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ORIGINAL PAPER

Product Planning techniques: investigating the differences between research trajectories and industry expectations

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Abstract According to several literature sources, Product Planning is acknowledged as a primary driver of future commercial success for new designed products, and it is schematically constituted by the identification of business opportunities and the selection of most promising alternatives. Despite the recalled relevance of Product Planning, it emerges that a marginal quantity of companies have adopted formal methods to carry out this task. The paper attempts to provide a major understanding about such a limited implementation of Product Planning techniques and other open issues emerging from the analysis of the literature concerning the initial phases of engineering design cycles. The presented study investigates the claimed benefits of methods described in the literature, the level to which such tools are diffused through educational programs in Technical Institutes, the expectations and the demands of a sample of enterprises with respect to new tools supporting Product Planning. It emerges that, whereas existing methods strive to fulfil relevant properties according to the perception of the companies, limitations come out in terms of the transfer of the proposed techniques and their perceived reliability.

Keywords New product development · Fuzzy front end · Idea generation · Review of design methods · Industrial survey · Design education

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1 Introduction

The capability to innovate the commercial offer is becoming a key aspect for the survival of companies due to the high competitiveness of the market. In this sense, a crucial role is played by the design activities belonging to the New Product Development (NPD) process.

Actually, several schemes of NPD cycles exist (e.g. Pahl et al. 2007; Shinno et al. 2006; Ulrich and Eppinger 2011; Guo 2012); however, even though quite different terminologies are used, all of them can be represented through the overall model shown in Fig. 1.

The first two phases of the product development process, i.e. Product Planning and Conceptual Design, generally constitute the so-called Front End. This initial part of the design process is often referred as "Fuzzy Front End" (FFE); Smith and Reinertsen (1991) have first popularized the term. The adjective "fuzzy" has been attributed to Front End phases, because they typically involve random process and "ad hoc" decisions based on intuition, observations, discussions or accidents (Stasch et al. 1992; Montoya-Weiss and O'Driscoll 2000; Flint 2002).

Conceptual Design is acknowledged as a fundamental step towards the definition of original, novel and sustainable technical solutions (Al-Hakim et al. 2000). Product Planning consists in the identification of customer needs, the analysis of current lacks in the market and the definition of new product characteristics capable of fulfilling customer expectations (Pahl et al. 2007). Therefore, the outcome of this phase constitutes the product idea on which companies will concentrate design efforts and resources (Montagna 2011).

As shown in Fig. 1, the Back End ranges from Embodiment Design to those activities oriented to the introduction of new artefacts in the marketplace.

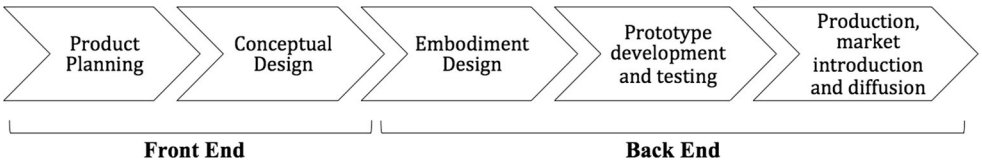

Fig. 1 Shared phases of the product development process

The literature pays a growing interest towards initial phases, which are considered critical to carry out innovation initiatives successfully (Kim and Wilemon 2002; Reid and de Brentani 2004; Riel et al. 2013). Indeed, several scholars highlight that a great percentage of product failures is ascribable to inefficient planning activities (Cooper 1999; Shinno and Hashizume 2002; Haig 2011). Moreover, Ulrich and Eppinger (2011) estimate that up to 80 % of the forthcoming cost of a product is committed by the decisions undertaken in the initial phases. Furthermore, managers and researchers claim that improvements in the management of the Front End phases are capable of producing benefits far exceeding those resulting from enhancements concerning later stages (Zhang and Doll 2001).

The appropriate accomplishment of the activities at the beginning of design cycles strongly reduces problems in the subsequent product development tasks (Cagan and Vogel 2001; Flint 2002), drives revenues and increases firms' profitability (Dahl and Moreau 2002; Reid and de Brentani 2004; Alam 2006; Kahn 2011). In brief, well-managed initial design phases are the prerequisite to create successful new products (Kim and Wilemon 2002; Ernst 2002; Guo 2012). As claimed by Pahl et al. (2007), formal processes through which to perform Front End phases help execute the whole product development cycle effectively. Notwithstanding the critical role they play, initial design phases are still insufficiently supported (Koen et al. 2001; Flint 2002; Soukhoroukova et al. 2012).

In this perspective, plenty of proposals have been advanced to carry out the design of new products advantageously. However, despite some decades of research focused on NPD processes, those attempts have not obtained the expected results (Flint 2002), especially from the viewpoint of introducing formal practices and methodologies in industry.

Nijssen and Frambach (2000) remark problems about poor awareness in companies of methods supporting NPD, as well as they highlight that practical results are sometimes arguable. On the one hand, unsatisfying results may arise as a consequence of the wrong implementation of NPD methods in industry, e.g. by making reference to incorrect NPD phases for which the proposed techniques are designed (Yeh et al. 2010). On the other hand, misalignments can be explained by the fact that methods presented by academicians lack industrial validation and/or are developed with no real connection with business settings in plenty of cases (Cantamessa 2003). López-Mesa and Bylund (2011) include the cited issues among the causes that provoke the insufficient implementation of academic methods in industry. They investigated previous literature sources in preparation to an ethnographic study conducted in Volvo Car Corporation, which assesses similarities and differences between effectively employed decision-making strategies (considered as a crucial design activity) and procedures suggested by academic NPD methods. In-depth studies of industrial practices and questionnaires surveying the diffusion of academic methods are the most diffused means to investigate the implementation of formal NPD techniques. Graner and Mißler-Behr (2012) have recently conducted a critical analysis of the studies published in authoritative design journals and aimed at evaluating the degree to which proposed NPD methodologies are employed in industrial environments. The survey emphasizes the descriptive approach of most of the treated papers, which follows the varying quantity of investigated enterprises. A large number of studies are restricted to verify the awareness of companies with respect to a sample of design techniques. With regard to these samples, it is claimed that the heterogeneity of the methods populating such sets represents a considerable limitation to the creation of specific knowledge in the field. Therefore, still with reference to Graner and Mißler-Behr (2012), it is recommended to adopt a systematic approach in selecting the methods subjected to investigation. Besides, Blessing and Seering (2016) point out how successful applications of design research refer to specific NPD tasks.

Consistently with these indications, the present paper addresses the investigation of a specific phase of NPD cycles, i.e. the crucial stage referred as Product Planning, with respect to the problems concerning the implementation of methods in industry. Information about the diffusion and the proficiency of specific tools and techniques can be extracted through the numerous literature sources available, by trivially selecting, among the surveyed methods, those that are useful in Product Planning. This is not considered sufficient to explain the lack of practices based on academic findings. In this sense, the present research investigates the adequacy of existing methods in terms of

fulfilling companies' needs and the context factors that are supposed to foster or hinder the adoption of academic proposals. It is hereby proposed to achieve such an outcome by discussing and comparing:

- the hot topics and the open issues of the literature about Product Planning, with a particular attention to what concerns the suitability of methods for industrial settings;
- the benefits that are claimed by the developers of Product Planning methods; from this viewpoint, no review has been performed according to authors' knowledge;
- the factors that enable the diffusion of said methods, with a particular reference to their adoption in University courses;
- the priorities assigned by enterprises; to this regard, the authors are aware that a large number of factors can be subsumed by previous studies conducted within industrial environments. However, the knowledge is extremely dispersed, the ways through which information is extracted is hardly comparable, and therefore, no specific reference can be adopted to extract such priorities, at least for what concerns Product Planning.

Section 2 is devoted to describe the research approach followed in the present paper to provide a clear vision about these specific topics. Section 3 digs into the specific research objectives emerged as a consequence of scrutinizing the literature about Product Planning. The emerged research questions are further discussed in Sect. 4 where strengths and weaknesses of Product Planning methods are compared with NPD practices in a sample of industrial firms and a survey of contents taught in relevant courses in a range of highly ranked technical schools. Section 5 presents an articulated discussion about the new findings of the paper with respect to the treated topics. Eventually, Sect. 6 closes the paper by recalling the main achievements and indicating authors' future research intentions.

2 Research methodology

As mentioned in the introduction, the overall goal of this paper is to investigate the appropriateness of academic research outcomes on Product Planning for the real needs of industry and to highlight possible mismatches and suggested directions for further research. The overall study has combined literature analysis, investigation of relevant courses in academia and daily practices in a sample of companies.

In this perspective, it was first necessary to perform an in-depth review of Product Planning literature. A preliminary survey of the main topics addressed by the ongoing research brought evidence to the specific objectives that have attracted the biggest attention by researchers in the field. Such a naïve investigation has been then examined by means of statistical text mining tools, so as to highlight the most debated research threads in quantitative terms and to identify their evolution in time.

On the one hand, the study based on text statistics has confirmed the validity of the open issues emerged from the initial literature survey. On the other hand, it has pinpointed specific aspects requiring further investigation.

The second phase of the study concerned the extraction of some properties suitable for comparing methods for Product Planning and, through them, the punctual, despite qualitative, assessment of the numerous methodologies proposed in literature, thus remarking their strengths and weaknesses. As anticipated, a preliminary review of Product Planning methods was carried out to extract said properties.

Thereafter, with the specific aim of analysing the diffusion of Product Planning methods, the authors have conducted a survey of academic courses dealing with NPD in worldwide high-ranked technical institutions. The underlying assumption is that methods and tools taught in leading schools should constitute a common background of future practitioners. In this perspective, it should not be surprising that contents not proposed in academic curricula, despite debated in scientific publications, have produced a negligible impact on industrial practice.

The last phase of the study moved to industry. As already underlined in the Introduction, industry-based surveys and hands-on investigations represent the standard for extracting information from the business domain. Whereas the former are commonly conducted in a large number of companies in order to achieve statistically significant results, the latter, which is abundantly more time-consuming, is carried out in few representative firms. By sharing the thought of Maurer and Widmann (2012) and several others, the authors believe that a standard questionnaire-based survey does not allow to realize to which extent the academic studies conducted so far fulfil the real needs of companies. Therefore, the authors decided to choose a sample of enterprises and to perform an ethnographic investigation of their standard practices for NPD, in order to assess the relevance and the suitability of the aforementioned properties of Product Planning methods. It is evident that the small sample of enterprises involved in this study cannot be considered as fully representative of the industrial sphere. Nevertheless, the authors argue that the issues strongly emerging in most of the analysed firms are good candidate topics for a scientific discussion.

The overall outcomes of this study and the related conclusions emerge as a combination of all the insights and suggestions produced through the above-mentioned activities, as described in the following sections.

3 Analysing the literature about Product Planning: treated themes and overlooked issues

3.1 Role and objectives of the Product Planning in the Fuzzy Front End

Many professionals and researchers do not judge FFE as a structured process because of its intrinsic ambiguity and uncertainty (Koen et al. 2001; Kim and Wilemon 2002; Alam 2006). This circumstance partially motivates the fact that many companies have neither adopted a structured approach to follow, nor do they entrust formal methodologies (Reid and de Brentani 2004; Achiche et al. 2013). On the contrary, a great number of organizations focus their attention on Back End activities, for which acknowledged methods are more diffused, by primarily aiming at reducing manufacturing errors. According to Cagan and Vogel (2001), this strategy is however hazardous, because the disregard of the FFE can lead to product failures or anyway to great expenditures for revising decisions, which dramatically increase as the design process progresses (Kim and Wilemon 2002; Cousineau et al. 2004; Achiche et al. 2013).

Some scholars (Flint 2002; Alam 2006; Soukhoroukova et al. 2012) suggest that FFE can become much less "fuzzy" if customers are involved in the initial stages of NPD. This thought is, however, not shared by other authors (e.g. Ulwick 2002), who argue that customers fundamentally focus on already fulfilled needs and consequently the opportunities that potentially emerge from the exploration of new market domains get lost. Computer applications supporting FFE are not considered reliable yet and require additional and more specific empirical research (Hüsig and Kohn 2009; Monteiro et al. 2010). Further on, proposals to manage FFE better include organizing teams in an appropriate way to conduct FFE activities (Kim and Wilemon 2002), managing in different ways the fuzziness related to customers, technology and competitors (Zhang and Doll 2001), focusing on the available resources of company (Achiche et al. 2013). Besides, studies about management of early stages of NPD cycles (Adams et al. 1998; Ramesh and Tiwana 1999; García et al. 2008) and strategic positioning of development projects (Balachandra and Friar 1997; Henard and Szymanski 2001) have already brought to clear evidences. According to these sources, key aspects to achieve commercial success lie in internal collaboration between different units of the company, attention dedicated to manifold organizational issues, trust in fostering cross-functional integration, R&D effectiveness, managers' experience. Thus, acknowledged success factors of the product development process do not pertain to what is directly designed, manufactured and marketed. It emerges that few efforts have been conversely devoted to analyse those activities that directly involve the product and its distinguishing features (Page and Schirr 2008), although, according to Hicks (2016), product-led research has a greater economic impact than process-led research. In this perspective, more knowledge should be acquired about best practices and means for carrying out Product Planning.

In literature, the term "Product Planning" has been adopted to define different design activities. Some scholars (Lee et al. 2010a; Li et al. 2012) affirm that the main purpose of Product Planning is the translation of identified client wishes into product technical requirements using the Quality Function Deployment, QFD (Akao 2004). Other authors claim that the main objectives of Product Planning are the assessment and selection of alternative product concepts (Jetter and Sperry 2013). Kahn (2011) defines Product Planning as the process of envisioning, conceptualizing, developing, producing, testing, commercializing, sustaining and disposing of organizational offerings, i.e. he considers the whole product lifecycle. Beyond these definitions, it is widely accepted (Shinno et al. 2006; Pahl et al. 2007) that the main objective of Product Planning is the identification of new product features capable of fulfilling customer expectations in order to exploit new market opportunities.

With this meaning, one of the main outputs of Product Planning is the list of product requirements that has to be taken into account in the subsequent design phases for defining, selecting and developing the most valuable technical solutions. In the residual of the paper, the authors will employ such a concept of Product Planning, which is the most popular. At the same time, by referring to customer expectations, Product Planning has to take into consideration the benefits generated by both physical goods and intangible services (Flint 2002; Alam 2006). For the sake of brevity, the authors will use the term "product" diffusely in this paper for indicating any commercial offer or deliverable of industrial processes that includes characteristics pertaining to both products and services (thus physical artefacts, pure services, mixes of tangible products and related services).

More specific scopes of Product Planning process emerge by considering its main constituent activities, currently standing in the generation of ideas about the new product to develop and the subsequent selection of alternatives.

The idea generation, sometimes called Opportunity Identification stage (Cagan and Vogel 2001; Achiche et al. 2013), allows to identify attributes, features or general ideas of the new product. For this reason, some scholars consider idea generation the basic task of Product Planning and a primary source of commercial success. However,

many companies do not allocate sufficient resources to carry out this stage accurately, since they perceive it as a random process. As a result, even recent proposals about structuring the FFE disregard the ideation process; (Riel et al. 2013) is among the few exceptions. "Appendix 1" summarizes the views of scholars with respect to functions and role played by idea generation. Each reported statement is linked with the references that claim the given argument.

Idea generation usually gives rise to several options. Hence, this divergent activity must be followed by a convergent idea selection task (Rietzschel et al. 2006). The idea selection, named Opportunity Analysis stage in some sources (e.g. Koen et al. 2002), constitutes the decision-making phase of the Product Planning that allows to choose the alternatives to be further developed. Also this activity is supposed to be insufficiently supported, as well documented in "Appendix 2" that reports literature claims about idea selection.

Other activities, beyond idea generation and selection, play a not negligible role in the commencing stages of product development, by supporting the management of available resources. All these tasks, reported in "Appendix 3" together with the related literature references, are out of the scope of the present work, because they mostly concern the management of innovation projects.

3.2 A general view on the literature about the initial design stages and specific objectives of this study

The presented overview about objectives and criticalities of the FFE (and more specifically to the design activities of Product Planning) has given rise to a framework characterized by conflicting views and a tangled network of problems. According to what has been discussed so far, the most relevant issues seem to regard:

- the possibility of effectively individuating business opportunities through tailored design methodologies;
- the most suitable means to limit the fuzziness of initial NPD phases;
- the capability of customers to unveil impacting new product characteristics;
- the identification of success factors concerning the product directly, rather than the management of the NPD process.

In order to provide a clearer picture of the themes faced in the scientific arena, the authors opted to examine the selected literature sources through a statistical tool of textual analysis. The objective of such an analysis is twofold:

- identifying further arguments that have not been sufficiently highlighted by authors' overview;
- observing the increasing/declining interest of the scientific community towards specific issues by clustering the literature sources according to their publication dates.

3.2.1 Performed analysis: examined body of knowledge and employed software instrument

The authors carried out the above task through the employment of an available computer application, i.e. Provalis Research products (http://provalisresearch.com/). More specifically, the activity required the combined use of the software tools named QDA Miner 4 and Wordstat 7 for the scope of analysing texts and obtaining statistical information of terms' frequency.

The selected sources were the articles cited in this paper from Sects. 1 to 3.1 (including the related "Appendixes"), considered as a relevant body of scientific knowledge concerning the initial design phases. The analysis did not include books, because their whole contents (besides normally more extended than papers) did not focus specifically on the treated subject, and hence the outcomes of data elaboration could result misleading. It was subsequently verified which full-text articles the software could handle. With respect to these texts, the authors subdivided the articles into groups, characterized by papers' publication dates, of approximately the same time length and including a similar quantity of manuscripts. This measure was deemed necessary to perform a balanced comparison between different publication periods.

More in detail, the groups are structured as follows:

- Group 1: 12 papers published from 1996 to 2001;
- Group 2: 13 papers published from 2002 to 2007;
- Group 3: 16 papers published from 2008.

3.2.2 Main evidences of the linguistic analysis

Among the various outputs of statistical analysis of the terms included in the reference papers, the employed software tool produced the representation reported in Fig. 2. This chart was judged as an effective overall view of the themes that are treated by the benchmark articles belonging to the three groups. It shows the extent to which the most popular 30 terms in the whole body (displaying from 434 to 3183 occurrences) of the text characterize the publication time, according to the closeness to the labelled quadrants in which the associated intervals are reported. The figure remarks how few terms or abbreviations (e.g.

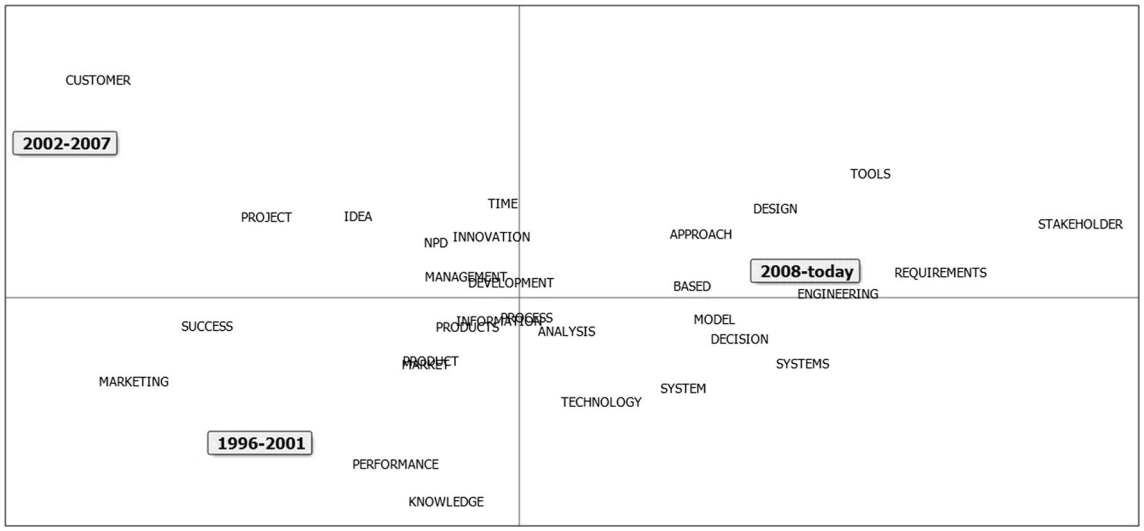

Fig. 2 Characterization of three subsequent timespans according to the main themes treated in published papers focusing on the initial phases of New Product Development cycles

NPD) are shared by the three periods in a balanced way, while several words basically feature single clusters.

According to this representation, the literature discussion seems to shift from successful product development practices oriented on performance enhancing strategies exploiting marketing knowledge (1996–2001) to customer-centred projects (2002–2007) and finally to engineering design tools and decision support models attempting to fulfil the requirements requested by multiple stakeholders (2008-today).

3.2.3 Issues to be further investigated and specific objectives of the present research

This picture of the literature debate clearly does not answer the posed questions reported at the beginning of Sect. 3.2. Conversely, it reveals a continuous change of themes that did not emerge from the overview of Sect. 3.1. It can be noted that this shift does not entail a deeper investigation of raised arguments, but, on the contrary, new problems are faced. Such dynamics can be explained by alternative hypotheses:

- the initially posed themes have been sufficiently explored and are not worth investigating further;
- the problems faced by past papers do not impact NPD practices, because of structural modifications of the competition among industries;
- the proposed solutions have not resulted in successful applications and, hence, new attempts are currently experienced.

Unresolved matters and further questions arising from the presented linguistic analysis suggest carrying out additional research on Product Planning, in order to elucidate:

- whether scientific and industrial arenas acknowledge any established Product Planning practice, irrespective of its arguable suitability for a worldwide competition framework increasingly focused on innovation;
- the claimed advantages deriving from the implementation of Product Planning methods;
- pros and cons of involving customers and product stakeholders during the FFE;
- the effective benefits of diffusing and implementing Product Planning models in industry;
- whether rigorous proposals have been advanced to identify successful new product characteristics regardless the followed NPD process.

The issues reported in the above bulleted list constitute specific objectives of the present paper.

With the aim of defining the baseline for investigating the above points, the authors opted to perform a state-of-the-art analysis of Product Planning methods, which follows in Sect. 3.3.

3.3 Review of Product Planning methods

A survey is presented hereafter of models and techniques to support the main activities of Product Planning, i.e. idea generation and selection, which are more closely connected with intrinsic characteristics of innovative products. The subsection is introduced by a first characterization of the approaches for executing Product Planning in terms of the role assigned to the customer. The review criteria to individuate relevant contributions are then defined, so as to

obtain a collection of methods to support Product Planning. The identified instruments are characterized according to the mentioned categorization. By scrutinizing such tools, it was possible to extract a preliminary set of properties pertaining to Product Planning methods, consisting in the declared scopes or strengths that literature highlights.

3.3.1 An acknowledged classification of Product Planning approaches

It is well acknowledged that the key to achieve organizational goals is to be more effective and efficient than competitors in identifying and satisfying the needs of target markets (Narver et al. 2004; Kotler 2007), developing and delivering products that are valued by customers (e.g. Kim and Mauborgne 2005; Atuahene-Gima et al. 2005). According to this objective, two main categories of Product Planning approaches can be identified in the literature: responsive and proactive methodologies (Narver et al. 2004; Atuahene-Gima et al. 2005).

The former consider the industrial standard as a reference for identifying lacks in offered product features and delivered performances. Responsive methods swivel on marketing surveys whose results are used as input information to define a new product idea. Hence, the task of pointing out desired improvements is almost entirely entrusted to the end user, who becomes the factual decision-maker. For this reason, the term "market (or demand) pull" is often used to define this kind of strategies (Schön 1967; Chidamber and Kon 1994; Brem and Voigt 2009; Di Stefano et al. 2012), while the innovation strategy implemented through these approaches is mainly based on the fulfilment of expressed needs. Therefore, the team in charge of Product Planning has to collect, analyse, interpret customers expressed needs and translate them into product requirements. The first three activities are typically managed by the marketing professionals, whereas the fourth one is often delegated to designers.

Proactive methods attempt to capture unspoken wants of customers or even induce new needs for end-users. They aim at developing product ideas radically different from the industrial standard. Therefore, these methods do not involve the end user in the investigation of the aspects that could represent potential innovation opportunities. Benchmarking analyses, usually performed by marketing experts, are used to analyse the business context, while the decisions about definition and selection of the most promising product ideas are in charge of design teams. This category of methods includes the so-called "technology push" strategies (Chidamber and Kon 1994; Rohrbeck et al. 2008; Brem and Voigt 2009; Di Stefano et al. 2012), in which emerging technologies can be exploited as driving forces for disruptive innovations (Wall et al. 2013). However, the use of a new technology is not generally sufficient to ensure market success (Leinsdorff 1995; Flint 2002; Haig 2011). Therefore, a balanced R&D–marketing coordination is strongly recommended to carry out proactive approaches (Gupta et al. 1986; Leinsdorff 1995). Despite the marginal role assigned to customers, investigated proactive strategies do not comprise methods based on design-driven innovation (Verganti 2008), because they basically aim at changing existing products' meaning (Battistella et al. 2012) instead of developing original artefacts.

Besides the recalled typologies of methods, the existence cannot be overlooked of contributions that actually merge peculiarities of both responsive and proactive approaches. They essentially try to discover and fulfil customers' latent needs by involving the end-users of products or the recipients of services in the idea generation process. Indeed, users provide feedback about the new product ideas that are generated by the design team and/or collaborate in proposing new ones. Due to this evidence, the authors introduce in the paper a further category of approaches, named "Hybrid", through which to classify all the methods that present both responsive and proactive characteristics.

3.3.2 Research criteria

By limiting the scope of the state-of-the-art to idea generation and selection, the review does not comprehend studies which emphasize the importance of the corporate image (e.g. Fombrun 1996), brands (e.g. Park et al. 1986), advertising (e.g. Drumwright 1996), retailing (e.g. Grewal et al. 2010), pricing (e.g. Nagle and Holden 1995). It includes methodologies that support planning activities besides idea generation and selection, but just their contribution to the recalled tasks will be discussed. In addition, the authors have not considered generic approaches for representing and monitoring the design process, e.g. Stage-Gate (Cooper 1990), or tools that support the management and the description of the outputs originating from the Product Planning, e.g. business model canvas (Osterwalder and Pigneur 2010) and strategy canvas (Kim and Mauborgne 2005).

The analysis comprises formal methods, i.e. more or less systematic procedures, and software tools to support Product Planning. For the sake of completeness, the survey has been limited to those methods that support the user in defining the list of competing factors (or in identifying the basic information to intuitively obtain it), which consequently allow to carry out product development cycles in the industrial practice. Such features include both current product characteristics and new attributes, commonly introduced to satisfy emerging or unspoken needs. In the remainder of the paper, the authors indicate with the term

"latent needs" the complex of unprecedented customer requirements that are discovered, stimulated or aroused.

Furthermore, for the scope of this research, the authors considered only contributions showing the applicability of the proposed methods in industry or documenting real case studies.

The literature search has been essentially oriented to literature sources within engineering design and, more in general, to innovation management, yet with a focus relevant for a discussion from an engineering design perspective. More in details, the survey has included different research sectors dealing with Product Planning and considered different jargons according to scholars' field of expertise. Besides "Product Planning", the main keywords for performing the research follow, indicating reference works that extensively use the matching terms:

- Fuzzy Front End (Guo 2012; Riel et al. 2013);
- New Product Development (Pahl et al. 2007; Ulrich and Eppinger 2011);
- New Value Proposition (Kim and Mauborgne 2005);
- customer needs and satisfaction analysis (Urban and Hauser 1993; Kano 1995);
- company general planning (Kahn 2011; Cooper 2011);
- product innovation (Cagan and Vogel 2001; Tripsas 2008);
- analysis of product success factors (Ayers et al. 1997; Ernst 2002);
- idea generation (Alam 2006; Soukhoroukova et al. 2012).

3.3.3 *Identification of the methods to support Product Planning*

The outcomes of the survey allowed to individuate 17 distinct methods to perform idea generation and/or selection. Table 1 shows the list of contributions, by specifying whether they belong to responsive, proactive or hybrid approaches. Whereas the developers have not assigned a specific name of the proposed technique, the authors have added the topic of the reference instrument.

4 Effects brought by the research on Product Planning

In order to fulfil the research objectives of the paper, the present Section introduces new elements of knowledge with respect to the information directly available from the literature. In particular, in Sect. 4.1, the authors classify the collected methods for Product Planning according to some properties, which clearly emerged from the above in-depth review (omitted for the sake of brevity). Further on, the authors have performed an analysis of the syllabi of product development academic classes held in the top 30 technical universities worldwide according to Quacquarelli Symonds rankings (Sect. 4.2). Such an investigation aims at verifying the popularity of the gathered methods for Product Planning, and, consequently, the degree to which engineers and technicians are expected to master these tools effectively. Eventually, Sect. 4.3 reports an insightful analysis of Product Planning approaches followed by a sample of convenience of firms. This activity intends to provide a preliminary evaluation of the interest paid by industrial subjects towards the capabilities of available Product Planning methods.

4.1 Properties of Product Planning methods

In order to compare the collected methods and tools, the authors have identified a set of properties. These properties include features originated from the research criteria, distinguishing factors of the analysed methods on which developers focus, clearly desirable characteristics. The latter encompass evaluation criteria with regards to the reliability, the systematic level and the accuracy of the investigated instruments within the support of Product Planning.

4.1.1 *Focus on the manifest properties of the tools supporting Product Planning*

Table 2 summarizes the whole sample of properties, their description and meaning within the Product Planning phase. The reference numbers of each characteristic are exploited in the following description by using curly brackets.

At first, the scrutinized methods can be distinguished into those with an initial focus on general product ideas (1) and approaches that consider customer requirements (2) as a starting point for innovation initiatives. In the second option, product features can be subsequently articulated in order to create an innovative product profile, i.e. a bundle of attributes associated with their matching offering levels to be transformed into an original product architecture. Conversely, turning general product ideas into a list of product characteristics is extremely helpful in the subsequent design phases.

The intuitiveness of a Product Planning method (3) can represent a basic requirement to allow the implementation of the tool in industrial environments. It is hereby supposed that extensive human resources requested to introduce new NPD approaches can prevent the effective exploitation of the benefits possibly descending from the use of a new methodology. According to the extant trend of assigning an increasing role to artificial intelligence also in the design

Table 1 List of identified methods to support idea generation and selection in Product Planning

Kind of approach	Name (or general topic) of the methodology	Reference source
Responsive	DSS for customer satisfaction assessment	Liberatore and Stylianou (1995)
	SW for marketing surveys analysis	Matsatsinis and Siskos (1999)
	DSS based on experts and customer surveys	Chan and Ip (2011)
	Marketing survey with persona model	Liao et al. (2008)
	Kano model (classic)	Kano et al. (1984)
	Kano model evolution	Nilsson-Witell and Fundin (2005)
Proactive	Scenario model	Lee et al. (2010b)
	Blue ocean strategy	Kim and Mauborgne (2005)
	Lateral thinking	De Bono (2010)
	Value assessment metric	Borgianni et al. (2013)
Hybrid	Brainstorming	Osborne (1953)
	Lead users method	Von Hippel (1986)
	Selection from new product ideas database	Büyüközkan and Feyzioğlu (2004)
	Kansei engineering	Nagamachi (1995)
	System for product conceptualization and customer surveys	Chen and Yan (2008)
	Customer value model for service design	Kimita et al. (2009)
	Virtual customer integration	Füller and Matzler (2007)

field, the availability of software applications implementing the surveyed methods (4) can result in a substantial strength. User-friendly computer applications emphasize the already discussed ease of use.

A specific benefit of some Product Planning instruments stands in the capability to individuate latent needs (5). As already highlighted, this chance allows to develop products showing a substantial diversification with respect to the artefacts populating the industry. Differentiation strategies can be likewise supported by methods that include or allow to represent a general picture of the competition in the reference market (6). Careful competitors' analyses are likely to ease the display of overlooked product performances. Taking into account the relentless modifications of customer preferences (7) brings an additional strength of Product Planning methods for achieving superior performances at the right time. Indeed, it can happen that long NPD cycles determine the market launch of products that are not valued anymore by customers, due to alterations of priority needs to be fulfilled.

The capability of new products to thrive in the marketplace is somehow related to the reliability of the employed Product Planning method (8). Previous properties (5–7) definitely range among the drivers that allow to develop successful products. However, the trustworthiness of the tool is not hereby considered in terms of rigour in correctly considering multiple factors affecting NPD, but by taking into account how a given method has proved to give rise to profitable results. Hence, Product Planning methods are considered reliable when, regardless their way of functioning, many practical implementations are documented leading to successful new products. The repeatability of positive outcomes within different industrial sectors has to be considered as an ultimate demonstration of methods' reliability.

The majority of the gathered methods support idea generation, potentially giving rise to many new product alternatives. This divergent phase must be followed by a convergent stage, capable of distinguishing the most successful options. In this sense, the existence of means to perform idea selection (9) represents a desirable property of Product Planning methods. It has to be noted that, however, several decision strategies exploit information that is extremely subjective or unreliable. It then comes out that it is preferable to opt for decision criteria not requiring a big amount of individual judgements and uncertain data (10).

4.1.2 Classification of the collected methods in terms of the emerged properties

With the aim of classifying the collected methods according to the above properties, the authors used the information provided by the scholars and/or further indications achievable from the literature. Table 3 shows the comparison among the reference methods and tools, listed according to the order they appear in Table 1, besides indicating their reference to responsive, proactive and

Table 2 Description of the properties through which to compare Product Planning methods

#	Property	Description	Relevance of the property
1	Initial focus on products attributes	Predominant attention on the identification of the attributes and features of the product to be developed. Subsequently, these attributes can be articulated in order to create an innovative product profile	The analysis of the single features of a new product allows to perform insightful evaluations of customer preferences. It favours the process of developing the requirement list
2	Initial focus on general product ideas	Approach aimed at identifying from the beginning new general product ideas, without analysing single attributes	The capability of framing a general product idea from the very beginning of the design process avoids the need to reconcile single and potentially conflicting customer requirements
3	Quickness and easiness of the method/tool	It features methods resulting easy, quick and intuitive for the user, who has to learn, implement and use them	It is important to support quickly and easily the Product Planning phase, in order to reduce the companies' committed resources
4	Development of computer applications	It features those methods that have been implemented in a computer-aided tool	Computer applications can effectively support the Product Planning in an easy and quick way; software tools are essential instruments in the present industrial context
5	Effective support in the individuation of latent needs	It considers the capability of effectively aiding the search of customer latent needs	The discovery and fulfilment of latent needs supports the development of breakthrough products and allows to avoid head-to-head competition
6	Integrated competitors' analysis	Characteristic possessed by the methods that include an analysis of the competition	The analysis of the reference industry can help to individuate the competition factors and to seek a differentiation strategy
7	Consideration of customer preferences dynamics	It features those methods that consider the variations in the time of the customers' preferences and tastes	Customer preferences vary in time and it is important to consider their dynamics in a right market at a right time
8	Reliability of the approach	Level at which the presented contributions have been verified or validated through practical applications in differentiated industrial fields	It is desirable to employ reliable and tested methods that can be beneficially exploited in a large range of industrial contexts
9	Support in selecting the most beneficial product idea	It considers the capability of selecting the most beneficial product idea that should be developed by the company	It is fundamental to support the last decision-making phase of the Product Planning, because it evaluates which product idea has the greatest chances to be turned into a potential market success
10	Independence from inputs subjectivity	It refers to the limited employment of personal judgments or uncertain inputs, which can alter the final results of the Product Planning	Such feature influences to a considerable extent the robustness and repeatability of the method or tool

hybrid approaches. The assigned name of the properties is not reported, but the numeration of Table 2 is exploited. A trivial dichotomous system (i.e. yes/no) is insufficient to describe all the methods according to each property, because, in some circumstances, the surveyed contributions fulfil certain requirements just partially. The superscripts in the cells of Table 3 clarify the cases in which the association of the properties to the methods is not straightforward and add further details; they have to be read as follows:

1. the information has been extrapolated, by considering potentially time-consuming activities such as the collection of customer/stakeholders interviews and the elaboration of the extracted data;
2. the instrument is not readily usable if historic information is not available; using it from the beginning requires customer interviews conducted in different years;
3. creative sessions using these tools can have very different durations;
4. the method requires potentially long-lasting iteration cycles due to multiple interactions between the company and its customer;
5. elucidated attractive customer requirements can be considered as uncovered latent needs;
6. lead users are expected to individuate latent needs also with respect to other customers' wants;
7. the number of practical case studies reported in the literature cannot be considered sufficient to infer a significant reliability of the methods across various industrial domains; some methods suffer from a development pattern performed outside of the

Table 3 Comparison of the collected methods according to the distinguishing properties of Product Planning tools

Kind of approach	Methodology	Property # (from Table 2)									
		1	2	3	4	5	6	7	8	9	10
Responsive	DSS for customer satisfaction assessment	Yes	No	No	Yes	No	Yes	No	Partially[7]	Yes	Partially[8]
	SW for marketing surveys analysis	Yes	No	No[1]	Yes	No	Yes	Yes	Partially[7]	Yes	Partially[8]
	DSS based on experts and customer surveys	Yes	No	No	Yes	No	No	Yes	Partially[7]	Yes	Partially[8]
	Marketing survey with persona model	Yes	Yes	No[1]	Yes	No	No	No	Partially[7]	Yes	Partially[8]
	Kano model (classic)	Yes	No	No[1]	No	Yes[5]	No	No	Partially[7]	Yes	Partially[8]
	Kano model evolution	Yes	No	No[2]	No	Yes[5]	No	Yes	Partially[7]	Yes	Partially[8]
Proactive	Scenario model	Yes	No	Partially[3]	No	Yes	No	No	Partially[7]	Yes	No
	Blue ocean strategy	Yes	No	Partially[3]	No	Yes	Yes	No	Partially[7]	No	No
	Lateral thinking	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No
	Value assessment metric	Yes	No	Yes	No	Yes	Yes	No	Partially[7]	Yes	No
Hybrid	Brainstorming	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No
	Lead users method	Yes	Yes	Yes	No	Yes[6]	No	No	No	No	No
	Selection from new product ideas database	No	Yes	No[1]	Yes	Yes	Yes	No	No	Yes	No
	Kansei engineering	Yes	Yes	No	Yes	Yes	No	No	Partially[7]	Yes	Partially[8]
	System for product conceptualization and customer surveys	Yes	No	No	No	No	No	Yes	Partially[7]	Yes	Partially[8]
	Customer value model for service design	Yes	No	No[1]	No	Yes	No	No	Partially[7]	Yes	Partially[8]
	Virtual customer integration	Yes	Yes	No[4]	Yes	Yes	No	Yes	Partially[7]	Yes	Partially[8]

Superscripts refer to the explanations of the assigned judgments

industrial environment and subsequent adaptations to face companies' challenges;

8. subjective inputs are required, but the use of statistical instruments allows to estimate which evaluations can be considered sufficiently reliable.

4.1.3 *General discussion about diffused strengths and weaknesses of Product Planning methods and approaches*

Table 3 shows that a large majority of the collected methods starts focusing on products attributes. In each case, most of the hybrid methods have the capability to take into account both the validity/feasibility of general product ideas and the role played by product attributes. It might be inferred that such a kind of methods, which involve the customer in various stages of the Product Planning, own a higher level of versatility for the designer.

As a whole, hybrid methods best support also the individuation of latent needs, but do not integrate the analysis of the competitors diffusely. It has to be underlined that, when this kind of investigation is made, it is commonly not aimed at providing a clearer picture of the competitiveness in the industry, but it basically provides inputs and factors needed for exploiting the methods themselves.

A recurring lack of the surveyed methodologies for the Product Planning is the absence of a quick and easy way to implement and use them. Such a matter can potentially hinder, in industrial contexts, the diffusion of reliable techniques developed in academia. The disregard of intuitiveness particularly affects responsive and hybrid methods, since they require individuating new needs to fulfil and performing customer surveys.

Overall, the most diffused weaknesses of the collected methods concern the subjectivity of the inputs, the scarce reliability and the absence of a dedicated analysis aimed at considering the rapid changes in users' preferences. The first problem is connected with the widespread use of experts' judgments as a main driver to define and assess new product ideas. The methods that exploit statistical analyses are less affected by this problem, because they analyse a wide sample of data and provide therefore a more general view of the opinions expressed by experts and decision makers. However, they imply the commitment of a large amount of time and resources in order to obtain a reliable sample of data. The scarce reliability of the collected methods is mainly due to the focus on specific application fields and to the limited quantity of industrial case studies shown so far. On the one hand, it is worth noting that the development of some of them has not started with the objective of directly supporting industrial

tasks, but they rather aim at fostering people's creativity regardless the final scope of idea stimulation. On the other hand, significant enhancements are expected for the examined methods, especially because most of them lie in the early development stage and own an algorithmic structure that might be implemented in computer-aided tools. Hence, in order to achieve more consistent feedback, the most recent methods are worth testing further.

Finally, the selection of the most beneficial product idea is included in the majority of the surveyed methods, although they mostly support generation activities.

4.2 Investigating the diffusion of Product Planning methods

The diffusion of Product Planning methods has been investigated through the analysis of the courses offered by some of the top technical universities worldwide. Indeed, universities represent the bridge between academic research and industry. The observation of offered courses can highlight whether and how Product Planning approaches and methods are taught to future practitioners.

The authors considered the top 30 technical universities ranked by topuniversities.com (last access on 30 January , 2015) based on the combination of different indexes, such as reputation, capability to attract students and professors from abroad, scientific productivity.

The study has analysed universities' websites by focusing on master degree, graduate studies and PhD courses concerning engineering, marketing and innovation management. In particular, the authors selected all the subjects that relate to Product Planning, such as product and service development/management, engineering design, innovation/technology management, marketing/consumer behaviour, creativity and innovation, entrepreneurship, business strategies. Available syllabi and/or descriptions of identified courses have been collected and analysed.

Two universities (i.e. Tsinghua University and Shanghai Jiao Tong University) could not be considered, because no information of offered courses was shown in English on their websites at the time of the survey.

The survey allowed to identify about 302 pertinent courses, among which 294 included syllabi or detailed descriptions of the contents. Table 4 shows the main obtained results, by indicating the quantity of courses and Institutes that fulfil the conditions reported in the left column. According to these data, about one-third of collected courses are quite irrelevant with respect to the contents of the paper. Another third (roughly) highlights the importance of the treated topics, but no specific method or approach to support Product Planning is reported in the courses' syllabi and/or descriptions. Eventually, the residual of the courses highlights the importance of paper's contents and include the description of one or more methods or approaches listed in Table 1.

Table 4 Main results of the survey that analyses the courses of top 30 technical universities worldwide

	Number of courses	Number of universities
Identified courses	302	
Analysed courses with available syllabus/course descriptions	294	
Courses whose contents are irrelevant in light of the topic of the paper	103	
Courses that highlight the importance of treated topics, but no method or approach to support Product Planning is reported in the syllabus and/or description	119	
Courses that include generic responsive approaches	47	19
Courses that include at least one proactive approach	8	8
Courses that include at least one hybrid approach	18	13
Courses that present Brainstorming	9	7
Courses that present scenario-based techniques	5	5
Courses that present the Lead user method	5	4
Courses that present BOS	2	2
Courses that present Lateral thinking	1	1
Courses that present Kansei engineering	1	1
Universities in which no responsive, proactive or hybrid method is included in the academic programs, even if they offer at least one course that shows the importance of the topics treated in the present paper	–	4

In this last group:

- 47 courses, taught in 19 different universities, concern generic responsive approaches based on the so-called Voice of the Customer (VoC);
- 18 courses, taught in 13 universities, include one or more hybrid approaches;
- 8 courses, taught in 8 universities, show one or more proactive methods.

Four universities (out of the 28 for which information is available) do not include any course with at least one proactive, responsive or hybrid approach; however, they offer at least one course remarking the importance of the topics treated in the present paper.

Eventually, focusing on specific methods, Brainstorming results the most diffused one (9 courses in 7 universities), followed by scenario-based techniques (5 courses in 5 universities), Lead user method (5 courses in 4

universities). Further identified techniques concern only one or two courses/universities as illustrated in Table 4.

The extracted data show that a very limited number of lectures held in technical institutes concern the description of strategies to generate and select new product ideas. Nevertheless, at the same time, the topic of the paper is outlined in the majority of the reference universities. This allows to conclude that most of trained engineers and technicians are aware of the challenges posed by Product Planning, but lack notions about the methods to perform it, their underlying theory and the practical effects they can bring.

4.3 Congruence of the benefits claimed by Product Planning methods with respect to industrial needs: an exploratory study on a sample of enterprises

In order to approach the investigation of Product Planning in the industrial domain, the authors performed an in-depth analysis of six companies characterized by well-established NPD processes. The quantity of involved firms is clearly insufficient to draw statistically significant conclusions about the difficulties encountered by organizations during Product Planning. Nor can the sample be considered representative of the variety of enterprises that can potentially benefit of methods and tools for Product Planning. However, three main reasons motivate the choice of accurately analysing few companies, rather than obtaining basic information from a greater number of firms (e.g. through online questionnaires):

- a detailed (and consequently time-consuming) analysis of a focus group of enterprises can provide more valuable results if compared with quick questionnaires administered to a large sample of industrial subjects, as inferable from the discussion about investigation methods included in (Ulrich and Eppinger 2011);
- companies often highlight their strengths and hide their weaknesses (Bell 2008), therefore the use of questionnaires without interacting with the firms and/or observing how they act can provide unreliable results;
- the relationship of trust with the selected firms, due to frequent partnership with authors' research teams, is supposed to provide a good understanding about their point of view with respect to Product Planning, as well as the actual strengths and weaknesses of their strategies. The authors have not included in the investigation other industrial partners, because of their lack of autonomy in undertaking decisions concerning the FFE, minor degree of mutual trust, supposed hurdles in sharing the intended concept of Product Planning due to fully unstructured and rather haphazard design processes. The lower reliability of the outcomes provided by other companies, although available to participate in the survey, could potentially lead to misleading conclusions.

Despite the limited number of analysed companies, the sample is characterized by great variety (see Table 5) in terms of:

- industrial sectors: from traditional mechanics to electronic products and ICT;
- the reference market: from mass market products to niches;
- the size of the firms: from few tens of employees (companies 1, 2, 3 and 5 are SMEs) up to branches of multinational corporations (firms 4 and 6);
- the turnover: from few to thousands of Mio. Euros.

Besides, all the involved enterprises have developed large market networks that allow them to sell their products worldwide; as a result, they have matured a wide vision about threats and opportunities in their industrial sector. With respect to the recalled variety and the entrepreneurial capabilities of the involved industrial subjects, the survey can disclose a first set of not negligible shared needs concerning Product Planning practices.

The survey has been conducted starting with an interview driven by several open questions ("Appendix 4"), to which respondents were invited to answer by adding digressions and examples. Additionally, at least one of the authors attended some Product Planning activities. The first task allowed to understand companies' strategies and their basic needs. The second activity examined in-depth actual demands.

With respect to the information that originates from the industrial investigation, the residual of the paper does not make reference to its extrapolation from questionnaires or direct observations of the authors.

4.3.1 Brief description of surveyed companies' Product Planning approaches

In company 1, the Product Planning phase is entrusted to a multidisciplinary innovation team that analyses customer needs (collected through social networks, Internet portals, industry trade fairs and professional associations) and new emerging technologies, in order to identify new opportunities. The most promising product idea is selected according to team's experience and company available resources (assets and know-how). Eventually, the company drafts a business model, which summarizes the new idea, the required technologies and includes a market analysis.

Unlike the previous firm, company 2 involves all the employees in Product Planning phase. The idea generation task is stimulated through collective thinking sessions,

Table 5 Main features of investigated companies

	Industrial field	Turnover (about)	European classification according to the number of employees (small enterprise: <50 employees; medium enterprise: <250 employees; large enterprise: >250 employees)	Business strategy (B2B = business to business; B2C = business to customer)
Company 1	Electronic systems	3 Mio. €	Small enterprise	B2B
Company 2	ICT	3 Mio. €	Medium enterprise	B2B
Company 3	Audio systems	30 Mio. €	Medium enterprise	B2B/B2C
Company 4	System providers for food and energy processes	5000 Mio. €	Large enterprise	B2B
Company 5	Glass system technology	5 Mio. €	Small enterprise	B2B/B2C
Company 6	Powered appliances for kitchen, cleaning and outdoor use	15,000 Mio. €	Large enterprise	B2C

company internal contests and thematic workshops. Identified ideas are then tested and improved through virtual interaction tools (Internet platforms) that allow to gain valuable feedback from potential customers. Eventually, the selected idea is structured through the *business model canvas* (Osterwalder and Pigneur 2010) that summarizes the new offer, required resources and potential customers.

In company 3, Product Planning is exclusively entrusted to the technical department. Engineers identify the main opportunities through the analysis of the VoC and try to satisfy emerging requirements through the implementation of the desired features into new products.

Company 4 is a large enterprise with several divisions in Europe, and it organizes internal innovation contests in order to collect new product ideas from all local groups and select the most promising ones. Innovation teams use a technology push strategy, primarily based on patent analysis, in order to support the idea generation phase. In addition, they perform benchmarking analyses and study customer preferences dynamics with the aim of supervising competitors' offers and trying to anticipate future consumers' needs. The central European board of managers selects the best ideas according to the expected development costs and efficiency of new products.

In company 5, some engineers identify new product ideas through industry trade fairs, web searches and primarily from the VoC (customers, suppliers and contractors). In addition, they carry out extensive analyses of competitors and patents, in order to deepen the knowledge of the reference industry. In a second instance, idea selection is mainly entrusted to the CEO and it is based on expected revenues.

Eventually, company 6 manages the Product Planning phase with a market-driven Stage-Gate approach (Cooper 1990). Idea generation is entrusted to market analysts that study customer behaviour and trends of preferences. In addition, marketing experts benchmark competitors' products, by monitoring sales, features and performances. Hence, the identified opportunities are compared with competitors' deliverables in order to select a subgroup of promising innovative ideas. Eventually, the company develops prototypes and tests them with a sample of potential customers. If a product obtains positive feedback, its development will be further carried out.

The strategies implemented by the analysed firms are summarized in Table 6, which remarks the followed kind of Product Planning approach, according to the involvement of customers in the process.

4.3.2 Main results of companies' survey

Table 7 summarizes the main outputs of companies' survey in terms of the most pressing exigencies related to Product Planning activities, as they emerged in at least half of the surveyed firms. The authors qualitatively considered that the needs expressed by this fraction of the sample do not arise randomly, but they are somehow relevant for a not negligible portion of industrial contexts. In order to stress the relevance of these kinds of demands within product innovation activities, the last column of the table reports illustrative literature sources that agree upon the need of considering these aspects in industry as a result of insightful investigations or meaningful experiences. Other needs represent peculiar features of the Product Planning (as indicated in italics). Hence, such methods' requirements cannot be documented in other sources in view of the lack of specific analyses of this design phase (at least in authors' knowledge).

Table 6 Approaches used by analysed companies

Company	Product Planning strategy	Kind of approach
Company 1	General approach based on the VoC	Responsive
Company 2	Virtual interaction	Hybrid
Company 3	General approach based on the VoC	Responsive
Company 4	Scenario technique	Proactive
Company 5	General approach based on the VoC	Responsive
Company 6	Scenario technique and selection approach similar to Kansei	Hybrid

Table 7 Companies' shared needs during Product Planning activities; the final column explains whether these requirements are considered relevant in other industry-oriented research contributions

Companies' needs	Firm 1	Firm 2	Firm 3	Firm 4	Firm 5	Firm 6	Sources
Quickness and easiness of the method/tool*	•	•	•	•	•		Chai and Xin (2006), Thia et al. (2005)
Effective support in the individuation of latent needs*	•	•				•	Yeh et al. (2010)
Competitors' analysis*	•	•		•	•	•	Chai and Xin (2006)
Independence from inputs subjectivity*	•	•		•		•	Evanschitzky et al. (2012)
Consideration of customer preferences dynamics*	•	•		•		•	*Peculiar of Product Planning*
Reliability of the approach*			•	•	•	•	Thia et al. (2005)
Support in selecting the most beneficial product idea*		•		•		•	Reich (2010)
Use of computer applications*	•	•		•	•		Araujo et al. (1996)
Possibility of involving customers in design activities		•	•	•	•	•	Graner (2016)
Possibility of entrusting multidisciplinary teams	•			•	•		Cooper (1999)
Possibility of schematizing the identified ideas formally	•	•			•		*Peculiar of Product Planning*

Asterisks indicate the needs that have a strict relationship with the properties described in Table 2

Hence, it is possible to claim that the development directions of Product Planning methods identify the exigencies of industrial subjects suitably, at least according to the considered sample.

From the perspective of single firms, Table 3 allows to individuate literature techniques that can satisfy companies' expressed needs.

In addition to already defined properties, the survey elucidated three diffused demands:

- possibility of involving customers in the Product Planning activities: this need is strictly related to the possibility of minimizing the risks related to the development of new products. It can be fulfilled by all the hybrid methods, because, as seen above, they involve customers in idea generation or selection;
- possibility of entrusting the Product Planning phase to multidisciplinary teams: this demand starts with the assumption that multidisciplinary teams can provide more point of views, which supports the successful development of innovative products. Although methods' developers do not claim this aspect as a peculiar strength, several mapped tools allow to involve multidisciplinary teams. In particular, scenario techniques, lateral thinking, brainstorming, service design methods developed by Chan and Ip (2011) and Chen and Yan (2008) can satisfy this demand fully;
- possibility of schematizing the identified ideas formally: this need is related to the demand of formalizing, saving and sharing generated ideas. Among the collected literature methods, BOS provides a specific tool, namely value curves, that allows to schematize new product ideas in terms of attributes and related performance levels that designers plan to offer.

4.3.3 Further information emerging from surveyed firms

The above comparison between industrial demands and properties of Product Planning methods highlights a good fit between research trajectories and companies' expectations. However, it can be remarked that certain relevant properties are fulfilled just partially or by a small subset of methods. The lack of industrial validation of Product

Planning methods, implying their scarce reliability, can be considered as a significant weakness in the landscape of academic research on the topic. Indeed, many surveyed companies have underlined the perception of the uncertainty about efficiency and efficacy of what is developed in the academics. This implies that no analysed enterprise is aware of the specific methods that have been illustrated in Sect. 3.3. More in particular, still according to the viewpoint of involved firms, the main reasons of the unsuccessful industrial implementation of methods developed in the academics can be summarized in:

- scholars' "dogmatic" approach;
- communication problems;
- insufficient promotion of research results (several firms do not know scholars' works);
- cultural problems;
- distance from the business world and its needs;
- supposed unsuitability of the methods' outcomes in certain industrial fields.

In this sense, the above issues clearly mirror claims by López-Mesa and Bylund (2011) about the unsuitability of NPD methods. According to this vision, scholars should start promoting their works and reinforcing the links with industry. In this way, they could achieve a better understanding of firms' needs and develop more suitable tools.

Regardless of the implemented approaches, the surveyed companies have highlighted organizational constraints that imply significant repercussions in terms of new potential procedures to be adopted to support Product Planning. Another possible constraint, at least for some organizations, stands in the higher trust towards methods tailored for their specific industrial field, which are supposed to be significantly more reliable than general-purpose tools.

A further relevant aspect regards the disposition of enterprises towards the required changes of their current Product Planning approaches. Whereas many companies would not reject radical transformations a priori, a very structured firm claims the impossibility to introduce meaningful alterations of its well-established organizational structure.

5 Discussion

5.1 Considerations on the reasons behind the poor adoption of Product Planning methods

The results obtained from the performed investigations allow to draw some considerations about the impact of the research in Product Planning on industrial and educational fields.

On the one hand, the analysis of technical universities highlighted a widespread interest of scholars towards issues and problems belonging to the FFE activities of the NPD cycle and specifically related to Product Planning. However, the body of knowledge taught in regular courses considered for the survey includes specific methods to a negligible extent. Also when training about Product Planning is done, it is centred on transferring approaches generically based on the VoC. Hence, the taught approaches are quite vague and less formalized than the methods debated in scientific literature.

On the other hand, the comparison shows a good correspondence between exigencies related to Product Planning activities and the features offered by literature methods. Indeed, many needs raised by the surveyed companies might be satisfied by the considered Product Planning approaches, or at least, they mirror relevant research objectives. From this viewpoint, the present study draws a parallel with the outputs of the research conducted by López-Mesa and Bylund (2011), centred on decision-making practices during the whole NPD cycle. In other words, industries' practices reflect structures and approaches of Product Planning methods to a considerable extent, despite their poor adoption and awareness. Other companies' demands do not match the claimed strengths of the methods closely; however, they can be fulfilled adequately by a significant set of tools. A strong limitation has emerged in terms of the direct usability of the surveyed methods for industrial purposes, capability of integration and implementation within the firm context and impact on the outcomes of the design process.

In this sense, a partial conclusion is that, besides being poorly promoted already at educational level, formalized Product Planning methods require a stronger orientation towards industrial environments and, first of all, a full demonstration of their operational efficacy. The limited diffusion of the treated methods is likely to reflect both scarce efforts to disseminate their underlying concepts to novel technicians and engineers and intrinsic limitations in terms of their usability.

5.2 Discussion on the research questions

The present subsection discusses the research issues that have emerged in Sect. 3.2 by introducing specific paragraphs for each of them. While the presented manifold investigations have fully addressed some of these questions, others require further studies and likely different research approaches or experiments.

5.2.1 *Whether scientific and industrial arenas acknowledge any established Product Planning practice*

Both the educational field and the industrial domain show a preferential orientation towards responsive approaches or strategies that foresee a strict synergy with customers. With respect to what is discussed in Sect. 3.3, it is arguable establishing whether these approaches are capable of leading firms towards radical product improvements, which better feature a competition oriented on innovation, rather than based on quality and customer satisfaction.

5.2.2 *The claimed advantages deriving from the implementation of Product Planning methods*

The research issue has been largely addressed in Sect. 4.1 by showing the most remarkable properties of Product Planning methods and then classifying the tools according to all these features (Table 3).

5.2.3 *Pros and cons of involving customers and product stakeholders during the FFE*

The difference between proactive and responsive approaches has been already treated in several literature sources. The lack of industrial experiments cannot properly address the debated questions about the suitability of responsive methods to produce fundamental product enhancements and the reliability of proactive strategies. A new group of methods, the hybrid approaches introduced by the authors in the present paper for the sake of convenience, represents a sort of trade-off between responsive and proactive techniques. However, strengths and weaknesses are likewise combined.

5.2.4 *The effective benefits of diffusing and implementing Product Planning models in industry*

Section 5.1 has widely pointed out the poor diffusion of formalized Product Planning paradigms in industry, thus confirming the findings of a large number of studies aimed at elucidating the real impact of NPD and engineering design methods on the business world. The present investigation points out an insufficient transfer of Product Planning methods at the educational level, an incomplete demonstration of their utility, diffused scepticism in industrial environments with regards to academics' work (at least with reference to the topics treated in the paper). These issues are deemed to represent a subset of the reasons behind the limited implementation of said methods. Besides, the scarce information about industrial experiences does not allow to demonstrate whether the claimed benefits of Product Planning methods are verified in practice. Nevertheless, the outcomes of future adoptions are promising if we take into account the fit between the industrial demands exposed by a small set of companies and the advantages Product Planning methods claim to achieve.

5.2.5 *Whether rigorous proposals have been advanced to identify successful new product characteristics regardless the followed NPD process*

Acknowledged contributions have not arisen. Conversely, firms tend to adopt strategies that involve customers, whose judgments are seen as a fundamental driver to tackle decisions throughout NPD processes. Three different hypotheses emerge that would require further studies. First: firms are structurally permeated by a customer-focused culture and cannot figure out strategies that do not rely on consumers to a considerable extent. In this sense, the goodness of product features just depends on customers' evaluations. Second: companies' expectations about Product Planning basically lie in enhancing the management of NPD initiatives. It is worth noting that many emerged demands, also beyond the properties of the Product Planning methods, regard the management of intrinsically responsive approaches and the way of organizing innovation processes. While the awareness of Product Planning techniques is very poor, some formal management frameworks (e.g. *business model canvas*) are implemented also within the small set of investigated firms. Third: proactive product-oriented strategies are so poorly reliable that, in each case, it is preferable to trust customers and/or consultants. The limited documentation available from the literature could somehow disguise a certain awareness of industrial subjects with respect to this kind of strategies.

5.3 Limitations of the performed investigation about Product Planning

The evidences presented in this paper originate from considerations extracted from the literature (and authors' interpretation of identified contributions), the syllabi of academic courses, the examination of a small sample of enterprises. Information arising from these sources can be biased by the partiality of these investigations. In particular:

- authors could have omitted relevant literature contributions or overlooked some of the methods' distinguishing features;
- the courses held in the most prestigious technical universities, chosen as a sample of convenience, could

be poorly representative of the NPD-related contents taught in universities worldwide;
- the quantity of investigated firms is surely limited and their belonging to a specific geographical area could affect the reliability of the outcomes. In this sense, the investigation in the industrial field suffers from one of the limitations identified by Graner and Mißler-Behr (2012) with respect to studies about NPD methods. The authors have already clarified (Sects. 2 and 4.3) the reasons behind preferring to analyse few companies in-depth rather than obtaining less focused outcomes from a richer group of organizations. However, in order to temper the described biases, just demands emerging from a significant share of companies have been considered for the subsequent analysis and discussion.

In this sense, we encourage any reader to extend the present research on Product Planning strategies, by expanding the domain of the investigation, so to confirm or put into discussion the inferred conclusions.

6 Conclusions

With the aim of assessing the suitability of academic contributions for innovation in industry, the present paper builds upon previous literature findings about the adoption of developed NPD formal methods. Such an issue is tackled by investigating a relevant stage of engineering design tasks, i.e. Product Planning, instead of the whole NPD cycle and by introducing an original approach based on the popularity of methods' claimed benefits, rather than considering methods themselves. These choices have been made with reference to individuated lacks of previous literature sources, as remarked in Sect. 1. The authors have focused on methods' strategies to innovate firms' deliverables, rather than successful managerial practices that greatly affect the FFE, by considering the latter largely debated in specialized literature. However, firms' aptitude to consider aspects peculiar to NPD processes has raised issues that partially overlap with the research field investigating success factors in Product Planning management, e.g. Cooper (1999). In particular, the relevance attributed to and the reliability of customers' indications for the scope of innovating products is a focal point of the present study.

Not surprisingly, in order to characterize the Product Planning methods from which claimed advantages have been extracted, the authors have classified them into three broad categories according to the role played by customers. This categorization can help companies to identify the most suitable techniques according to the planned involvement of their consumers or other stakeholders. The study has attempted to put into relationship the trajectories of research into the early stages of NPD cycles, the benefits and limitations of existing approaches, the effort paid by technical universities in diffusing the fundamental concepts of Product Planning, the perceived needs of industrial subjects. The latter was deemed necessary because of the mare magnum of NPD success factors claimed by numerous literature sources, besides poorly focusing on early design stages. This allowed to lay bare peculiar aspects of Product Planning which had not emerged through studies on methods concerning the whole NPD cycles.

Overall, the main findings of the present work can be summarized as follows:

- Product Planning methods can be characterized with respect to a set of remarkable properties, which appear to range among the most meaningful factors that determine the adoption of these tools;
- the main problems affecting the diffusion of Product Planning methods are supposed to stand in a limited role played by the University world as a catalyst to enlarge the knowledge about their benefits and the low number of applications demonstrating their efficacy in industry;
- industrial subjects tend to implement responsive approaches, despite their argued performances in supporting the generation of disruptive innovations. The reasons behind this emergence require additional research efforts.

As highlighted in Sect. 5.3, these results require an ultimate demonstration by broadening the field of the investigation. Despite this limitation, the authors are currently evaluating the presented outcomes in order to develop original Product Planning frameworks, intended to overcome the weaknesses of existing methods and specifically tailored to ensure industrial usability and usefulness.

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Appendix 1: Facts about idea generation

The table illustrates the literature sources discussing the characteristics, the role and the practices concerning idea generation.

	Statements about idea generation					
	Idea generation plays a key role in the NPD process	Creativity stimulation holds a high relevance in idea generation	There is a strong correlation between idea generation and commercial success	Not sufficient resources are allocated by companies to perform the idea generation accurately	Companies perceive idea generation as a random process	It is important to structure the ideation activity in the NPD process
Feldman and Page (1984)				•		
Sowrey (1990)				•		
Rochford (1991)	•					
Stasch et al. (1992)					•	
Ayers et al. (1997)			•			
Ernst (2002)			•			
McAdam and McClelland (2002)		•				
Alam (2006)	•			•	•	
Pahl et al. (2007)					•	•
Riel et al. (2013)	•					•

Appendix 2: Facts about idea selection

The table shows the literature sources discussing the role and the practices regarding idea selection.

	Concepts about idea selection				
	Companies lack coherent or formal process for selecting ideas	Companies have difficulties to distinguish lucrative from poorly beneficial alternatives	Long time and vast human resources are currently dedicated to fulfil idea selection (due to the great number of ideas to be assessed)	Difficulties lie in assessing radical innovative ideas (due to greater uncertainties about potential market results)	There is a strong correlation between idea selection and commercial success
Johne and Snelson (1988)				•	
Mishra et al. (1996)				•	
Song and Parry (1996)					•
Ayers et al. (1997)					•
Ernst (2002)					•
Rietzschel et al. (2006)		•			
Toubia (2006)			•		
Barczak et al. (2009)	•				
Cascini (2012)			•		
Soukhoroukova et al. (2012)	•		•	•	

Appendix 3: Additional Product Planning activities

The table lists the literature sources individuating activities to carry out Product Planning, other than idea generation and selection.

	Additional Product Planning activities			
	Monitoring the financial position of the company	Allocating resources and planning timing	Analysing existing and potential new technologies	Identifying legal regulations and patents
Verma and Fabrycky (1997)				•
Shinno et al. (2006)	•		•	
Agouridas et al. (2008)				•
Gausemeier et al. (2009)	•		•	
Montagna (2011)	•	•	•	
Ulrich and Eppinger (2011)		•	•	

Appendix 4: Product Planning Questionnaire

Question 1

How frequently does the company define new product/service features in your firm, or do you decide to rethink the existing offered ones?

Question 2

Who manages this activity in your company?

Question 3

How do/es he/she/they manage this activity? Do/es he/she/they use any method and/or tool to identify the basic features of new products or services?

Question 4

How are the most promising ideas selected (in the case that in the previous step more than one idea have been identified)?

Question 5

Are you satisfied with your current product/service idea generation and idea selection approaches? Why?

Question 6

What are the main lacks of your approach/es according to your point of view?

What could be primarily improved?

Question 7

Do you know other methods (also implemented in software application) that can support the product/service idea generation and selection, besides the approaches that the company has adopted?

*(if the answer is **YES**) Why aren't they employed in the firm?*

Question 8:

What are the reasons, according to your point of view, of the unsuccessful transfer to the industry of product/service idea generation and selection methods developed in the academic world?

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