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## Industrial Graduate Schools – University-Industry Interaction for Development of Absorptive Capacity

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**Abstract:** Absorptive capacity and integration skills of firms are crucial factors when it comes to reaping the benefits from university-industry relations. Education and training of individuals with both academic and industrial experience that can act as brokers of knowledge is therefore of great importance. During recent years industrial graduate schools have been developed as an answer to this challenge. We investigate them through an interview study with PhD students and supervisors. We also assess long-term impact through interviews with graduated individuals focusing on their use of integration skills within their work. We conclude that although industrial graduate schools require a multitude of favourable conditions in order to realise their potential they are also a powerful tool for developing absorptive capacities of PhD students and supervisors. We show that positive effects of industrial graduate schools extend in time, through increased capacities to e.g. participate in collaborative R&D projects or educate new students.

**Keywords:** Collaborative R&D; University-industry relations; Open innovation; Absorptive capacity; Doctoral education; PhD students; Industrial Graduate Schools; Knowledge brokers; Higher education; Learning.

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### 1 Introduction

University-industry relations have the potential of contributing to intensified knowledge exchange and a higher rate of innovation (Etzkowitz 1998; Van Looy, Debackere & Andries 2003; Sparrow, Tarkowski, Lancaster & Mooney 2009). There exists a variety of channels through which universities and firms interact, such as technology transfer, conferences, training of qualified individuals and consultancy (D'Este & Patel 2007). The most intensive and long-term relations have the form of collaborative R&D (Perkmann & Walsh 2007). These are increasing in importance as more and more firms embrace the principles of open innovation (Chesbrough 2003).

Absorptive capacity and integration skills of firms are crucial factors when it comes to reaping the benefits from university-industry relations as they enable firms to assimilate and apply knowledge gained from external sources (Cohen & Levinthal 1990; Chen 2004; Spithoven & Teirlinck 2010; Spithoven, Clarysse & Knockaert 2011). The absorptive capacity of an organization is dependent on the ability to disperse knowledge between its units as well as on the individual absorptive capacities of its employees. Education and training of individuals with both academic and industrial experience that possess high absorptive capacity and can act as brokers of knowledge is therefore of great importance for both industry and universities.

Industrial graduate schools have been developed during recent years as an answer to this challenge. In such schemes doctoral students are employed by a firm and devote part of their working time to a thesis project with relevance to the firm under the supervision of both an academic and an industrial supervisor. The students are part of a community together with other industrial doctoral students and for example take academic courses together. In the following study we investigate the benefits and weaknesses of industrial graduate schools and their long-term impact which is observed through the activities of graduated individuals and their use of integration skills within their work.

This study aims to answer the following questions:

- i) How can industrial graduate schools be used to enhance absorptive capacity of firms?
- ii) What are the necessary conditions for successful long-term outcomes of industrial graduate schools?

The paper is structured in the following way: in the next section a theoretical background is provided, subsequently the concept of industrial graduate schools is elaborated upon. Then, methods and data are described, and results are presented. These are followed by a concluding discussion and implications.

## **2 Theoretical background**

The role of universities within innovation systems is undergoing a change process moving from a focus on scientific discovery, characterised as Mode 1, towards focus on application-oriented knowledge production, so called Mode 2 (Gibbons et al. 1994). Knowledge production within Mode 2 involves openness, transdisciplinarity and border-spanning collaborations with a diversity of actors being actively involved in research (Nowotny et al. 2003). Simultaneously, the spheres of university, industry and government are gradually becoming more intertwined in what can be described as a “Triple Helix” system of dynamic relations (Etzkowitz & Leydesdorff 2000). University-industry links are gaining in extent and importance while at the same time becoming more multi-faceted. Previous research suggests that relations between firms and universities are valuable throughout the whole innovation cycle and often focused on learning and capacity-building (Perkmann & Walsh 2007). Following this development several new organisation forms have evolved including technology transfer offices (TTOs), long-term research programs encompassing both basic and applied research, research institutes focused on specific sectors and industrial graduate schools (Jacob 2001; Wallgren & Hägglund 2004; Salminen-Karlsson & Wallgren 2008; Bienkowska & Klofsten 2009; Bienkowska et al. 2010).

Engagement in border-spanning collaborations and open innovation processes requires the presence of highly developed absorptive capacities in all involved organisations in order to be able to recognize and make use of external knowledge. Experience-based learning, and therefore investment of time and resources, is viewed as significant for development of capacities. Building absorptive capacity entails developing three important conditions: structures of communication within organisations as well as towards external environment; distribution of expertise in the organisation; and individual employees' absorptive capacities (Cohen & Levinthal 1990).

Various ways of enhancing absorptive capacity of firms have been discussed and studied in previous literature. Spithoven, Clarysse and Knockaert (2011) have shown how collective research centres can act in order to increase absorptive capacity in traditional industries such as textiles and construction. These centres are supported by both private and public funding and perform R&D activities as well as R&D-related activities such as testing or scientific information services. Rohrbeck and Arnold (2006) have studied how spinning off a research organisation that employs both academics and industry researchers can contribute to a large firm's absorptive capacity and innovation potential.

Industrial graduate schools constitute an innovative form of university-industry collaboration where several aims can be pursued at once. Firstly, PhD students are being trained in research and commonly supervised by both academic and industrial supervisors. This contributes to the development of absorptive capacities of both the involved individuals and their organizations. The individuals with this kind of experience increase their ability to translate and transform available knowledge and can take on the role of "knowledge brokers" (Meyer 2010). Secondly, research projects are carried out with potential benefit in both commercial and academic terms. Thirdly, a common network is being developed between PhD students affiliated to different firms, also including industrial actors and the wider research community.

In the next section the concept of industrial graduate schools is explained in more detail.

### **3 Industrial Graduate Schools – PhD education involving industrial partners**

In this paper we focus on the concept of Industrial Graduate Schools as it is applied in the Swedish context. This organisational form was initiated by The Knowledge Foundation in 1995. The Knowledge Foundation is a public organisation which provides financial support for co-production of knowledge that actively involves academic and industrial partners (The Knowledge Foundation, 2012 a).

To qualify as an Industrial Graduate School and receive partial financial support from the foundation graduate schools have to fulfil a number of specific requirements stipulated by the foundation. The PhD students admitted to these schools are expected to have an affiliation to a specific firm/organisation outside the university and have to share their time between workplace at the university and at the firm. A major part of their working time should be devoted to the PhD studies. Furthermore, PhD students are supposed to have one academic supervisor and one supervisor/mentor from the firm. The Industrial Graduate Schools should also be run as unified and cohesive graduate programmes. Research projects pursued within this framework have to be relevant for the involved firms and the firms' active participation is required. In addition, the business

partners are required to contribute financially to the Industrial Graduate School, by an amount that at least equals the financing from The Knowledge Foundation (The Knowledge Foundation, 2012 b).

The purposes of this initiative include strengthening Swedish industry, contributing to long-term competitiveness, increasing research expertise within business sector and improving conditions for collaboration between firms and universities (The Knowledge Foundation, 2012 b).

Until 2012 the foundation has supported twenty-one Industrial Graduate Schools, in various sectors including Food, Biotechnology, Robotics, Surface Chemistry and Rock Engineering (The Knowledge Foundation, 2012 c). Each school has had on average thirteen PhD students and received approximately two million euro in total during a six-year period. Eleven Industrial Graduate Schools are in operation currently, while ten are already completed.

Schemes similar to the industrial graduate schools investigated here include Engineering Doctorate and Co-operative Awards in Science & Engineering in the UK which have been studied by Butcher & Jeffrey (2007). They conclude that perceived success of these collaborations where PhD students are jointly supervised by academic and industrial supervisors depends on factors such as high degree of time spent within the firm during PhD education and compatibility of the supervisors. It is important to note that these schemes are often not run as unified “schools” and therefore not completely comparable to the Swedish Industrial Graduate Schools.

#### **4 Methods and data**

This study uses interview data from four industrial graduate schools in Sweden within following industrial sectors: Medical bioinformatics; Applied IT; Management; and Construction. Each of these schools is affiliated with a specific Swedish university – Karolinska Institutet Medical University, Chalmers University of Technology, Linköping University and Lund University. They are among the larger industrial graduate schools, with more than twenty PhD students each. Two of the schools are still ongoing – Medical bioinformatics and Applied IT & Software Engineering, the other two are no longer operating.

In total 46 PhD students and 31 supervisors were interviewed. A majority of the interviews were carried out during face-to-face meetings, in most cases at the PhD students’ workplaces at firms. In some instances interviews were carried out via telephone. The interviews were semi-structured and took about one hour each. A first round of interviews took place in 2001 and 2004; these interviews included questions on how the informants’ work is organised, their learning experiences and how they view university-industry collaboration.

19 of those PhD students who graduated from the industrial graduate school in Applied IT were interviewed anew in 2010. This second round of interviews centred on their roles in industry and academia as well as use of knowledge integration skills after graduation.

## 5 Results

Involvement in an industrial graduate school is a long-term commitment and requires a multitude of conditions in order to be able to realise its potential for firms' absorptive capacity. The benefits of this kind of scheme are significantly increased individual absorptive capacities of the employees, where both the PhD student and the academic and industrial supervisors develop their knowledge and integration skills.

Our interviews show that the PhD students' and supervisors' own interest in translating and transforming knowledge as well as drive to simultaneously engage with both the academic and industrial spheres is a major factor contributing to the successful development and use of absorptive capacity. Therefore, careful recruitment is a key issue when setting up industrial graduate schools. The academic supervisors occupy a position of power over the process of PhD education as they influence the direction of research and ensure that required levels of academic quality are maintained. It is thus important that academic supervisors have a real interest in and understanding for the involved firms and their conditions.

Regarding the firms involved in the studied cases we can identify three important factors influencing the outcome of firms' engagement in industrial graduate schools. Firstly, the extent of research-related activities within the firm matters for further development of absorptive capacities. Secondly, the total amount of employees with academic experience within the firm is positively linked to learning and development outcomes of industrial graduate schools. Both these results confirm the cumulative nature of absorptive capacity as stated by Cohen & Levinthal (1990). Thirdly, the time frame within which the firm operates is an influential factor. A long-term perspective on operations is beneficial for development of absorptive capacities.

The follow-up interviews with graduates of the industrial graduate school in Applied IT show that a vast majority was in 2010 employed by industry (18 out of 19) with one being employed by academy. Half of the individuals employed by firms are still with the same firm that they were affiliated to during their PhD studies. The other half is comprised of individuals that have been moving between different firms, mostly due to reorganisations and closures of their employer firms.

Regarding the long-term outcomes of the industrial graduate school it is remarkable that a majority of the interviewed graduated individuals (17 out of 19) have actively used and further developed their integration skills since graduation. They have done so for example through participation in EU-funded research projects; in collaborative R&D; and in conferences, both scientific and industrial; as well as through coaching of high growth firms or through being industrial supervisors themselves. The majority of the individuals that have continued their employment at the same firm as during PhD studies have had considerably more possibilities for cooperation with academia than others. However, two of them claim that they have no scope within their current position to use and develop their absorptive capacities due to incompatible work tasks and a short-term focus of their employer firms. At the same time, some of the graduates have described how they through their own efforts were able to expand their work assignments to include more academic contacts, despite hesitation and lack of interest from the firm. The drive of the individuals can therefore counteract an unfavourable approach of a firm.

## 6 Concluding discussion

This paper has shown how industrial graduate schools can contribute to the development of absorptive capacity of firms as well as presented the first study of long-term outcomes of such an initiative. In previous research various models for enhancing absorptive capacity have been studied, such as collective research centres (Spithoven, Clarysse & Knockaert 2011) and spin-off research organisations (Rohrbeck & Arnold 2006). Industrial graduate schools constitute a recently developed scheme with the aim of developing absorptive capacity of individuals within firms through PhD studies carried out in close collaboration between university and industry. In conclusion, we claim that most important conditions for successful outcomes regarding development and use of absorptive capacities are:

- Motivated individuals with own interest in brokering & integrating knowledge from industry and academia
- Factors within the firms such as previous experience from research and PhD education and a long time perspective
- Academic supervisors with interest in the challenges of the firm

Although industrial graduate schools require a multitude of favourable conditions in order to realise their potential they are also a powerful tool for developing individual absorptive capacities of both PhD students and supervisors. In addition to that, we have found that the positive effects of industrial graduate schools extend in time, through increased capacities to e.g. participate in international collaborative R&D projects or educate new students.

Going forward, we observe that there is a need for further research concerning capacity-building through PhD education within the framework of university-industry links. There are for example more industrial graduate schools that by now have enough graduates to enable studies of long-term impacts of this type of initiatives. Further studies of similar schemes in other countries are likewise needed in order to increase our understanding of these phenomena and allow for cross-country comparisons.

## 7 Implications

Our study provides valuable implications for firms interested in engaging with academia. Successful involvement in industrial graduate schools requires both careful recruitment of potential PhD students and conditions such as existing experience from research within the firm. Without these factors the considerable investment such involvement entails could end up being underutilized.

Policymakers and academic leaders are provided with insights on important criteria when developing and supporting industrial graduate schools. Their efforts should be channelled into motivated individuals already interested in integrating industry and academia both when it comes to academic supervisors and PhD students.

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