

CLOSED LOOP SUPPLY CHAIN MANAGEMENT IN THE INDIAN AUTOMOTIVE INDUSTRY: STUDY OF SELECT ISSUES

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CLOSED LOOP SUPPLY CHAIN MANAGEMENT IN THE INDIAN AUTOMOTIVE INDUSTRY: STUDY OF SELECT ISSUES

by

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CERTIFICATE

The thesis entitled ‘Closed loop supply chain management in the Indian automotive industry: study of select issues’, being submitted by Mr. Shisam Bhattacharyya to the Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy (Ph. D.) is a record of *bona fide* research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for submission of this thesis, which has attained the standard required for Ph. D. degree of this institute. The results presented in this thesis have not been submitted in part or in full to any other university or institute for award of any degree or diploma.

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ABSTRACT

In recent times, new forms of closed loop supply chain have evolved in order to increase the viability of end-of-life vehicle recovery program and provide maximum value to the end-user. Closed loop supply chain encompasses four distinct components – network design, flexibility management in collaboration, strategic and operational intervention. The decision making for original equipment manufacturer becomes most vital to sustain a profitable recovery program in long run. The strategic decisions related to acquisition and cannibalisation is equally important with operational decisions related to logistics, performance parameters and indicators. Original equipment manufacturer cannot undermine the influence or risk of such decisions over the profitability of closed loop supply chain network for end-of-life vehicle. Thus, automobile reintegration index; as a concept, is a continuum, where the level of decision making could be quantified by a scientific or analytical approach and benchmarking is possible in all four aspects of the recovery program or the original equipment manufacturer as an organisation.

The value of closed loop supply chain network design is well recognised in the literature and practicing world due to the fact that it mostly benefits to the original equipment manufacturers. For a fair distribution of benefits between the original equipment manufacturers and external remanufacturers this study aims to instantiate an optimization model with multiple incentive policies for primary and grey market. The proposed framework emanates a roadmap to leverage the perquisites of unorganised external remanufactures enjoy in the automobile reintegration business. The perks like larger control over end-of-life vehicles, proximity to customers, low reintegration cost, void for clearances from regulatory authorities, acquire a mix of end-of-life vehicle irrespective of parts, variants and brands etc. On the other hand original equipment manufacturer can

contribute towards the economic and social benefits for the external remanufacturers by collaborating with an organised closed loop supply chain network, incentivising higher value in acquisition, developing information sharing infrastructure, achieving sustainability in sourcing part or raw material from all segments of consumers, improving ergonomics at remanufacturing facilities etc. Even more, the quantitative framework reattributes the probability or percentages for inter-playing the set of decisions to be made to maximize the profit in the automobile recovery program.

One major theme presented in this proposed strategic closed loop supply chain theory is to incorporate the risk profiles of each decision making units on more realistic assumptions based on cause effect relationship among the enablers of achieving customer delight and retaining core components of end-of-life vehicle. We developed analytical model to assess cause-effect relationship among strategic and operative decisions units based on experts' opinion. On top of that, a predictive model is raised to assess the risk based on probabilities or percentages evident in the optimization model. A prescriptive model in the thesis investigates the probabilities or percentages came out from the predictive model to suffice an index value for benchmarking the original equipment remanufacturer or the end-of-life vehicle reintegration program assessing all four types of decision making units in terms of closed loop supply chain's performance and contribution margin. A qualitative framework for original equipment manufacturer also assesses an adoption capability and critical areas of flexible management system for collaboration with external remanufacturers to re-intermediate the closed loop supply chain network with an appropriate agent. The study provides guidelines relevant to academia and supply chain practitioners in taking automobile reintegration index to their specific business environment. It can also allow an entrepreneur to draw a landscape of a near ideal closed loop supply network with most competitive and sustainable measures.

सार

हाल के समय में, बंद लूप आपूर्ति श्रृंखला के नए रूप विकसित हुए हैं ताकि एंड-ऑफ-लाइफ वाहन रिकवरी प्रोग्राम की व्यवहार्यता को बढ़ाया जा सके और एंड-यूज़र को अधिकतम मूल्य प्रदान किया जा सके। बंद लूप आपूर्ति श्रृंखला में चार अलग-अलग घटक शामिल हैं - नेटवर्क डिज़ाइन, सहयोग में लचीलापन प्रबंधन, महत्वपूर्ण (रणनीति-संबंधी), और परिचालन हस्तक्षेप। लंबे समय में लाभदायक वसूली कार्यक्रम को बनाए रखने के लिए मूल उपकरण निर्माता के लिए निर्णय लेना सबसे महत्वपूर्ण हो जाता है। अधिग्रहण और नरभक्षण से संबंधित महत्वपूर्ण (रणनीति-संबंधी) फैसले रसद, प्रदर्शन मापदंडों और संकेतकों से संबंधित परिचालन निर्णयों के साथ समान रूप से महत्वपूर्ण हैं। मूल उपकरण निर्माता एंड-ऑफ़-लाइफ़ वाहन के लिए बंद लूप आपूर्ति श्रृंखला नेटवर्क की लाभप्रदता पर ऐसे निर्णयों के प्रभाव या जोखिम को कम नहीं कर सकता है। इस प्रकार, ऑटोमोबाइल रीइंतेग्रेशन इंडेक्स; एक अवधारणा के रूप में, एक निरंतरता है, जहां निर्णय लेने का स्तर वैज्ञानिक या विश्लेषणात्मक दृष्टिकोण द्वारा निर्धारित किया जा सकता है और वसूली कार्यक्रम या संगठन के रूप में मूल उपकरण निर्माता के सभी चार पहलुओं में बेंचमार्किंग संभव है।

बंद लूप आपूर्ति श्रृंखला नेटवर्क डिज़ाइन का मूल्य साहित्य में अच्छी तरह से पहचाना जाता है और इस तथ्य के कारण दुनिया को अभ्यास कर रहा है कि यह ज्यादातर मूल उपकरण निर्माताओं को लाभ देता है। मूल उपकरण निर्माताओं और बाहरी पुनःउत्पादक के बीच लाभ का एक निष्पक्ष वितरण के लिए इस अध्ययन का उद्देश्य प्राथमिक और ग्रे बाजार के लिए कई प्रोत्साहन नीतियों के साथ एक अनुकूलन मॉडल को तत्काल करना है। प्रस्तावित ढांचा ऑटोमोबाइल पुनर्संरचना व्यवसाय में असंगठित बाहरी रीमूनिचर्स के लाभ का लाभ उठाने के लिए एक रोडमैप तैयार करता है। एंड-ऑफ़-लाइफ़ वाहनों पर बड़े नियंत्रण, ग्राहकों से निकटता, कम पुनर्निवेश लागत, विनियामक अधिकारियों से मंजूरी के लिए शून्य जैसे बड़े भत्तों जैसे भागों, वेरिएंट और ब्रांडों आदि

के बावजूद एंड-ऑफ़-लाइफ वाहन का मिश्रण प्राप्त करते हैं। हाथ मूल उपकरण निर्माता एक संगठित बंद लूप आपूर्ति श्रृंखला नेटवर्क के साथ सहयोग करके, बाहरी अधिग्रहण के लिए आर्थिक और सामाजिक लाभों के लिए योगदान कर सकता है, अधिग्रहण में उच्च मूल्य को प्रोत्साहित कर सकता है, सूचना साझा करने के बुनियादी ढांचे को विकसित कर सकता है, सोर्सिंग भाग या कच्चे माल के सभी क्षेत्रों से स्थायित्व प्राप्त कर सकता है। उपभोक्ताओं, रेमनॉन्स्यूरिंग सुविधाओं आदि में एर्गोनॉमिक्स में सुधार करना। और भी अधिक, मात्रात्मक रूपरेखा ऑटोमोबाइल रिकवरी कार्यक्रम में लाभ को अधिकतम करने के लिए किए जाने वाले फैसलों के सेट को अंतर-खेलने के लिए संभावना या प्रतिशत को फिर से चित्रित करता है।

इस प्रस्तावित महत्वपूर्ण (रणनीति-संबंधी) बंद लूप आपूर्ति श्रृंखला सिद्धांत में प्रस्तुत एक प्रमुख विषय ग्राहक निर्णय को प्राप्त करने और जीवन के मुख्य घटकों को बनाए रखने के समर्थकों के बीच संबंध प्रभाव के आधार पर अधिक यथार्थवादी धारणाओं पर प्रत्येक निर्णय लेने वाली इकाइयों के जोखिम प्रोफाइल को शामिल करना है। वाहन। हमने विशेषज्ञों की राय के आधार पर महत्वपूर्ण (रणनीति-संबंधी) और ऑपरेटिव निर्णय इकाइयों के बीच कारण-प्रभाव संबंध का आकलन करने के लिए विश्लेषणात्मक मॉडल विकसित किया। उसके ऊपर, अनुकूलन मॉडल में स्पष्ट संभावनाओं या प्रतिशत के आधार पर जोखिम का आकलन करने के लिए एक पूर्वानुमान मॉडल उठाया जाता है। यह अध्ययन शिक्षाविदों को प्रासंगिक दिशा-निर्देश प्रदान करता है और अपने विशिष्ट व्यावसायिक वातावरण में ऑटोमोबाइल रीइंस्ट्रक्शन इंडेक्स लेने के लिए चेन प्रैक्टिशनर्स की आपूर्ति करता है। यह एक उद्यमी को सबसे अधिक प्रतिस्पर्धी और टिकाऊ उपायों के साथ निकट बंद लूप आपूर्ति नेटवर्क के परिदृश्य को आकर्षित करने की अनुमति भी दे सकता है।

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LIST OF ABBREVIATIONS

GDP	Gross domestic product
USD (\$)	United states dollar
INR	Indian rupees
SIAM	Society of Indian automotive manufacturing
PV	Passenger vehicle
CAGR	Compounded annual growth rate
OEM	Original equipment manufacturer
OERM	Original equipment remanufacturer
ERM	External remanufacturer
ELV	End-of-life vehicle
MVT	Marginal value of time
MILP	Mixed integer linear programming
TISM	Total interpretive structural mode
BBN	Bayesian believe network
ERA	Evidential reasoning approach
BERA	Bayesian evidential reasoning approach
MT	Markovian tree
SAP LAP	Situation, actor, process, learning, action, performance
DS	Dempster Shafer theory
CLSC	Closed loop supply chain
MICMAC	Matriced' impacts croise's multiplication appliquée a un classement
PWCP	Pair-wise conditional probabilities