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KNOWLEDGE MANAGEMENT TOOLS AND TECHNIQUES: EXTENT OF USE IN ORGANIZATIONS AND SUPPORT FOR MODULARIZATION

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Abstract

Customers always hold a lot of needs and requirements that are essential to undertake during every design decision. One way to meet these different needs and generate product family members that all have some commonality are by modularization and platform based product development (PBPD). Modularization and PBPD strongly deal with knowledge management (KM) and considerable slice of the knowledge of the company is included in the products and can be reused in the earlier stages of the development.

Literature describes several KM tools that have the ability to support organizations in their product development process. Despite organizations recognize more and more knowledge as a strategic lever that can be used and managed, it is not still clear the role of KM as a support for modularization and standardization. Therefore, this paper contributes to the discussion on how knowledge management can serves as leverage for modularization. First, it defines general KM techniques and tools, and by looking at 103 organizations it also shows how well they are used. Secondly, via statistical analysis significant relationships of variables representing the KM tools and modularization are shown.

Keywords: Knowledge management, Modularization, Platform based product development, Product architecture

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1 INTRODUCTION

Companies have devoted much attention to build product families that can efficiently adapt to the enormous amount of requirements that are set to satisfy all customers. Product family and platform development deals with a multitude of different requirements that are often contradictory. This entails a conceptual structure and overall logical organization of generating a family by providing a generic base to capture and exploit commonalities. The rationale lies in not only relieve the knowledge base from holding variant designs of the same solution, but also in modelling the design process of an entire class of products that can widely vary designs based on individually customized requirements within a connected framework. Sawhney (1998) defines a product platform as "set of subsystems and interfaces developed to form a common structure from which a stream of derivative products can be efficiently developed and produced". The primary issue is to exploit the shared logic and cohesive architecture behind a product platform. A product platform can be seen as the group of assets that are shared by a set of products (family). The assets include components, processes, knowledge, as well as people and relationships (Mahadevan, 2010). Also, modularization can be seen as a reuse of engineering resources (Miller and Elgard, 1998) Organizations recognize more and more knowledge as a strategic lever that can be used and managed. Considerable slice of the knowledge of the company is included in the products and can be reused in the earlier stages of the development, for example through the engineering specification. This makes boundary between modularization and knowledge management vague (Sanchez and Mahoney, 1996). Despite platforms strongly deal with knwoledge, the neighbouring field of knowledge management is rarely considered and knowledge management contributes with aspects that regularly are not considered in platform development. There are not so many investigations that relate the knowledge management process and tools to platform development: few studies examine the connection between the management of knowledge on a high level, and platforms on an operational level. However Knowledge management theory brings several processes and techniques that can support knowledge to be (re)used, created and captured. Theory defines a need for the supporting knowledge to be available at the right time and at the right place to maximize its value.

With the aim to fill this gap, this paper addresses knowledge management tools and techniques that are used by manufacturing companies connected to high product modularization. The undertaken study explores 103 manufacturing organizations, providing a descriptive study of current used best practice. It presents current types of tools and techniques that correlate with the degree of platform-based product design and development. The following research questions are set for this study.

RQ1. *What generic KM tools and techniques can be used in PD?*

RQ2. *How frequently are KM tools and techniques used?*

RQ3. How are KM tools and techniques related to modularization and standardization?

The next section describes the research method, followed by an overview of the theoretical background of platform-based product development together with some key concepts in the field and next knowledge management support for product family design and development. The empirical study are presented including the data and statistical analysis of the empirical data acquired from the exploratory survey together with the interviews. The results are discussed and the paper concludes with some key insights.

2 METHOD

The main objective of this paper is to illuminate and evaluate which Knowledge Management tools and techniques are available and used by organizations and analyse if they potentially act as drivers for modularization and standardization. In order to achieve this objective, literature was studied to frame KM and modularization, further an exploratory survey has been designed and run through face-to-face interviews. Data have been collected from March 2012 to February 2013 in Italy, within the GeCo Observatory[1] research initiative. The survey served as preliminary investigation on the existence of significant relationships between the use of a list of KM tools and techniques, and the adoption of modularization and standardization methods.

[1] Italian research initiative launched by the Business School of Politecnico di Milano, which investigates on the topic of innovation, product development and design (http://www.osservatori.net/progettazione_plm).

Totally 15 knowledge management tools and techniques are investigated and considered. These are acting as independent ordinal variables against the dependent ordinal variable that are formal adoption of modularization and standardization technique.

To test if there are statistical relationships between the KM tools and techniques and the adoption of modularization and standardization, the Kruskal Wallis test has been used. Particularly this test is appropriate when there is one independent variable with two or more levels and an ordinal dependent variable. Moreover, it can be considered as the non-parametric version of ANOVA since it admits not normally distributed populations, as in this case (Bruin, 2006). The aim of the analysis is to test the null hypothesis of equality in the use of Modularization/Standardization methods across the populations. To reject the null hypothesis basically means that there is a significant relationship between the use of modularization and standardization and the use of the considered KM method/tool. In other words it will be investigated if the higher the use of all (or some) of the investigate KM tools, the higher the use of modularization and standardization. Only statistic relationship will be tested at this phase of the research, while for causality explanation further research will be required.

3 PLATFORM-BASED PRODUCT DEVELOPMENT

Platform design refers to a product development (PD) strategy in which a company develops a family of products, which can share components and assets to target specific market segments (Utterback and Meyer, 1993, Jiao and Tseng, 2000, Krishnan and Ulrich, 2001). While they target specific market segments, component and assets can be combined in different set-ups that give rise to variant of various products addressing different market needs. A product platform can consist of the design, components, processes, knowledge as well as people and relationships, which are shared by a set of products. By combining components in different set-ups, a platform can give rise to variant of different products addressing different market needs.

3.1 Product family

A product family may have its beginning in a differentiation process of a base product or a combination process of different products. The product family has high impact on the organizations ability efficiently to deliver a wide variety of products and drives profound impact on the PD process (Simpson et al., 2001). The family design process combined with platform-based products affects many different areas such as: product variety, product change, product performance, component standardization, manufacturability and PD management (Simpson et al., 2001). An effective platform for a product family can allow derivative product variants to be developed more rapidly and efficiently, with each product providing the features and functions desired by particular stakeholders. Meeting the best balance of design modularity, component standardization, and product offering in both product and process design is of course important and is referred to as *design for variety* (Zha and Sriram, 2006).

3.2 Product Architecture

Ulrich (1995) referred to product architecture as the “scheme by which the function of a product is allocated to physical components”. He defined it more precisely as: (1) the arrangement of functional elements; (2) the mapping from functional elements to physical components; and (3) the specification of the interfaces among interacting physical components. Modularity is described as a characteristic of product architecture (Ulrich, 1995). Baldwin and Clark (2000) define a module as a “unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements on other units. Clearly there are degrees of connection, thus there are degree of modularity”. The collection of the defined interfaces between modules can then be regarded as the product’s architecture (Sanchez and Mahoney, 1996).

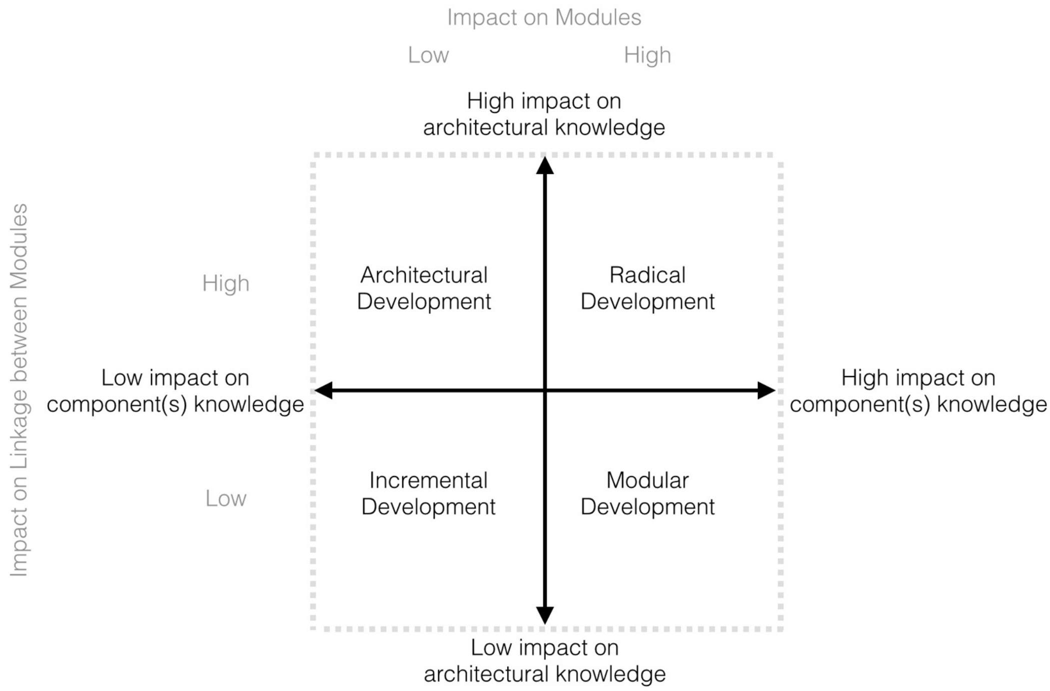

Figure 1. A framework for categorizing between component and architectural knowledge in Platform-based product design and development. Adapted from Henderson & Clark (1990).

3.3 Knowledge in different kind of innovations

There exist a need of having systems and processes supporting the platform-based product family development with accurate knowledge (Zha and Sriram, 2006). Moreover, product modularity affects how knowledge is allocated and managed, e.g., according to physical modules (Pasche and Persson, 2012). Different design changes or innovations have different application of the existing architectural and component knowledge of the organization (Henderson and Clark, 1990). A component in this paper is defined as a distinct portion of the product that embodies a core design concept and performs a well-defined function. Architectural knowledge is the knowledge about how the modules are linked together.

In Figure 1 development are categorized into four different categories that have different use of (and affect) the existing knowledge different. The horizontal dimension capture the impact on component while the vertical capture the architectural knowledge. There are, of course, other ways to describe different kinds of development. But given the context of platform based product development, the framework is useful because it focuses on the impact on the usefulness of the existing architectural and component knowledge in relation to type of development.

3.4 Technology platform

The interaction of knowledge in the form of know-what and know-how to traditional engineering software such as CAD systems is a challenge and standards have primarily focused on standardizing the exchange of data and not knowledge. In the area of exchanging data, progress have been made and various organizations and standard committees are developing representations for data linked to assembly models, parametric information and tolerances etc. (Szykman et al., 2001). These approaches do not consider knowledge pertaining to manufacturing or design features or design knowledge that might be present in the corporate database (Szykman et al., 2001).

Technology platforms can support organizations that are not satisfied with only traditional geometry-oriented corporate design or electronic part catalogue databases. These repositories of variant knowledge and data that are intended and designed to support representation, capture, sharing, and reuse of corporate design knowledge. Technology platforms are distinguished from traditional design databases in several significant ways:

- Technology platforms attempt to capture a wider product representation than traditional CAD databases, including the types of knowledge discussed previously such as know-what, know-how, know-why, design rationale, etc.
- Design databases usually contain images (drawings), CAD models, and unstructured text documents. Technology platforms tend to be more heterogeneous and may contain formal schemata and data structures, structured text, animations, video, mathematical simulation models, problem-solving documentation, lessons learned, and other types of documentation.
- Design databases tend to be static sources of information (but their contents may increase with time). While they are used for storage and acquisition of design data, capabilities to support the design process are not usually built into these systems. Such capabilities may include search for components/assemblies that meet the desired function, explicit representation of physical and functional breakdowns and the mappings between them, (semi-) automated reasoning about a design, and more. Since design databases are not designed especially for these purposes, they are limited in their ability to meet needs for design of large-scale technical systems.

The nature of large-scale engineering technology platforms requires complexity management techniques for efficient management of the complex and thorough sets of data elements associated with them. Furthermore, many existing knowledge-based systems require time-consuming intervention by people to input, update and reuse the necessary information, which is a challenge for large organizations in today's industry where in-house technology platforms of design and manufacturing knowledge is increasing in scale (Stenholm and Landahl, 2014).

4 KNOWLEDGE MANAGEMENT SUPPORT FOR PRODUCT FAMILY DESIGN AND DEVELOPMENT

Design process is knowledge-intensive as there is a vast amount of knowledge that designers call upon and use to match the ever-increasing complexity of design problems. Given that even the most routine of design tasks is dependent upon vast amount of expert design knowledge, there is a need for knowledge support (Stokes and Consortium, 2001). Moreover, knowledge management plays a crucial role in PD, it is one of the most important activities that are vital for enterprise success (Wiig et al., 1997). A correct acquisition, application, creation, refinement and transfer/sharing of knowledge among people across PD phases (concept, feasibility, design, test, prototyping, validation) is seen as a basis for maintaining a competitive advantage and crucial to improve the product design (Goh, 2002, Markus, 2001, Nonaka and Takeuchi, 1995, Davenport and Prusak, 1998, Sanchez and Mahoney, 1996, Stenholm and Landahl, 2014). Design knowledge refers to the collection of knowledge needed to support the design activities and decision-making in the design process. To be successful with the main characteristics of product family design, which are modularity, commonality/reusability, and standardization right knowledge defining their characteristics needs to be supplied to the right people at the right time (Zha and Sriram, 2006, Teece, 2000).

4.1 Knowledge Management tools and techniques

To categorize and capture organizational knowledge, a knowledge repository/design repository is typically applied. In this paper it is referred to as a technology platform solely composed of knowledge records of explicit knowledge (Levandowski et al., 2013). The knowledge is exclusively related to technologies describing product and manufacturing systems. It is designating the link between product systems and manufacturing systems, by the communication between man-computer, computer-computer and computer-man. The knowledge records are delimited to describe manufacturing systems capabilities, guidelines of "know how" (Levandowski et al., 2013) and ISO as well as corporate standards, in a PD context. This communication can be unstructured or structured documentation (**specification documents, checklists, intranet, shared folder, blogs etc.**). Effective knowledge management requires infrastructure made of technology, formalization of knowledge into rules -which should be up to date-, formal reuse of previous knowledge, continuous improvement methodologies for capitalization, update and reuse past of knowledge of a company (Gold et al., 2001, Teece, 2000, Kamsu Foguem et al., 2008, Sanchez and Mahoney, 1996, Baumeister et al., 2011). Also the ability to access to the most relevant **lessons learned** at the most appropriate time, in the most appropriate format is critical (Weber et al., 2001, Carrillo et al., 2013) and the project success is increased through learning (Kotnour, 2000).

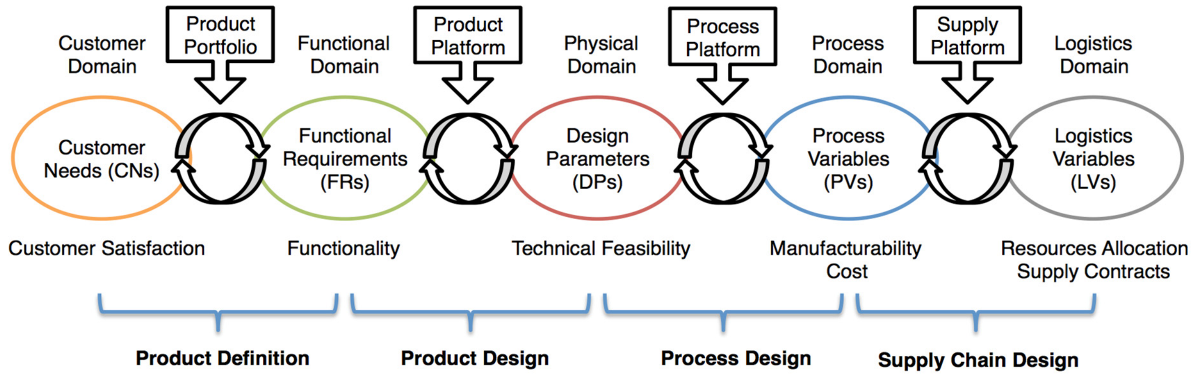

Figure 2. A holistic view of product family design and development, redrawn from Jiao et al. (2007).

Another instrument that is taking huge place in knowledge management for new PD in lean environments is **visual communication**, which in lean is applied through the so-called Obeya Room (Parry and Turner, 2006, Morgan and Liker, 2006, Lindlöf, 2014). This is one form of **verbal communication** that increases sharing knowledge and learning. Also **Wiki** tools are seen as enhancing learning process and support knowledge creation and sharing (Parker and Chao, 2007, Wagner, 2004). Finally for supporting knowledge management tools as **Product Lifecycle Management** (PLM) or **Product Data Management** (PDM) are applied to provide flexible means to maintain coherently all product related information during the main phases of products life-cycle and allow to capture customer requirements better, create more innovative ideas, and develop products faster (Terzi et al., 2010, Hameri and Nihtilä, 1998, Stark, 2005). Also **Knowledge based engineering** (KBE) tools serve as support to organize information flow, enhance business performance, and provide potential for engineering design applications (Catic, 2011, Chapman and Pinfold, 1999, Rocca, 2012).
The framework for design activities and decisions of product family design and development along the whole spectrum of product realization includes consecutively five domains, according to the concept of design domains (Suh, 2001). The domains are: customer, functional, physical, process and logistics (see Figure 2). Product family activities and decision-making involves a series of know-what and know-how between and during these domains to support product definition, product design, process design and supply chain design (Jiao et al., 2007).

5 THE EMPIRICAL RESEARCH

5.1 The Variables

In the following paragraphs first the variables investigates through the questionnaire are introduced and then the interviewed sample is presented. As stated in section 4.1, many tools and methods support the KM process within organizations. The proposed survey investigates the frequency of use and effectiveness of those techniques within organizations, through multiple-choice questions, scored with a multiple-points evaluation scale, as reported in Table 1. Totally 15 KM tools and techniques are investigated and considered here as independent ordinal variables (5 points scales are used, 1-3-5-7-9). Formal adoption of modularization and standardization technique acts as dependent ordinal variable (4 points scale is assumed, 1-3-6-9). Example of a question is: *How often Lessons Learned Documents are formally used to capture, share and reuse knowledge (Never, Sometimes, Often, Always)? Are they effective (Low, Moderate, High, Very High)?* The question is scored with a 5-point scale through an index of frequency weighted under effectiveness. The structured of the whole questionnaire, together with the explanation of the used scale is in Appendix 1.

Table 1. The Investigated Variables: description, code and evaluation scale.

Variables	Variables' Code
Formal sources of knowledge are continuously update and reviewed, such as:	
- Written design rules defined by the company	Up_writ_company_rules
- Written design rules text books/standards	Up_writ_stdrds
- Written rules defined by external parts (customers, suppliers, etc.)	Up_writ_extern
Rely on previous knowledge for PD projects	PP_know
Structured Tools and techniques formally used to capture, share and reuse knowledge:	
- Verbal communication with colleagues	KM_Verb_c
- Lessons learned documents	KM_less_le
- Specification documents of the projects	KM_Spec
- Questionnaire / Checklist	KM_Checklist
- Obeya rooms, poster and visual management	KM_visual
- Network shared folders	KM_Shared_fold
- Intranet	KM_Intranet
- Wiki	KM_Wiki
- Blogs, forum, noticeboards	KM_forum
- PDM/PLM systems	KM_PDM/PLM
- KBE software and design automation	KM_KBE
Formal adoption of rules for parts modularization and standardization (modular, platform, cluster design, etc.)	M_mod_std

5.2 The Sample

The study, part of the broader research initiative of the GeCo Observatory[1], has been conducted on 103 national (Italian) and multinational companies, with at least one product development site in Italy. Each company has been interviewed through a face-to-face interview (average last 2.5 hours) that involved a project manager, a technical director, and/or a team of engineers working in product development department. The sample is constituted of both small and medium enterprises (SMEs), and large enterprises. Details of the size of the sample are to the left in table 2. The surveyed companies can be framed into four principal industrial sectors: mechanics, electrics, electronics and other sectors (such as Fashion, Chemical and Food). Table 2 to the right summarizes the distribution of the sample across the sectors.

Table 2. The Sample: Size of Companies (left), Companies' Sector (right).

Size (based on number of employees)	N° of companies	Class	N° of companies
Micro (<10)	4		
Small (10>=employees<50)	13	SMEs	38
Medium (50>=employees<250)	21		
Big (250>=employees<1000)	29	LARGE	65
Macro (>=1000)	36		

Sector	N° of companies
Mechanics	44
Electrics	27
Electronics	18
Other	14

6 RESULTS

In particular, statistical correlations have been estimated between the 15 knowledge management tools and techniques and the use of modularization and standardization. Afterwards, descriptive statistics on the investigated KM variables has been performed. In the following the statistical analysis is presented and the main results are discussed. Table 3 reports the complete results of the test to see if there are statistical relationships, conducted considering the use of modularization and standardization as dependent variable and the KM tools and methods, one by one, as independent variables.

Significant statistical relationships exist between modularization and standardization application and a series of KM variables, at different levels of confidence. The null hypothesis is rejected (which shows a significant relationship) for 4 of the investigated KM tools: checklists, shared folders, intranet, PDM/PLM. In the specific (see Table 4) there are differences in the use of modularization and standardization as the levels of adoption of the mention KM tools vary. On average at medium high level of adoption and effective use of the KM tools, correspond higher use of modularization and standardization, especially for the use of checklists and PDM/PLM, while the role of intranet and shared folder as drivers for modularization and standardization is not clearly supportable from data evidences.

Table 3. Kruskal Wallis Test between the 15 KM independent variables and the use of Modularization/Standardization dependent variable.

H_0: equality in the populations in the use of Modularization/Standardization			
Kruskal Wallis test (n=103)	*p-value*	*Kruskal Wallis test (n=103)*	*p-value*
Up_writ_company_rules	0.0120*	KM_visual	0.3871
Up_writ_stdrds	0.0133*	KM_Shared_fold	0.0085**
Up_writ_extern	0.3351	KM_Intranet	0.0268*
PP_know	0.1667	KM_Wiki	0.6865
KM_Verb_c	0.0832	KM_forum	0.1892
KM_less_le	0.1018	KM_PDM/PLM	0.0130*
KM_Spec	0.0839	KM_KBE	0.5079
KM_Checklist	0.0082**		

**p < 0.01, *p < 0.05

Table 4. Modularization/Standardization across KM Tools

KM_Checklist	*Summary of m_mod_std*		*KM_Shared_fold*	*Summary of m_mod_std*		*KM_Intranet*	*Summary of m_mod_std*		*KM_PDM/PLM*	*Summary of m_mod_std*	
	Mean	*Std. Dev.*		*Mean*	*Std. Dev.*		*Mean*	*Std. Dev.*		*Mean*	*Std. Dev.*
1	4.43	3.05	1	8.00	1.73	1	3.78	2.92	1	3.67	2.71
3	4.14	2.48	3	2.11	2.20	3	5.40	2.80	3	4.83	3.19
5	3.67	2.81	5	4.12	2.42	5	4.70	2.95	5	7.20	1.64
7	7.00	2.35	7	5.39	2.73	7	4.47	2.56	7	5.36	2.69
9	6.3	2.21	9	5.02	2.99	9	6.24	2.72	9	5.55	2.90

Regarding the existence of formal structured source of knowledge, the higher the level of newness and update of those formal rules, the higher the attention of the organizations in modularization and standardization (see Table 5).

To answer RQ3, Table 6 summarizes which of these KM techniques, highly linked to the use of modularization and standardization, are more diffused and used nowadays within companies. At first place the use of rules to guarantee the respect of law quality constraints; secondly the use of shared folder, despite we saw it is not necessary linked to a higher use of modularization and standardization approach. Also the retrieve of knowledge, the formalization of rules for quality performance and the update of rules are quite diffused within the sample. The use of PDM/PLM tool and the existence of rules for life cycle consideration in the design and development process are still at a lower level of diffusion.

Table 5. Modularization/Standardization across Update of Formal Sources of Knowledge

Up_writ_company_rules	*Summary of m_mod_std*		*Up_writ_stdrds*	*Summary of m_mod_std*	
	Mean	*Std. Dev.*		*Mean*	*Std. Dev.*
1	1.67	1.15	1	5.20	4.02
3	2.43	2.44	3	3.07	3.47
5	4.40	3.11	5	4.25	2.69
7	5.62	2.62	7	5.27	2.60
9	5.58	2.31	9	7.29	1.60

Table 6. Use of KM Tools/Techniques

KM Tools/Techniques	*Mean*	*Std. Dev.*
KM_Checklist	3.408	2.777
KM_Shared_fold	7.136	2.262
KM_Intranet	4.282	3.154
KM_PDM/PLM	4.903	3.656
Up_writ_company_rules	5.971	1.790
Up_writ_stdrds	5.678	1.931

7 CONCLUSIONS

The role that knowledge management tools and techniques assume for enabling modularization and standardization is still under discussion. An exploratory research has been run in Italy within 103 organizations to investigate whether and which KM tools and techniques are used and also which of them potentially serve as drivers for modularization and standardization. The literature study framed a number of generic KM tools and techniques that are available and they worked as an input for

Table 7 Summary of the generic KM tools and techniques available. Variables that shows significant relationship with modularization and standardization are bolded.

Category/question	Variables	Mean (low 1-3, medium 4-6, high 7-9)
Formal sources of knowledge are continuously update and reviewed, such as:	**- Written design rules defined by the company**	5.97
	- Written design rules text books/standards	5.68
	- Written rules defined by external parts (e.g. customers, suppliers, etc.)	5.50
	- Rely on previous knowledge for PD projects	7.12
Structured Tools and techniques formally used to capture, share and reuse knowledge:	- Verbal communication with colleagues	6.83
	- Lessons learned documents	4.05
	- Specification documents of the projects	6.77
	- Questionnaire / Checklist	3.41
	- Obeya rooms, poster and visual management	2.60
	- Network shared folders	7.14
	- Intranet	4.28
	- Wiki	2.20
	- Blogs, forum, noticeboards	1.74
	- PDM/PLM systems	4.90
	- KBE software and design automation	2.17

designing a survey (see Table 7). How common the KM tools and techniques are in the organization are received from the data analysis and can be found in Table 7.

From the data analysis KM variables that have significant relationships to modularization and standardization are pointed out and found in bold in Table 7. It emerges that checklists and PDM/PLM are potential supporting modularization and standardization by showing that they coexist. Despite these KM instruments and methodologies are strictly connected to the use of modularization and standardization, not all of them are equally diffused within industry. In particular companies highly adopt rules for respecting law constraints and quality performance; they update their formalized knowledge and they retrieve and reuse previous knowledge. However, the adoption of life cycle oriented methods, such as rules for life cycle cost and PDM/PLM, is under average.

Today there is a sense that companies has been seen an extended pull for mass customization supported by Product-Service Systems (PSS) during the last years. Where customers expect that their specific needs will be fulfilled with individual solutions, consisting of products and services. Worth to note is that the customer requirements are mainly function oriented and not solution oriented which is in line with the process performed by mapping between the domains. Especially from customer needs, functional requirements and design parameters (Jiao et al., 2007). PSS will gain manufacturers competitive advantage if they offer individual solution that is more efficient than the solutions of their competitors (Meier et al., 2010) and according to Mannweiler and Aurich (2013) are standardized products not able to cope with this market development. The modular system increase the possibility to remanufacture components and speed up the process but adds further emphasis in the way we design (Tchertchian et al., 2011). To increase the profit of remanufacturing the products need to be easier to analyse, easier to repair or change parts etc. If companies pursue with PSS they probably need to consider the KM tools and techniques linked to modularization and standardization identified in this paper. However, further research needs to be done to perceive if these KM tools and techniques work as drivers for modularization and standardization.

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APPENDIX 1

Questionnaire Structure and Scoring.

Variables' Code	Question	Multiple-Scale
 Up_writ_company_rules Up_writ_stdrds Up_writ_extern	*How often formal sources of knowledge are update?* - Written design rules defined by the company - Written design rules text books/standards - Written rules defined by external parts (customers, suppliers, etc.)	Rule Not Formalized (1) Never (3) Sometimes (5) Often (7) Always (9)
PP_know	How much, in %, does the company rely on previous knowledge for PD projects?	Between 0% - 20% (1) Between 21% - 40% (3) Between 41% - 60% (5) Between 61% - 80% (7) Between 81% - 100% (9)
  KM_Verb_c KM_less_le KM_Spec KM_Checklist KM_visual KM_Shared_fold KM_Intranet KM_Wiki KM_forum KM_PDM/PLM KM_KBE	*How often are the following tools and techniques formally used to capture, share and reuse knowledge? Are they effective?* - Verbal communication with colleagues - Lessons learned documents - Specification documents of the projects - Questionnaire / Checklist - Obeya rooms, poster and visual management - Network shared folders - Intranet - Wiki - Blogs, forum, noticeboards - PDM/PLM systems - KBE software and design automation	Never/Low (1) Never/Moderate (1) Never/High (1) Never/Very High (1) Sometimes/Low (3) Sometimes/Moderate (3) Sometimes/High (5) Sometimes/Very High (7) Often/Low (3) Often/Moderate (5) Often/High (7) Often/Very High (9) Always/Low (5) Always/Moderate (7) Always/High (9) Always/Very High (9)
M_mod_std	Formal adoption of rules for parts modularization and standardization (modular, platform, cluster design, etc.)	Never (1) Sometimes (3) Often (6) Always (9)