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Overview of new product development strategies and models

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Abstract

Motivation: The motivation for the overview presented in this article is to provide a starting point for considering whether existing new product development methodology and its level of detail allows product teams to develop high-quality and business-effective product concepts.
Aim: The aim of this article is recognise the current state of research into new product development methodology and to present the strategies and models for New Product Development (NPD).
Materials and methods: The systematic review of the literature was applied in the article.
Results: The first section outlines the main strategies for new product development and how they are divided by methodological stance, degree of planning, search pattern, focus and response. The second part discusses the known models of new product development including: the craft model and the 5 generations based on the innovation models described by Rothwell and the stages of the manufacturing process defined in the literature. Part four looks at new trends in new product development, including: Open Innovation, Rapid Product Development (RPD), Agile New Product Development (ANPD), Sustainable New Product development (SNPD), the Design Thinking method and the new technologies of Industry 4.0.

Keywords: *new product development; product management; innovations; product quality*
JEL: *M10; M11; M13; O10*

1. Introduction

Every year, countless new products are launched on the market. Many of them pretend to present innovative value. Rapidly developing technology, the growing popularity of start-ups, and government financial support for innovation projects are causing companies to become more ambitious, and designers and new product development departments to become more active. However, it turns out that few initiatives are able to generate profits that would allow them to recover the costs incurred in their creation. In the literature, we find statistics on how many new products succeed and how many end in market failure. Kotler & Keller (2012) states that new products fail half of the time, other estimates are that this happens 95% of the time in the US and 90% in Europe. Thomas (2001), CEO of Nissam Motor Corporation cites that the US company Amoco Chemical revealed that out of 100 products offered to the market, only four were more popular with customers.

However, Castellion and Markham (2012) believe that although it is used to claim that new product failures in the marketplace are as high as 80%, some empirical studies conducted with business practitioners in various industries indicate failures around 40%.

Despite the uncertainty about the exact percentage of new product failures, the risk of market failure is still high. One of the reasons for this is the lack of acquisition of sound scientific knowledge on the methodology for product teams to develop high-quality product concepts. Contrary to the widespread access to information, still few companies seek research on product development methodologies. An approach based on intuition and post-analysis is still often used, despite the fact that scientific literature contains descriptions of strategies, models and individual stages of development processes. However, it is not only a lack of knowledge that causes problems. Existing models for new product development present a high level of generality and their application by product teams brings only limited practical benefits.

The aim of this article is to present the strategies and models for new product development described in the literature and to analyse their level of detail and completeness, as well as the possibility of their application by teams developing new concepts for solutions introduced to the market. It is also a starting point for considering whether their completeness and level of detail allows project teams to effectively develop high-quality and business-effective product concepts.

2. Literature review

2.1. Strategies for new product development

Any company focused on achieving certain results should develop a strategy according to which it will produce new products, i.e. take synchronised action on its own development defined as: "directional ways of solving the problems of designing, developing and marketing new products" (Rutkowski, 2007). The choice of a specific strategy determines the direction of the search for new solutions. It also determines the composition and competencies of teams, as well as the company's behavioural policies and types of reactions to changes happening in its market and marketing environment. We can divide new product development strategies according to:

1. Methodological stance. There are currently two development strategies divided by methodological attitude. The first one, i.e. the incremental strategy, assumes that the innovation process is an incremental process and takes place through successive iterations of improvements (this strategy is in line with the Japanese Kaizen philosophy of behaviour). The second is a product development strategy based on defining a set of characteristics of the ideal product. This approach was more widely disseminated by Nadler, founder of the IDEALS (Ideal Design of Effective and Logical Systems) organisation, and Altszuller (1972). The ideal product strategy offers the chance to achieve more innovative results, but is more risky and requires considerable foresight and visionary skills on the part of the designers.
2. Degree of planning. In terms of the degree of planning in the product development process, there are two tactics: programmed strategy and agile strategy. A programmed strategy involves defining an action plan in advance. Sometimes it also involves detailed planning of costs and deadlines. An adaptive strategy, on the other hand, allows the plan and scope of the development process to be flexibly adjusted due to unforeseen events within the organisation, changing stakeholder behaviour and unexpected customer reactions to a new product. It also involves an inability to accurately predict costs and lead times.
3. Exploration pattern. New product development strategies can also be divided according to the search pattern (Wirkus & Lis, 2023). In this view, we distinguish

between: the strategy of determining and evaluating individual solutions for a new product based on making an analysis, used in problems with determining sets of solutions and with limited resources, and the strategy of determining a set of acceptable solutions for a new product.

4. Targeting. Strategies can also be divided by orientation i.e.: external buying strategies and internal development strategies. Detailed subtypes of this division are shown in Scheme 1. Each organisation must individually answer the question of which development path is most appropriate for it. Launching research and development processes internally is time-consuming and costly but guarantees the building of valuable know-how. An example of an internal strategy is the resource-based strategy (Paladino, 2007). It involves using surplus resources in terms of production capacity, knowledge, research, technology, marketing, talent and other resources. Buying a strategy from outside may be quicker, cheaper and safer, but in the long run it does not allow the organisation to acquire knowledge and self-improve, so the decision taken should coincide with the long-term strategy of the whole organisation.
5. Reactive approach. We can also divide new product development strategies into proactive and reactive ones. The proactive route involves the creation of new products in line with the company's established marketing strategy. In such a model, the determinant of all actions is the desire to achieve a defined level of revenue and competitive advantage that the company wants to achieve in the market. New product ideas are evaluated on the basis of their ability to open up new revenue opportunities. There are currently 4 models for implementing a proactive strategy (Rutkowski, 2007):

- combining marketing knowledge with new technology to enter a new customer segment;
- development of a better product than previously offered;
- introducing innovation to ensure market leadership;
- realising greater customer value while reducing costs.

A reactive strategy is primarily chosen by companies wishing to minimise production risks and costs. The premise of this approach is to observe the activities and offerings of competitors and analyse the marketing environment. In the next step, an assessment of the risks and threats determined by the competitors' actions is undertaken. The company then decides to modify its own offer or copy existing products on the market. Two models of reactive strategy are particularly conducive to success:

- product second on the market but better than the original;
- product that perfectly imitates the original.

There are many routes that can be taken to secure a smaller or larger profit and an attractive market position. Strategies based mainly on reacting are generally safer but also make the company navigate the closed area of the "red ocean". The likelihood of success in new segments is low. For companies whose health is precarious, a product failure may cause a retention problem. However, it is risk-taking that brings the greatest opportunities in business so choosing the right approach is not easy. Choosing the right strategy should be done after a careful analysis of the business context that is different for each product, even if it is produced by the same company (MacCormack et al., 2009).

The primary objective of a new product strategy is to provide a unified direction. In particular, to spot any tempting areas for development and to identify those where effort should be made (Stoner et al., 1999). However, the various definitions of new product development strategy are not clear-cut. They are approached from very different points of view and often touch on a selected aspect of the product idea. In practice, the market success of a product depends on many factors,

so focusing on only one dimension described above may not be sufficient.

The idea is that strategy is a broad programme to guide and achieve an organisation's goals (Stoner et al., 1999). Many of the strategies described do not carry the characteristics of an integrated programme, but indicate an approach in one selected area. They also do not define how to go down to a lower level of detail with their help, e.g. how to examine whether the adopted measures are adequate and whether they fulfil it to an appropriate degree. It is also difficult to define whether something is a stand-alone strategy or whether it merely indicates one of many areas to be considered when developing new solutions. In today's complex market reality, a one-dimensional approach does not guarantee success. A way out of the situation is to choose combined strategies that allow not only to diversify a company's activities and minimise danger, but also to gain an advantage in many fields, and this is particularly important in times of intensifying competition. However, there is a lack of studies that define how to combine different strategies to make them more complete and thus increase the chances of success for a new product. There is also a lack of new product development strategies that address the specifics of today's market, its dynamics and technologisation. It should also be examined whether the strategies defined in the 20th century are still valid and complete.

2.2. Overview of new product development models

However, new product development strategies are not sufficient for new product development teams. They need a specific methodology that describes the scope, ways of working and a defined process of action. New product development models have been described in the literature, which define some of the aspects that still need to be considered during the creative process. Unfortunately, the term "new product development model" itself has not crystallised sufficiently, so different researchers understand the concept differently. Sometimes it refers to a general approach, other times to the production of an innovation and still others to the successive stages of the conceptual process. The models named and described in the literature are presented below.

The oldest model of new product development was known as early as the turn of the 15th century. The artisanal model in question is characterised by the fact that a new product is created on the express order of a specific customer. The entire process of designing, prototyping and manufacturing the product is managed by one and the same person, which greatly facilitates the complex management of the development project. Since the 15th century, a number of more complex models have been developed. Most of these have evolved from the generation of innovation models developed by Rothwell (1992) (shown in Table 1).

In the 1960s of the previous century, NASA disseminated the linear (sequential) 1st generation model (Scheme 2). Its premise is a supply-side approach, which assumes that innovation is "pushed" by technology. The model defines a phased creative and manufacturing process, where dedicated departments within the company are responsible for the next stages of development. The danger in first-generation models is the lack of communication and collaboration between members of successive project teams. Additionally, it happens that even minor difficulties at any stage of the process significantly delay and sometimes even jeopardise the entire project. Nevertheless, such a model is convenient and structured, which encourages some companies to use it.

The 2nd generation model is also called a linear model but is characterised by a demand-driven approach — it is "pulled" by the market (Scheme 3). In the English literature, the epithet lean is often used to describe this approach (Jaruzelski et al., 2011). This model offers much greater resource efficiency but still defines product attributes too quickly. This results in closure to information coming from inside and outside the organisation. An example of a second-generation process is

the Stage Gate Model (Scheme 4). Another example of a linear approach is the BAH model (Booz et al., 1982), which involves treating the product strategy as the starting point for the entire conceptual process (Scheme 5).

The 3rd generation model called coupled uses the assumptions of simultaneous engineering. With parallel operation and excellent information flow systems, the execution times of individual teams can overlap (Scheme 6). This means that the people responsible for designing, manufacturing, implementing and collecting information from future potential product buyers are working continuously to produce the product. The key to success in the 3rd generation model is continuous testing and design done on a collaborative basis with the customer. Examples of the application of the 3rd generation model is concurrent engineering.

In generation 1–3 models, we can distinguish between several types of detailed models (Rutkowski, 2007).

1. Departmental stage model. This model assumes the transfer of a product at different stages of the development process from department to department in an organisation.
2. Activity stage model and simultaneous engineering. In this model, the product development process is viewed holistically and design proceeds interdependently with other elements of the process, e.g. manufacturing, testing, implementation or maintenance.
3. Cross functional teams model. Creating cross-functional design teams significantly reduces the length of the product development process. A key role is played here by R&D and marketing, which is responsible for the continuous participation of customers and suppliers in the design process.
4. Decision-stage models. This involves dividing the process into stages that culminate in a decision to continue, close or go back to a previous stage of the process. The value of interdepartmental work is unfortunately often underestimated in such a scheme.
5. Conversion-process model (response model). This type of model approaches the product development process as a series of inputs and outputs that are, for example, customer needs or new technology.
6. Response model. The response model focuses primarily on the reactions of customers and members of the organisation to a new product.

At the beginning of the 21st century, 4th generation models (Reformat, 2018) called integrated emerged. Their premise was primarily the sharing of information, combining knowledge from different areas and its subsequent integration overlap (Scheme 7).

The significant acceleration of technology development and the increased dynamics of change in the socio-economic environment have led to the development of so-called 5th generation coupled innovation models (Reformat, 2018) (Scheme 8). These assume the interaction of all elements of the innovation process during the emergence of new products and solutions.

Contemporary researchers also distinguish an extended 5th generation model called the network model (Scheme 9). It was born in the 1990s as a result of the need to take into account the coupling between elements of the new product development process. In its application, great emphasis is placed on the role of technology, information, databases and continuous internal and external communication (Szymura-Tyc, 2011).

In the scientific literature we find descriptions of both models and stages of new product development. Unfortunately, there is no clear distinction between these two concepts. As can be observed, some models, in particular linear models, boil down to describing successive phases of the conceptual process. For this reason, a description of the most commonly identified phases should be included in the review. A simplified diagram of the product development process assumes the existence of several consecutive phases: the product development decision, the concept search phase, the concept development phase, and the implemen-

tation and market launch phase (Rutkowski, 2007) (Scheme 10).

More or less elaborate variants of this process can be found in studies. Some of them assume that the conceptual phase is broken down into a number of minor stages, as in Scheme 11 (Łuczak, 2009), while other diagrams detail the tasks involved in producing the product and bringing it to market. Some of the skeletons of the development process also cover the entire product life cycle, which seems appropriate because both the manufacture and the existence of a product on the market make up a single process of its management.

Each stage of the product development process should end with a satisfactory result from the company's point of view. Their characteristics (Kotler & Keller, 2012) are outlined below.

1. Development of the new product strategy. This is one of the most important and most often overlooked phases. New products developed within the organisation should implement the company's overarching long-term strategy. In order to secure high-quality ideas, it is first necessary to outline the attractive and promising market sectors in which the organisation would like to be present. In order for the R&D teams to work properly, they should be given a set of clear, high-level strategic objectives into which the ideas they develop should fit. It is important to note that predefined goals and frameworks do not at all negate the work of exploring blue ocean ideas. They allow the development of an innovation that is in line with the company's mission and focus area.
2. The search for ideas. In any smaller or larger company, idea generation should follow a planned and programmed process. In order to improve the stream of creativity, Michalski (2003) suggests using the following tools for generating new ideas: analysis of buyers' needs, list of product attributes, dependency analysis of existing products, identification of buyers' needs, brainstorming, morphological analysis, employee initiatives (e.g. in the form of idea boxes). Kotler and Keller (2012) suggest: holding informal sessions between employees and the company's customers, free time for employees to generate ideas, introducing brainstorming among company visitors, researching customers from behind the scenes, monitoring industry publications, creating an open and easily accessible idea bank.
3. Idea selection. Idea selection is the stage that generates the most excitement among both employees and company managers. Often used, idea screening aims to "kill" unsuccessful ideas at an early stage. This approach saves time and money in developing documentation for unprofitable, doomed products. It should be mentioned here that the authors of ideas usually become strongly emotionally attached to them. Careful action on the part of decision-makers can keep the company from losing the motivation of employees to re-generate proposals. Most organisations establish their own set of indicators against which to analyse the value of an idea for a product. Among the most common are: revenue potential, level of manufacturing effort required, alignment with strategy, use of current existing resources, innovation and others.
4. Concept development and testing. In the next step, promising ideas are described and subjected to first POC (proof of concept) testing. Concept testing should consist primarily of interviews with potential customers of the proposed product, consultations with experts, distributors and everyone inside and outside the organisation who will help verify the main assumptions. The reliability of the execution and quality of the results of this phase will largely determine the future success of the idea.
5. Economic and financial analysis. In this part of the process, detailed revenue analyses are carried out, product manufac-

turing costs are estimated and potential business models and distribution channels are described. The preparation of more or less detailed calculations is the basis for the decision to agree or to abandon the idea. One of the better-known tools for measuring the profitability of a project is the net present value (NVP) forecast and the initiative's internal rate of return (IRR). It is important to bear in mind that, by reaching this stage, the product development process has already managed to generate a significant cost (for example, by taking up staff time) therefore, improving the mechanisms for early screening of ideas is very important. At this stage, the biggest challenge for company heads is to avoid making the so-called DROP-error of rejecting a valuable idea with a chance of future product success.

6. Testing prototypes. In the next step, a partially or fully functioning prototype of the product is produced. This allows better planning of the production process for the entire batch and enables a deeper analysis of the future value of the product by the end customers. To avoid the high cost of creating a prototype, a method called rapid prototyping has recently been used to replace most mock-ups with their computer-generated counterparts.
7. Marketing tests. After the prototype stage, a number of functional and marketing tests can be carried out to minimise the risk of failure in the market. Tests including: alpha tests (in-house tests), beta tests (making the product available to potential customers and observing them) controlled market tests, sales fluctuation studies and simulated marketing tests can help. In addition, descriptions of gamma testing (involving testing of the product not only by customers but also by other stakeholders and experts) and delta testing (i.e. the process of guiding a product tested over a long period of time into further development) can be found in the literature.
8. Commercialisation. Deciding to produce a full batch of a product carries a high cost. In many cases, the production process takes a very long time. Sometimes so long that the market situation changes considerably and competitors anticipate the company's moves by their actions. Making changes to an already running production is a complex process and generates a lot of controversy. The fact is, however, that it is better to increase production costs and sell the product in the future than to maintain the previously declared cost level and never find a market for the product.
9. Building acceptance, promotion, sales. The end of production is not the end of product development work. The most important part of working towards success is just beginning and it starts with working towards customer acceptance of the product. Acceptance "is an individual decision by the customer to become a regular user of the product" (Kotler & Keller, 2012). The process of product acceptance among buyers takes place in successive stages: building awareness of the product's innovation, expressing interest, being evaluated, trying or tasting, and accepting the product. Michalski (2003) distinguishes five stages of new product design: idea generation, idea selection, idea selection, product design and commercialisation (Scheme 11).

2.3. New trends in new product development

In the existing scientific literature, we can find material on models and methodologies for planning new developments. Most of these have grown out of innovation models. However, they are not exhaustive and therefore references to new methods, models and techniques need to be made. The most important of these are outlined below.

1. Open innovation. Nowadays, a 6th generation model, called open innovation (Chesbrough, 2003), is increasingly prominent. Its premise is a holistic approach that inte-

grates different sources of inspiration, both internal and external. The involvement of partners and customers in the process takes place at every stage of concept development, as well as in the commercialisation phase (Rojek, 2014). The model uses all possible ways of exploring potential fields of development (Inauen & Schenker-Wicki, 2011) including those based on the wisdom of the crowd based on social media, outsourcing and croudfounding (Brzeziński, 2017). Open innovations build on the achievements of concurrent engineering (CE) sometimes also called as concurrent design and manufacturing or integrated product development (IPD).

2. Sustainable New Product Development (SNPD). Sustainable New Product Development implies additional sustainability criteria (ZR) at each stage of the conceptual and manufacturing process. Their need is driven by increasing customer awareness, NGO requirements and legislation (Bevilacqua et al., 2007). Studies are proposing to expand product development models with new components. E.g. the Phase-Brama model proposes to identify and prioritise sustainability at the idea generation and selection stage while BAH-type models propose to define a vision of ZR at the strategy development and business case development stage (Su, 2020).
3. Design thinking. When discussing the new product development process, mention should be made of the widely used method of stimulating creativity known as design thinking. The first to use the term was most likely Bruce Arche, author of Experiences in Visual Thinking, but the originator of the method is considered to be David Kelley, founder of the design consultancy IDEO, who combined the tools used in product design and industrial design with their application in strategic consultancy for companies (Denning, 2013). "Design Thinking is an intuitive working method through which innovations are created in multi-disciplinary teams by combining elements of engineering, business, design and social science" (Helman & Rosienkiewicz, 2016). The aforementioned design process consists of 5 phases: empathising, defining the problem, generating ideas, building prototypes and testing and is used as an innovation enabler in new product development.
4. Rapid Product Development (RPD). In a fast-changing market environment, all methods that shorten the conception and creation period in favour of an interactive development process, rapid product launch and testing of how customers react to the product are gaining popularity (Bullinger et al., 2000). This approach often uses the go-to method of minimal valuable product creation (MVP) and cheap and easy prototyping methods such as 3D printing and digital mock-ups.
5. Agile New Product Development (ANPD). Although the term agile management is not new, in the context of new product development it was only formalised in 2001 in the much-discussed Agile Manifesto (Kettunen, 2009). It originally described a software development methodology that has become standard in companies such as Google, Amazon and Spotify and, over time, has been applied to the development of products and services outside of IT. The main distinguishing feature of this approach is the incremental nature of development. With each iteration of work on a product, new value is created in the form of, for example, a prototype or new functionality, with continuous testing being an integral part of the whole process. At the same time, the process is accompanied by continuous customer involvement and feedback, ensuring that product features meet changing customer requirements. The academic literature mentions the use of decision-making techniques based on multi-criteria analysis (MCA, MCDA) (Yadav & Desai, 2017) in the context of new product development using

the ANPD method. They allow the selection of a single best option from a number of possible options or to improve performance, modelling factors in new product development and even to select an appropriate methodology (Palsodkar et al., 2022).

6. New Technologies of Industry 4.0. In the process of developing new products, not only mathematical analysis but also modern technologies are starting to be used, among them: big data solutions, AR, VR, AI, IoT, 3D prototyping and cognitive technologies (Ardito et al., 2019). They allow better decisions to be made in the process of developing new concepts but also to gain competitive advantage through digital transformation (Wijewardhana et al., 2020).

3. Materials and methods

The research method used in this research is the analysis of scientific sources: literature study based on national and foreign scientific publications describing applied strategies and methods of new product development.

4. Results

The study brings together the most important strategies and models for new product development. The first section outlines the main strategies for new product development and how they are divided by methodological stance, degree of planning, search pattern, focus and response. The second part discusses the known models of new product development including the 5 generations based on the innovation models described by Rothwell (1992) and the stages of the development process defined in the literature. Part four looks at new trends in new product development, including: Open Innovation, Rapid Product Development (RPD), Agile New Product Development (ANPD), Sustainable New Product development (SNPD), the Design Thinking method and the new technologies of Industry 4.0.

5. Conclusion

New product development methodology does not have a long history. It only began to be described more extensively in the 1980s. There are still many aspects of the NPD process waiting to be thoroughly investigated. Unfortunately, as can easily be seen, their scope is general and high-level. They are not sufficient for creative teams, and on the basis of them it is difficult to define a specific scope of development activities and to work out the features of the target product.

The general thinking is that every product is different, so it is impossible to define what the conceptual work should be about. However, it is easy to list a number of aspects and attributes common to many new products, e.g. attractiveness and graphic fit, exploitation of legal opportunities, degree of complexity, degree of application difficulty, degree of usability, potential for funding sources, etc. What lies below the level of generality presented in the literature is concretisable and must be researched and described. New product development models should define the areas that need to be addressed, so that product teams act methodically and not chaotically. If there are business model canvas templates that can be applied to different market situations, also new product templates should be invented. With the new models and frameworks product teams will no longer be forced to discover new products by the costly and risky way of learning only on own mistakes.

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Appendix

Table 1.
Generations of innovation models

Generation	Model name	Type
1st	linear model	technology push
2nd	linear model	demand pull
3rd	coupling model	interaction and feedback loop
4th	integrated model	internal integration and partnership with external companies
5th	networking model	interaction with customers, a flexible approach and continuous innovation

Source: Rothwell (1992).

Scheme 1.
Types of new product strategy

Source: Own preparation based on Rutkowski (2007).

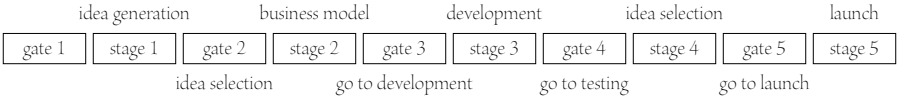
Scheme 2.
First generation innovation model

Source: Own preparation.

Scheme 3.
Second generation innovation model

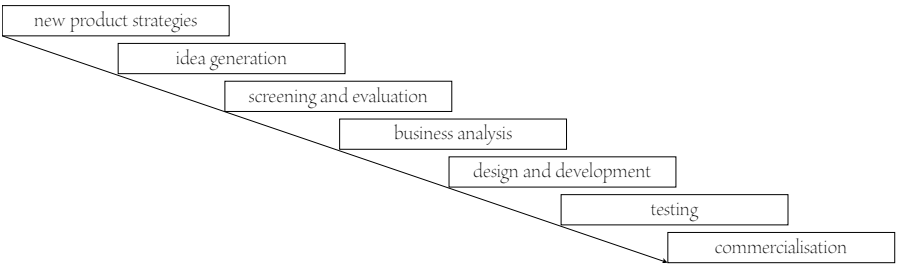
Source: Rothwell & Gardiner (1983).

Scheme 4.
Example of a 2nd generation model: Stage-Gate process



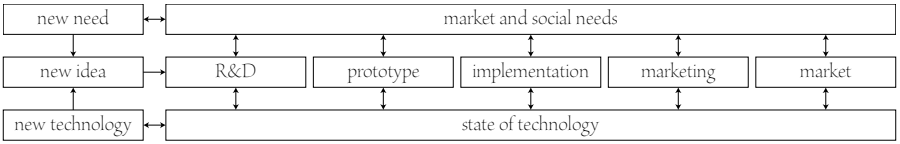
Source: Own preparation based on Cooper (1990).

Scheme 5.
Example of a 2nd generation model: BAH model



Source: Booz et al. (1982).

Scheme 6.
3rd generation innovation model

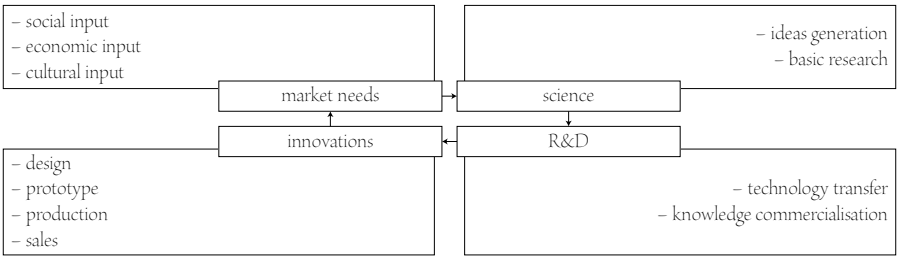


Source: Piątkowski & Sankowski (2002).

Scheme 7.
Parallel (integrated) 4th generation model

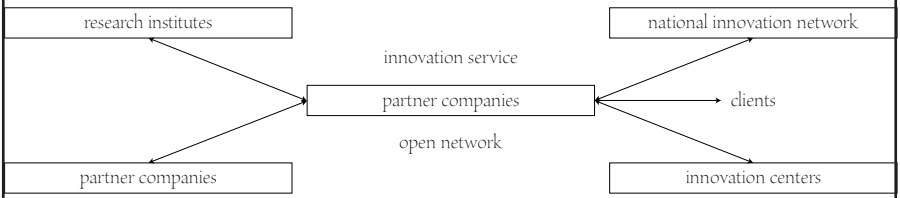
Source: Rothwell & Zegveld (1982).

Scheme 8.
Coupled 5th generation model



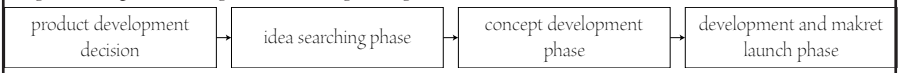
Source: Rothwell & Zegveld (1985).

Scheme 9.
5th generation networked model



Source: Grudzewski and Hejduk (2000).

Scheme 10.
Simplified diagram of the product development process



Source: Own preparation based on Rutkowski (2007).

Scheme 11.
Stages of the conceptual phase

Source: Own preparation based on Łuczak (2009).