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ANALYSIS OF SELECTED BARRIERS IN GREEN MANUFACTURING USING AHP

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Abstract

Increased awareness of the consequences of environment degradation due to manufacturing activities coupled with government regulatory guidelines are galvanizing organizations to adopt practices which are environmentally benign. Green manufacturing paradigm enables companies to improve their sustainability index, bolster their resource efficiencies and bestows competitive advantages. Such practices have umpteen advantages for any business but a number of formidable challenges act as barriers for proactive environmental policies.

Keywords: *green manufacturing, barriers, AHP*

1 Introduction

A number of innovative green technologies are being embraced by companies in quest for environmental protection. The green transformations of manufacturing operations approach aligns with focus of businesses' on customers, environmental protection and future readiness. The unique combination of innovative manufacturing operations powered by green practices and products are helping manufactures achieve ambitious business targets. Companies adopting green practices in manufacturing are able to establish newer benchmarks in environmental protection. These benefits are not restricted to reduced environmental impact but also in cost efficiencies and greater adherence to regulatory compliance. Adoption of green manufacturing brings in increased revenue due to higher customer preference for environmentally friendly products. While manufactures have embraced green practices in one form or the other, they are predominantly lagging in unleashing the true potential of using green process and products due to numerous reasons acting as barriers to the cause of espousing proactive environmental policies.

2 Objectives of study

The present study attempts to identify the barriers that are primarily responsible for the successful adoption of green manufacturing. This is being done through an extensive literature review and structured expert opinions. Furthermore, the development of the relationships among these identified barriers has been done using the AHP approach. This will enable organizations to initiate steps for mitigating the effects of these barriers. Various barriers that deter the progress towards green manufacturers have been identified. These are given in table 1.

Table1: Identified barriers in Green manufacturing

S. No	Description of Barriers	References
1	Technology Risk	Hellström, T. (2003), Tofail, S. A. M. et al. (2018)
2	Neglect of green issues at the strategic level	Gavronski, I. et al. (2011), Diabat, A., & Govindan, K. (2011), Chin, T. A. et al. (2015)
3	Inadequate Government and regulatory support	Abdullah, M. et al. (2016), Oladokun, M. G., & Aigbavboa, C. O. (2018)
4	Suppliers Resistance	Zhu, Q. et al. (2005), Mathiyazhagan, K. et al. (2013), Deif, A. M. (2011)

5	Human resources issues	Masri, H. A., & Jaaron, A. A. M. (2017), Miles, R. E., & Snow, C. C. (1984)
6	Financial Risk aversion	Kawas, B. et al. (2011), Fang (2016)
7	Customer acceptance	Vaidyanathan, J. et al. (2012)

These barriers and their sub-barriers are shown in table 2.

Table 2: Identified Barriers and their sub-barriers

S. No.	Barrier		Sub-Barriers
1	Technology Risk	1.1	Integration
		1.2	Adaptability
		1.3	Performance.
		1.4	Development
		1.5	Reliability
2	Neglect of green issues at the strategic level	2.1	Lack of clear vision
		2.2	Disregard of the tenets of CSR
		2.3	'Out-of-responsibility' zone mentality
		2.4	Inadequate management commitment
3	Inadequate Government and regulatory support	3.1	Lack of effective environmental enforcement
		3.2	Lack of uniform eco-benchmarking indices
		3.3	Permitting the use of non-green techniques
		3.4	Reluctance of financial institutions to fund green projects
		3.5	Low priority for establishing green infrastructure
		3.6	Lack of Tax incentives /subsides
4	Supplier Resistance	4.1	Complexity in measuring financial gains
		4.2	Low commitment due fear of failure
		4.3	Unwillingness to share technology
		4.4	Uncertainty of benefits
5	Human resources issues	5.1	Paucity of professionals having technical expertise
		5.2	Scant respect for ecology among employees
		5.3	Employee resistance to change
		5.4	Dearth of training institutions
		5.5	Sceptical about gains
6	Financial Risk aversion	6.1	High initial capital cost
		6.2	Uncertain Return on investment (ROI)
		6.3	Long gestation period
		6.4	High cost of 'green' certification
		6.5	Shareholders pressure for profit maximisation
7	Customer acceptance	7.1	Low customer preferences
		7.2	Reluctance to pay higher price
		7.3	Lack of customer awareness
		7.4	Resistance to change buying habits of consumers

These barriers are described below:

2.1 Technology Risk

Green manufacturing requires huge initial capital investment for incorporating new technologies in process, product design, installation, production and maintenance. The absorption and implementation of these technologies is a challenging task, both, operationally as well as economically. Integration of these technologies with the existing system carries the risk of adaptability and performance. These risks put businesses' in a predicament and augment their reservations to pursue green avenues. Complexity

of design and lack of flexibility in operation makes it difficult for businesses' to transition to new processes and products. Limited technological competencies, managerial capabilities and additional infrastructure requirements to support new technology, materials and processes further hinder their re-orientation towards green manufacturing systems.

2.2 Neglect of green issues at the strategic level

There is a lack of clear vision and path to be adopted for implementing green manufacturing at strategic level. Absence life cycle thinking approach leads to weak environmental performance concern. Disregard of green considerations at the strategic level may stem from reasons such as lack of confidence in the potential benefits, inadequate management commitment, and perception of 'out-of-responsibility' zone towards environmental protection. Businesses' are reluctant to incur any expenditure on research and development of innovative capabilities in design and testing to support green manufacturing activities. Such policies delay the implementation of decisions concerning new technology, materials and processes to support green manufacturing. Non-availability of proven alternative solutions for green manufacturing, due to lack of focus on research and development has inhibited the efforts of many organizations to adopt green manufacturing.

2.3 Inadequate Government and regulatory support

Effective environmental enforcement by the regulators and government agencies is crucial for the promotion of green manufacturing. Government inability to provide appropriate infrastructure, training, consultancy, tax incentives etc hinders the growth of green manufacturing. An ambiguous regulatory policy of financial subsidies and allotment of pollution abatement permits discourages businesses to invest in green manufacturing. Lack of transparency, short-sightedness and a weak political resolute prevent the development and implementation of green policies. Haphazardly conceived environmental legislations, without proper due diligence, which mandate the use of economically unviable techniques and setting unreasonable deadlines act more as deterrents than enablers.

2.4 Supplier Resistance

Green manufacturing mandates use of environmentally benign processes and products. Establishment of a green supply chain management system faces a challenge due to vendor resistance emanating from the requirement of increased initial investment. Conflict of interest between the manufacturers and vendors aggravates the situation further. Vendor resistance is also augmented due to ignorance about long term benefits of adoption of green processes and material. The vendors are reluctant to share their process and product technology with buyers which aggravate the problem of developing credible supply chain.

2.5 Human resource issues

Businesses' face a challenge of paucity of professionals having technical expertise in green manufacturing. Green manufacturing is an emerging paradigm and demand for talented professional outstrips the availability .This talent crunch is due to dearth of institutions to train, monitor and mentor professionals in green manufacturing. Businesses' need to change their employee attitude and resistance to adopting new technology. Likewise, companies need to provide employees with training on environmental issues and enhance their commitment to environmentally friendly practices.

2.6 Financial risk aversion

Substantially huge initial expenditure is required to implement green manufacturing. Uncertainty with regards to the return-on-investment generates reluctance among manufacturers to invest in green manufacturing systems. Even financial institutions are reluctant to fund green initiatives making it difficult for manufactures to raise capital. The absence of financial gains in the short term and long gestation periods, further drive away the manufactures from investing in new technologies. High cost of 'green' certification is also a barrier. Investors measure the performance of any business in terms of ROI. Companies are under constant scrutiny and pressure for delivering maximum returns to their shareholders. Manufactures take decision on investing in new process and products based on a trade-off between ecological benefits and profits. Investors are wary of the claims by businesses' about the projected environmental benefits and corresponding increase in the cost. Complexity in measuring and monitoring financial gains of investment in green technologies is yet to be indexed properly. Investors have exhibited a risk aversion attitude towards investing in green manufacturing.

2.7 Customer acceptance

There is a direct impact of customer pressure on companies' decisions regarding environmental

practices The ultimate test of green initiatives is the acceptance of products by the customers The customers are reluctant to pay higher price for greener products. Low customer preferences & demands for green products discourage manufactures. Businesses' are unwilling to undertake huge marketing expenses to stimulate consumer demand for green products.

3 Methodology adopted for the Study

The main procedure for the AHP-method is described below.

Step 1: The construction of a hierarchical model based on literature review and expert opinion.

Step 2: To develop the comparison matrix based on judgmental analysis of experts. In this, the set of elements are compared using the fundamental scale of pair-wise comparison using Saaty's scale.

Step 3: Estimate the overall weight of each barrier using AHP

Step 4: Rank the barriers according to their weight.

Table 2 represents the relationship between the main barriers based on AHP methodology. Consistency Index (CI) is evaluated for each barrier.

Table 3: Relationships between the green barriers

Barrier	B1	B2	B3	B4	B5	B6	B7	CI
Technology Risk (B1)	1	1/2	3	2	3	1/2	2	0.167
Neglect of green issues at the strategic level (B2)	2	1	2	3	2	½	3	0.202
Inadequate Government and regulatory support (B3)	1/3	1/2	1	2	3	1/3	1/2	0.104
Suppliers Resistance (B4)	1/2	1/3	½	1	1/2	1/2	1/2	0.068
Human resource issues (B5)	1/3	1/2	1/3	2	1	1/4	2	0.090
Financial Risk aversion (B6)	2	2	3	2	4	1	3	0.273
Customer acceptance (B7)	1/2	1/3	2	2	1/2	1/3	1	0.095
							CR	0.085

Table 2 reveals that the value of Consistency ratio (CR) is 0.085 which is less than the maximum acceptable limit of 1.0. This signifies that there is significant consistency in the judgemental opinion of experts and the AHP analysis. The ranking of green barriers based on CI values is given in Table 4.

Table 4: Ranking of the various green barriers

Barriers	CI Index	Rank
B6	0.273	1
B2	0.202	2
B1	0.167	3
B3	0.104	4
B7	0.095	5
B5	0.09	6
B4	0.068	7

Table 4 signifies that Financial Risk aversion (B6) is a crucial barrier towards the adoption of green manufacturing. This barrier consists of 5 sub-barriers namely High initial capital cost, Uncertain Return on investment (ROI), Long gestation period, High cost of 'green' certification and Shareholder pressure for profit maximisation. A holistic approach involving various stakeholders like government, consumers, industry may alleviate these sub-barriers in order to encourage manufacturers to make fresh investments.

4 Results and Discussion

For businesses', environmental protection implies a paradigm shift in the way they undertake manufacturing operations, marketing strategies, delivery of products and infuse fresh investments. Business appetite and intent for green manufacturing is being jeopardized by the numerous barriers which inhibit transformation towards cleaner production. The AHP results indicate that financial risk aversion is the paramount barrier for businesses' to adopt green practices. The multi-fold transformations of manufacturing operations which have far reaching economic consequences make businesses reluctant for espousing green practices. The uncertainty with regard to successful technology absorption also inhibits heralding of green practices. Green manufacturing needs to weave a collaborative approach among various stake holders for boosting cleaner production. The businesses' face numerous difficulties due to ambiguous and vacillating government and regulatory support. The businesses' need to device innovative strategies for mitigating the listed barriers. Manufactures need to

use cost effective methods to enhance consumer experience for greener products.

5 Conclusion

The present work is aimed at evaluating the barriers towards the adoption of green manufacturing. An AHP methodology which is a well known MCDM technique has been adopted for the same. The study provides crucial information into the barriers of green barrier. Businesses' need to ideate out-of-the box innovative techniques to extinguish these barriers.

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