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Design and selection process of Production Business Management System using AHP Approach

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ABSTRACT

A number of current production sectors are striving hard to introduce innovative long-term strategies into their operations. As a result, many scholarly studies have found it fruitful to investigate advanced production strategies such as agile, computer-integrated, and cellular production. Through the example of downstream cases, production sectors have learned that financial benefits garnered through automated technologies cannot be counted on as a sole measure to ensure their success in today's competitive and fluctuating marketplaces. The objective of this study is to integrate those advanced techniques with sustainable operations, to promote advanced sustainable production so those production sectors can thrive even in uncertain markets. To establish this connection, this study analyzes the drivers of advanced sustainable production through a proposed framework validated through a case study in India. Common drivers are collected from the literature, calibrated with opinions from experts, and analyzed through an analytical hierarchy process (AHP), which is a multi-criteria decision making (MCDM) approach. This study reveals that quality is the primary driver that pressures production sectors to adopt advanced sustainable production. Manufacturers can easily note the top ranked driver and adopt it to soundly implement advanced sustainable production. In addition, some key future scopes are explored along with possible recommendations for effective implementation of advanced sustainable production systems.

Keywords: advanced sustainable production systems; drivers; AHP; MCDM

I. INTRODUCTION

Production is one of the world's most dynamic industries both in developed and developingnations. Because of production's broad scope, it attracts a multitude of developments and innovations, including advanced technologies that seek to add a benefit or to improve a process. Some advanced technologies consider green and lean practices, risk assessment, societal perspectives and so on [1–4]. Surprisingly, however, according to a report published by Infosys [5], whereas 85% of advanced production techniques receive global acceptance, only 15% of organizations end up adopting those advanced processes. The Global Production Outlook report [6] finds that 48% of respondents vote to adopt new production technologies as efficient drivers for new growth and innovation in production sectors. Hence, with these considerations, this study chooses advancedproduction as a core of the research, in order to identify innovations related to sustainability.

According to literature's definitions, advanced production technology is nothing but the application of innovative technology to make processes and systems work more efficiently. If we identify 1960 as the starting point for advanced production systems, various strategies are grouped under that umbrella term. For instance, Tao et al. [4] identify a substantial list of production strategies; their list includes flexible, computer-integrated, cloud, additive, virtual, concurrent engineering, production grid, crowd sourcing, sustainable, agile, dynamic alliance, networked, lean, green, product service system, and reconfigured production.

The above-mentioned production technologies can be broadly classified into two groups with respect to their benefits. The first group features a "technological" approach and includes the first eight strategies: flexible, computer-integrated, cloud, additive, virtual, concurrent engineering, production grid, and crowd sourcing. Benefits from the technological group are designed to improve production and to increase financial profits.

The second group centers on all "environmental" strategies and include the techniques of sustainable, lean, and green production. The remaining five approaches do not fit precisely into either broad group, and therefore a discussion of those approaches shall be the focus of a future study. Obviously, the benefits from the second group emphasize social and environment concerns with little attention to finances. The majority of studies deal with only one of the above-mentioned production strategies. Zhu et al. [7], for example, studied energy optimization in sustainable production but did not touch on other technological perspectives. Rather than keeping a separate focus on the two strategy groups, organizations need to embrace both for maximum value creation. Hence, there is a need for scholarship that integrates the technology strategies with environmental and social concerns, as this study attempts to achieve.

The proposed framework needs to be tested for reliability, so it will be applied to a case industry, and a South Indian firm has been selected. Many studies presume that developing nations are less accepting, less tolerant of new strategies, so our choice of a company in a developing nation presents an appropriate example with which to validate the proposed model. India is one of the globe's fastest growing nations; its significant population works hard to sustain their position in global production and to maintain societal and environmental health. The degree to which a company implements advanced sustainable production strategies has a direct impact on its performance level, and the challenges that company faces are significant. The proper use of land resources, human health, and economic instability are major issues faced by corporations, especially those in developing nations. Thus, it is even more important for production sectors in developing nations to enact sustainable strategies to combat the exploitation of natural resources. As two developing nations, China and India may initially be judged in similar terms, but a number ofdifferences exist between them. The Indian context presents a better example by which to examine concepts of advanced sustainable production because no previous studies exist with that focus.

The remaining sections of the paper are organized as follows. Section 2 describes the research problem along with the proposed framework of the study. The methodology used for the solving the problem is given in Section 3 and includes a step-by-step explanation. Section 4 reports the application of the proposed model in the selected case industry with three phases of implementation. Sections 5 and 6 present results with corresponding discussions; these sections also provide the useful managerial implications of the study. Finally, the paper concludes with a summary of the findings, a statement of limitations, and some recommendations for future enhancements.

II. PROBLEM DESCRIPTION

Competition resides at the heart of business, even for international companies. A primary goal for companies is to adopt production strategies that will help them to best compete successfully against other businesses. Manufacturers realize that technical advancements can help protect the firm from unexpected economic crises, and help them meet customer expectations when decreasing resources threaten the company. No studies currently exist that combine technological advancements with sustainable concerns, so this study seeks to integrate automation with sustainability in production sectors. The most common motivating factors are called drivers, so once drivers are clearly identified, it will be an easy task for manufacturers to use those drivers to improve their rate of advanced sustainable production.

Framework of the study:

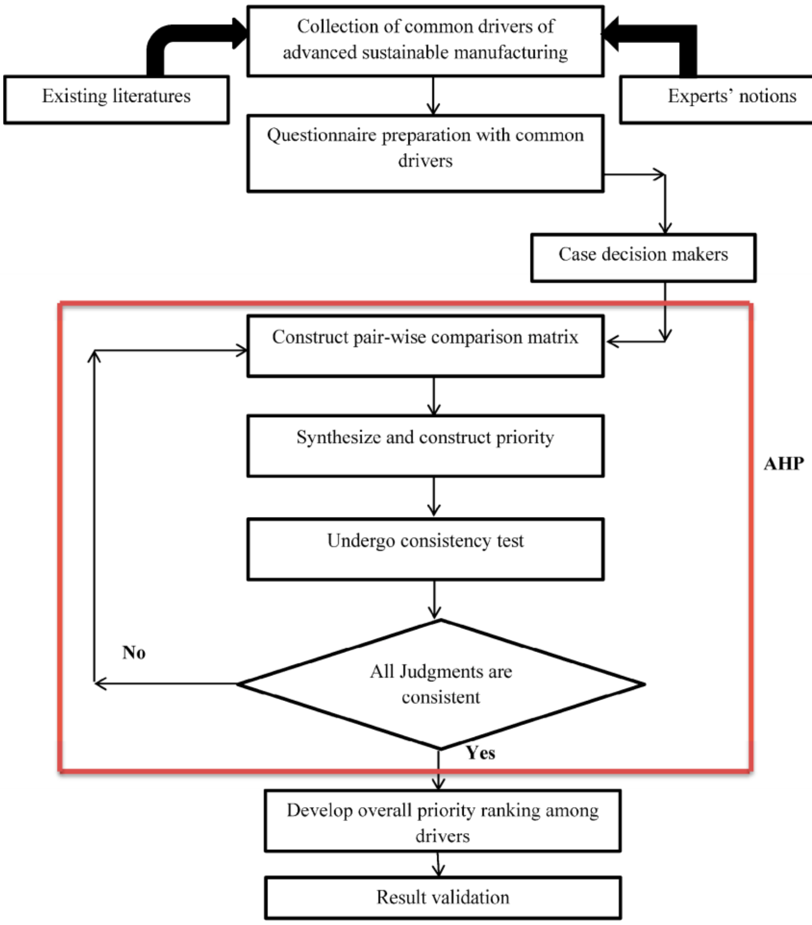

Figure 1: Proposed framework of the study

A model framework, shown in Figure 1, demonstrates the drivers of advanced sustainable production. Because the reliability of the proposed framework is under question unless it has been validated, this proposed framework was applied to a case industry situated in Indian geography. Generally, as discussed earlier, developing nations are still far behind in adopting efficient long-term strategies, so this study believes that a case study from India will make a significant contribution to the literature.

The proposed framework starts with the collection of common drivers of advanced sustainable production from the support of existing literatures and experts' notions. Once the common drivers are collected, a questionnaire is prepared along with a rating scale. From the replies of the case industry's decision makers, a pair-wise comparison is made among common drivers; this step is an initial process of AHP. The pair-wise comparison matrix is synthesized and the drivers' priority is constructed. Next, a consistency check is run to validate the AHP process. If the consistency check is successful, then the drivers' priority is revealed along with their corresponding ranks. Finally, the ranks are validated with the valuable feedback from the case industry's decision makers.

III. SOLUTION METHODOLOGY

Advanced sustainable production provides an organization with many advantages but choosing an appropriate strategy is still a difficult task because, upon occasion, a company may face conflicting factors. In order to handle multi-criteria problems, this study features a multi-criteria decision making methodology. There are number of MCDM techniques available, but analytical hierarchy process (AHP) is among the most powerful. According to Lee and Drake [8] and Ishizaka et al. [9], AHP is a reliable tool in modern scenarios because it provides optimal solutions for many complex multi-criteria decision making problems. Originally proposed by Saaty in 1980, AHP has been applied in a variety of applications; it measures intangibles with the assistance of experts' judgments through pair-wise comparisons [10]. In AHP, complex problems are solved by inserting them into a hierarchical structure in order to measure the level of impact from one level to another. In addition, AHP is useful when a large number of factors are employed [11]. Some studies, for instance [12–18], articulate the advantages of AHP within their research; Liberatore and Nydick [19] argue that AHP allows decision makers to ensure the consistency of their judgments towards factors.Many recent studies successfully apply AHP in production sectors.

Step 1: Select the list of attributes (drivers) related to an advanced sustainable production system combined from the assistance of existing literature review and from field experts' notions.

Step 2: From the assistance of the decision makers, create a pair-wise comparison on the given criteria. This comparison will be based on the Likert 5-point scale further modified to the Saaty scale for numerical ease. (See Table 1).

Step 3: Evalaute the global weights by formal arthimetic operations of AHP including normalization.

Step 4: Check the reliability of the results through the Consistency Index (C.I.) and the Consistency Ratio (C.R.)

Step 5: If the C.I. < 0.1, then the verdict is satisfactory. Otherwise, pair-wise comparisons can be repeated to elucidate the error. The progression must be a cyclic process until the consistency condition is made satisfactory.

Step 6: Based on the final weights, the drivers of advanced sustaianble production are prioritized and further circulated to the case industry's decision makers in order to focus on the most highly-weighted driver.

The Saaty scale is the scale proposed in order to explain the relative importance of factors one over other. For instance, according to the Saaty scale, if criteria A and criteria B are measured to have apair-wise comparison, and if A is seven times more important than B, then we represent it as 8; if B is seven times more important than A, then we represent it as 1/7. As noted above, each and every criterion is analyzed by comparing one with another, and from this process, the weights of the criteriaand sub-criteria are identified.

I. APPLICATION OF THE PROPOSED MODEL

In order to validate the proposed model, it was applied in a case industry situated in southern India. This case company is one of the leading tire manufacturers in South India; they have been in the field since 1972, with six branches in and around South India, and their head office is located in Chennai. This case industry introduces many new innovative technical and technological strategies within their operations in order to sustain their business, and they have been successful for several years. However, due to the dynamic business world, this case industry began to lose their market share and to face peril due to the emergence of new competitors. Hence, they needed to improve their organizational culture in order to achieve more intangible benefits rather than focusing only on fiscal performance. By coincidence, our research team had just sent a proposal to this case industry explaining the new age of production and its benefits, so the company fortuitously accepted our research proposal. This case industry also supplies clients in some developed nations, so they were urged to improve their production strategy as a separate issue from their financial goals. Currently, this industry follows lean production standards with an emphasis on waste reduction; they had not yet considered automation technologies or sustainable strategies. Our study arrived at a point that might be highly useful for this firm to retain their position in a fluctuating business market. With the case industry's approval, our research team sought to validate the proposed model, which was categorized into three phases: (i) collection of drivers; (ii) application of AHP; and (iii) verification of results.

Phase I: Collection of Common Drivers of Advanced Sustainable Production

The first phase of the proposed model is to collect the common drivers of advanced sustainable production through the assistance of existing literatures and the opinions of field experts. A standard search procedure was followed using the key terms of the research, such as "advanced production", "sustainable production", "drivers", and so on. Reputable search databases, including Web of Science, Google Scholar, and Scopus were utilized. Twelve major drivers were originally selected. To complete a reliability check and to bridge the gap between researchers and practitioners, we gathered the field experts for a one-day workshop and circulated our list of drivers.After several rounds of discussions in which the experts offered insights into the processes that existin virtual production, the original 12 drivers were expanded to 15. Hence, this study utilizes 15 drivers recommended for analysis, as shown in Table 1.

Table 1: Common drivers of advanced sustainable production

S. No.	Drivers
1	Quality (D1)
2	Market capabilities (D2)
3	Financial benefit (D3)
4	Supply chain requirements (D4)
5	Delivery speed and performance flexibility (D5)
6	Compliance with regulations (D6)
7	Green purchasing (D7)
8	Optimized usage of resources (D8)
9	Green innovation (D9)
10	Environmental conservation (D10)
11	Education and training (D11)

12	Employee welfares (**D12**)
13	Stakeholders (**D13**)
14	Internal motivations (**D14**)
15	Customers' expectations (**D15**)

Phase II: Application of AHP

Once the common drivers were collected, the next step was the analysis through analytical hierarchy process (AHP). Because the conceptual and preliminary steps of AHP were explained in previous sections, we list here the four basic steps.

Step 1: Based on the replies of case industry decision makers and the support of the Saatyscale, a pair-wise comparison among the collected common drivers of advanced sustainable production was made.

Step 2: The pair-wise comparison matrix was normalized with standard arithmetic operations to form a normalized matrix, which has elements ranging from 0 to 1.

Step 3: From the normalized matrix, Eigenvalues were obtained and posed for a consistency check in order to ensure that the consistency ratio should be less than 0.1.

Step 4: Finally, the priority of the factors are ranked based on the Eigenvalues obtained by eachdriver. The rank, along with the priority of the drivers, is shown in Table 2.

Table 2: Ranks and priority among drivers

No.	Drivers	Eigenvalue	Rank
1	Quality (**D1**)	0.2335	1
2	Market capabilities (**D2**)	0.00832	15
3	Financial benefit (**D3**)	0.1684	2
4	Supply chain requirements (**D4**)	0.02488	10
5	Delivery speed and performance flexibility (**D5**)	0.08216	5
6	Compliance with regulations (**D6**)	0.0659	6
7	Green purchasing (**D7**)	0.03298	9
8	Optimized usage of resources (**D8**)	0.04054	8
9	Green innovation (**D9**)	0.01949	11
10	Environmental conservation (**D10**)	0.05201	7
11	Education and training (**D11**)	0.01525	12
12	Employee welfares (**D12**)	0.01203	13
13	Stakeholders (**D13**)	0.1291	3
14	Internal motivations (**D14**)	0.00975	14
15	Customers' expectations (**D15**)	0.1057	4

IV. RESULTS AND DISCUSSIONS

This section presented the results obtained from the study; this research aims to analyze the drivers of advanced sustainable production systems with the assistance of AHP. 15 drivers, collected from literature support and from field experts, are further analyzed with the help of the case industry's managers. The ranks and priority of the common drivers of advanced production technology are shown in Table 2.

Table 5 shows that Quality (D1) holds first position among the common drivers of advanced sustainable production with its Eigenvalue of 0.2335. Next, Financial benefit (D3) captures second place with the weights of 0.1684, and the least driver of advanced sustainable production is reported as Market capabilities (D2). The other drivers, ranked by priority, are as follows: D1 > D3 > D13 > D15 > D5 > D6 > D10 > D8 > D7 > D4 > D9 > D11 > D13 > D14 > D2. In order to validate the results, a two-way analysis was applied. Initially, the results are compared with the selections from existing literature and the acknowledgements of researchers. Secondly, we shared the results with the case industry decision makers. Joung's publication [20] offers an important observation. He points out that while many parameters and indicators exist in the current contemporary production environment, new strategies are mainly developed to maintain standards and to preserve resources without compromising quality. This statement reinforces a central result from our study, that quality is a primary factor that motivates firms to adopt new strategies.

When the results were shared with the case industry decision makers, they were surprised to learn that Quality (D1) was the priority driver. They expected some new factor to be revealed as central to the implementation of an advanced strategy. However, because the fundamental element of quality emerged as first priority, that ranking helped to establish that the decision makers needed to rethink their approach toward implementing sustainability into their production strategies. Our results reaffirmed the importance of quality and provided the decision makers with the motivation to become more self-aware.

This study provides countless managerial implications and serves both scientific and societal contributions. For managers, integrating automation technologies with sustainable practices can increase the company's financial benefits and may improve intangible factors on their organizational development. Furthermore, this integration has the potential to attract foreign clients, bringing globalization efforts to a developing nation like India. This study assists the shop floor managers to identify essential drivers for implementing advanced sustainable production in their firm. It also points out other influential drivers, so managers can consider a range of options. This study can be considered as a novel research effort, owing to the exploration of the advanced sustainable production context whereas previous studies examined only one of the themes. Apart from its scientific contributions, this study also considered social elements such as stakeholder satisfaction (including that of customers), resources conservation, green concerns, employee ergonomics, safety, and so on. An important element of this study is that it focuses on a developing nation; hence, this study might helpful in other Indian production sectors in order to eliminate cumbersome practices that restrict progress. This study also explains the importance of advanced sustainable production so it is likely to motivate shop floor and top-level managers to adopt relevant sustainable technology. This study bridges the literature gap by providing in-depth insights to assist practitioners in the successful implementation of advanced sustainable production.

V. CONCLUSIONS

This study's objective was to explore the necessity of adding sustainable strategies into advanced production systems, and we determined that an effective first step was to identify strategy drivers and practices. We analyzed the drivers, collected both from literature resources and from experts' opinions, and created a model framework which we validated with an Indian case industry. We utilized the analytical hierarchy process (AHP) because it is a skilful tool to identify weights of factors under multi criteria. Our study revealed that "Quality" (D1) is the major driver of advanced sustainable production systems, as has been covered in the previous sections. Our study has provided both scientific and technical contributions, but includes some limitations. The Indian context is very multicultural with various political backgrounds, and this study considered a case industry situated in southern region of India. Studies done in other regions of India might reach different results. Future studies may wish to explore similar concepts with a statistical background. Our study may serve as a pioneer in the field, and it may be used as benchmark when employed in other political settings or in different developing countries.

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