IDEAS, KNOWLEDGE AND TECHNOLOGY – A PRODUCT DEVELOPMENT FRAMEWORK FOR OPEN INNOVATION

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Abstract. *Creativity is the human capability that makes innovation and product development possible. Behind creativity, there is a fundamental element called "idea". Within the fields of innovation and product development, "idea" is a word that is constantly employed, but rarely defined. It carries many different and equivocal meanings, though. Often, ideas are conceived as representations (images) of existing things. Sometimes, however, idea is a synonym for notion or opinion. Yet, it can also mean suggestion, concept or even designate anything that comes into one's mind. Since it is a word that can bear so many equivocal meanings, it urges to be clearly and precisely defined. In times of rising relevance of collaboration, such as today's, much is discussed about inflows and outflows of "ideas" from different players (firms, universities, laboratories, community and so on). Within the new field of research on Open Innovation, which inquires this kind of phenomena, "idea" is an element present in the very definition of the concept: as commonly defined, Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market. Within this context, this article aims to propose a framework for product development suitable to incorporate open innovation practices. It is based on a literature review on Product Development, where classical product development models such as the product development funnel and the stage-gate approach are complemented with some considerations and definitions borrowed from Knowledge Management and OECD manuals of the "Frascati family" in order to build a coherent theoretical model to explain the Product Development Process (PDP) in a collaborative environment. In this model, it is made a distinction among "datum", "information", "knowledge", "technology" and "idea", being the latter regarded as creative impulses that finds and investigates possible combinations of existing intangible assets (data, information, knowledge and technologies) for the creation of new intangible assets, aiming the introduction of new or significantly improved products (goods and/or services) in the market. The model proposed in this paper does not intend to enclose the whole of product development. As it happens to all models, also this one runs into simplifications and restrictions, which are analyzed in the paper. Nevertheless, it has the advantage of successfully representing the mainstream of knowledge maturation within the PDP and the points of potential inflows and outflows of intangible assets, which is what Open Innovation is all about.*

Keywords*: New Product Development, Open Innovation, Knowledge Management.*

1. INTRODUCTION

Creativity is the human capability behind innovation and product development. Without it none of these fields of research would make sense. Behind creativity, there is a fundamental element called "idea".

But what is an idea, anyway?

The etymology of the word "idea" comes from the Greek word ιδέα (idéa) or ειδέα (eidéa), whose root is ειδοσ (eidos), which stands for "image".

The origin of the term dates back to the classical Greek philosophy ages. Plato (V century B.C.) has introduced the current of **idealism**: conception that beyond the sensible world – the reality that the senses realize – there would be the world of the Ideas. This world would be composed of perfect, eternal and immutable entities (the Ideas), whose existence would be independent from men's will. All material things would be nothing but ephemeral and imperfect reflexes of the Ideas, the only existing beings in reality. According to this theory, the perception captured by the senses would be to reality as shades on a wall are to the objects that produced them, as Plato explains in the famous myth of the cavern in the VII book of the "Republic" (HESSEN, 2003). Only Philosophy could give true knowledge, which could be able to release men from the cavern of the senses to the true world: the world of the Ideas. (FRANCA, 1965)

Against this current arises the theory of **realism**, whose most prominent names are those of Aristotle (IV century B.C.) and Saint Thomas Aquinas (1225-1274), which affirms that the world captured by the senses is the real world, indeed. Idea, in its turn, would be an entity of reason that, although immaterial, exists in reality in the intelligence of rational beings, not in a contiguous existence as idealism claims. According to realism, ideas are seized by the senses by means of observation and abstraction from the real world. Knowledge is related, thus, to this capability of abstracting true and universal laws from the material world. (FRANCA, 1965)

A more contemporary definition of the philosophical concept of "idea" is found in the **Dictionary of Philosophy and Psychology** of the Encyclopædia Britannica, compiled by James Mark Baldwin between 1901 and 1905. One finds there that idea is *"the reproduction with a more or less adequate image, of an object not actually present to the senses"*.

Not going further into the philosophical discussion, which does not matter to this work, what is relevant to highlight is that, with the advent of the modern idealism in the Modern Age, whose exponent is French philosopher René Descartes (1596-1650), different meanings for the word "idea" have arisen besides that of mental images of universal beings. This changing of meaning was perceived by English writer Samuel Johnson (1709-1784), whose life is known by means of his biography written by also English writer James Boswell (1740-1795), who wrote:

> *"He [Samuel Johnson] was particularly indignant against the almost universal use of the word idea in the sense of notion or opinion, when it is clear that idea can only signify something of which an image can be formed in the mind. We may have an idea or image of a mountain, a tree, a building; but we cannot surely have an idea or image of an argument or proposition. Yet we hear the sages of the law 'delivering their ideas upon the question under consideration;' and the first speakers in parliament 'entirely coinciding in the idea which has been ably stated by an honourable member;' – or 'reprobating an idea unconstitutional, and fraught with the most dangerous consequences to a great and free country.' Johnson called this 'modern cant'." (BOSWELL, 1791)*

What Dr. Johnson considered eccentric in the XVIII century is currently common sense. Nowadays, the word "idea" has many different and equivocal meanings. Often, ideas are conceived as representations (images) of existing things, as the classical definition sustains. However, as Dr. Johnson realized, idea can nowadays be a synonym for notion or opinion. Yet, it can also mean suggestion, concept or even designate anything that comes into one's mind.

Within the field of innovation and product development, "idea" is a word that is constantly employed, but rarely defined. And since it is a word that can bear so many equivocal meanings, it urges to be clearly and precisely defined.

In times of rising relevance of collaboration, such as today's, much is discussed about inflows and outflows of "ideas" from different players (firms, universities, laboratories, communities and so on). Within the new field of research on Open Innovation, which inquires this kind of phenomena, "idea" is an element present in the very definition of the concept: as commonly defined, Open Innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market (CHESBROUGH, 2003).

Therefore, this paper aims to propose a framework for product development suitable to incorporate open innovation practices, in which a distinction is made among the concepts of "datum", "information", "knowledge", "technology" and "idea".

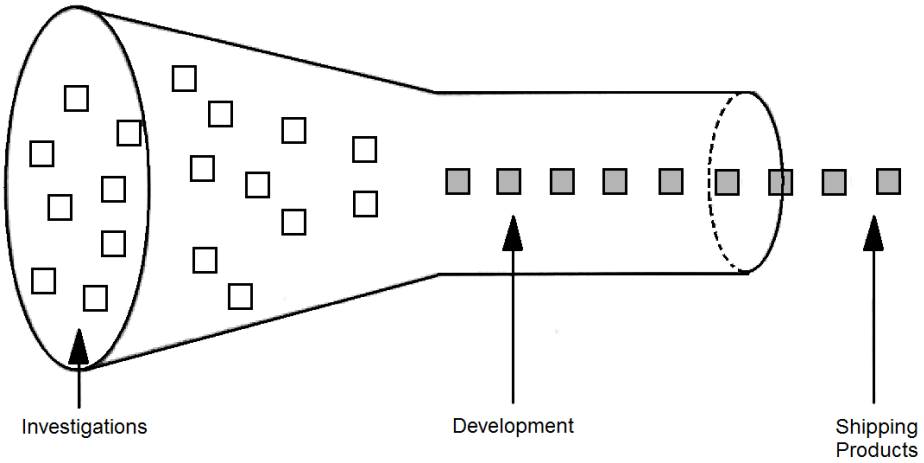
2. A FRAMEWORK FOR PRODUCT DEVELOPMENT

Product development sits in the broader literature on innovation, which consists of two broad areas of inquiry: one of them is attached to the economics-oriented tradition, which examines innovation on the macro level of patterns across industries and nations and its impact to the economy in general; the second, attached to organizations-oriented tradition, focuses the micro level regarding how products are developed and how this process can be more effectively structured and managed. This latter broad area is what product development is about (ADLER, 1989 apud BROWN et EISENHARDT, 1995).

In this field of study, product development is regarded as a business process, what is to say that it is a flow of activities that can be formalized, measured, managed and optimized (CLARK et WHEELWRIGHT, 1993; ROZENFELD et al., 2006; LOCH et KAVADIAS, 2008). After all, it comprises a set of activities that aims the design of products and production processes, for their posterior manufacturing, distribution, use, maintenance and disposal (KAMINSKI, 2000; ROZENFELD et al., 2006; JUGEND, 2010).

2.1 Linear product development models: development funnel and the stage-gate method

The starting point to the construction of the product development framework in this paper is the well-known "development funnel" model proposed by Clark and Wheelwright (1993), reproduced from the original in Figure 1.

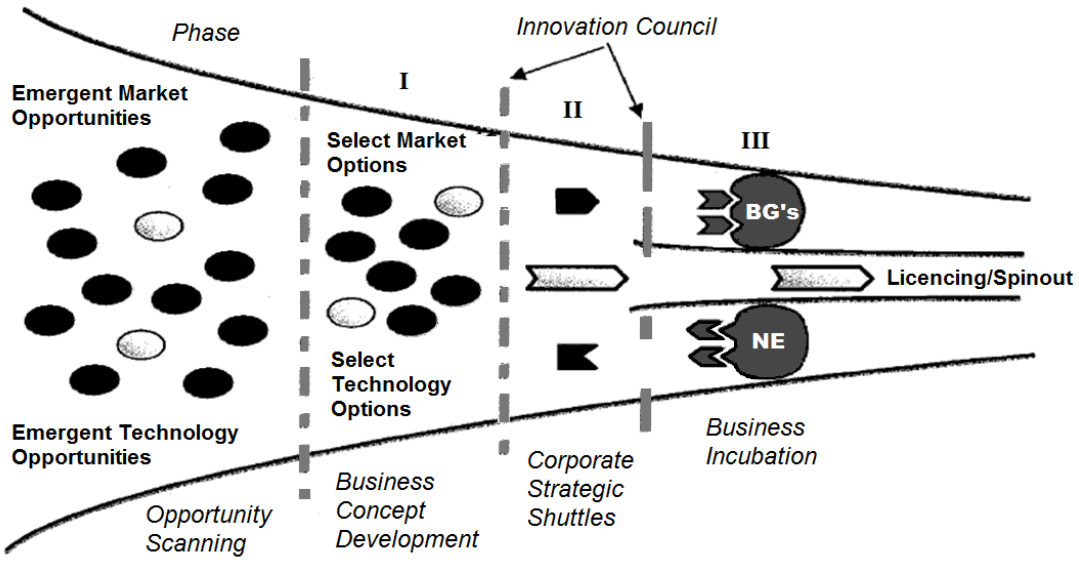


Source: Clark et Wheelwright, 1993.

Figure 1. The product development funnel

This model describes the process of selection of "ideas", represented by the white squares, which are progressively filtered and recombined inside the research part of the funnel, being narrowed down until they take the form of development projects (gray squares), which will, in their turn, result into goods and/or services that are shipped to the market. It is a linear straight-forward oriented process which suits well to describe the *modus operandi* of Research and Development (R&D) performed in companies. The two major limitations of this model are the lack of representation of knowledge feedbacks that occur in product development and the potential that this approach has to bias limiting and constraining creativity due to overkill of structure.

The literature on Product Development (CLARK et WHEELWRIGHT, 1995; COOPER et al., 2001; MANKIN, 2004; LOCH et KAVADIAS, 2008) suggests many examples of companies that have their R&D process designed as funnels such as that of Figure 1. The product development process at Xerox's PARC (Palo Alto Research Center) is a good example for that, as presented by Chesbrough (2003), and which is reproduced from the original in Figure 2.



Source: Chesbrough, 2003.

Figure 2. XEROX's PARC development funnel in 1996

The development funnel suggests that projects have to be somehow evaluated and discarded if they do not prove to be economically and/or technically feasible or aligned with corporate business goals.

In this sense, Cooper (1986) developed the stage-gate method, whose basic idea behind is to see the Product Development Process (PDP) as a linear bipartite graph, which consists of two kinds of activities: "*stages*" and "*gates*". In order to pass from one stage to the next, the project must necessarily go through a gate, where the decision of continuing funding the project or not is typically decided by a manager or a steering committee.

XEROX's model combines both the development funnel and stage-gate method in its framework: it allows a great inlet of "opportunities", i.e. of "ideas", which are analyzed by "innovation councils": evaluation rounds ("gates") represented by the vertical dashed lines. On one hand, these "gates" progressively discard "ideas" that are less viable or

less interesting to the firm's strategy and, on the other hand, they develop the business concept for the "ideas" that are selected, as they go through the "stages" of the funnel. At the end of the process, remaining "ideas" have been specified and conceived in the shape of product development projects, which are then incubated in one of the business units of the company, for internal development, or to be licensed out if it is not related to the firm's business core.

Chesbrough (2003) criticizes this development framework, for it does not systematically look outside the firm's boundaries neither for searching for external sources of knowledge nor for looking for external alternatives to the knowledge generated within the boundaries of the firm.

It is to fill this conceptual gap that this paper proposes the incorporation of other concepts to this framework, in order to indicate the process of "maturation of knowledge" within the funnel. The ultimate goal in doing so is to give a conceptual approach to inbound and outbound flows that characterize open innovation processes.

2.1 Building a conceptual model

Initially, the funnel shall be regarded as a tripartite process, with three well-distinguished stages, according to division of R&D proposed by Frascati manual (OECD, 2002), a document prepared and published by the Organisation for Economic Co-operation and Development (OECD), which is one of the most distinguished worldwide references for measuring R&D activities in industry. According to the sixth edition of the manual, R&D begins with basic research (initially "pure" and later "oriented"), which is followed by applied research, and ends up with experimental development (OECD, 2002).

Figure 3 shows these three phases inside a funnel that represents the PDP as a whole. The placement of these three processes within the funnel-like figure is meaningful. The narrowing represents the processes of selection, combination and filtering that take place in the investigatory phases of the PDP, that is, within basic and applied research. The straight end of the funnel represents the final phase of the PDP (development itself), where 100% efficiency is sought: every project that gets in the development stage is intended to result in a specific product or process.

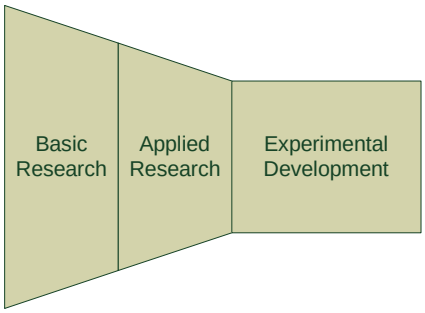


Figure 3. Division of the R&D funnel, according to the Frascati manual

At this point, one should be aware to the use of the term "experimental", always added by Frascati manual (OECD, 2002) when referring to development.

It is worth to recall that this manual, whose first edition dates back to 1963, aims defining R&D in order to make it easier its measurement, as well as providing a theoretical basis to allow legislation from governments on the subject. Therefore, this manual has a particular interest in establishing limits to the R&D, especially in terms of expenditures. The authors of the manual wished to segregate those activities where there are technological risks and uncertainties ("experimental development") to those that, although an integrant part of the PDP, have less or no uncertainties and risks associated to them, such as manufacturing ramp-up.

In the introductory text of the sixth edition of the manual one finds:

> *"21. Technological innovation activities are all of the scientific, technological, organizational, financial and commercial steps, including investments in new knowledge, which actually, or are intended to, lead to the implementation of technologically new or improved products and processes.* ***R&D is only one of these activities and may be carried out at different phases of the innovation process****. It may act not only as the original source of inventive ideas but also as a means of problem solving which can be called upon at any point up to implementation." (OECD, 2002. Highlights are ours).*

It can be inferred from the quotation above that, on the one hand, R&D is within the scope of technological innovation. On the other hand, there are other innovation activities that the manual does not consider as part of the R&D.

Regarding development itself, the very authors of the manual state the existence of two "types" of development: the "experimental" and a "pre-production" development, with a subtle border between them:

> *"111. (...) it is difficult to define precisely the cut-off point between **experimental development** and **pre-production development**, such as producing user demonstration models and testing, and production that is applicable to all industrial situations. It would be necessary to establish a series of conventions or criteria by type of industry." (OECD, 2002)*

Frascati manual adopts the rule originally laid down by the US National Science Foundation (NSF) for the exercise of judgment in difficult cases, which states that:

> *111. (...) "If the primary objective is to make further technical improvements on the product or process, then the work comes within the definition of R&D. If, on the other hand, the product, process or approach is substantially set and the primary objective is to develop markets, to do pre-production planning or to get a production or control system working smoothly, the work is no longer R&D." (OECD, 2002)*

However it is a pertinent and interesting topic for discussion, this distinction does not make sense in this paper, once its objectives differ from those of Frascati manual. This article intends to propose a framework for the whole cycle of innovative product development from the "idea" to the market, and not to distinguish the "scientific" to the "non-scientific" steps of the process.

In practice, if a company goes through experimental development, it will likely perform "pre-production" development if the experimental phase succeeds and, therefore, they are both to be performed by the company. "Pre-production" development performed without its respective previous "experimental" phase only makes sense when regarding non-innovative projects, which is out of the scope of this work.

Therefore, in this work's PDP model the word "experimental" is suppressed when referring to development. That is to say that this model embodies both "experimental" and "pre-productive" development into one single development stage.

Figure 4 illustrates this incorporation into the development funnel previously presented and the junction of both development stages into one general "development" phase.

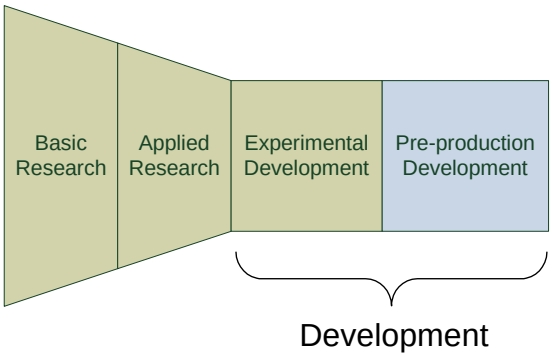


Figure 4. Incorporation of "pre-production" development into Frascati's framework

This merger aims to facilitate the classification of activities within the funnel and to avoid the difficulties highlighted in the manual.

OECD document that deals with innovation is the Oslo manual (OECD et EUROSTAT, 1997). In consonance with Frascati, Oslo manual also includes "pre-productive" development as an innovation activity:

> *"331. Enterprises' development of innovations may include a number of in-house activities that are not included in R&D as defined by the Frascati Manual. They include both the **later phases of development activities** and, importantly, the introduction of product and process innovations that are new to the firm, but not new to the market (or, in terms of the definition of R&D, do not increase the stock of knowledge or contain an appreciable element of novelty). Development and implementation activities for the adoption of new goods, services and processes may represent an important share of innovation activity." (OECD et EUROSTAT, 1997. The highlights are ours)*

If this "pre-productive" is part of innovation activities, it follows that it shall also be part of the PDP, as it is usually considered in the literature on product development (BROWN et EISENHARDT, 1995; KRISHNAN et ULRICH, 2001).

After defining the three phases of the funnel, the next step is to define the inputs and outputs of each stage.

Frascati manual defines basic research as

> *"experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view." (OECD, 2002)*

It is evident from the definition itself that the primary output of basic research is **knowledge**. As for the inputs, since basic research is fundamentally a learning process, the primary input shall be the "raw materials" of knowledge, which in this work are called **data** and **information**.

These terms shall be understood in this work according to the definitions of the Australian standard HB 275-2001, the first standard in the world exclusively dedicated to Knowledge Management (VEYBEL et PRIEUR, 2003).

According to this standard:

> *"Une donnée se réfère à des bits et des caractères dans um système informatique ou dans d'autres manifstations physiques de la communication, comme le son ou la temperature" (STANDARDS AUTRALIA, 2001 apud VEYBEL et PRIEUR,2003)*

> *["Datum refers to bits and characters in an information system or in other physic manifestations of communication, such as sound or temperature"]*

In relation to the concept of information:

> *"L'information est une donée contextuelle pouvant servir à une prise de décision. Une donée est habituellement mise en forme pour fournir un sens à l'observateur. Il s'agit plutôt d'un texte, mais peut être une image, une séquence de vidéo, une conversation ou tout simplement le signal d'occupation d'une ligne téléphonique." (STANDARDS AUTRALIA, 2001 apud VEYBEL et PRIEUR,2003)*

> *["Information is contextual datum that can be useful for decision taking. Data is normally organized in order to make sense to the observer. It's rather a text, but it can be an image, a video sequence, a conversation or even the busy sign of a telephone line"]*

Finally, the standard also defines:

> *"La connaissance est la nature même de la compréhension et représente ce qui est mentalement construit par les individus." (STANDARDS AUTRALIA, 2001 apud VEYBEL et PRIEUR,2003)*

> *["Knowledge is the very nature of understanding and represents what is mentally constructed by individuals."]*

In short, one can assume that the mainstream of maturation within basic research is the transformation of data and information into knowledge, as Figure 5 illustrates.

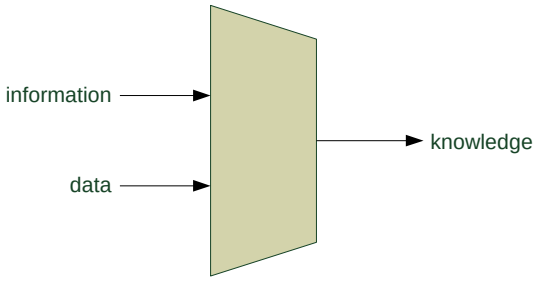


Figure 5. Maturation mainstream within basic research

It does not mean that basic research cannot make use of technologies and/or previous knowledge in order to construct new knowledge. It does not neglect that, except for the case of some disruptive breakthroughs, knowledge is often incremented from previous knowledge. This model just indicates the **mainstream** of maturation inside the funnel development model that is being constructed, as caption in Figure 5 points out.

Next, as to applied research stage, once again quoting the Frascati manual:

> *"Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective." (OECD, 2002)*

From this definition, one can infer that the same inputs of basic research (i.e., **data** and **information)** are inputs here as well, although it is also important to consider **knowledge** as input, especially the knowledge generated within basic

research. As for the output, the result of applied research is applied knowledge, which is assigned as **technology**, according to Merriam-Webster dictionary (http://www.merriam-webster.com):

> *"**Technology:** The practical application of knowledge especially in a particular area; a capability given by the practical application of knowledge" (Merriam-Webster Online, retrieved 2010/09/13)*

Based on that, Figure 6 illustrates the mainstream of maturation within applied research, from knowledge (along with information and data) to technologies.

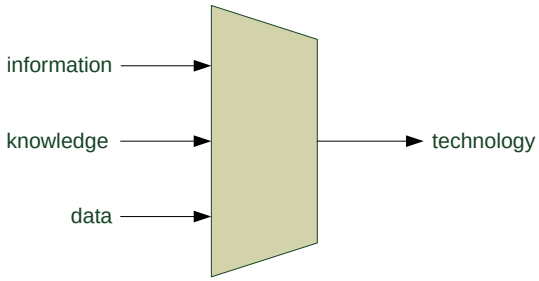


Figure 6. Mainstream of maturation within applied research

Jugend (2010) provides another definition of technology, which is more related to the product development process:

> *"(...) pode-se definir tecnologia como o conjunto de conhecimentos teóricos e práticos aplicados ao desenvolvimento de produtos, processos, serviços ou novo método voltado para a gestão de uma empresa." (JUGEND, 2010)*

> *[(...) technology can be defined as the set of theoretical and practical knowledge applied to the development of goods, processes, services or a new management method.]*

By this definition, **technology** is, thus, an input to the development process, where the outputs of research efforts (basic and applied) are transformed into products (goods and services) to the market. This conclusion is consistent with the very definition of experimental development given by Frascati manual:

> *"Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed." (OECD, 2002)*

In the theoretical framework that is being modeled, development joints technologies with more information, data and knowledge originated or not from practical experience, always aiming their incorporation into products (goods and services) for the market. Figure 7 illustrates this mainstream.

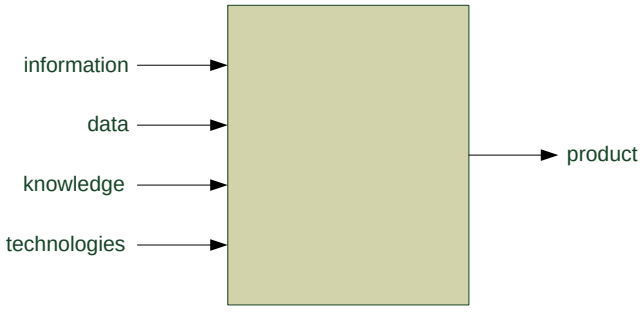


Figure 7. Mainstream of maturation within development

In short, the development process contemplated in this work follows the following fashion:

- It aims the attainment of product and/or processes that are new of substantially improved in relation to what the company had before;
- It involves significant technological risk;
- It contains a non-routine ("experimental") phase;
- It includes later phases of development ("pre-production") technical activities, up until it is put into operation (for the case of processes) or it is introduced in the marketing (for products).

One advantage of this approach it that the end of the funnel is properly the market, with nothing else in between. Figure 8 presents the final result of the framework modeled in this section.

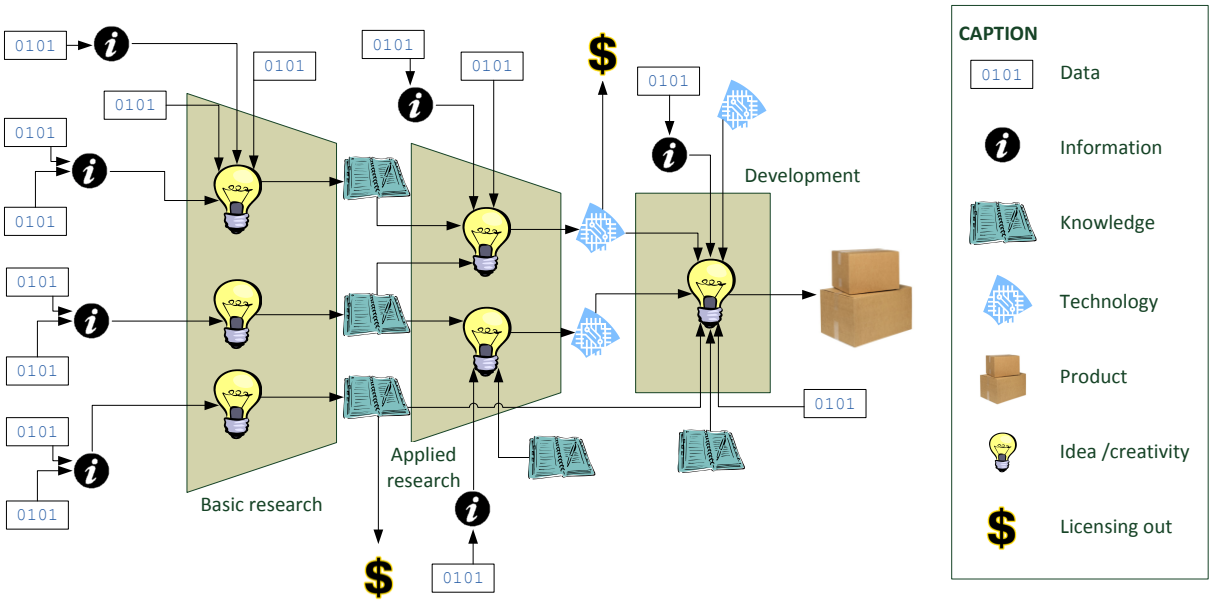


Figure 8. Product development framework

In this conceptual model, the "material" that flows inside the funnel is an intellectual asset that changes throughout the process: it can be called datum, information, knowledge or technology, depending on its degree of maturity. Some characteristics can be identified, though:

- Data and information are everywhere;
- Although knowledge can be created at any stage, this is more prominent (and is the main goal) within basic research;
- Applied research has as main goal the conversion of knowledge into technologies;
- Technology is the main input within development;
- Innovative products are the result of the creative combination of different kinds of intellectual assets;
- Knowledge and technologies are stable stages in this maturation process that constitute finished intangible "goods" that are eligible for trading: a firm's development funnel can use knowledge and technologies generated internally, as it can internalize external knowledge and technologies. Likewise, a firm can profit from other firm's use of its own knowledge and technologies generated internally.

The difficulty to make correlation between different models from different authors in the specialized literature (academic or not) lies in the name that is given to this "intellectual asset". Some authors call it "knowledge", as for example the whole literature on knowledge management that employs the word "knowledge" in both senses (LIYANAGE et al., 1999; VEYBEL et PRIEUR, 2003). Others refer to it as "technology", which is the case of the Technology Readiness Level (TRL) approach, for instance (MANKINS, 1995). In both cases, a figure of speech is employed, a synecdoche, in which part of something is used to refer to the whole thing.

Others designate as "ideas" the elements that flow through the funnel, when in reality, according to the conceptual model of Figure 8, ideas are the elements that combine different kinds of intellectual assets in order to form new "intellectual assets", as well as products and/or processes. That is the case of Chesbrough (2003) and Hansen and Birskinshaw (2007), for instance. In fact, due to the influence of Chesbrough's works in open innovation literature, many papers in the field use the word "idea" in this sense, as for example Dittrich and Duysters (2007).

3. RESUMING THE DISCUSSION ABOUT THE CONCEPT OF "IDEA"

With this conceptual model in mind, let us go back to the initial question of this subsection: what are ideas after all?

The concept of idea within the literature on product development and innovation seems to refer to a faculty related to the very human ability to create. It is part of the creative being to have many ideas. And what else is generated in the creative process but ideas?

Ideas, as well as creativity, are not exclusive to any of the three phases of the funnel modeled previously. On the contrary, they are part of all of them. It is men's creativity that biases the investigation of new possibilities of combination and/or use of available knowledge, information and data in a fashion not previously conceived. It is within

this process that innovation arises. On the other hand, ideas are not something that can be sold or borrowed, for they do not constitute a finished state of knowledge.

Under this view, ideas are, therefore, as the **catalyst** that transforms data, information, knowledge and technologies (the "intellectual assets") into new knowledge, technologies, which ultimately will become products, services and production processes.

Thus, this work proposes a formal definition for the term as follows: **"Ideas are creative impulses that allow the combination of existing data, information, knowledge and technologies into new knowledge, technologies, products and/or processes."**

According to this definition, it is creativity that generates ideas that produce knowledge, technologies and products, in their turn. The activities within the three-phased PDP are nothing but systematic tasks aiming the creation and validation of such ideas.

4. LIMITATIONS AND ADVANTAGES OF THE CONCEPTUAL MODEL

As a linear framework, this conceptual model incurs the limitation of this kind of models, not representing feedbacks that can happen in the knowledge maturation process in all steps of the funnel. Secondary knowledge and technologies can and are generated, for instance, during development.

It is a fact that research also makes use of technologies, for example, those incorporated into the equipments used for research purposes. Those technologies are not represented in the framework, which constitutes another limitation of the model.

Nevertheless, the framework presented in Figure 8 has the advantage of successfully representing the mainstream of knowledge maturation within the PDP.

One additional benefit of this model id that is allows the identification of the three core processes within open innovation (GASSMANN et ENKEL, 2004) within the funnel. Indeed:

- An outside-in process happens when knowledge and/or technologies enter a firm's funnel. It is normally formalized by licensing or other intellectual property (IP) agreements or by an acquisition;
- An inside-out process happens when knowledge and/or technologies leaves a firm's funnel to be used by another firm. Likewise, it is normally formalized by licensing or other IP agreements or by selling;
- A coupled process happens when collaboration arrangements uses knowledge and/or technologies from two or more institutions, with benefit to all institution funnels. It is formalized by mutual collaboration agreements, and likewise by licensing or other IP agreements.

5. CONCLUSIONS

Notice by this conceptual model that the new "marketable assets" within OI are knowledge and technologies. Ideas are not exchangeable things if they are regarded according to the previous definition.

In order to do so, companies should have their technologies and knowledge somehow formalized and protected. From that follows the importance of IP protection in OI, which allows the company to build a portfolio of intangible assets that can be commercialized by means of an openness process (CHESBROUGH, 2003).

What open innovation literature suggests is that industrial organization is going through a paradigm shift, in which the capability to collaborate and interact with external agents and assets is becoming more and more vital for a company's competitiveness. The implication for product development managers is clear in the conceptual model drawn above: formal processes must be elaborated in order to organize a firm's intellectual assets portfolio, so that that company can enhance its capability to collaborate and take advantage of the new environment that is rising.

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