

# Activating the Innovation Potential of SME: The Bottom-Up Approach

Kyrill Meyer, Michael Thieme

Department of Computer Science  
Business Information Systems  
Johannissgasse 26  
04103 Leipzig, Germany  
meyer@informatik.uni-leipzig.de  
thieme@informatik.uni-leipzig.de

**Abstract:** In this paper we propose an innovation model for the collaboration between SME and public research institutions in order to enhance knowledge transfer and to foster the creation of a regional innovation network. A third aspect is to enhance a more intense cooperation in the public research sector between institutions and departments. In this paper we discuss the term innovation and describe the following aspects: (1) the general idea of the developed bottom-up innovation model, (2) the organizing framework of the participants in the network and (3) the procedure in the innovation process.

## 1 Innovation is the Key

Successful innovation is the basis of a competitive economy and sustained economic long-term growth. Research and development (R&D) accounts for nearly half of the economic growth in the U.S. [PK03] [AW08]. As innovation cycles become shorter and development costs continuously increase, companies are under constant pressure to adjust their innovation development and management schemes. Nowadays it is more and more essential to collaborate with other businesses, customers, institutions and even with competitors in order to include expertise not covered by the company itself into the innovation process. Using open innovation in order to share internal and integrate external knowledge within the process of idea generation, research, development and commercialization stages help to reduce costs and risks of innovation schemes [Ch03]. The open innovation paradigm provides the opportunity to pursue innovations which do not fit into the current company strategy or to commercialize ideas generated outside the company [PD09] [GE06]. Furthermore, innovations are increasingly not developed by one single company, but are more and more created cooperatively through an entire value chain with several companies involved. Especially high-tech businesses such as information and communication technologies are forced to open up their internal innovation process and band together in networks to adjust to the global evolution pace. For small and medium-sized enterprises (SME) it is vitally important to create innovation networks, as they are frequently neither able to provide all skills needed in

the R&D process due to limited human resources nor do they possess the financial capability to run a research laboratory.

The proposed innovation model for the collaboration between public research institutions and SME deals with the questions (1) how to enhance the knowledge transfer between SME and research institutions, (2) how to overcome restricted resources in SME and thereby (3) activate innovation potential of SME. The model has been developed based on the idea of bottom-up innovations (see 6.). It has been elaborated and adjusted iteratively by applying the framework in practice. The approach is being supported by the development of additional methods and tools which are described in [MT10]. This approach has been documented in over 50 exploratory case studies [Yi03] [MT10]. In this paper, first we discuss the term innovation; then we describe the general idea of the developed bottom-up innovation model, the organizing framework of the participants within the network and the proceeding in the innovation model. The main goal of our approach is to create a regional innovation network with public research institutions as the driving force in order to boost the regional innovation potential.

As service science is interdisciplinary and is examined from different scientific points of view and backgrounds such as computer science, marketing, psychology and many other disciplines, intense relationships in the research sector are likely to generate benefits and stimulate new approaches. Recent research in Germany has produced internationally acknowledged findings, for example in the field of service engineering. This approach was originally designed with the idea in mind to transfer the methodical knowledge existing in order to enhance a systematical service development in SME, but the approach is not limited to this scientific background and can be adopted in, or combined with, other areas.

## **2 Technology Push and Demand Pull**

The trigger for innovation can be divided into two streams: technology push and demand pull [Ha04]. Technology push means that research gives rise to new technologies or applications that are thereafter applied to create new solutions. Demand pull means that the market signals a need for a solution to a particular problem which is then solved in the innovation process. The 1970s debate about the impact and importance of each of the triggers came to the conclusion that a separated view would be leading nowhere. In practice, innovation is a coupling and matching process where interaction is essential. Successful innovation requires the interaction between (technology) “push” and (demand) “pull” actors. Typical push actors are public research institutions, while SME are typical pull actors.

In reality, public research institutions often have no or poor contacts to local SME and vice versa. The interaction between these actors is strongly limited. In fact, linear push-pull models still influence much practice and debate, especially in financing public research, although more realistic dynamic models have been proposed [MP07] (see [Ti06] for a review on literature). Research of the (public) push actors is usually guided by personal interest or public funding programs. One can observe a priority in public

funding programs to promote cutting-edge research in specific industries identified as key technologies, currently bio-, nano- and microsystems technologies that focus on path-breaking product and process innovations. With that being the case, the organization of the knowledge transfer resulting from research activities is commonly organized top-down and can be described in terms of the traditional waterfall-model known from software engineering [Ro70]. In this model, impact research triggers the development of basis innovations which result in new innovative products or processes [Ed97] [RS06]. These products or processes are gradually commercialized and create new or invigorate existing markets. It can be seen as the classic way from basic research, through applied research, engineering, development and product design, to commercialization [RZ85]. This approach aims to produce market or niche market leaders in high-tech and skill-intensive sectors with major value creation, high growth rates and new employment. This approach is widely established and has been validated through many successful developments and major breakthroughs in the past years. The disadvantage of this approach is that the research is done prior to identifying useful applications of the findings. The top-down organization of research activities and knowledge transfer is especially disadvantageous for SME, as useful related output is often generated by coincidence or in the worst case misses the needs completely. The German approach of funding so-called “Verbundprojekte”<sup>1</sup> has attracted worldwide attention and is clearly a step forward to overcome the simple linear top-down model.

The aspect of demand pull, and especially concerning the needs of SME, has been disregarded in the development of public R&D subsidies. Recently, one can see a shift and a higher notice of these actors, as special funding is provided to strengthen the innovation potential and interaction with research institutions (e.g. the so-called innovation vouchers or innovation assistant programs).<sup>2</sup>

### 3 What is Innovation?

Innovation is a stylish term used in many contexts; yet it lacks a single definition. A variety of literature has accumulated around the topic of innovation management examining the topic from different scientific backgrounds [ABP06]. Over time many definitions, distinctions and classifications have evolved [Ha04]. Therefore, it is necessary to clarify the meaning of the term innovation used in this context. On the scientific level, this classification is important in order to be able to classify and compare the findings. Many scientific studies are not comparable because of an inconsistent understanding of innovation [TK82]. On the practical level, defining the term’s meaning is important in order to use the right methods and tools in the innovation process.

Schumpeter was the first to coin the term innovation [Sc39] for the use in business studies [TS07]. Logically, the definitions of the term proposed by different authors are

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<sup>1</sup> Verbundprojekt translates into joint research project

<sup>2</sup> For more information see [www.innovationsgutscheine.de](http://www.innovationsgutscheine.de); [www.innovationsgutschein-bayern.de](http://www.innovationsgutschein-bayern.de) or [http://www.innovation.nrw.de/wissenstransfer/kleine\\_und\\_mittlere\\_unternehmen/innovationsassistenten/index.php](http://www.innovation.nrw.de/wissenstransfer/kleine_und_mittlere_unternehmen/innovationsassistenten/index.php)

close to his ideas of creative destruction and the classification into the innovative entrepreneur and the entrepreneur's imitators [Sc31]. First of all, it is necessary to distinguish the terms idea, invention, innovation and imitation, especially with regard to the knowledge transfer aspect of this approach. An invention stands for an idea made manifest, while innovation describes ideas applied (successfully) in practice. There is a general consensus in the scholarly literature that innovation consists of invention and its first exploitation [Ve80] [Sc66] [Ki69] [Ro83]. Second, it is necessary to distinguish innovation and imitation. Innovation describes the first successful application of an invention or solution while imitation describes a reproduction or replication of an already developed invention or solution. At first this distinction seems to be clear. In fact, it is a matter of individual determination of when the line between imitation and invention is crossed or of how significant the change has to be. For example, from the (subjective) point of view of an imitating company, changes are a completely new field of action and can be seen as innovation. Usually, inventions are not imitated by several companies in the same way, but are adapted to the individual needs and are, therefore, slightly different, particularly organizational or process innovations. Thus the bottom line is that innovation is an improvement of an existing solution (incremental innovation) or a creation of a completely new solution (radical innovation) without a clear specification of the dimension of the change.

For the purpose of transforming existing knowledge and dealing with the innovation potential of SME, we require a "soft" definition of innovation. The OECD definition distinguishes and defines four types of innovation: product, process, marketing and organizational [Oe10] (see table 1).

Product Innovation	This type involves new or significantly improved goods or services including significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. In the education sector, a product innovation can be a new or significantly improved curriculum, a new educational software etc.
Process	Process innovation involves a new or significantly improved production or delivery method. This type includes significant changes in techniques, equipment and/or software. In education, this can be a new or significantly improved pedagogy.
Marketing Innovation	Marketing innovation comprises a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. In education, this type can, for example, be a new way of pricing the education service or a new admission strategy.
Organisational Innovation	Organisational innovation involves introducing a new organizational method into the firm's business practices, workplace organization or external relations. In education, this type can, for example, be a new way of organizing work between teachers, or organizational changes in the administrative area.

Table 1: Four Distinctions of Innovation, source: [Oe10]

More importantly, the definition states:

*“These innovations can be new to the firm/educational institution, new to the market/sector or new to the world”.*

This meaning allows us to consider adaption of existing solutions on company level as innovations (“new to the firm”). Likewise, this definition describes the dimension of the change as “significant”, giving room for interpretation. For our purpose, we assume that every change has a positive effect on value creation, cost reduction etc. as innovation, no matter how extensive the action or effect is. If, for example, a change of color of a product results in a higher price for which the product can be sold, then from our point of view we face an innovation process (in this case the action classifies as marketing innovation). Using Tidd’s and Bessant’s [TB09] words:

*“...we should also remember that it is the perceived degree of novelty which matters; novelty is very much in the eye of the beholder. For example, in a giant, technologically advanced organization like Shell or IBM advanced networked information systems are commonplace, but for a small car dealership or food processor even the use of a simple PC to connect to the internet may still represent a major challenge.”*

That is, we do not focus on low-end incremental innovations, but nor do we wish to exclude them, as SME are likely to require simple solutions or adaption of existing knowledge, in our case provided by the research and transfer institutions.

## **4 The Bottom-Up Innovation Model**

Rothwell [Ro92] describes five generations of innovation models: the technology push model (1st generation), the need pull model (2nd), the coupling model (3rd), the parallel lines model (4th) and the integrated systems and networking model (5th). Marinova and Phillimore [MP07] extend Rothwells typology and describe six generations (see table 2).

<b>G</b>	<b>Innovation Model</b>	<b>Description</b>
1 <sup>st</sup>	black box model	Innovation needs inputs and creates outputs. Process of the transformation is not analyzed.
2 <sup>nd</sup>	linear models (technology push and need pull)	The innovation process is a linear sequence of functional activities.
3 <sup>rd</sup>	interactive models (coupling and integrated models)	Interactions between several (internal) actors linking the in-house functions and linking to science (state of the art).
4 <sup>th</sup>	system models (networking and national systems)	Cooperation between many (internal and external) actors linking in innovation networks using synergies.
5 <sup>th</sup>	evolutionary models	Innovation as an evolutionary process of generation, selection and survival of the fittest with high dependence on the background.
6 <sup>th</sup>	innovative milieu	Regional innovation cluster, collective learning and importance of geographical location.

Table 2: Six generations of innovation models, author's illustration based on [MP07]

We propose an approach to create an innovative milieu on the basis of a system model in the field of knowledge transfer between public research institutions and SME. The aim is to create a regional innovation network with the research institutions as the driving force. In the system model, firms that do not have the resources to cover the whole innovation process can benefit by establishing a network in order to share knowledge and resources. Hobday [Ho91] summarizes the benefits of the collaboration as follows:

- groups of SME can maintain leading edge technologies by using support from each other and by sharing costs;
- collaboration enables skill accumulation and collective learning for the benefit of all participants of the network;
- collaboration increases the exchange of key individuals between the firms;
- skills can be combined and recombined to overcome bottlenecks;
- innovation time and costs can be reduced;
- the network provides entry into the industry for small innovative firms;
- individual firms within the network operate with high flexibility and in low-cost ways including small overheads.

Participating in networks enables access for SME to regional experience and knowledge pools but the real strength lies in links to global networks [St00]. By adding public research institutions to the network, SME gain access to state-of-the-art knowledge and technology. This innovation network is supposed to grow into an innovation milieu. Camagni [Ca91] describes the components of an innovative milieu as follows:

1. a productive system
2. active territorial relationships
3. different territorial socio-economic actors
4. a specific culture and representation process
5. dynamic collective learning

The interactions creating the innovative milieu are not necessarily based on market mechanisms, but include movement and exchange of goods, services, information, people and ideas among one another. They are not always formalized in cooperative agreements or any other contracts. Major features of such an environment are the ease of contact and trust between the partners, which reduces uncertainty in the development of new technologies and proves to be a source of exchange of tacit knowledge [CC00].

## **5 The Organizational Framework**

The proposed model contains all of the above components. The actors in the model include SME, public research institutions and local associations and chambers being used as gateways to company contacts (3. different territorial socio-economic actors). The bottom-up innovation process is the core of the approach (1. 2. and 4.), focusing on idea development and inter-organizational cooperation (5.) (see figure 1). In our approach the public research institutions play a central role as the driving force behind the regional innovation system. They are supposed to manage the network, attract new members and initiate innovation projects and knowledge transfer activities. An obstacle that has to be resolved is the institutional barrier in the collaboration between research institutions and departments, the biggest challenge probably being in the motivation of single departments to take part in the process. Typically, departments work isolated from one another and do not try to identify possible cross-research activities and benefits nor do they share their industrial contacts. Preferably, as many departments as possible merge together in order to include expertise and knowledge from different scientific backgrounds. Other barriers are the typical collaboration problems such as asymmetric information, communication, spatial distance etc. Therefore, competence and expertise of every participating institution has to be identified and classified. Building on that, an internal communication strategy has to be installed. We developed several instruments in order to overcome the barriers. The creation of a competence matrix summarizes all previously defined fields of expertise of the participating institutions in the project consortium. A responsible person to contact is appointed. This process of a deep self-analysis helps to identify potential gains of a closer collaboration among each other. The launch of an online communication environment consisting of a server that allows online file sharing, group discussions as well as contact, calendar and information management, helps to overcome the spatial and information barriers. This online collaboration

environment is also used in the collaboration with companies during the work in single innovation projects. An intern glossary of important key words helps to reduce misunderstandings.

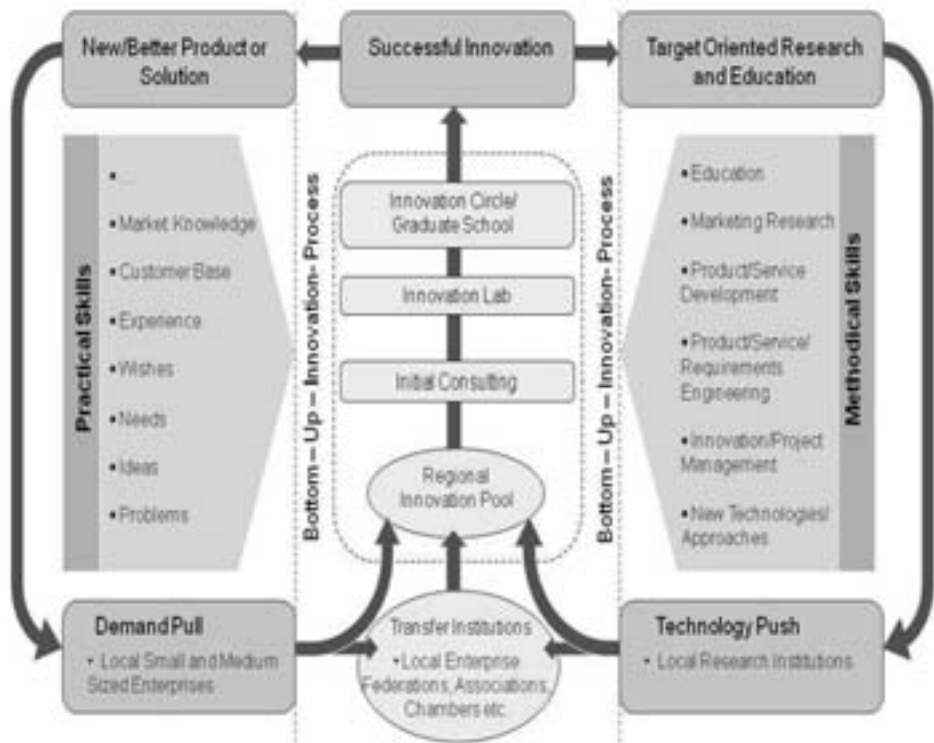


Figure 1: The Bottom-Up Innovation Model, author’s illustration.

Using local industries associations, chambers, federations etc. enables easier contact to local SME and includes more know-how and knowledge, especially in the knowledge transfer sector, into the network. In the model we assume an existing regional innovation pool that arises from the knowledge, experience, ideas and know-how of the described actors in the regional innovation network. With the bottom-up innovation process we describe a way to bundle the existing practical and methodical skills of the partners in order to exploit successfully the innovation pool.

## 6 The Bottom-Up Innovation Process

The purpose of the bottom-up innovation is to cooperate closely with businesses, strengthen the relationships to local SME and consider their needs and problem statements in the structuring of research activities. The idea is to open up space in which business and education could meet at a basic level discussing everyday problems and



identifying needs, innovation potential and possible research activities. The core of the idea is to examine the innovation chain backwards; i.e. “bottom-up” instead of “top-down” based on value creation chains and customer needs. The difference in such a setting is that the approach is problem-driven in terms of “what a company really needs” and not organized top-down as usually in terms of “what a company should do”. This approach enables a problem-oriented focus on the research demand of SME. We comprehend our approach as an amendment to the existing approaches with the aim to exploit innovation potential that is not reached and has therefore been lost so far. The process consists of four stages: incentive, analysis and specification, realization as well as sustainability. It covers the steps from the origination of an idea to its transformation into something useful.

The incentive stage is the first step and covers all activities concerning the first contact with a company such as impact, initiation, mutual presentation and topic screening. In this step we deal with the firms and identify their needs and innovation potential. The innovation consulting is an event we developed to use for the first meeting with a company. It is designed as a workshop and can be supplemented by the innovation lab which is mainly supposed to be used in the second step. An idea or requirement draft is generated, which marks the end of this stage and leads to the next step.

The second stage is called analysis and specification. It covers all activities concerning the analysis of innovation potential based on the company’s ideas or needs, the specification of possible topics for research activities, goals and form of collaboration as well as the assessment of technical feasibility and resources needed. Furthermore at this step we try to identify companies with related needs, problems or interests in order to create a project consortium with the aim to share costs and experience or to include skills that are not covered so far, but are essential for a successful finalization. At the end of this stage a full project plan is developed and usable for the next step. To support this stage we develop the innovation lab. The goal of the innovation lab is to provide a physical environment that will boost creativity and provide the necessary tools for the generation, discussion and assessment of innovative ideas. While large companies may have special departments dealing with R&D, within SME those activities are either located with the management or need to be done by regular departments. A creative environment can be seen as a key factor for innovation [Ek97], especially for SME, it can be helpful to use a facility that is separate from the usual working environment and is equipped with special tools. Simulation of the developed solution allows a more accurate estimation of the probability of a successful implementation.

In many cases the firms know exactly where their problems lie, but in the case of SME, they do not have the time, resources and expertise to deal with the problems in an appropriate manner. After analyzing the company’s situation, possible solutions are discussed. Thereby, the company is supposed to picture their ideal state fading of the technical practicability. After the optimal solution has been modelled, the implications, which derive from the implementation, are examined. The solution is divided into parts, which are already practicable, and parts, for which we need conduct further R&D. For the R&D activities the effort and resources needed are estimated and the project is checked for emerging costs and realistic positive achievement. If the presented solution

is not practicable, the solution is redesigned with fewer requirements but without changing the objectives. At the end of this process we conceptualize a first project draft containing a problem statement and solution. The next step is to set up a detailed schedule for the R&D project containing a description of the problem statement, the identified research demand, the estimated research activities, a practicability assessment and the benefit for the company. Furthermore the project is divided into several work packages, which are split among the project partners depending on their expertise. For each work package objectives are determined, a time schedule developed and responsible persons or project partners assigned. This proceeding results in a detailed project plan with a clear assignment of duties, deadlines, work-sharing and objectives which is the basis for a cooperation agreement and further collaboration. Next, funds for the realization of the innovation project have to be assured. The easiest and straightforward way is that the financial means are provided by the participating companies themselves. The alternative is to identify matching funding programs and apply for public research funding.

The third step in the model is called realization stage. Based on the needed resources identified in the project draft, information on possible ways to implement the project are enquired. The “innovation circle” describes the collaboration between companies and research facilities. The main idea behind the innovation circles is to unite companies with related needs, problems or interests. This kind of collaboration allows sharing risks, costs and experience or allows involving further players along the value chain into the innovation process in order to include further expertise. In this stage the graduate school can be used to accomplish several tasks. The graduate school is meant to give scientific support to companies. It covers all activities with relation to research and teaching and focuses on the collaboration between students and SME. The idea behind the graduate school is to involve students in the innovation and research process whenever it is possible and gradually lead them to the objectives. Possible research topics are identified in the innovation projects and are offered as a bachelor, master or PhD thesis depending on the complexity and challenge. Students can participate in the innovation process by employing them as student research assistants or arranging internships and part-time jobs. Furthermore the project matter contributes to the day-to-day teaching by offering seminars, workshops or summer schools with current reference to the projects.

The fourth and last step is called sustainability. In this stage an assessment of the project takes place by means of defined criteria based on the goals set in the earlier stages. Furthermore, in case of a successful implementation the project is checked for further innovation potential. The focus in this stage lies on securing a broad effect of the findings.

Figure 2 shows the basic process in the model which can be modified depending on the requirements of the single innovation project.

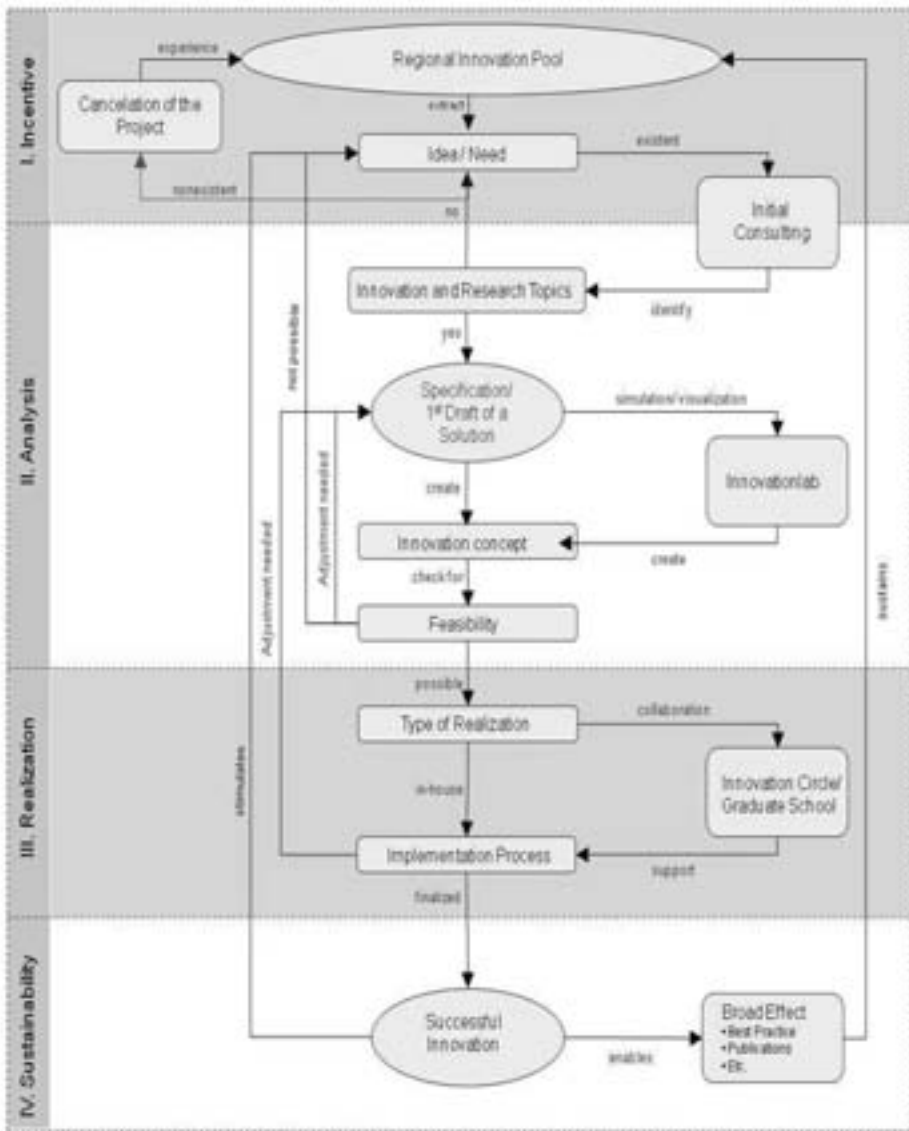


Figure 2: The Bottom-Up Innovation Process, author's illustration.

## 7 Conclusion and Further Research

With over 50 innovation projects accomplished in the last three years, we can summarize that we have developed a highly appreciated approach for local SME. The methods and instruments developed for the bottom-up innovation model focus on the first two stages of the model, as these are the most interesting for inducing research activities and boosting the regional innovation potential.

Due to the practical experience documented in case studies we identify two aspects of particular interest: the “initial consulting” and “innovation lab”. The initial consulting is an excellent event to establish first contact and identify innovation topics. The participating firms obtain a quick overview over their needs and potentials with hints how to activate hidden innovation possibilities and which key skills are missing and have to be acquired. SME especially value the openness of the approach and the independent consulting concerning their needs, solutions and possible partners for collaboration. The innovation lab’s main intention is to provide an environment to boost creativity but it is not limited to this. It is an excellent way to use infrastructure already existing at public research institutions. By gaining access to resources SME cannot afford on their own it is possible to reduce the disadvantage of resources shortage, a typical problem of SME. On the one hand this can be technical resources such as access to large capacity computers, virtual machines, simulation and test environments. On the other hand this can ban human resources such as knowhow in process modeling for example. Further research will be focused on this aspect, in particularly on the development of IT-supported tools to be used in the innovation lab.

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