# From Lead User to Embedded Innovator

## Developing a Descriptive Framework for User Innovations in the Medical Technology Sector

Working Paper
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**Abstract:** This article is examining how the medical technology industry has maintained its high level of innovativeness by looking at the unique role of user involvement in the innovation management of medical technology companies. First and foremost, this article illuminates the embedded innovator phenomenon. In the case of the medical technology sector, embedded innovators are innovative medical doctors who are developing innovations for medical technology firms while they are working at hospitals. Consequently, this article is constructing a descriptive framework by reviewing existing literature about user generated innovations in the medical technology sector as well as by drawing from studies beyond lead user research. This article is extending the lead user concept by introducing three dimensions of the embedded innovator phenomenon. Firstly, the innovator dimension that characterizes the typical attributes of embedded innovators in the MT sector, in this case medical doctors. Secondly, the employer dimension that describes the organizational climate in which embedded innovators can thrive or that can hinder innovative behaviour when they are lacking. Thirdly, the manufacturer dimension that typifies the basic elements that make collaborations mutually beneficial for the embedded innovators and the partnering companies.

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## *Introduction*

According to European Patent Office 2006 data, medical technology is top in patent applications, with over 15,700 inventions' patents registered. This represents 11.4 percent of all patent applications. Telecommunications and Data Processing were following medical technologies, with respectively 10 and 7.6 percent (Eucomed, 2009). What is the medical technology industry doing right in its overall innovation strategy? Edward Roberts (1987) explains that particularly in the MT field users (medical doctors) play a much more substantial role than merely being a source of helpful information to an innovating manufacturer. According to his study, the user is frequently the innovator. He states that it is near impossible for a medically-oriented company to perform effectively independent of the clinical environment. A study by Shaw (1986) reveals that clinics and doctors accounted for 53% of new product development in the MT sector. Consequently, this article is examining proactive user involvement as a success factor in the innovation strategy of the medical technology sector by establishing a descriptive framework for the analysis of "embedded innovators."

Von Hippel (Urban and von Hippel 1988; von Hippel 1986) defined two key characteristics of lead users: First, lead users are facing needs months or years before the bulk of the marketplace encounters them. Second, lead users benefit significantly by obtaining a solution to those needs and therefore are highly motivated to engage in the innovation process. Contrary to lead users who pursue innovative activities during their leisure-time, lead users from the medical domain tend to be medical doctors who are pursuing technological innovations while they are working at hospitals. The term "embedded innovator" has been used in the technological realm for advanced product servicing. In technical terms a networked product sends back information that can help manufacturers optimize service delivery, eliminate waste and inefficiency, and raise service margins (Almedinger and Lombreglia, 2005). This article will introduce a different use of the term: in this case a lead user is embedded in an employer organization while he is developing innovations for another company.

The unique embeddedness of innovative user in the MT sector raises several questions: What are the motivational factors of these innovators in the light of the fact that hospitals are their employers and yet they are developing innovations for medical technology companies? What are the challenges and opportunities arising from the circumstantial factors affecting these users in the clinical working environment? What are the success factors that make a user-manufacturer collaboration work effectively in the light of the challenges facing both users and manufacturers?

## *The Lead User Concept and Medical Technology*

The latest studies about user generated innovations in the medical technology sector are analyzing the phenomenon from the perspective of the lead user concept. Lüthje (2003) explored innovations developed by surgeons working at university clinics in Germany. He identified lead user characteristics and technical competencies as being important attributes of these innovative surgeons, and reported that 48 percent of the innovations developed by these surgeons were or soon would be marketed by manufacturers of medical equipment.

In two studies, Lettl et al. (2006 and 2008) explored the characteristics and the context of lead users who develop radical innovations in the medical technology sector. They pointed to the importance of intrinsic motivation, expertise, tolerance of ambiguity, openness, technological competence, and imagination in addition to the lead user characteristics, and explored the access to interdisciplinary know how and the availability of research resources such as time and money as positive contextual factors for these lead users. They argued that the involvement of lead users turns out to be an effective learning mechanism to enhance a firm's radical innovation capability.

Lettl et al. defined two types of lead users with regard to enabling factors. The first type was embedded into a context with close access to interdisciplinary know-how such as surgeons at university hospitals which were part of technical universities with access to departments of technical universities. Another contextual factor for this group was the availability of resources for research (time, money, personnel). The second type did not have these contextual factors but exhibited a high amount of intrinsic motivation. Their findings therefore highlight the importance of contextual factors and in identifying strong intrinsic motivation, they were extending the lead user concept.

## *The Embedded Innovator Framework*

Most user innovations in the MT field derive from medical doctors who are typically working full time for hospitals. Unlike other lead users, they are not developing innovations when they are off-work or pursuing recreational activities. They are drawing their inspiration from working closely with the patient at the hospital, which is their primary employer. Thus, their working environment is determined by the organizational features within the hospital. Consequently, when they are cooperating with medical technology companies, they are involved in a challenging balancing act between the routine aspects of working for the hospital and the scientific or technological development aspects of initiating innovations for a beneficiary who is outside their immediate working environment. Hospitals tend not to have a direct short term benefit from letting the users develop innovations. Only in the long term, when the innovation has been established first in the scientific community and then in the hospital leading to a much improved procedure, it can have a positive impact on the size of the patient base and ultimately the hospital's revenue or scientific reputation (as in the case of teaching hospitals). When medical technology companies are interested in building effective relationships with embedded innovators, they must respond to their needs and help them face this challenge by providing them the right kind of support and openness in order to more thoroughly benefit from their innovations.

To examine the innovative potential as well as the challenges arising from the circumstantial factors of embedded innovators, the following descriptive framework focuses on three dimensions. Firstly, the innovator dimension that characterizes the typical attributes of embedded innovators in the medical technology sector. Secondly, the employer dimension (hospital) that describes the organizational climate in which embedded innovators can thrive or that can hinder innovative behaviour when they are lacking. Thirdly, the manufacturer dimension (technology company) that typifies the basic elements that make a collaboration mutually beneficial for the embedded innovators and the partnering company.

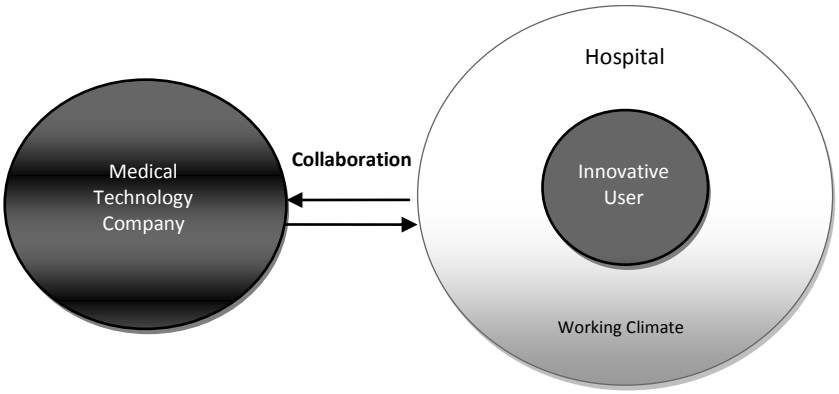


**Fig. 1 User Embeddedness**

The underlying assumption of this framework is that the innovative output of the user depends upon the user attributes, the working climate and the way the partner company is collaborating with the user.

## Innovator Dimension

The process of initiating innovations is closely linked to an individual's competence (Talke et al. 2006). In their study about radical user innovations in the medical technology sector Lettl et al. (2006) argue that to develop own solutions for radical innovations, one needs to have a profound understanding of the elements, the causes and effects of a certain domain. The basic attribute of an embedded innovator is his competence and technical knowledge. While not all medical doctors have the required technological affinity, their competence in terms of their educational and in-hospital training is commendable (Gail Weiss, 2003) compared to that of other professions. However, competence and technical knowledge alone are not going to make any user innovative.

Creativity is the real starting point for innovation; indeed, creativity is a necessary but not sufficient condition for innovation (Woodman, Sawyer, & Griffin, 1993; Amabile, 1996). In order to come up with a useful invention which can subsequently be marketed, users have to get beyond the routine aspects of their work, use their imagination and start bringing about new ideas. As past research has shown, creativity and innovativeness, as behavioral attributes, heavily rely on intrinsic motivation (Amabile, 1983; Deci and Ryan, 1985); namely the engagement in an activity for its own sake (McReynolds, 1971). Lettl et al (2006 and 2008) have alluded to this phenomenon by pointing out that medical doctors who are lead users are driven by intrinsic motivation, and that high intrinsic motivation can even compensate for adverse contextual factors.

Amabile (1993) has argued that extrinsic motivators do not necessarily undermine intrinsic ones: under certain combinations of personality traits and organizational context, extrinsic motivators and intrinsic motivators can combine to yield high levels of performance and personal satisfaction. Literature about compensation schemes in companies has identified long term financial incentives (like gain sharing), as encouraging factors of innovative activities (Quinn and Rivoli, 1991, Stephan, 1996; Baron and Byrne, 1997). However, the extrinsic motivators are no inevitably of a financial nature. Particularly, innovative users who contribute innovations to open source software (Demil and Lecocq, 2006; Von Hippel and Van Krogh 2006) or scientists (Merton 1973) rely to a large extent on reputation as an incentive for their academic and technological advances. User innovations in the field of medical technology are often the result of scientific

research at teaching hospitals, where the tested products may be used to generate scientific research results and publications and thus increase the prestige of the institute, the department and the individual scientists (Biemans, 1991).

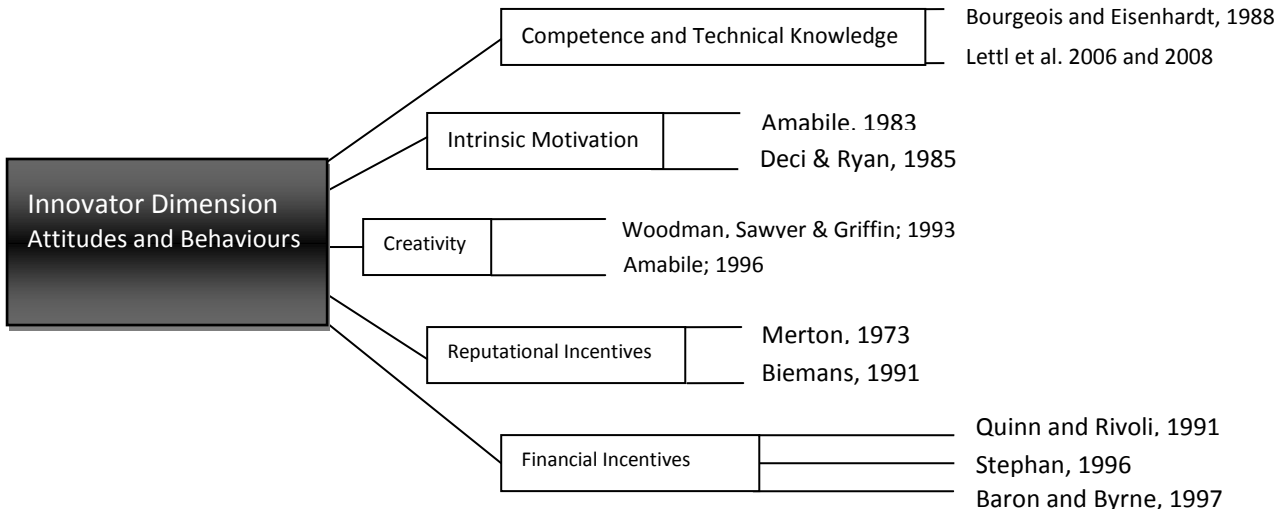


**Fig. 2 The Innovator Dimension**

## Employer Dimension

The activities of embedded innovators are taking place in a professional environment. Of course, the prerequisite to user innovation is that the user already has a predisposition to becoming innovative; however, when there are severe organizational barriers, he might not realize his creative and innovative potential. According to Amabile et al. (1996) the social environment can influence both the level and the frequency of creative behaviour. In their research, which included a literature review of the most significant empirical studies in the field, they focused on the intra-organizational foundations of innovation. They analyzed creative project work by teams and individuals, and examined the psychological context of creativity, the work environment, and perceptions that can influence the creative work carried out in organizations. Amabile et al. defined the positive features determining the context of creativity. Amabile's KEYS (1998) evaluate six factors of the organizational climate. She identifies challenge, freedom, resources, work-group features, supervisory encouragement and organizational support as the key contextual factors. Not all them makes sense for the purpose of researching embedded innovators in the MT sector.

Let us first examine those that are relevant. Independence is an important feature of the medical professions as it gives individual doctors clinical *freedom* and the profession collectively the authority to decide about standards of professional practice and education, the organisation of medical work, and discipline (Irvine, 1997). Compared to other professions, doctors have a relatively high autonomy in the day-to-day conduct of the work and a sense of ownership and control over their own work and their own ideas.

Medical doctors are dealing with multiple *challenges* as clinical practice, organisation, information management, research, education, and professional development are interdependent and built around self adjusting and interacting systems. Unpredictability and paradox are ever present, and some things will remain unknowable (Greenhalgh and Plsek 2001). Thus, medical doctors need to be able to deal with a high amount of complexity and are consequently facing intellectually stimulating environment.

On the other hand, a lack of *resources* such as money or time can put severe limitations on the innovative activities of embedded innovators. Due to the aforementioned existence of intrinsic motivation and the fact that doctors are typically already standing on a solid financial basis in terms of innovative activity, time tends to be more important than money. Since hospitals do not to receive a short term monetary benefit from user innovations, they typically do not have an incentive to allow medical doctors to spend time on innovative endeavours, while they are treating patients. In a similar vein, the increased documentation now required of physicians to avoid allegations of fraud and abuse inevitably competes with time spent providing patient care, conducting research and pursuing innovations (Einhorn et al. 2002).

Of the six KEYS three factors—namely *work-group features, supervisory encouragement and organizational support*—are not appropriate for the purpose of researching embedded innovators. Since the medical technology companies rather than the hospitals are the primary beneficiaries of the user innovation, it is clear that hospitals are not taking on the responsibility of creating a work environment that allows for innovative activity. Granted, teaching hospitals have the mandate to make a scientific contribution, that mandate, however, does not include the development of new technological products, although they might be a positive byproduct of these scientific endeavours. Consequently, this article hypothesizes that, while organizational encouragement, supervisory support and work group features might be important contextual factors of innovative activity, they cannot be expected from hospitals and are thus not suitable factors of the embedded innovator framework.

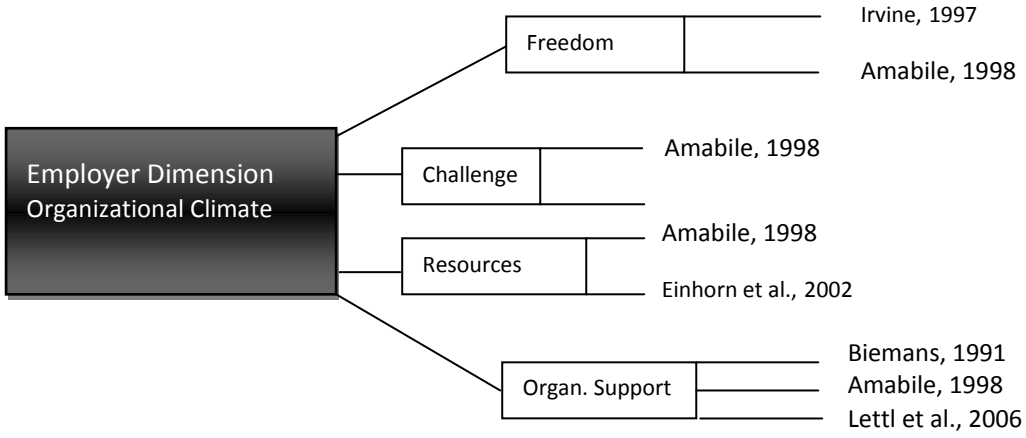


**Fig. 3 The Employer Dimension**

## Manufacturer Dimension

Embedded innovators typically cooperate with technology companies. There are certain factors that make such cooperation successful and that determine an effective relationship between the embedded innovator and the technology company. The mutual inspiration and the knowledge transfer effect between experts of different fields working together on one project has been documented well in the literature of innovation management (Takeuchi and Nanako, 1986; Looy et al. 2005, von Hippel, 1994; Thomke and von Hippel, 2002; von Hippel, 2005). Specifically, in the medical technology field users rely on complementary technological knowledge for the development of own solutions in their domain and the access to technological know-how is critical for embedded innovators to get an immediate response with respect to the technological feasibility of their solutions (Lettl, 2008). Shaw (1986) notes that in the medical technology field there is a high level of communication between scientists, engineers and clinicians within very efficient informal and formal networking systems. When users are not a part of technical universities, were they can potentially work together with engineers, these doctors rely on medical technology companies to provide them with the necessary know-how.

Innovation represents a long-term investment to an organization, thus a firm is likely to encounter more innovativeness in a user/customer and long term oriented culture (Han, Kim, Srivastava, 1998). Indeed, more long-term incentives are associated with more heavily cited patents, more frequent awards, and patents of greater originality (Moers and Brüggen, 2007). Embedded innovators in the medical technology field should not be an exception to this general rule.

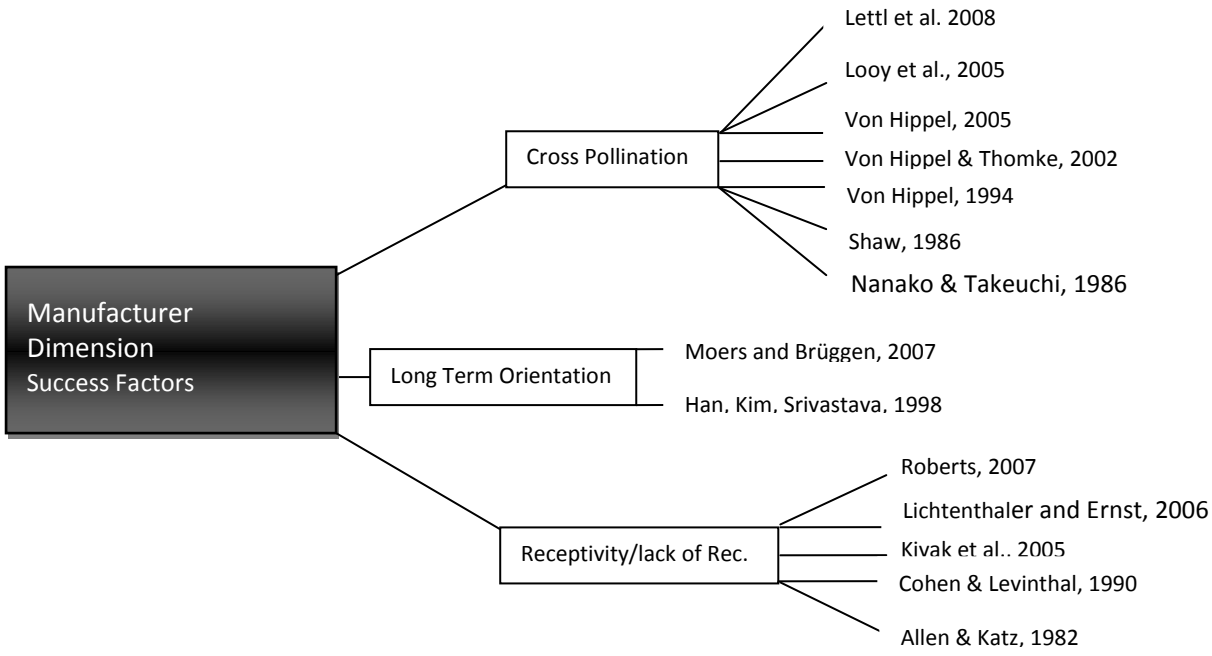


**Fig. 4 Manufacturer Dimension**

Indeed, receptivity is a critical aspect of technology-based innovation and a source of competitive advantage as more users develop sophistication regarding product technology attributes (Roberts, 2007, Kiyak et al., 2005, Cohen and Levinthal, 1990). Significantly, a company should refrain from falling into the "not-invented here" trap (Allen and Katz, 1982; Lichtenthaler and Ernst, 2006) and neglect the importance of receptivity to information sensed from external sources of innovations. Particularly in the medical technology field where as much as half of the innovations are developed in cooperation with users and medical doctors contribute to product development by expressing specific needs that arise from treating the patient at the hospital (Shaw, 1985), receptivity is a critical aspect of maintaining and improving the innovative output of a company. On the other hand, a medical doctor can be incredibly innovative, however, when a company is not willing to take on this opportunity he will face severe challenges in bringing the innovation to the market. Although, some lead users in the medical domain have taken on the option of developing radical innovations outside of manufacturing firms (Lettl et al. 2008) the manufacturer has the fundamental advantage of incurring economies of scale, having the marketing know-how and network, and a much higher capacity to bear the financial risk associated with the development of an innovation.

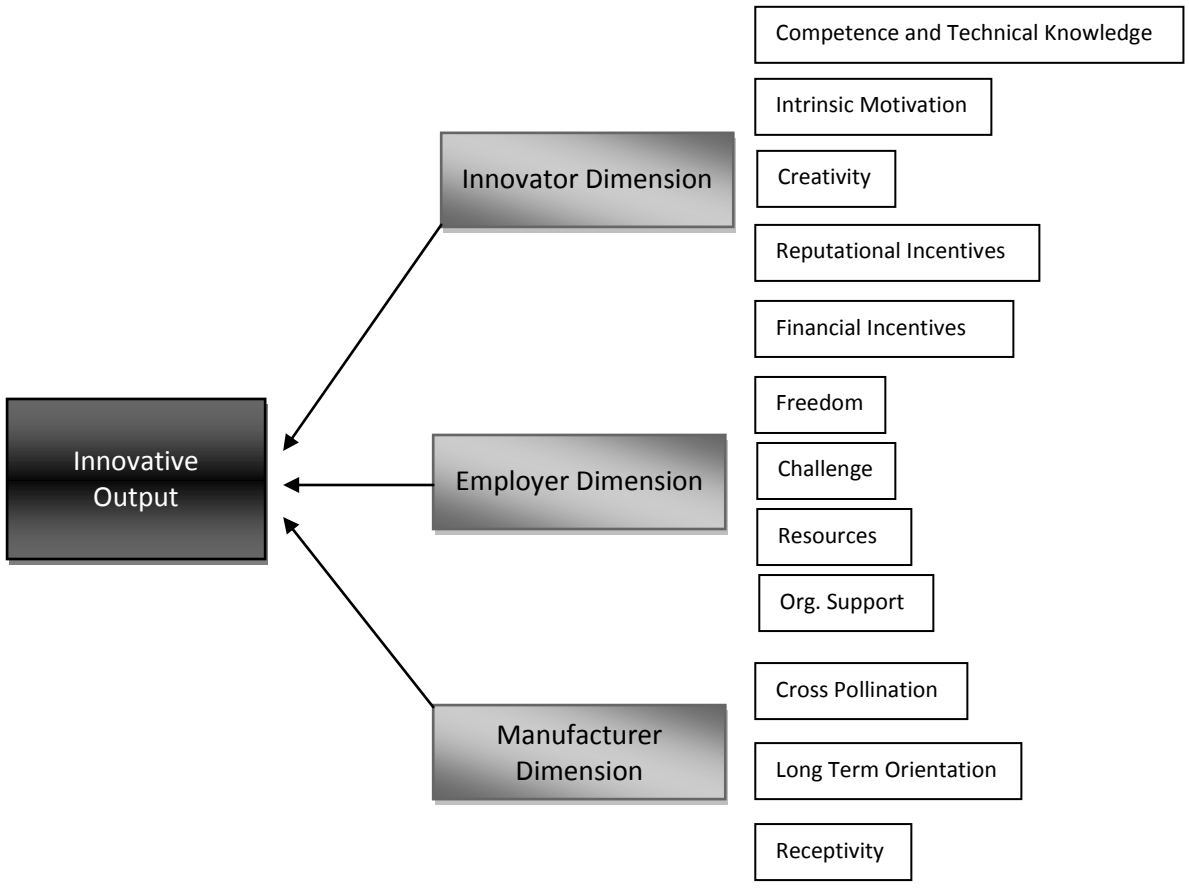


**Fig. 5 The Embedded Innovator Model**

## *Conclusion*

An analysis of both general studies of innovation management, that are relevant for user innovations, as well as previous studies of user innovations in the medical technology sector served as the basis for the development of a descriptive framework that analyzes innovative activities of embedded innovators in the medical technology sector. The characteristics of the embedded user were defined by establishing the individual dimension which consisted of intrinsic motivation, creativity, competence and reputational as well as long term oriented financial incentives. Amabile's Keys were introduced as a framework for examining the employer dimension, which explores the factors that make possible user innovations in the organizational milieu they are embedded in; such as challenge, freedom, resources. As it turned out, work group features and supervisory support on the other hand are not particularly suitable indicators as these factors would mean that the organization actively fosters innovative activities which will primarily benefit another organization. Ultimately, criteria for the analysis of the relationship between the embedded innovator and the company were set up, consisting of cross pollination, long-term orientation and receptivity.

### Implications for Management

The embedded innovator model allows for tentative conclusions on user integration by medical technology companies. Since the intrinsic motivation and the non-monetary incentives (like reputation) seem to generally be quite strong, companies might be able to build beneficial relationships with doctors by supporting them in their developmental activities. For example, instead of providing a share of revenue companies might offer them support in publicizing an innovation that has a scientific relevance, in order to improve their reputation. Instead of providing monetary resources they might provide them with engineering assistance to speed up the prototype development phase. This would increase the innovative activity since it would lead to more cross-pollination. In return for the innovative activities of the user they can bear the financial risks involved in the development of a new product. Based on the findings of the research model, it is safe to hypothesize that such activities will often satisfy the user to the extent that they will forgo financial rewards. In cases in which a financial reward is demanded, long term financial incentives like share of revenue, are more inductive to prolonged innovative activity than short term bonuses. Medical technology companies should keep clear of the "not-invented-here" syndrome and remain receptive to user innovations because user innovations are a critical aspect of innovativeness particularly in this sector.

### Implications for Research

In terms of future research activities, the embedded innovator framework serves as a basis for research about the specific issues arising from triangular interaction of embedded innovators (medical doctors), manufacturers and employer organizations (hospitals). Particularly the characteristics of users of medical technology in terms of their motivational attributes and the question of how manufacturers can effectively collaborate with users who are embedded in non-manufacturer organizations deserve more attention in future research endeavours. The lead user approach, which stands at the centre of this article, has been amended by both including empirical findings in the medical technology sector in the past and findings from significant studies within the innovation management research field. The latter is particularly important, since many aspects of the phenomenon of user innovation in the field of medical technology hold true to general findings in the field of innovation management and should not be neglected by too narrowly focusing on just one concept. While the individual features of the embedded innovator framework are based on empirical studies, the framework as a whole remains to be tested empirically in future studies.

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