Title:
The Probability Analysis in Addressing the Level of Maturity of Using PLM Systems by SMEs

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Introduction:

A Product Lifecycle Management (PLM) system is considered as a set of tools and methodologies to manage the evolution of product-related information and processes during a product's life cycle from the initial stage of conception to the last stage of product disposal. On the other hand, previous research [1] has provided different 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, i.e., wherever information is needed throughout the product life cycle. PLM as a business strategy is not only a key consideration for large companies, but is also becoming a must for small to medium sized enterprises (SMEs), who consider product development as a core competency [2].

Due to competition and globalisation in the marketplace, working in supply chain networks has become essential for enterprises to have access to optimal information and communication technologies in order to enhance their performance. However, inspite of SMEs also being interested in the same technologies, problems in structuring prevent them from having good exchanges of information [3].

When a company is planning to develop or implementing 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 [4]. In the authors' previous study [5], the maturity levels relating to collaboration between SMEs and Original Equipment Manufacturers (OEMs) was analysed. This maturity exercise, which had five levels, depicted the situation of collaboration from initial level to the optimal point. Based on the proposed PLM axes of Strategy, Organisation, 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 adoption indicators of PLM to determine more precisely their correct level. The role of the 'Adoption' indicator of PLM in SMEs will be considered further in the next section and the effectiveness of these indicators, through the employment of probability methods, will be measured.

The Proposed Methodology:

PLM adoption

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.

On the other hand, further research [6] 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. However, although the ICT-productivity link is proven, SMEs do not feel the need to adopt PLM. Based on the analysis of PLM axes and an in-depth literature review, it is possible to identify further indicators of PLM adoption (ICT adoption), such as indirect costs, manager, type of communication and size of SMEs, shown in Fig. 1.

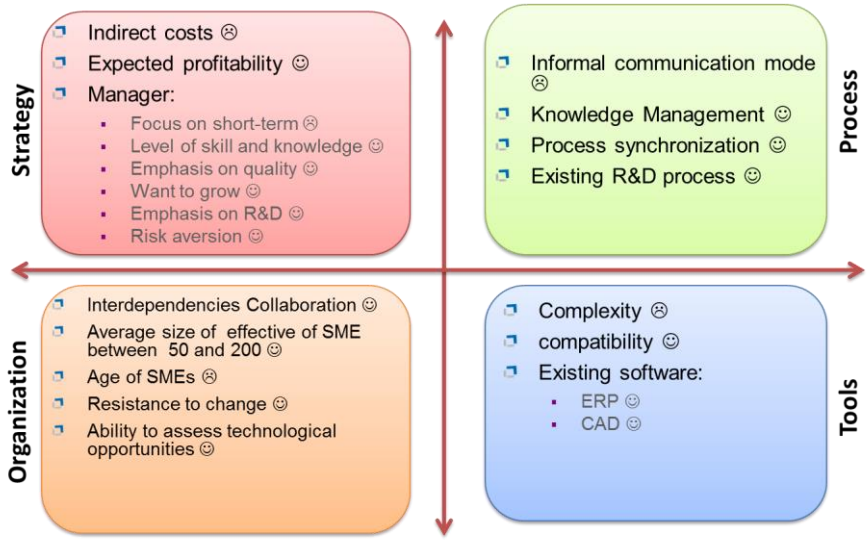
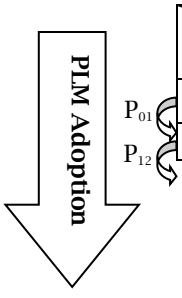


Fig.1: PLM adoption synthesis.

Figure 1 shows the proposed model for adopting ICT and especially PLM, against the four axes of Strategy, Organisation, Process and Tools. These four elements directly relate to the situation of SMEs. By way of example, the negative impact of "Informal Communication Mode" may be seen in the Process axis since, in the majority of cases, SMEs have an informal communication mode, given their small size, and this type of communication impacts directly on the adoption of PLM.

Again, in line with the objectives of this research, these indicators should also inform SMEs of the advantages of a PLM system. As a result, it was decided to propose a framework which merges the two elements of Maturity and adoption indicator together, shown in Table 1. Table 1 shows the likelihood of passing to a new level of collaboration maturity based on the effectiveness of the PLM adoption indicators. A questionnaire, based on this combination of maturity and PLM adoption, was then prepared for distribution to SMEs located in the Normandy region of France. The results of the questionnaire will determine the current level of SMEs and validate the activities shown in Table 1.



Axes / Maturity	Strategy	Organization	Process	Tool
Level 0				
Level 1				

P_{01}

P_{12}

P_{23}	Level 2				
	Level 3				
P_{34}	Level 4				

Tab. 1: PLM adoption versus maturity levels.

Discussion

In this study, based on Table 1, the concept of probability and a stochastic process, such as a Markov chain, is explored to measure the impact of the adoption indicators in order to reach a higher level of collaboration maturity. A Markov chain is a specific type of stochastic process whereby the next stage of the system depends on a preceding state. One of the main elements of the Markov chain is a transition diagram that shows the state and the probability of going from one state to another. In this research, the states are the levels of collaboration maturity and the probability of each step expressing the probability of passage to a new level of collaboration maturity based on the effectiveness of PLM adoption indicators, shown in Figure 2. It is clear that if the situation of the SME corresponds to a level of maturity, then the next level will always be the upper level for it or still remain in its previous state i.e. the probability of returning to a level lower than current one will be equal to 0.

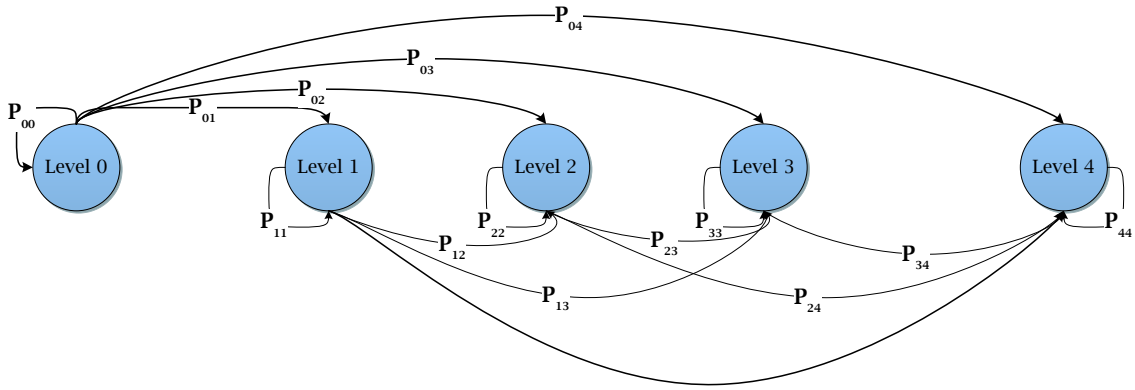


Fig.2: Transition diagram of collaboration maturity level of SME in term of PLM.

The associated transition matrix will be:

$$P_{ij} = \begin{bmatrix} P_{00} & P_{01} & P_{02} & P_{03} & P_{04} \\ 0 & P_{11} & P_{12} & P_{13} & P_{14} \\ 0 & 0 & P_{22} & P_{23} & P_{24} \\ 0 & 0 & 0 & P_{33} & P_{34} \\ 0 & 0 & 0 & 0 & P_{44} \end{bmatrix}$$

Finally, it will be possible for SMEs to understand the percentage impacts of these indicators, which may help them to improve their level of maturity, as shown in Figure 3.

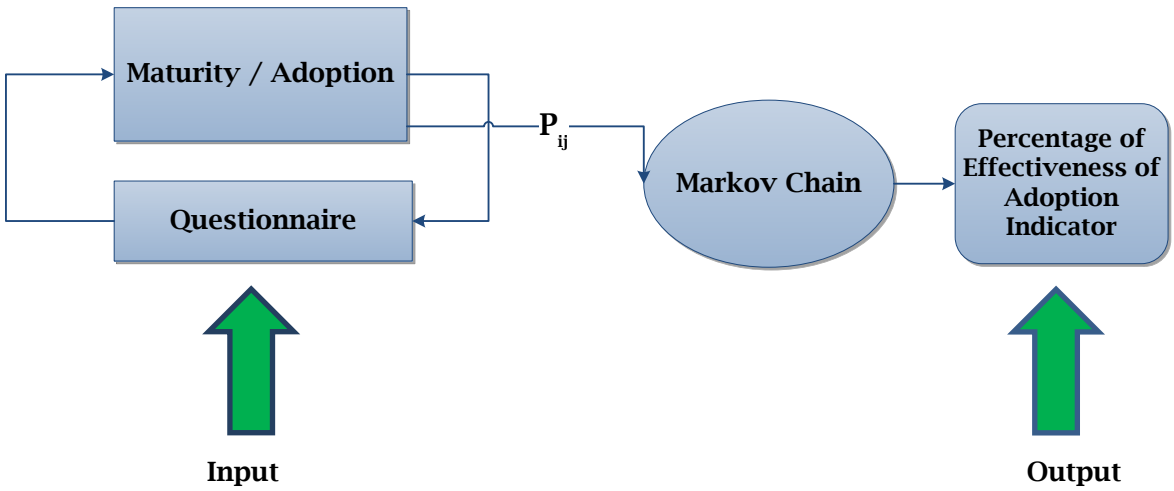


Fig.3: overview of the research. .

Conclusion:

The proposed model of PLM adoption will complete the Maturity levels evaluation. The evolution from one level to another depends on the adoption of key performance indicators. The model described, through the Markov chain, where the probability of moving from one level to another is obtained through a questionnaire. The representation through a Markov Chain provides an evolutionary model, where $P_{i,j}$ is obtained from real values provided by the questionnaire. A model based on probability and a stochastic process like the Markov Chain, offers a dynamic approach and will improve the effectiveness of adoption indicators and the level of collaboration maturity for SMEs.

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