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## 'Innovation Profiler' – Identification and Prioritisation of Innovation Factors Based on Social Network Analysis

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**Abstract:** Innovation is essential for both economies and companies to ensure competitiveness in today's global markets. While many companies struggle with this task, others seem to take maximum advantage of their resources. The difference between innovation leaders and less innovative organisations can be ascribed to a variety of factors such as innovation infrastructure or corporate culture. Given limited resources, companies need to prioritise their efforts to become and remain innovative. The 'Innovation Profiler' is a tool to undertake an individual analysis of a company's innovation infrastructure and behaviour. It takes into account not only success factors but identifies disruptive factors for the development of a robust innovation management. The 'Innovation Profiler' provides insights into interrelations between various factors in order to understand their individual impact on the innovation capability. Analytical measures to analyse complex interrelations are based on methods of social network analysis (SNA). As a result, organisations are enabled to leverage their innovative potential by focusing on selected factors that are identified as highly relevant for their specific innovation management [1].

**Keywords:** Innovation Audit; Innovation Factors; Disruptive Factors; Innovation Barriers; Innovation Behaviour; Innovation Infrastructure; Innovation Strategy; Complexity Management; Social Network Analysis.

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### 1 Background

#### *Innovation Challenges*

Organisations face severe challenges in terms of being innovative. On the one hand, they need to respond quickly to new opportunities in global markets, on the other hand they have limited resources and need to focus their efforts [2]. Some organisations achieve a

high innovation output while others – although acknowledging the benefits of innovation – seem to struggle with this challenge.

There is a high interest of academics and practitioners in understanding success factors of outperforming companies. The basic idea of so-called success factor research has developed since the 1960s and is as simple as appealing: if a definite set of success factors can be defined and their direct impact on the innovation output can be specified, a company will be intent on improving its performance, i.e. their innovation performance, by implementing success factor based measures.

Due to its application-orientation, the success factor approach gained attention in the realm of business administration. Business scientists and management consultancies both developed or, respectively, adjusted success factors that determine corporate success from their point of view. Today, solutions range from single success factors to extensive lists, e.g., as used in the approach of the learning organisation [3].

The demand for standardised answers to rather complex problems decreases as the results of the success factor approach are less than convincing. Empirical results show that attempts to copy success factors from one company to another are determined to fail [4] due to a lack of universal validity: a success factor that can be relevant for a given company in a given situation might not be relevant for another company as well. Moreover, success factors often highlight single factors that seem to determine a company's success without including factors that diminish or reduce these effects. Therefore, disruptive factors should be taken into account to develop a robust innovation management.

### *A Disruptive Factor Based Innovation Strategy*

Innovations imply a substantial change of structures, processes, and functions to organisations and are major drivers of current developments and future success. However, expected success may be reduced through disruptive factors. A disruptive factor based innovation strategy therefore allows the development of a robust innovation management [5].

A disruptive factor is defined as a barrier to the innovation process which inhibits, delays, or converts an innovation. In contrast to other approaches, a barrier may also have a positive influence on the innovation, e.g., in terms of filtering inadequate or unusable ideas.

To understand the multiple causes and effects of innovation barriers, it is important to note their multidimensional character. In order to improve the innovation capability, we have to systematically take into account the different fields of innovation activities, involve an innovation environment and develop a holistic view of the innovation process. Our conceptualisation of a disruptive factor based innovation strategy includes both specific internal (person-related, organisational, technical) and external complexities (inter-organisational, market-related, others) during the different stages of the innovation process.

### *Complexity of Innovation Success*

Companies, from small to large, are a form of organisation whose complexity cannot be reduced to a set of isolated factors. In terms of their capability to be innovative, companies may find a range of innovation factors to be relevant, while other companies

regard the same factors as irrelevant. Although processes and regularities might be similar, companies differ from each other by other characteristics. In fact, organisations, even with comparable infrastructures, develop very specific corporate innovation cultures and informal processes that can be more or less efficient and that are often recognised only by their members. Every organisation that deals with innovation, whether it might be an incremental innovation process or a large product innovation development, has a unique innovation culture [6].

Innovation culture can imply formal and informal actions that deal with the adaptability of a company to change. An innovative company is able to adapt to relevant changes that occur in its environment. Stimulation of a company's innovation capability is a challenging and complex issue because every company works with different preconditions. Nevertheless, management research often continues to attempt to reduce the given complexity by providing standardised solutions. A major shortcoming of current research is the lack of understanding of the specific context of a given company. It can be assumed that the people who directly deal with innovation issues, namely the company's employees, customers, suppliers, and partners, are a useful starting point for a better understanding of the individual relevance of innovation factors and, thus, for leveraging the company's innovation potential.

## 2 Approach

### *'Innovation Profiler'*

The 'Innovation Profiler' is an analytical tool developed to cope with the given complexity of innovation factors within organizations [1]. It is based on the idea of collecting potentially relevant data on innovation factors to examine whether these strengthen or weaken the innovation capability. Thus, the 'Innovation Profiler' aims at understanding the individual characteristics of innovation factors of a given organization and their specific relevance. Therefore, it is necessary to integrate the people that deal with innovations and to understand their perceptions towards these factors.

**Figure 1** 'Innovation Profiler'



As illustrated in Figure 1, the 'Innovation Profiler' provides an evaluation of a company's innovation behaviour ('Innovation Finger Print'), innovation infrastructure ('Innovation Inventory Map') and disruptive factors ('Innovation Management Devils', cf. [5]).

### *Identification of Innovation Factors*

Understanding a company's innovation culture includes an understanding of relevant topics of its innovation capability. Topics of innovation can be observed in the communication within groups of people that deal with it [7]. On the one hand, these topics relate to specified innovation issues, e.g., an innovative product and its advantages. On the other hand, communication also deals with abstract topics such as motivational issues that might have a deep impact on the perceived innovation culture.

Evaluation of communication is a useful approach because relevant innovation factors can be both formal (processes, regulations, management decisions) and informal (transparency, implicit knowledge, flexibility). Here and throughout this paper, innovation-related potentially relevant topics are called innovation factors.

There are numerous innovation factors that are potentially relevant for an organisation. Considering the uniqueness of every company, we may assume that some factors are not always as relevant as academic business research or former analysis of companies might imply. E.g., some companies with traditional hierarchies have a significant innovation capability, while other companies prefer flat hierarchies. Since it is impossible to predict relevant innovation factors a priori, the tool aims at identification and prioritisation of innovation factors that are particularly relevant for a specific company.

**Table 1** Examples of Innovation Factors (here: Innovation Behaviour)

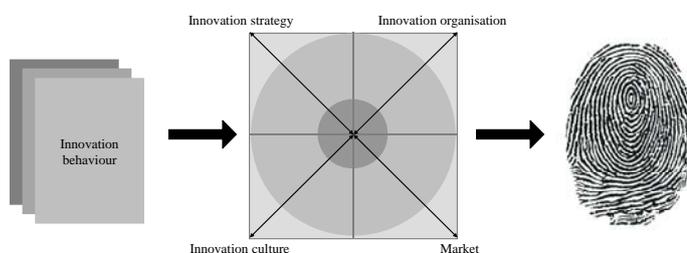
<i>Innovation categories</i>	<i>Innovation factors</i>	<i>Examples</i>
Innovation organisation	Knowledge management processes	Knowledge documentation; best practices; lessons learnt; feedback loops
Innovation culture	Personnel development	Incentives; creativity; coaching
	Organisational openness	Cooperation with customers, suppliers, other partners
	Flow of information and communication	Sharing information; collaboration
Innovation strategy	Tolerance	Tolerance towards failures, risks, and conflicts
	Innovation goals	Growth/profit goals, intellectual property
	Fields of innovation	Technology/product portfolio; process innovations
Market	Strategy form	Integration of R&D strategy, linkages between strategies, roadmapping
	Market observation	Competitors; customers
	Timing strategy	Innovation leaders; followers

With regard to innovation behaviour, innovation factors are grouped into four main categories as presented in Table 1:

1. Knowledge management processes include a systematic knowledge management within the company, e.g., project evaluation and documentation (best practices, lessons learnt). They also include acceptance, i.e. motivation and willingness to share knowledge, and integration of feedback loops.
2. Personnel development refers to both the implementation of different kinds of incentive systems in order to improve employee performance and the integration of creativity measures to develop new ideas and concepts.
3. Organisational openness includes open cooperation with customers, suppliers, and other relevant business partners.
4. Flow of information and communication refers to information sharing and collaboration (e.g., between different business units such as marketing and R&D).
5. Tolerance towards risks and failures is a prerequisite for the generation of innovations; however, it should be balanced.
6. Innovation goals are part of the corporate strategy with regard to the company's growth and profits as well as intellectual property (IP) management. They need to be communicated to change the innovation behaviour.
7. Innovation fields as part of the innovation strategy focus on the company's technology/product portfolio and process innovations.
8. Strategy form simply refers to the existence of an innovation strategy and its specific form. This includes synchronisation with the corporate strategy and the implementation of innovation roadmaps.
9. Market observation aims at determining a company's position in relation to competitors' as well as technology/knowledge transfer with external partners.
10. Timing strategy defines a general understanding of a company's innovative position (e.g., pioneer or follower).

Innovation factors and their characteristics cover a wide range of innovation topics that are potentially relevant for a company. More innovation factors may be additionally integrated into the analysis during the evaluation process. With regard to innovation behaviour, the 'Innovation Profiler' provides a company with its 'Innovation Finger Print' (cf. Figure 2).

**Figure 2** 'Innovation Finger Print'



Source: [www.innoplex.eu](http://www.innoplex.eu)

### *Prioritisation of Innovation Factors*

For a prioritisation of innovation factors with regard to the evaluation of a specific company, we must understand the interrelations between these factors. The process to analyse and, thus, to prioritise innovation factors as implemented by the ‘Innovation Profiler’ is based on methods of social network analysis [8]. It includes four steps:

1. Evaluation preparation (i.e. collection of available documents like innovation strategy, guidelines, etc.)
2. Workshop (heterogeneous team, i.e. people from different departments/with different functions discuss innovation factors and their relevance)
3. Attribution of interrelations (the analyst arranges innovation factors into a matrix; interrelations are attributed by the workshop members)
4. Prioritisation of innovation factors (network analysis)

Data input for application of social network analysis is a so-called adjacency matrix [9], indicating directed ties between the factors (from rows to columns; cf. Figure 3). The workshop participants discuss these interrelations to reach mutual agreement. Then, data is analysed by a network analysis tool, e.g., UCINET [10].

**Figure 3** ‘Innovation Profiler’ Matrix

‘INNOVATION PROFILER’ - INNOVATION FACTORS INTERDEPENDENCIES					
	KM PROCESSES	PERSONNEL DEVELOPMENT	ORGANISATIONAL OPENNESS	FLOW OF INF. & COM.	...
KM PROCESSES	-				
PERSONNEL DEVELOPMENT		-			
ORGANISATIONAL OPENNESS			-		
FLOW OF INF. & COM.				-	
...					-

Innovation factors, as described above, are potentially important for the specific innovation behaviour and the innovation capability of a given company. E.g., academic research has shown the potential relevance of organisational openness regarding the innovation capability. However, its actual importance depends on the specific situation of a company. Employees of a company might recognise the organisational openness as a very relevant issue because it affects other innovation factors that are also relevant. While it is assumed that innovation factors are not isolated from each other, it is important to uncover their interdependencies. The influence of innovation factors describes the relationships between them.

Social network analysis provides useful methods to evaluate factor interrelations by understanding the network structure and, thus, prioritise the innovation factors [9]. Social network analysis is a sociological paradigm that has gained a wide recognition in terms of understanding networks structures [11]. Methods of social network analysis are used by the ‘Innovation Profiler’ for prioritisation of innovation factors (cf. Table 2).

**Table 2** Examples of Methods of Social Network Analysis

<i>Analytical range</i>	<i>Measure</i>	<i>Description</i>
Whole network analysis	Density	Ratio of existing ties and possible ties
	Centralisation	Extent to which a network revolves around a single or few nodes
Sub-network analysis	Blocks	Structural equivalence of groups of nodes
	Cliques	Densely connected (sub-) groups (all possible ties actually existing)
Positional analysis (individual nodes)	Degree centrality	Number of ties to others
	Closeness centrality	Distance of one node to all other nodes within network
	Betweenness centrality	Gatekeepers or brokers within a network

Identifying the network's density and centralisation:

- A network's density is the ratio of the total number of existing and possible ties. In social networks, density shows the overall linkage of nodes. It is a useful measure to understand the overall interconnection between these innovation factors.
- Centralisation indicates whether a network is centralised around one or few central nodes. High network centralisation indicates that there are innovation factors that are more central to the overall network than others. This is an important finding in order to later prioritise innovation factors.

Identifying blocks and cliques within the network:

- Blocks are groups of nodes that can be identified by their similarities of linkages. The basic idea is that network nodes can be similar regarding their structural equivalence. These nodes for example might take up similar positions within a network and therefore have similar influences. Innovation factors that can be block-modelled might have cumulative influences on the same aspects of innovations. This is important to know because a lack of influence from one innovation factor can be balanced by another innovation factor that is structurally similar.
- Cliques are network nodes that have a significant higher linkage between each other compared to the overall density of the network. In a network of innovation factors these factors have numerous direct and indirect influences towards each other. The change of characteristics of one of these factors will have a strong effect on the other factors of a clique. Moreover, clique members might be more independent of other innovation factors.

Characteristics of innovation factors:

- The understanding of individual characteristics of innovation factors can only be achieved through an understanding of the overall network structure, as described above. Once this first insight has been gained, methods of social network analysis can help to identify relevant single innovation factors based on different aspects of their network position.

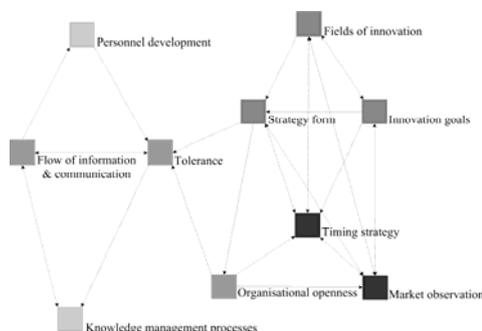
- One important aspect is degree centrality. It is the number of ties of a node. It is a strong indicator for the power of network members. Innovation factors with a high degree centrality are also powerful in terms of their quantitative relevance to other factors.
- Another aspect is closeness centrality of an innovation factor that shows the integration or isolation of network nodes by measuring the average node distance. Innovation factors with a high closeness centrality are characterised by a high degree of influences on other central factors. Some innovation factors might have a high quantitative influence but only on less central and relevant innovation factors. The closeness degree is therefore an indicator to analyse the qualitative relevance as well.
- Betweenness centrality measures the extent to which nodes of a network are located at pivotal positions within the network, e.g., nodes that connect different sub networks of otherwise isolated members. Innovation factors with a high betweenness centrality can be considered as gatekeepers. If these innovation factors exist, they do have exclusive influences and can therefore be highly relevant within the innovation network.

Analysing the interrelations between innovation factors by means of social network analysis supports identification and prioritisation of those factors that are highly relevant for companies. Based on the workshop participants' perception, we can make use of the powerful effect that the participants do not necessarily need to be aware of the different factors' relevance themselves. Once they have provided their individual view, the 'Innovation Profiler' is designed to develop the big picture and to describe a complex setting in terms of a manageable action plan.

### *Results and Action Recommendations*

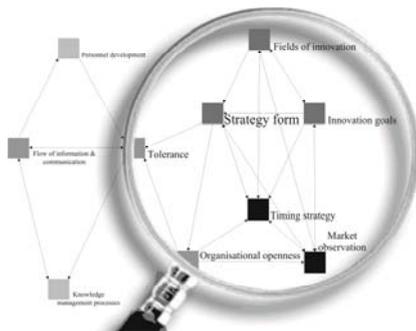
Results and action recommendations presented in this paper illustrate example outputs based on social network analysis as explained above. Examples given here focus only on innovation factors with regard to innovation behaviour (as described above), while innovation infrastructures ('Innovation Inventory Map') and disruptive factors ('Innovation Management Devils') are not subject to the discussion of this paper.

**Figure 4** Network Visualisation



Figures show the directed influences (ties) between innovation factors (nodes). Network illustrations are arranged in a way that innovation factors with a higher centrality are located in the centre, already giving an intuitive understanding for the differences of their individual relevance (cf. Figure 4). In the example presented here, three highly relevant innovation factors have been identified. As the following discussion will show, first, all these factors are very influential to other relevant factors, and second, they can be influenced by management efforts to leverage the innovation output.

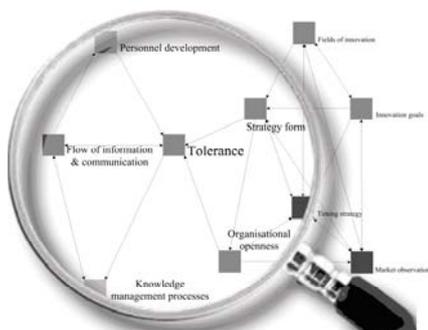
**Figure 5** Strategy form



Strategy form is identified as a primarily relevant factor (cf. Figure 5). It has a pivotal position within the network because its influence on other factors in terms of degree centrality is relatively high. There are ties with six other innovation factors. It is also one of the two innovation factors that have a significant influence on (failure/risk) tolerance.

(Risk/Failure) Tolerance of the company is regarded as less influential in terms of its direct influences but has a high betweenness centrality because its absence would lead to a structural hole and break the network into two parts. The workshop participants highlighted the deficits of the company's strategy form; the strategy itself was meaningful and accepted by those who knew its details. However, most participants did not know the details of the strategy; they could not appraise it. A written form of the strategy must be communicated more widely in order to give a better orientation towards the company's goals. In the perception of the participants, this action would significantly improve aspects in terms of tolerance and openness, too.

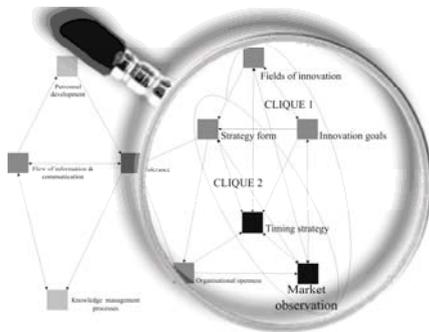
**Figure 6** (Failure/risk) Tolerance



As mentioned above, risk/failure tolerance is another innovation factor with a pivotal position within the network (cf. Figure 6). It can be directly influenced by management methods and further affects personnel development, flow of information and communication as well as specific knowledge management processes. Innovation factors of this kind partly influence each other but are not affected by other innovation factors. However, some aspects of tolerance have been identified as already fairly managed such as the tolerance towards risks. Nevertheless, there is a high need for action in terms of conflict management which was perceived as being insufficient with regard to the company's innovation challenges.

Workshop participants mentioned the need for a better integration of new colleagues on the one hand and a consensus in the solving of problems that occur from a repetition of similar mistakes at regular intervals on the other hand. These mistakes lead to conflicts that disrupt innovation processes.

**Figure 7** Market observation



A third very important innovation factor is market observation (cf. Figure 7) that influences numerous other factors and belongs to two cliques of strongly interacting sub-networks of factors. However, participants rated the company's performance in terms of its market observation as sufficient. This is an example for an innovation factor that has already been identified as highly relevant and therefore been managed fairly. The analysis highlights the accuracy of this procedure and its necessity to continue the efforts in the future.

All in all, the results of social network analysis of innovation factors in the above illustrated example have shown three innovation factors with a significant impact on the innovation behaviour. While market observation is already fairly managed, there are various aspects of (failure/risk) tolerance and strategy form that need to be adjusted in order to improve the innovation output. Strategy form, identified as highly relevant but yet insufficiently applied, should be communicated to the employees to avoid a lack of orientation to organisational objectives and the long-range innovation strategy. This may improve the individual performance because employees will get an understanding of how they can specifically support the company. Moreover, as mistakes and disputes stay largely unsolved and therefore diminish the innovation capability, this company should consider creating a process on how to manage failures that occur while dealing with innovation issues. Knowledge management processes such as best practices and lessons learnt could be an approach to avoid repetition of common mistakes.

### **3 Conclusion**

The 'Innovation Profiler' is a new and innovative tool to understand and manage the complexity of innovative behaviour within the organisational infrastructure of a company while taking into account possible disruptive factors. Since every company is a unique organisation with a unique history, employees, culture, technologies, and processes there is no 'one size fits all' strategy for innovation. Success factor research still tries to provide standardised solutions while organisational reality shows its widespread failure.

The approach of the 'Innovation Profiler' focuses on these innovation factors that are especially relevant for a concrete organisation. It takes into account the fact that employees know their company better than anyone else, often enough without being aware of their knowledge. The 'Innovation Profiler' is designed to uncover the implicit knowledge of employees by using social network analysis methods. The attempt to exploit these methods on innovation factors and their influences between each other has already shown most useful results. Highly relevant factors can be identified and prioritised in terms of designing individual action recommendations (action plan). Action recommendations consider the limitations of resources of a company and possible side effects because of the specific character of these resources.

The 'Innovation Profiler' is a powerful instrument to analyse the innovative situation within a company by integrating employee perception. It provides a practical approach to complexity management in R&D environments. Based on methods of social network analysis, it allows identification and prioritisation of relevant innovation factors and, thus, it establishes a profound fundament for further improvements with limited resources to leverage the company's innovation output.

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