Title:
The Role of Statistics in Addressing the Level of Maturity of SMEs in Terms of PLM Collaboration

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Introduction:
Product Lifecycle Management (PLM) systems are considered as a set of tools and methodologies to manage the evolution of product-related information and processes during their life cycle from the initial stage of conception to the last stage of product disposal. On the other hand, research [1] has provided differing definitions for PLM, including that it is a business strategy to enhance the integration and collaboration activities during definition, sharing and usage of engineering data wherever information is needed throughout the product life cycle. PLM systems as a business strategy are not only a key consideration for large companies, but also they are becoming a must for small and medium sized enterprises (SMEs), whom consider product development as a core competency [2].
Due to competition and globalization in the marketplace, it is essential for enterprises that work in domain of supply chain networks to have access to optimal information and communication technologies to enhance their performance. However, in spite of SMEs also being interested in the same technologies [3], problems in structuring prevent them from having good exchanges of information [4].

When a company is planning to develop or implement a PLM system, a key consideration for those responsible, is to complete a maturity assessment. Through the use of a maturity model, the company will be able to measure the level of implementation of PLM or the methods required to extend it [5].
In our previous study [6], the maturity levels relating to collaboration between SMEs and Original Equipment Manufacturers (OEMs) was analyzed. This maturity exercise, which had five levels [5] [7] depicted the situation of collaboration from initial level to the optimal point. Based on the proposed PLM axes [6] of Strategy, Organization, Processes and Tools, it was possible to classify the activities of each level; this method of classification was important from the point of view of identifying the domain and personal responsibilities by activity.

Given the situation that all SMEs, in following certain maturity level, are not the same, it is believed that maturity levels in themselves are not sufficient to determine levels of collaboration and may need further factor analysis to determine more precisely their correct level.

On the other hand, some research [8], [9]has considered the impact on business performance of the greater adoption of Information and Communication Technologies. It has been demonstrated that there is a close relationship between the introduction of ICT and productivity gains and other measures of corporate performance [9]. However, although the ICT-productivity link is proven, SMEs do not feel the need to adopt PLM. Based on the analysis of PLM axes that we have proposed [6] and an

in-depth literature review, it is possible to identify further factors of PLM adoption that leads to obtain a PLM maturity level for SMEs. The analysis of principal component of PLM collaboration maturity in SMEs will be considered further in the next section and the effectiveness of these factors to reach to a desired maturity level, through the employment of statistic methods, will be measured.

Main Idea:

Factor analysis of PLM maturity level

The previous section explored articles which focused on different aspect of the challenges presented in PLM, such as those relating to maturity and collaboration for SMEs, but it is still necessary to explore new methods which may allow for the more effective cooperation of SMEs with extended enterprises, including OEMs. It is always interesting to be able to identify alternative means which allow for the greater integration within product development programs. In line with the aims of this project to improve collaboration between SMEs and OEMs, a PLM collaboration maturity framework is now presented for SMEs.

These days, in order to understand the current situation of PLM collaboration maturity level of SMEs in region of Normandy in France with their OEMs, we are doing investigation with some of them through a questionnaire .This questionnaire consists of 10 group of information such as , Product data management, Product development program, Collaboration program, PLM program, Information system & sharing data, deployment of ICT tools, Measurement of performance, Structure of SME, Training the employment and Number of employment. Each group for us is as an effective factor that the value given to the activities if each of them by SMEs will be effective to obtain certain level of maturity level since this maturity value will be obtain by average of value given to these factors. In addition more we will do deceptive statistics of these factors for our samples according to Tab. 1.

Again, in line with the objectives of this research, these factors might have different coefficient correlation which the interval between them lead to certain maturity level. So we will show this correlation coefficient between factors correspond to obtained level, Tab. 2.

As a result, answering to some questions will make the main idea of this investigation. These questions are:

1. Is there relation between the effective factors of PLM collaboration maturity level?
2. In case of relation between effective factors, what is the coefficient between them?
3. Is it possible to estimate the PLM collaboration maturity level in case of increment or decrement of each effective factor?
4. How we can help SMEs to improve their cooperation with OEM through detecting the aspects that they have focus working on it?

In discussion we will show how we will be able to respond questions above through statistic methods.

Effective factor	*average*	*Minimum*	*Variance*	*Maximum*
Product data management	factor i^{th} $\bar{X} = \frac{\sum X_i}{n}$ Number of group with similar maturity	Min value of factor i^{th} in group with same maturity	factor i^{th} $S^2 = \frac{\sum (X_i - \bar{X}_i)^2}{n-1}$ Number of group with similar maturity	Max value of factor i^{th} in group with same maturity
Product development program				
Collaboration program				
PLM program				
Information system & sharing data				
Deployment of ICT tools				
Measurement of performance				
Structure of SME				
Training the employment				
Number of employment				

Tab. 1: Descriptive statistical analysis of PLM maturity factors.

Effective factor	*In group with maturity of n (for n=0,1,2,3,4)*
Product data management	$\gamma=\frac{n_s-n_d}{(n_s+n_d)}$ ↓ The correlation coefficient n_s =The number of coordinate pairs n_d =The number of reverse pairs
Product development program	
Collaboration program	
PLM program	
Information system & sharing data	
Deployment of ICT tools	
Measurement of performance	
Structure of SME	
Training the employment	
Number of employment	

Tab. 2: The correlation coefficient between factors.

Discussion:

Multiple regression

In this study, based on Table 1&2, the concept of stochastic methods, such as multiple regression is explored to estimate the level of PLM collaboration maturity for SMEs through the efficient factors. Researchers often are looking for ways to find the relation between the effective variables & the differences between the groups under study and to determine the value of dependent variables by independent variables [10].

Regression analysis is a statistical process that will provide researchers to estimate the relationships between variables. It includes different techniques to model and analyze various variables, when the aim is to focus on the relationship between a dependent variable and one or more independent variables [11]

More precisely, regression analysis will provide us to understand how the typical value of the dependent variable (or 'criterion variable') will change in case of manipulating any of the independent variables.

According to a multivariate population, estimating of a variable from the known value of two or more variables- also called the predictors with Multiple regression which is a powerful technique used for predicting [11]. Fig.1 is a procedure that helps the researchers to find the suitable way to analysis the multivariable (effective factors). In this research since there is a dependency between the level of maturity and the factors (the level of maturity comes from the average of factor's value), regards to Fig.1, we will use the multiple regression for estimating the level of maturity base on exist factors in large scale. By means of it, we will understand that how the level of PLM collaboration maturity will change when any factors change.

Conclusions:

Our proposed framework of PLM maturity collaboration consists of efficient factors that the average value of them will calculate the maturity level of each SME. In order to improve this level, it is necessary to focus on the proper factors. Since the sectors or domain of application of SMEs are different, we cannot propose a unique consultant to them. So according to their activities, it will be interesting to provide them the aspects that they need to work more on it. In this research, after finding effective factors & the correlation coefficient between them, we proposed to use multiple regression to estimate the future level of maturity in case of manipulating the efficient factors.

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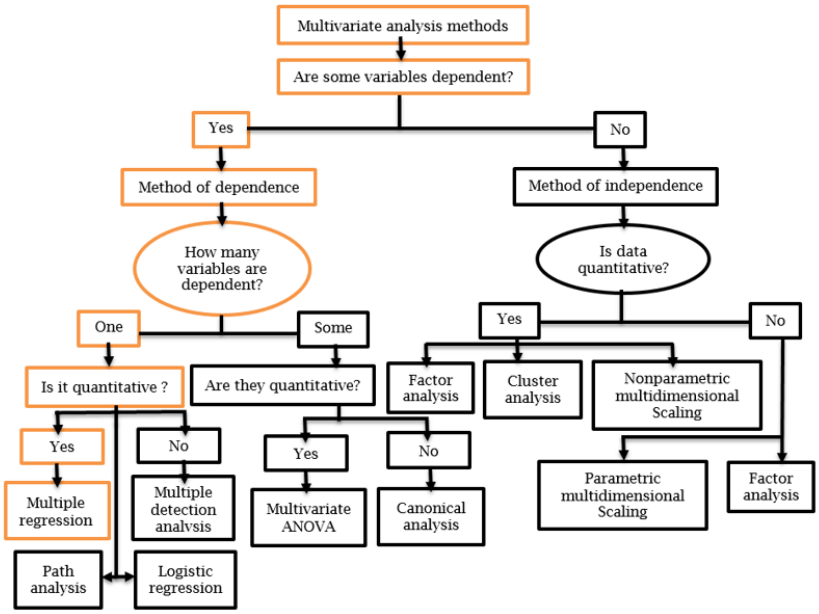

Fig. 1: Procedure to analysis the multivariable.

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