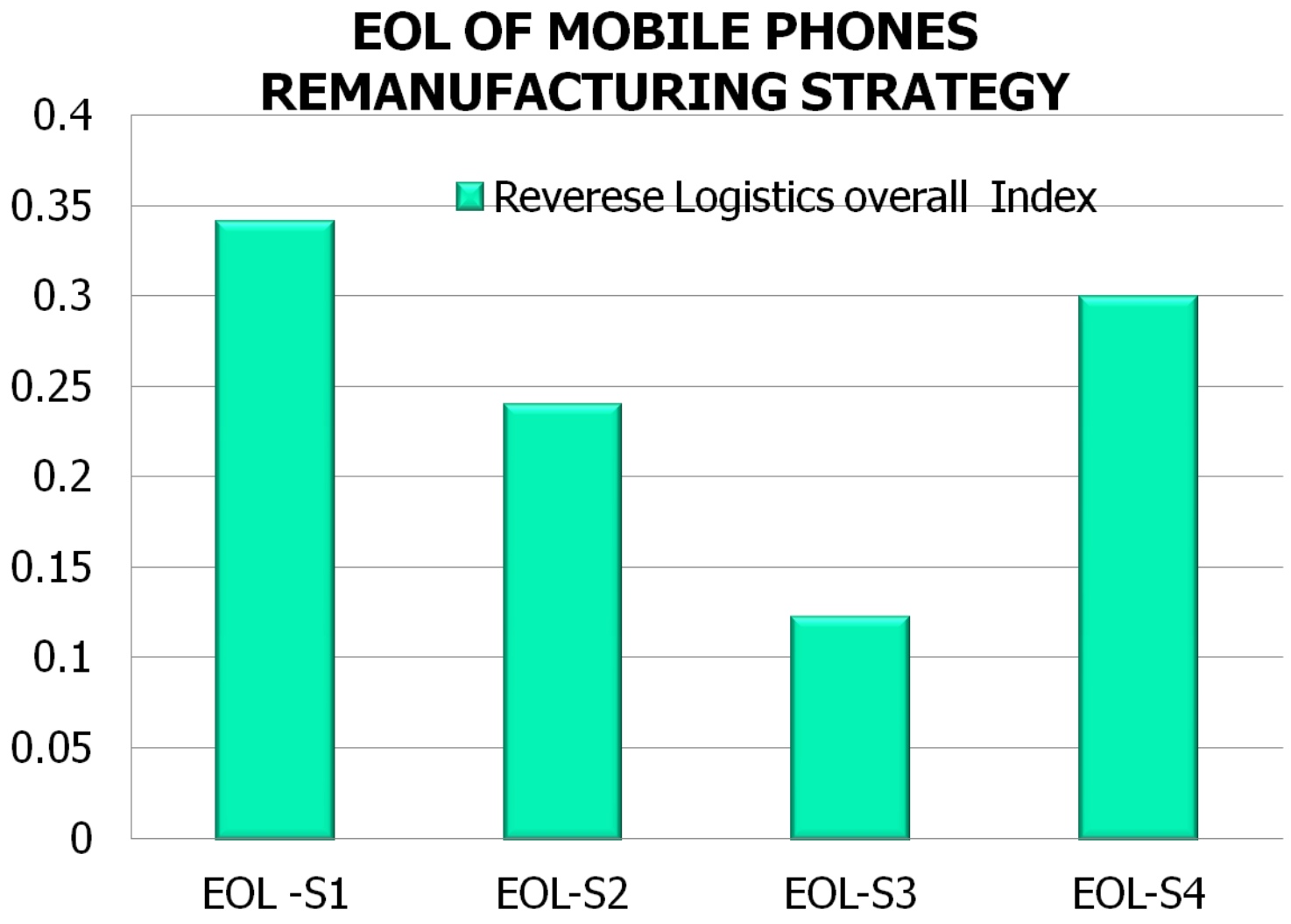
Pair-wise Comparison for Green Business Perspective under Environmentally Conscious Business Practices(ECBP) determinant

ECBP/GBP	RC	SO2	CO2	WR	E-VECTER
RC	1	3	5	1	0.3935
SO2	1/3	1	2	1/3	0.1376
CO2	1/5	1/2	1	1/5	0.0754
WS	1	3	5	1	0.3935
CR=0.0016					

- Table Reverse Logistics overall weighted Index

Logistics overall weighted Index						
Alternatives	ECBP	LF	OP	OLC/LF	LOW I	Normalized values for LOW I
Weights	0.0656	0.3638	0.3638	0.2069		
EOL-S1	0.1078929	0.1981808	0.1030396	0.1078929	0.138985	0.3403
EOL-S2	0.0871902	0.1242377	0.0788480	0.0871902	0.097642	0.2391
EOL-S3	0.038042	0.067707	0.040589	0.038042	0.049765	0.1218
EOL-S4	0.071449	0.187266	0.09468	0.071449	0.122042	0.2988

- It is observed from Table that EOL-S1 (Repair, Refurbishing & Reuse (RRR) of Mobile Phone) is the most-suited alternative for the reverse logistics operations for used mobile phones for the mobile manufacturing/remanufacturing industries. Alternatives EOL-S4, EOL-S2 and EOL-S3 in sequence follow alternative EOL-S1 respectively.
- It is observed from Table that legislative factors and operating performance factors plays a major role in the conduct of reverse logistics operations for used mobile phones.
- It is further observed from the second column of this table that EOL-S1 (0.1078929) performs business in the more environmentally conscious RL operation as compared to EOL-S2 (0.0871902), EOL-S3 (0.038042) and EOL-S4 (0.071449).


EOL OF MOBILE PHONES REMANUFACTURING STRATEGY
Reverese Logistics overall Index
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
EOL -S1
EOL-S2
EOL-S3
EOL-S4

RESULTS AND CONCLUSIONS

- The proposed methodology provides for simplification of a complex multi-criteria decision-making problem.
- It may also be used to quantify many subjective judgments, which are necessary to evaluate different EOL mobile remanufacturing alternatives/strategies.
- Another advantage of this methodology is that it not only supports group decision-making but also enables us to document the various considerations in the process of decision making.
- In this study, the results indicate that EOL Scenario 1 (Repair, Refurbishing & Reuse (RRR) of Mobile Phone) is the best End-of-life remanufacturing strategy for mobile phones collected by the case company.
- **This option may be attributed to its more environmentally conscious business practices (ECBP), legislative factors, and organizational performance and operation life cycle/logistics focus capabilities.**
- The option of EOL-S4 (Recycling of complete mobile phone for material recovery) in the framing of environmentally conscious business practices (ECBP), legislative Factors and operation life cycle/logistics focus capabilities policy also supports this result.
- It is pertinent here to discuss the priority values of the dimensions, which influence this decision. From Table 50 , it is observed that **financial perspective (0.3507) and internal operation performance (0.3507)** is found to be equal and most important dimensions in the selection of an EOL Scenario for used mobile phones. It is followed by social perspective SP (0.1892) and Green business perspective (0.1093).

FUTURE SCOPE OF WORK

- For future research, it would be worthwhile to implement the ANP model with a decision maker or a set of decision makers. Such research endeavour could be used to validate the effectiveness of the ANP model.
- More importantly, managerial implications can be empirically derived regarding the selection of best remanufacturing strategy/option for used mobile phones collected by the concerned companies. Such research should include a comprehensive sensitivity analysis to examine the significance of individual attributes to the selection decision.
- It is also worthwhile to compare the proposed ANP approach with other evaluation approaches. Here ANP approach illustrated in this paper has a few limitations as well.
- For example, the model result efficiency is dependent on the inputs provided by the reverse logistics manager of the particular industry segments. The possibility of bias of the decision-maker towards any particular strategy/option cannot be ruled out while applying this model.
- Therefore, group decisions should be preferred in the pair-wise comparison. Moreover, the formation of pair-wise comparison matrices is a time-consuming and tedious task. Inconsistency and human error may also occur in calculating the pair-wise comparison of matrices, which may give wrong results.

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Thanks!