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INFORMATION SYSTEM EVALUATION FROM A GREEN PRODUCTION MANAGEMENT PERSPECTIVE IN AN AUTOMOTIVE SECTOR COMPANY

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Abstract: *Worldwide economies have as a pillar the manufacturing industry – a sustainable one. Hence this paper's main objective is to evaluate the information system (IS) success within an automotive sector company from a green production management perspective. The innovative methodological approach will integrate DeLone and McLean's model adapted to the production management sustainable requirements. In this case study the statistical approach is a complex one and uses the survey method based on a questionnaire. The research results are both methodological and empirical. Thus, a viable methodological framework is developed to evaluate IS success from a green production management perspective. Also, based on quantitative results, relevant conclusions are formulated for the automotive company's particular case.*

Keywords: *information system (IS), automotive sector, green production management, DeLone & McLean model, success measurement model, sustainability.*

1. INTRODUCTION

A pillar associated to worldwide economies is the manufacturing industry – a sustainable one [1]. The information system (IS) success in an automotive sector company – from a green production management perspective – could be consider as an extremely important vector. Hence, the IS success evaluation, based on an innovative methodological approach which integrate DeLone and McLean model [2, 3] require a statistical complex approach [4] that that could be appreciated as mandatory.

In literature the recurring observation was found, repeated many times, with small variations, that the production industry imperatively requires ecological or green strategies. These are undoubtedly imposed due to the complex issues made up of elements such as resources, energy, and the environment [5].

If we observed the resources wasted voluntarily or involuntarily in the manufacturing process, such as scraps, marginal materials, or end-of-use products, as well as at those generated in this process, such as residues, residual solid or liquid materials, or emissions of greenhouse gases, we can only see a big conflict [6]. This conflict is between the natural environment and the use of its resources. On the one hand, the economy is experiencing an unprecedented development. This implicitly implies a higher demand from the consumer. This leads to the development of the industry to respond to the demand and implicitly create the offer. Thus, the industry develops, but also increases competitiveness. In this industrial competition, there are also opportunity costs.

We found in the literature two statements that print two directions within the companies. First, the authors support paying more attention both to macro-control and to the constant supervision of green technologies. Secondly, it is argued that an effort must be made both to optimize environmental management and to increase incentives for ecological promotion [7].

Other authors have also directed their attention in their research work to proposals for the simultaneous development of the following aspects of industries: the implementation of ecological production strategies, the consolidation of the improvement of ecological products, the strengthening of a green production method, as well as the coordinated ecological development [8].

Other authors have brought proposals of models for sustainable processes or sustainable work cycles that can lead, in a subsidiary way, both to influencing innovation and to the sustainability of the enterprise itself [9].

Other authors have presented an analysis of the possibility of developing a framework including elements such as compatibility, factors, and barriers for the integration of three production strategies: Lean, Green, and Six Sigma [10].

Some authors hypothesized that the environment should even have the quality of an objective within an enterprise. Ideally, the environmental objective should be composed of sub-objectives such as detachment, recycling, maintenance, or reuse [11].

Also in literature, some authors put forward the idea of a work cycle based on a remanufacturing process to ensure a green work practice [12].

One of the most ecologically oriented works promotes concepts of an entire ecological system, from ecological design, ecological manufacturing or production, and ecological operations, to green accounting, environmental management, and even ecological management of the supply chain. Among other ecological strategies, we can also count the lighting or the consumption of pressurized air.

All such tools within the usage of green production, are focused on in the following broader actions: elimination or waste reduction, energy conservation, increase of product life, product cost reduction, and finally protecting the environment. There was even talk about building an ecological image that would bring or contribute to the competitive advantage, and implicitly to the increase in industrial performance [13].

Some authors have stated that the entire system involved in ecological production is downright challenging for conventional thinking from design to the management of production operations [14]. Attention was also drawn to the relatively few explorations.

The main need identified within companies is the adoption of completely new strategies to achieve the objective of sustainability in production. Some authors noted that this objective appeared in response to the demand of the market, clients, and of end users. Also, sustainability may be the main answer to the current and major problem caused by the shortage of natural resources. [15]. Next, when we talk about sustainability, we consider its three traditional dimensions, such as environmental, economic, and social sustainability. The study promotes a hierarchy of the three dimensions according to their importance. By far, the most important dimension in the tripartite theory is the environmental one, which seems to be the most sufficient for achieving sustainability.

2. AUTOMOTIVE AND GREEN MANUFACTURING

Focusing on the automotive sector, we can see how the entire automotive industry is currently oriented toward optimization and sustainability. The big question with relevance for our study is whether this industry uses, develops, and promotes ecological processes, technologies, and strategies. In extenso, can the production and manufacture of scrap metal reduce or even, ideally, eliminate the negative impact on the environment? Regarding sustainability trends, we approached a relevant study from the automotive field. To be more precise, the main attention is moved toward ecological marketing, recycling, or re-usage of the remaining material after manufacturing or ecological logistics. Also, the following specific elements with applicability in the automotive industry were noted: Waste Management, Green Product Design, Green Procurement, Green

Technology Implementation, Green Logistics, Lean Management, and Green Labeling.

The study outcome shows some expected behaviour, as well, some important ones in terms of green manufacturing.

Therefore, both concepts of green logistics and green energy are of high priority. At the opposite pole, with low priority are ecological purchases. In terms of final impact, greater importance is given to safety compared to the impact on the environment. From the point of view of competitive environmental policies, the first parameters followed are innovation, flexibility, and productivity. Also, the study identified the main major challenges that create conflicts within organizations in the automotive industry. One of the major confrontations is represented by the migration to ecological or more ecological technologies compared to the existing ones. Also, a similar confrontation is the migration of production processes in the ecological zone or more ecological compared to the existing ones. These migrations involve significantly higher costs than conventional methods. Also, another disadvantage, compared to conventional methods, the ecological ones involve low yields. Precisely because of high costs and low returns, top management puts in less effort and shows less dedication to migrating to green or greener. The second major confrontation is represented by the undoubtedly necessary difficulty of generating the optimal amount of energy through ecological or renewable methods and means. From another point of view, the sample of the applied survey has referred instead to prioritizing green energy and ecological logistics. On the other hand, the respondents of the questionnaire applied in the study mentioned above prioritize both green energy and ecological logistics. Yet, ecological purchases have not received a prioritization. Considering the study results on a specific sample, we draw the following supported conclusions: the automotive industry has implemented ecological practices in all its sub-industries, and it constantly supports, develops, and innovates green technologies in everything related to production [16]. Both worldwide and in the automotive industry, ecological production, and sustainable production, are still questions to which answers are constantly being sought. The trend of continuous greening implies this process of migration from conventional to new, the new being green technologies.

In terms of both sides, from a social and scientific, point of view, sustainability has become one of the most current important and challenging topics nowadays. Referring to the automotive industry, the sustainability concept became one of its main important issues.

The automotive industry faces many scandals. The most notorious topics are related to electric motors and CO_2 emissions. Some authors have found a niche topic related to the interior of a used car. They raised the following questions: Do the producers use natural fibers? Does this promote ecological use? Do manufacturers develop ecological solutions for the interior? Does the end customer accept ecological solutions? [17] The answers to these challenges are particularly interesting in terms of sustainability. On the opposite pole, other authors exclusively analyse whether the customer's requirements are sustainable or not, without giving importance to the behaviour of the car interior manufacturer [18].

3. RESEARCH METHODOLOGY

3.1 Research model

The contextualization that we propose through this work is based on a variation of the model for measuring the success of the information system, an updated model designed by DeLone and McLean. Thus, we propose the usage of the six dimensions research model to investigate and explain information system (IS) success in determining the green manufacturing practice (GMP) within the automotive sector – Figure 1.

Focusing on the model advanced by McLean and DeLone, the main dimensions of the updated model have the following essential characteristics.

If we talk about the quality of the system, we approach an instrument designed to measure the user's wishes, such as ease of use, response time, and system flexibility. If we refer to information quality, we are focusing on points such as content and outcome, as well as its relationships, as well as characteristics such as promptness, accuracy, reliability, and trust.

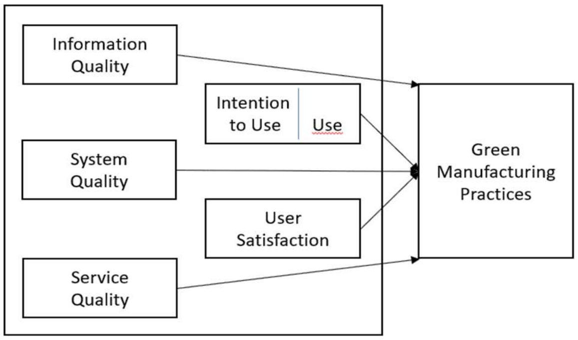

Fig.1. Research proposed model

Referring to quality service, the support, help, safety, and promptness offered by the developer to the user through the support department are considered. Intention to use or use refers statistically to the intention to use, real, effective use, as well as perceived usefulness. One of the most relevant dimensions of the model is rendered by user satisfaction which implicitly leads to the achievement of system success [19].

3.2 Study Design and Instrument

The targeted sample was made up of key user respondents from an automotive company with locations in Europe, including Romania. To collect the data, a questionnaire consisting of previously validated items was built. Thus, based on previous studies, the questions were adapted and adjusted to verified and validated scales. To fulfil validity, the items within the questionnaire were adapted from validated scales used within previous studies.

Questions assessing each construct were adapted from prior studies with validated scales both for McLean and DeLone model items [20-24] and for all GMP [25-28].

The questionnaire comprises a list of 25 items apart from demographic questions. The respondents had to respond by using a five-point Likert scale.

3.3 Method of data analysis

From the theoretical background and research objectives, the identification of the main associated components (dimensions) associated with the proposed research model can be done using principal component analysis (PCA).

The initial variables are aggregated into 6 latent variables, also eliminating collinearity, and thus facilitating the analysis. Consider a set of initial variables, Xi (i=1...n), and determine new variables (components) of the form Cj (j=1...m), where [29 - 32]:

$$C_j = \alpha_{j1} \cdot X1 + \alpha_{j2} \cdot X_2 + ... + \alpha_{jn} \cdot X_n \qquad (1)$$

and $m \le n$.

Using PCA in the computational environment, the components can be estimated, respectively the associated scores calculated based on correlation coefficients between the initial variables and the main components [equation (1) based on the estimates associated with α_j parameters].

To identify the main components associated with the proposed models, using PCA and respectively the scores on each component separately, six associated dimensions were considered (System Quality, Information Quality, Service Quality, Intention to Use [Use], User Satisfaction, Green Manufacturing Practices), presented in the literature.

4. RESULTS

In the analysis, 52 valid received responses were used. The demographic information associated with the used sample is presented in Table 1.

Table 1

Demographic information's

Variables & options		Frequency	Percent	Valid Percent	Cumulative Percent
Last form of education:	Bachelor	5	9.6	9.6	9.6
	Vocational school	7	13.5	13.5	23.1
	Bachelor	21	40.4	40.4	63.5
	Master	14	26.9	26.9	90.4
	PhD	5	9.6	9.6	100.0
	Total	52	100.0	100.0	
Hierarchical level:	Non-management	20	38.5	38.5	38.5
	Middle-management	20	38.5	38.5	76.9
	Top management	12	23.1	23.1	100.0
	Total	52	100.0	100.0	
Ag e:	18-25 years	2	3.8	3.8	3.8
	26-35 years	14	26.9	26.9	30.8

	36-45 years	20	38.5	38.5	69.2
	46-55 years	12	23.1	23.1	92.3
	56-65 years	4	7.7	7.7	100.0
	Total	52	100.0	100.0	
Gender:	Female	16	30.8	30.8	30.8
	Male	36	69.2	69.2	100.0
	Total	52	100.0	100.0	

Starting from the variables included for each dimension in the model, in PCA the components were determined, and parameters associated with proposed models were estimated.

Hence, the following (i) econometric models have been proposed for each dimension – equations: (2), (4), (6), (8), (10), and (12), and (ii) associated analysis results/ component parameters estimates/ coefficients (using PCA) – considering, based on literature, as relevant all the model factors/ components (without factor reduction; maintaining in 100% phenomenon variances):

(i) System Quality component

$$\text{System Quality component} = \alpha 1 \cdot I1 + \alpha 2 \cdot I2 + \alpha 3 \cdot I3 + \alpha 4 \cdot I4 \quad (2)$$

where:

I1. IS is easy to use; I2. desired IS is easy to obtain; I3. IS is flexible to interact; I4. IS is easy to be learned.

In PCA for the proposed model, starting from the data included in the analysis, the following values of proposed model parameters – System Quality component – were estimated (equation (3)):

$$Score_{\text{System Quality component}} = 0.270 \cdot I1 + 0.259 \cdot I2 + 0.258 \cdot I3 + 0.261 \cdot I4 \quad (3)$$

(ii) Information Quality component

$$\text{Information Quality component} = \beta_1 \cdot I5 + \beta_2 \cdot I6 + \beta_3 \cdot I7 + \beta_4 \cdot I8 \quad (4)$$

where:

I5. IS generates correct information; I6. IS generates useful information for its purpose; I7. IS generates information in optimum time; I8. IS generates reliable data.

The analysis (PCA) result is (equation (5)):

$$Score_{\text{Information Quality component}} = 0.262 \cdot I5 + 0.260 \cdot I6 + 0.267 \cdot I7 + 0.255 \cdot I8 \quad (5)$$

(iii) Service Quality component

$$\text{Componenta Service Quality} = \Omega 1 \cdot I9 + \Omega 2 \cdot I10 + \Omega 3 \cdot I11 + \Omega 4 \cdot I12 \quad (6)$$

where:

I9. adequate technical support (associate to SI); I10. Are benefits associated with overall infrastructure; I11. IS is reliable; I12. IS generates complete information for work processes;

The analysis (PCA) result is (equation (7)):

$$Score_{\text{Service Quality component}} = 0.256 \cdot I9 + 0.252 \cdot I10 + 0.256 \cdot I11 + 0.259 \cdot I12 \quad (7)$$

(iv) Intention to use [use] (IS) component

$$\text{Intention to Use [Use] component} = \mu_1 \cdot I13 + \mu_2 \cdot I14 + \mu_3 \cdot I15 \quad (8)$$

where:

I13. IS improves job performance; I14. Makes work easier; I15. IS is useful.

Parameters estimates (PCA) associated with the proposed model for this component are (equation (9)):

$$Score_{\text{Intention to Use [Use] component}} = 0.336 \cdot I13 + 0.336 \cdot I14 + 0.336 \cdot I15 \quad (9)$$

(v) User Satisfaction component

$$\text{User Satisfaction component} = \textstyle\sum_1 \cdot I16 + \sum_2 \cdot I17 + \sum_3 \cdot I18 \quad (10)$$

where:

I16. IS has satisfactory functions; I17. IS made work processes easier; I18. IS is satisfactory.

Parameters estimates (PCA) associated with the proposed model for this component are (equation (11)):

$$Score_{\text{User Satisfaction component}} = 0.340 \cdot I16 + 0.342 \cdot I17 + 0.335 \cdot I18 \quad (11)$$

(vi) Green Manufacturing Practices component

$$\text{Green Manufacturing Practices Component} = \theta_1 \cdot I19 + \theta_2 \cdot I20 + \theta_3 \cdot I21 + \theta_4 \cdot I22 + \theta_5 \cdot I23 + \theta_6 \cdot I24 + \theta_7 \cdot I25 \quad (12)$$

where:

I19. Life-cycle assessment as organizational practice; I20. reused and recycled contents - plastics and glass; I21. power consumption reduction associated with manufacturing and transport; I22. hazardous substances (e.g.: mercury and chromium) used in the production process; I23. eco-technological equipment and process - in manufacturing; I24. products that reduce (in their use) materials and energy consumption; I25. implemented organizational environmental management systems.

Parameters estimates (PCA) associated with the proposed model for this component are (equation (13)):

$$Score_{\text{Green Manufacturing Practices Component}} = 0.156 \cdot I19 + 0.163 \cdot I20 + 0.203 \cdot I21 + 0.179 \cdot I22 + 0.199 \cdot I23 + 0.195 \cdot I24 + 0.140 \cdot I25 \quad (13)$$

To explain information system (IS) success in determining the green manufacturing practice (GMP) within the automotive sector – using the multiple regression equation – we obtain the following synthetical quantitative result – equation (14):

$$Y\ [GREEN\_MANUF.\_PRACTICE] = 2.541 + 0.2872 * SYSTEM\_Q^2 - 0.086 * 1 + e^{-SERVICE\_Q} - 0.4632 * INFORMATION\_Q^2 + 0.3342 * USE\_SI^2 + 0.085 * 1 + e^{-USER\_SATISFACTION} \quad (14)$$

where:

[SYSTEM_Q – System Quality dimension; INFORMATION_Q – Information Quality dimension; USE_SI – Intention to Use dimension; SERVICE_Q – Service Quality dimension; USER_SATISFACTION – User Satisfaction dimension] – dimensions associated with the proposed model and that could explain information system (IS) success in determining the GMP.

R Square = .682 (a relatively good R^2 value associated to the model)

In the analysis was performed a curve fitting evaluation (in SPSS 22 software) with the purpose to identify the model that provides the best fit. Hence (i) the dimensions “Service Quality” and “User Satisfaction” have as characteristic “S”- shaped curve/ sigmoid curve; (ii) the other three dimensions have as characteristic the power curve.

Analysing the estimate parameters associated with the proposed econometric models, it can be observed that on average the associated values (coefficients) indicate a representative but relatively reduced level of components positive determination; except for the estimate parameters associated with components of dimensions *Intention to use [use]* (IS) ($\mu_{1-3} = 0.336$) – equation (9) and *User Satisfaction* ($\sum_{1-3} = \pm 0.34$) – equation (11), which are approximately equal and relatively higher.

Instead, equation (14) – the linear multiple regression analysis results, indicate (predict)/ explain that IS success in determining the green manufacturing practice (GMP) within the automotive sector, is provided by an increase of *System Quality* and *Intention to Use* (use IS) dimensions. However, an increase in Information Quality will generate a negative impact; this outcome could be explained by the fact that will overload the IS informational circuits.

6. CONCLUSIONS

This paper proposes to explore the IS role/ success in green manufacturing practices, without approaching the subject of the hybrid concept of green information systems. Considering McLean and DeLone, a systemic model comprising green manufacturing practices as an outcome has been developed and tested.

Our study results have mainly shown that the survey respondents have indicated low involvement of the company in IS dimensions. Therefore, green manufacturing practices have received as well low rates. However, a “better human resource context” and a viable SI quality could change/ improve this phenomenon.

The outcome of this study can be used as a basis for future research within different fields, by reviewing the most important relevant factors in green manufacturing practices. Moreover, future studies can support the designing of ways to improvement about the results.

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Evaluarea sistemului informațional al unei companii din sectorul automotive din perspectiva managementului producției verde

Economiile din întreaga lume au unul din piloni industria manufacturieră – dar una sustenabilă. Prin urmare, obiectivul principal este de a evalua succesul sistemului informațional (SI) în cadrul unei companii din sectorul automotive din perspectiva managementului producției verde. Abordarea metodologică inovatoare va integra modelul DeLone și McLean adaptat cerințelor de management sustenabil al producției. În acest studiu de caz abordarea statistică este una complexă și utilizează metoda anchetei bazate pe un chestionar. Rezultatele cercetării sunt atât metodologice, cât și empirice. Astfel, este dezvoltat și propus un cadru viabil pentru a evalua succesul SI din perspectiva managementului producției verde. De asemenea, pe baza rezultatelor cantitative obținute, se formulează concluzii relevante pentru cazul particular al companiei din sectorul automotive.

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