Innovation Modelling: Understanding the Fundamentals of the Transformation of Research to Innovation

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Abstract: Innovation represents a challenge for research teams, SMEs, large industries and economies in general, as it is viewed as a catalyst for competitiveness in an increasingly competitive world. Reaching significant research results and achieving technological progress does not by each own create a competitive advantage. A further step is needed in order to transform research to innovation and turn research results into innovative products and services. Building a model for innovation helps towards understanding the fundamentals of the research to innovation transformation process.

Keywords: Innovation, Modeling, Process.

1. INTRODUCTION

Invention represents the first occurrence of a new idea for a product, service or process. On the other hand innovation is about the commercialization of this idea, i.e. bringing it to the market. It may be stated that in general innovation may be analysed as an invention and its commercialization; yet boundaries are not always clear since invention may be relevant to not only research and development work but also optimization or enforcement of new methods and processes, while on the other hand commercialization might include significant research work as well.

Not all inventions are possible to turn into innovation at a certain point of time. There might be a significant time delay between the invention and the relevant innovation due to several factors, including non fulfilment of commercialization conditions, i.e. lack of technological elements for turning an idea to a product or lack of market demand for such a product at a certain point in time.

The scope of this work is relevant to innovation related with two ICT relevant sectors, i.e. Embedded Systems and Industrial Informatics. In this context the present paper focuses on new ideas and inventions relevant to these two sectors. Thus, the starting point for the process leading to innovation is presumed the existence of some research result and not just an abstract and not validated generic idea.

Chapter 2 of this paper presents a definition and classification of innovation. Chapter 3 presents the different options for the transformation of a research result into innovation. Chapter 4 identifies the innovation process. Finally, chapter 5 presents conclusions. Work presented in this paper is funded under the SEE/A/219/1.1/X – I3E project co-financed from the INTERREG IVB –SEE initiative (Kalogeras 2009).

2. INNOVATION

Innovation in general describes an idea successfully applied in practice. According to the Organisation for Economic Co-operation and Development (OECD) and the Oslo Manual (European Commission 1992) for measuring Innovation there are four different types of innovation:

- Product Innovation: it represents a new or improved product or service, in terms of technical specifications, components, materials, software, user friendliness, or other functional characteristics

- Process Innovation: it is about a new or improved production or delivery method, in terms of techniques, equipment or software

- Marketing Innovation: it involves a new marketing method relevant to changes in product design or packaging, product placement, product promotion or pricing

- Organizational Innovation: it is relevant to new organisational methods in a firm's business practices, workplace organisation or external relations

A fifth type (Hamel 2006) represents

- Managerial Innovation: it is relevant to management principles and processes that ultimately change the practice of what managers do and how they do it.

With reference to the changes induced to existing developments, innovation is classified (Schumpeter 1934) to three types:

- Incremental or marginal: it represents some novelty induced to an existing product, process or method reflecting some added value in the framework of its continuous improvement

- Radical: it represents a significant level of novelty and generation of significant added value it terms of totally new product, process or method

- Technological revolution: it is relevant to clustering of innovations that all together may change human life bringing a significant impact

3. MOVING FROM RESEARCH TO INNOVATION

The inventor / researcher and the innovator may be the same or different entities. The innovator, called the "entrepreneur" by Schumpeter, should combine all necessary factors for the transformation of a novel idea / research result into innovation. There are different alternatives with reference to the commercialization of an invention and generation of innovation with different envisaged roles for the inventor.

3.1 Selling a Research Result

A first alternative is to sell the invention / research result to a third party. The role of the inventor / researcher in this option is limited to protecting the Intellectual Property rights of the invention / research result, marketing the research result and finding an interested third party, negotiating the research result selling and getting a payment for the research result. The third party plays the role of the innovator that will pursue the transformation of the research result into innovation. The innovator will undertake totally all risks associated with the innovation and will be the sole benefactor from its potential success.

3.2 Licensing

A licence is a legal instrument governing the usage of an invention / research result. The role of the inventor / researcher in this case is the protection of the Intellectual Property rights of the invention / research result, marketing the research result and finding interested licensees, negotiating the licensing agreement and patent prosecution issues. The researcher receives licensing fees during the licensing period by the licensees. The Intellectual Property rights are maintained by the researcher, yet significant control is given to the licensees. Both the researcher and the licensees share the role of the innovator in this case. Yet, from the researcher point of view commercialization effort and cost is limited.

3.3 Creating a Partnership

Seeking partnerships represents another path towards the commercialization of an invention / research result. The role of the inventor / researcher is relevant to the protection of the Intellectual Property rights of the invention / research result, marketing the research result and finding interested partners that might undertake along with the researcher the transformation of the research result to innovation. Intellectual Property rights are maintained by the researcher that also maintains a role in the development of innovation. The innovator is in this case the allied partnership. The partnership may utilise an existing firm for the transformation of the research result to innovation or build a new company. In both options the commitment of the researcher and the needed capital are much higher that in9 the aforementioned cases.

3.4 Creating a Start-up

In this case the inventor / researcher undertakes the task to transform the invention / research result to innovation on his/her own. Becoming also the innovator usually requires the setting up of a new start up company. This new company will be assigned with the Intellectual Property rights of the research result and will deal with all the different issues that are associated with the transformation of research result to innovation. Start up time frame and needed capital is greater with reference to then aforementioned cases. The risk is also greater since the new company will have to employ all the needed capabilities that will lead to the efficient commercialization of the research result. Payback time for the inventor / researcher is longer. A critical task in this case is to acquire the necessary financing for setting up the start-up company and proceeding in the transformation of the research result to innovation.

4. INNOVATION PROCESS

Innovation is quite an important asset for an enterprise as it enables it to withstand market competition more effectively. Formalizing and modelling the generation of innovation is thus quite important for building up a common understanding of the path that needs to be followed for the transformation of an invention to innovation.

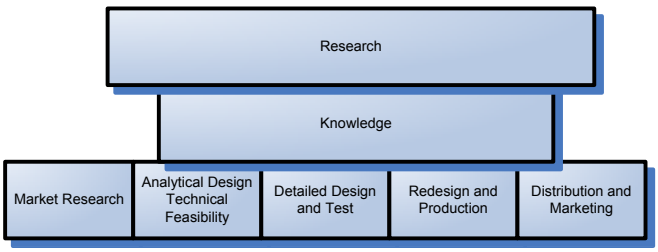

Fig. 1. Chain-link innovation model

A useful approach to this problem is the "chain-link model" (Kline 1986), depicted in Figure 1. The chain-link model addresses the process that the innovator needs to follow in order to generate innovation out of a research result. The model envisages interactions between the innovator and the real world, i.e. the market, while it views research as a form of problem solving rather than as a source of inventive ideas. In other words given a research result that may be provided by a researcher, the process for the production of a product, process or method out of it need first of all to take advantage of all the available knowledge on the innovator side. In case of problems the knowledge base is enriched through research.

The comprehensive process for the transformation of research to innovation according to the aforementioned model is shown in Figure 2.

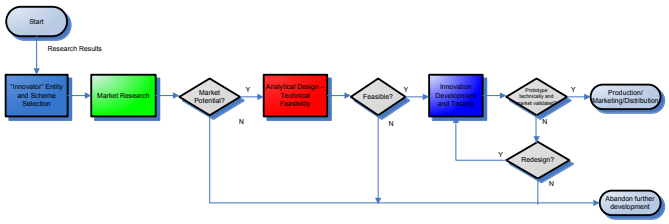

Fig.2. Innovation Process

The first step of this process being the "innovator" entity selection has been detailed in chapter 3. The next steps are described below.

4.1 Market Research

Bringing a new product, process or method to the market needs to pass through a first step of market research in order to determine whether there is indeed a market and that the product, process or method may effectively penetrate it. The interaction with the end users / customers of the intended innovation although time consuming is essential in order to identify the possibility for a successful product or diagnose a market failure. Market research should answer the following topics:

- Identify the target market of the innovation and the special characteristics of the customers if any
- Identify market segments of the target market and the special characteristics of the customers in each segment
- Identify and analyze the overall user requirements with reference to the intended innovation
- Identify the target market size
- Identify the market competitors and the current status of the market (market leaders, their market shares)
- Indentify the market trends, i.e. the expected size of the market as well as the changing habits of consumers leading them towards specific directions in terms of used technologies, fashion etc
- Identify market barriers, i.e. elements that might prevent the intended innovation to get a share in the market
- Identify the special characteristics of the research result that would make the resulting innovation uniquely appealing to the market and map them to the competitive solutions as well as to the user needs
- Identify the competitive advantage of the innovator that will commercialize the research result with reference to the existing competition
- Get feedback from the market on the intended innovation characteristics from potential customers, sellers or industrial experts
- Identify the business case that the intended innovation focuses on.

Market Research sub process workflow is shown in Figure 3.

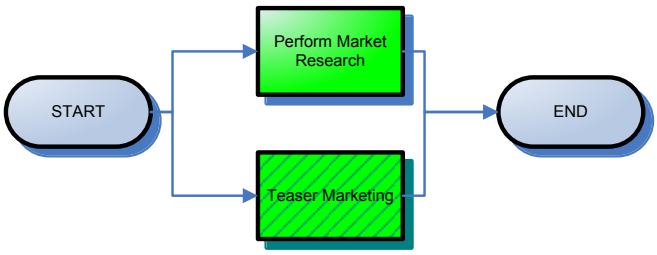

Fig.3. Market Research

4.2 Analytical Design – Technical Feasibility

Based on the user requirements and the initial specification of the research result an analytical design has to take place detailing the functional specification of the expected innovation. This analytical design is expected to provide the needed input for the elaboration of a technical feasibility study of the innovation, i.e. to answer the question whether the envisaged research result is possible to be developed taking into account the current state of technology.

Regarding the development of innovation out of a research result as an innovation project, the analytical design will outline the innovator vision quantifying the project objectives. Starting from a generic architecture and a rough design of the components of the overall project, an analytical design will be sought seeking feedback from the user requirements. The quantification of the project and component specification is expected to elaborate potential technical risks and solutions.

The analytical design of the project will provide useful information on the project specifications as well as the needed capabilities to fulfil these specifications. The innovator will have to face the challenge of relying on existing capabilities or outsourcing part of the project development. Finally, the analytical design of the project will indicate what part of the project and the ensuing innovation

might be protected in terms of Intellectual Property rights and what not.

Some topics that are associated with this phase are the following:

- Survey of the state-of-the-art and state-of-research in the sector of interest. This will help determine the placement of the intended innovation with reference to the current technological status.

- Detail the architecture of the innovation project as well as an anticipated workplan that will lead to the successful elaboration of the project. The aim of the workplan will be to effectively address the technical objectives of the project.

- Detail the systems, subsystems, components, processes, methods that the innovation project need to develop. Determine their functional specification addressing what will be the final characteristics of the innovation. Go into as much detail as possible at this step providing models, drawings, outlines of the innovation so that it may be easily represent a clear description of what the intended innovation is about.

- Identify potential risks in the fulfillment of the aforementioned specifications and develop a risk management plan.

- Present the intended innovation specifications to industry experts in order to get their feedback and assistance.

- Upon the finalization of the technical specifications juxtapose them against existing patents, in order to be sure that existing patents are not violated. Review the parts of the innovation that could be protected in terms of Intellectual Property rights.

- Map the technical specifications of the intended innovation as well as the innovation project workplan to existing capabilities of the innovator or of other entities (outsourcing). Consider the collaboration with and engagement of academic / research institutions in the innovation project with reference to specific parts.

- Based on the technical specifications and the workplan make a preliminary estimation of the cost associated with the actual development of the innovation project.

A sub workflow of this step is shown in Figure 4.

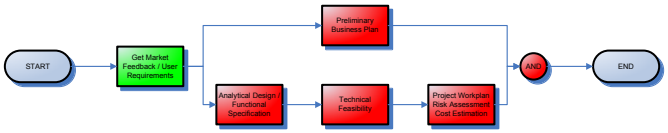

Fig.4. Analytical Design – Technical Feasibility

4.3 Detailed Design and Testing

Having a functional specification and a feasibility study that prove the technical feasibility of the innovation as well as a business plan showing the profitability of the effort the innovator can start the implementation of the innovation project that is expected to lead to a prototype. This third phase is about the actual development of the intended innovation and its testing. It is also the phase when the substantial financing is needed.

Innovation Development and Testing Sub workflow is shown in Figure 5.

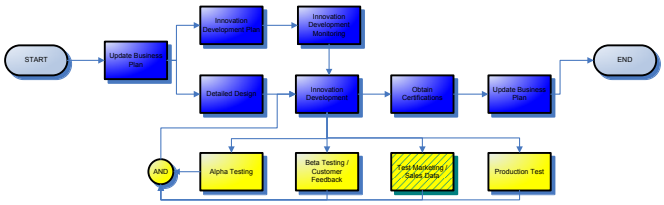

Fig.5. Innovation Development and Testing

Based on the functional specification and the workplan defined during the analytical design and technical feasibility phase a detailed project design need to be performed along with an Innovation Development Plan detailing the workplan of the innovation project. The development of an Innovation Development Plan should take into account the following

- Break down the innovation project to main tasks and subtasks - Elaboration of an action plan.

- Assign start and completion dates for all tasks and subtasks as well as milestones for important points in the innovation project lifecycle

- Define outputs (results / deliverables) for the tasks and subtasks and interfaces between tasks and subtasks

- Assign a a project leader with an expertise in managing projects and the authority to effectively manage the project

- Choose qualified project team members; if necessary to define additional qualification of the staff (outsourcing or additional trainings). Engage in the project team people with different backgrounds so that all different aspects of the innovation project are dealt with by people offering different perspectives

- Clearly define the responsibilities of the project team members and assign them to particular tasks.

- Define the project cost carefully (budget plan with detailed costs allocated to each task),

- Monitor the project evolution so that the tasks are implemented in time and with the expected quality of deliverables; verification and validation should be applied with completion of each task

Having a detailed design and following an Innovation Development Plan a prototype (product / process) will be available for testing. The testing phase should validate the prototype before it enters full scale production. The validation of the prototype needs to take place in near actual conditions so that problems are fixed before market launch. This validation is relevant to testing its market acceptance as well as testing its quality. The testing phase comprises the following activities:

- Performing alpha tests, i.e. in house testing of the prototype that allows fixing of bugs and validation against functional specifications. The project team should use the prototype like customers and try to identify overall bugs and problems. In the case that the project team does not have the facilities or the qualified staff to perform a physical test of the prototype then maybe a specialized organization is needed.

- Performing beta tests, i.e. field trials involving potential customers and getting feedback from them. Customer focus groups are invited to test the prototype and their reaction is monitored and feedback is collected in near actual conditions of operation. A plan on how focus groups will be involved in the testing and what feedback will be gathered is needed.

- Performing a production test, i.e. running a production process for the innovation to validate the overall efficiency. This final testing is expected to provide the final innovation specifications as well as production requirements.

- Undertaking test marketing, i.e. selling the innovation to a limited market that has characteristics representative of the overall market. The outcome of a market test is accompanied by collection of sales data that may be used for the prediction of the acceptance of the innovation in the entire market.

- Obtaining certifications is necessary for different types of products depending on their actual usage. Such certifications may be relevant to for instance Electromagnetic Compatibility in the case of electronic devices

There should be continuous iterations between development and testing, so that the feedback of testing activities is taken into account.

4.4 Redesign and Production

The outcome of the previous phase is either a validated prototype in which case the innovator moves to full scale production or a non validated prototype in which a redesign is needed.

The non validation of a prototype may be due to different reasons:

- The necessary certifications are not possible to obtain

- Legal structure to be researched, possibly external expertise to be acquired, customer centered (re-)design

- Alpha and beta testing indicate that the achieved innovation lacks the characteristics of the intended innovation

- Market demand is not sufficient for the achieved innovation at the time of redesign although it had been sufficient at earlier phases of the process, due to a new product occupying the market for example

- There are problems with the production requirements of the final innovation specification

Any of the above cases will lead to a redesign of the innovation that may be more or less radical. A decision may be taken at this point to abandon the project in the case that the redesign is quite radical and the expected alterations lead to a complete change in the business plan.

A feedback from this step along with the innovation redesign will reiterate the phase of Detailed Design and Test. Focus groups should be formulated to test and research user friendliness, usability, capabilities etc that need to be taken into account during this re-iteration.

Having a validated prototype is a major milestone in the innovation process. In the case of product innovation it signals the need for a full scale production. In the case of a process innovation it signals the full scale application of the new process. In the case of a new method it signals the enforcement of the new method. The term production in this paragraph will denote all three cases. Before nevertheless proceeding to production an update of the business plan is needed in order to ensure that the project is still feasible before full scale production is undertaken. In the case that market conditions are influenced in such a way that the production is no longer feasible, full scale production may be cancelled even at this point. Otherwise production is undertaken dealing with different aspects including:

- The facility that the production will take place is chosen. In the case of product innovation this facility represents the plant where the manufacturing of the product will take place. In the case of process innovation the facility represents the plant of the innovator that the new process will

be enforced. In the case of product innovation different criteria apply to the selection of the production facility, such as accessibility, proximity to suppliers, distributors.

- A decision on outsourcing or building industrial alliances or in-house production is quite significant. Industrial learning curve is significant. In the case of not outsourcing, it should be examined whether learning curve could be eased through employing an experiences expert. In any case economies of scale, marginal cost and return should be taken into account.

- The staff associated with the production has to be trained. Training is relevant to the production specifications that were determined during the previous phase and especially production test. A team with sound industrial expertise is significant during this phase. Production and quality assurance experts / engineers should participate in this team.

- A quality assurance plan is elaborated and followed with reference to the production so that high quality standards are met and production problems are recorded.

4.5 Distribution and Marketing

Marketing is a phase that starts almost simultaneously with the market research phase. So there are marketing activities even at the initial phase before even innovation is implemented. For instance teaser marketing could build awareness about a foreseen innovation. Then as already mentioned, test marketing is a method of testing the overall innovation and its acceptance by the targeted clients. The purpose of all marketing activities either before or after the development of innovation would be to have a deep understanding of the customer thinking and behaviour. At the last phase of the innovation process when the innovation is available it needs to be officially launched to the market. The innovator needs to prepare / update a Marketing Plan that includes a Market Launch Plan with the needed actions to launch the innovation to the market. The different actions during this phase include:

- Developing a Market Launch Plan that details the initial promotion of the innovation, attracting awareness of the consumers and creating demand. Such activities could for instance include distribution of copies or advertisement.

- Developing a complete Marketing Plan that details the marketing actions after the launch phase. Such actions could be for instance participation in exhibitions or trade shows. The marketing plan should take into account all information generated at the previous phases so that the actual innovation is depicted.

- The Marketing Plan should build on a specific Marketing Strategy that is detailed in the Business Plan relevant to the 4Ps (Price, Promotion, Place, Product/Service)

- The Market Strategy could be quite differentiated relevant to the business model of the innovator, e.g. niche market player. Penetration might be initially sought through competitive pricing.

- Collecting feedback from the customers is essential in the process of maintaining the competitive advantage of the innovator or the innovation. This feedback should be used in order to initiate a new innovation process when needed.

- Training staff on the marketing needs so that the marketing plan is closely followed.

- Regular reviews of the project are needed in order to identify its profitability and take decisions on potential changes.

- Distribution and Logistics should be also taken into account in the case of products. Lean Management could for instance be employed

5. CONCLUSIONS

The present paper elaborates on the process of transforming a research result in the areas of Embedded Systems or Industrial Informatics to an innovative product, service or process. The chain link innovation model is presented and a relevant process is elaborated out of it and presented as a workflow. This workflow provides a comprehensive guide for the potential innovator on the needed elements for the transformation of research results to innovation.

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