Enhance interaction between HEIs and SMEs to stimulate research and innovation

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Per Lövsund[1], Angela Hillemyr[1], Nikolaos Krikis[2]

[1] Chalmers University of Technology, Dept. of mechanics and maritime sciences, Goteborg, Sweden
[2] NOESIS Technologies, Patras, Greece

Abstract

To be more competitive and innovative, SMEs (Small and Medium-sized Enterprises) should benefit from access to more advanced research through an increased collaboration with HEIs (Higher Education Institutions). Based on the need to improve understanding of both the obstacles and opportunities regarding collaborations between SMEs and HEIs, the GIENAHS Erasmus Plus Project was established as a partnership between SMEs and HEIs from six EU countries. The study described in this paper aims to find ways for HEIs to improve their ability to interact with SMEs and vice versa, both through joint research and industry PhD students; as well as to propose strategies and methods for optimal long-term relationships and collaborations, including win-win situations for HEIs and SMEs.

A questionnaire was developed and sent out to both HEIs and SMEs in each of the six partner countries. The results are based on the responses from 37 HEIs and 73 SMEs, which were analysed using the accepted model in decision theory, the Weighted Sum Model (WSM). The results were based mainly on the questionnaires, but also to some extent on complementary interviews.

A great deal of the results are country specific, with some few exceptions. Besides the fact that the data differs between the countries, there is also a variation within the countries. There may be several reasons for these differences, for instance pre-existing SME/HEI relationships and collaborations, or if the university/department has a focus on applied or fundamental research.

Both similarities and dissimilarities were found in the answers from both HEIs and SMEs. Both HEIs and SMEs share the viewpoint that they are open to collaborations for the purpose of a mutual transfer of knowledge. SMEs are generally interested in investing in staff competencies. The majority of the interviewed SMEs had not considered PhD programs before this study. The results show a willingness towards extending networks and contacts in order to create relationships and thus establish fruitful collaborations between HEIs and SMEs, thereby also enhancing research competence. This could potentially be done by establishing a common European standard for interaction between HEIs and SMEs.

The conclusion of this study is in line with the project goal of increasing innovation capacity in the EU. It could broadly be summarised as: university-industry collaboration is a win-win experience for both parties as well as for society. It helps to close the gap between industry/SMEs and academia. A successful partnership involves strategies and goals for both HEIs and SMEs (industry) and for achieving impact.

Keywords

Research collaboration, innovation, University-SME interaction, PhD program, competitiveness

1. Introduction

The entire globe faces several major societal challenges and knowledge-based competition is increasing. There is an urgent need for a transition to a fossil-free and circular society, among other things. Collaborative research between small companies, academia, the public sector and research institutes plays a key role in addressing the great need for renewal. There is great potential here for developing solutions to societal challenges. The bulk of all business in the EU is based on SMEs, and SMEs represent the largest net contributor to the economy in a number of sectors and countries (Gertner et al, 2011; Charles et al, 2014). The European Commission considers SMEs and entrepreneurship as key to ensuring economic growth, innovation, job creation and social integration. The EU has many ways of supporting SMEs to be more innovative and competitive, for example the Open and Disruptive Innovation (ODI) scheme and the EIC Accelerator (SME Instrument), part of the European Innovation Council (EIC). These EU initiatives are fully in line with the view of Moedas (2019), who claimed that science and innovation are vital for the future of Europe and that there are three changes needed for the science and innovation landscape in the future: (i) increased collaboration, (ii) more work at the intersection of disciplines and (iii) more disruptive innovation. Research and innovation are different activities, even if it is often still taken for granted that there will be innovations just because you invest in research (Hörstedt, 2019). To be more competitive and innovative, SMEs should benefit from access to more advanced research and not least, through collaboration with HEIs.

A number of studies have shown that university-industry collaborations are far from straightforward and that most of these are centred on science-based collaborations and not generally focused on SMEs. There is thus a lack of guidelines and impact cases on getting new collaborations started and how to get a successful long-term collaboration up and running (Thune, 2007).

The EU-funded project Access, which is a collaboration between the Swedish universities Linköping University, Uppsala University and Örebro University, has developed a model for collaboration between HEIs and SMEs. It describes a process for successful collaboration between academy, industry and society called the 5i-process (Access, 2018). The 5i-process describes five steps with support activities: to inspire, identify, initiate, enter into, and intensify. All support activities which are carried out are mapped into these steps, thereby describing what work is happening and what it aims to do. The 5i-process has been used at the three universities and has resulted in an improved collaboration with primarily SMEs, which is fully in line with the aim of the Access project.

Görnerup (2018) found that, among member industries in the Confederation of Swedish Enterprise and in line with previous studies, that high quality at the research institutions is one of the most important factors when companies decide where to start their research collaboration. When comparing companies with in-house R&D with companies without, there were obvious differences that motivate their purpose for collaboration with a university. The companies with in-house R&D generally prefer to gain access to research-based knowledge, researcher networks and infrastructure. The same preferences and differences were seen when comparing product producing companies with non-product producing companies. A general conclusion from this study was that universities should be more visible at the companies, especially those with courses where internships/projects are carried out. HEIs need to have a better understanding of the companies' conditions and logic for collaboration, and that this in turn constitutes an important foundation for successful collaboration. To some extent

there are corresponding views from SMEs, but there are also clear strategical differences, for example those identified by Santoro and Chakrabarti (2001). SMEs do not have access to the huge resources that are spent by the large companies on performing research and development projects as part of the innovation process, and often lack both personal and financial resources. SMEs usually have specific, more technological, needs. SMEs are usually more interested in using their relationships with universities to address specific needs in relation to their business performance (Santoro and Chakrabarti, 2001).

Based on four case studies, Peças and Henriques (2006) proposed a way to collaborate with SMEs by asserting that the collaboration should be based on a small project focused on localised, specific areas, where the potential for improvement and innovation is large and hereby establish strong and long-term relationships between the university and industry. This is very much in agreement with Demain (2001), who claims that the involvement of SMEs with academia must have an interpersonal approach rather than a formal one, and that small projects allow collaborators, both academia and SMEs, to smoothly define their roles, achieve high levels of personal trust and design achievable expectations within their competencies.

Virani (2014), among others, found large variations in the outcome of collaborations between different universities and SMEs, and that earlier experiences in HEI-SME collaborations are more or less a presumption to its success; also, that the creative industries engage with a number of different actors that speak different collaborative languages. Furthermore, the study highlighted the need to manage the expectations and to balance different incentives when it comes to negotiating the outcome of these collaborations, since university and industry move in different phases and appreciate different values.

To improve the understanding of both the obstacles and opportunities for collaborations between SMEs and HEIs, the EU project GIENAHS (Grasping Innovation in Europe through a closer iNter-Action between HEIs and SMEs), www.gienahs.eu was initiated. For SMEs, GIENAHS will facilitate the improvement of internal skills and research to embrace innovation in a more structured and systematic way. Furthermore, GIENAHS will also find ways for HEIs to improve their ability to interact with SMEs by both common research and education in general, but particularly through industry PhD education. In this study (GIENAHS, WP3) a specific aim was to propose strategies and methods for optimal long-term relationships and collaborations, including win-win situations for both HEIs and SMEs (Hillemyr et al, 2015 and 2016; Aspgren et al, 2017; Lövsund et al, 2019).

A better match between SMEs and HEIs is still required: SMEs often need to develop their internal R&D skills and to embrace innovation in a more structured and systematic way, while HEIs usually need to improve their ability to interact with SMEs, so that researchers can also see a genuine career prospect within SMEs.

To support the growth of innovation culture in European SMEs, integration between research and training activities needs to be improved, with the aim of promoting a real exchange of knowledge between companies and universities. Since most collaborations are initiated between people in these organisations, it is crucial that these people have good collaboration skills. In the long-term, universities and businesses need to invest much more in people who can facilitate this relationship and act as role models with good collaboration skills.

Gienahs is a collaborative EU-funded project between six countries (Greece, Italy, Poland, Romania, Sweden, United Kingdom) structured into 10 WPs. In WP3, the focus is on gaining a better and more thorough understanding of the SMEs' needs for research, innovation and interaction with HEIs, also in comparison to HEIs' interest in collaborating with SMEs. An important knowledge platform based on questionnaires and interviews with both HEIs and SMEs was adopted. This paper describes the results from the WP3 activities.

2. Aim

The specific aims of this study and specifically the tailored questionnaires to HEIs and SMEs are:

- to find methods and indicators to measure the success or impact of the collaboration
- to find effective ways to stimulate HEI/SME interaction and to establish long-term collaborative research
- to propose effective strategies and methods for optimal long-term relations and collaborations, with win-win situations for both HEIs and SMEs
- to propose guidelines to be used in later phases of the GIENAHS project, focused on detecting the key processes for research collaboration and innovation in SMEs

3. Method

3.1. Questionnaire

In collaboration with the GIENAHS partners, two questionnaires, one addressed to HEIs and one to SMEs, were developed to gain insights about the willingness to interact and experiences from collaborations between HEIs and SMEs. Both questionnaires were tested on some HEIs and some SMEs before they were adapted to online versions. Nine questions were addressed to HEIs and six to SMEs. The questions to the HEIs and the SMEs dealt with similar issues, in order to be able to compare the answers as much as possible from both sides. The questionnaires were divided into blocks with interrelated questions (Interests/Needs, Obstacles, Condition for cooperation and Successful practices and indications). The questions had 4-6 response alternatives to choose from, plus the option to provide comments for each question. The respondents could choose a maximum of three alternatives and rank them. Besides the questions with alternatives there were also two open questions. Reminders were sent out after about a week, recurrently.

3.2. Sampling strategy and data collection

The HEIs and SMEs were chosen to get a good distribution over the respective countries, age and size of the companies, personal contacts and knowledge about possible ongoing HEI/SME collaborations. All the respondents were informed that all the responses would remain anonymous.

Due to GDPR regulations, the questionnaire to the SMEs had to be followed by a form, which had to be read and accepted before it was possible to start answering the questions. The selection criteria for the SMEs is in line with the EU recommendation 2003/361.

3.3. Statistical analysis

To analyse the data from the questionnaires the Weighted Sum Model (WSM) was chosen (Trantaphyllou, 2000). WSM is a well-known and simple Multi-Criteria Decision Analysis (MCDA) method used to evaluate several alternatives in terms of a number of decision criteria;

*Wd= n(1)*R1 + n(2)*R2 + n(3)*R3*

where:

n(x) = number of occurrences in x rank

Rx = Weighting Factor in accordance to the x rank

(used in the current statistical analysis R1-60%; R2-30%; R3-10%)

The auditing mechanism was based on the questions in the questionnaire. For each of the questions, a maximum of three prioritised answers could be given.

4. Results

4.1. Statistical analysis

The results from both HEIs (n=37) and SMEs (n=73) are based on organisations of different sizes and ages, internal cultures, traditions and experiences of coming from different parts of Europe etc. This resulted in a fairly substantial variation, also between the countries, for each question. Figures 1 and 2 show the integrated results from the HEIs and SMEs respectively. The results are normalised, as the number of answers varies between the countries.

4.2. Integrated results from the HEIs

Figure 1 shows the integrated HEI results from the GIENAHS countries for each of the questions (Q1-Q9) and the predefined answers (a-f). For some of the questions there is a clear preference for one of the predefined answers, while for other questions there is a more even distribution among the answers.

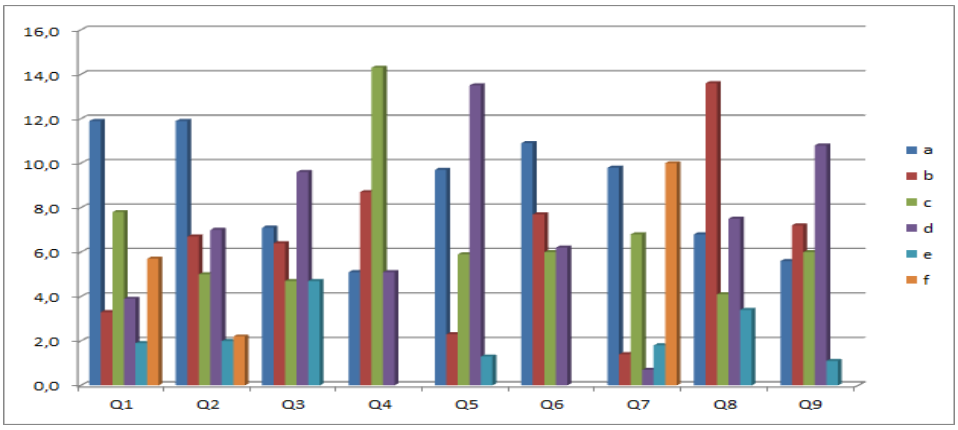


Fig. 1: WSM Analysis of HEIs. Data based on the number of answers from each country (n=37) and question (Q1-Q9). (a-f correspond to the different predefined answers).

Q1: Incentives from HEIs to start research cooperation with SMEs

- *a. Apply research findings and results in industry*
- *b. Test validity and maturity of research results*
- *c. Widen the application field of ongoing research activities within the university*
- *d. Get access to specific technologies a/o equipment*
- *e. Widen the network*
- *f. Encouragement from government*

Q2: Incentives from individual researchers to start research cooperation with SMEs

- *a. Apply research findings and results in industry*
- *b. Test validity and maturity of research results*
- *c. Widen the application field of ongoing research activities within the university*
- *d. Get access to specific technologies a/o equipment*
- *e. Widen the network*
- *f. Encouragement from government*

Q3: Barriers encountered from HEIs to start research collaboration with SMEs

- *a. Lack of academic relevance*
- *b. Limited university supervision resources dedicated to support a PhD student*
- *c. Lack of administrative resource*
- *d. Inadequate understanding of the business model of SMEs*
- *e. Legal aspects*

Q4: Obstacles to start research collaboration based on industrial or academic PhD programs

- *a. Too high TRL (Technology Readiness Levels) to be valid for PhD studies*
- *b. No appropriate application areas for university needs among possible SMEs*
- *c. Short-Term or commercial results expected from SMEs side*
- *d. No possibilities to fund costs for supervision and other costs at the university*

Q5: Type of support that should facilitate PhD programs with SMEs

- *a. SME based PhD programs are treated in exactly the same way as academic based PhD*
- *b. At the HEI centrally based team in charge of SME collaboration*
- *c. Staff located at the dept. level to specifically support SME collaboration*
- *d. Available funds at univ. a/o government to stimulate SME PhD programs*
- *e. Academic Mentors*

Q6: Best practice of PhD student employment

- *a. Employed as a PhD student at the university devoted mainly (>80%) to the SME project*
- *b. An SME employee registered as a PhD student at the university devoted mainly (>80%) to the SME project*
- *c. An SME employee registered as a PhD student at the university devoted part-time to the SME project*
- *d. Working on a scholarship in the SME project*

Q7: Activity to reach awareness of HEIs interest of SME collaboration

- *a. Informative website*
- *b. Brochure (print /electronic)*
- *c. Conferences*
- *d. Printed advertising*
- *e. Online advertising (other than own website)*
- *f. Word of mouth, "open house", or presentation. for SMEs about research and collaborations*

Q8: Desired outcome from research collaboration HEIs – SMEs

- *a. One or more doctoral degrees (PhD exams)*
- *b. Effective knowledge transfer in both directions*
- *c. Exchange of specialists (adjunct positions)*
- *d. New innovations/products/processes/methods*
- *e. More publications giving impact for the HEI*

Q9: Requirements on PhD programs

- *a. No customized programs for SMEs*
- *b. Customized programs for SMEs with other requirements on the PhD exam*
- *c. Partly adapted programs if the student see a career within an SME*
- *d. Same requirements for all PhD students but customized PhD courses for SMEs*
- *e. A half-time exam; 50% of a full PhD (like in Sweden a licentiate exam (Techn. Lic.))*

4.3. Integrated results from SMEs

Figure 2 shows the integrated SME results from all the countries' results for each of the questions (Q1-Q6) and the predefined answers (a-f). As with the HEIs' questionnaire, for some of the questions a couple of specific responses dominate, while for other questions there is a more even distribution among the answers. There is thus no real convergence towards unique options.

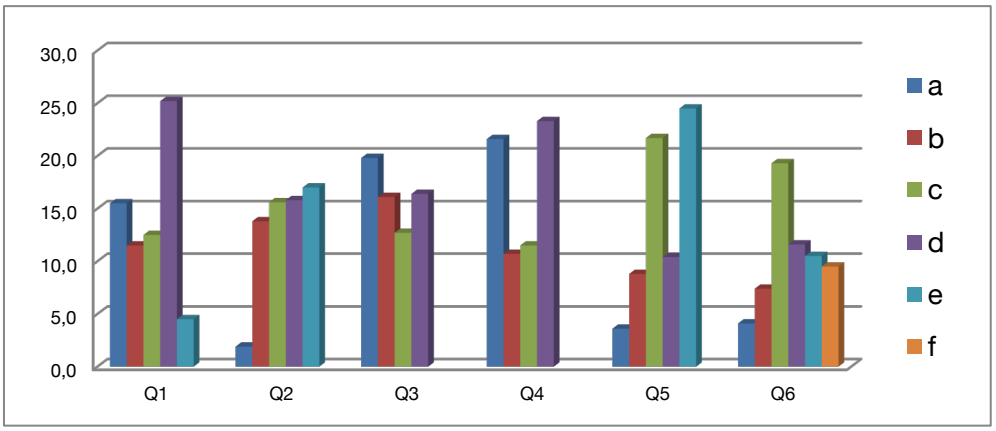


Fig. 2: WSM Analysis of SMEs. Data based on the number of answers from each country (n=73) and question (Q1-Q6). (a-f correspond to the different predefined answers).

Q1: Incentives to start research collaboration with HEI

a. Increase the market value for the SMEs by professional development of employees via industrial PhD programs.
b. Strengthen relationship through better communication with HEIs.
c. Opportunities to cooperate with students and diploma thesis workers.
d. Build and enhance scientific skills and deeper knowledge in certain areas.
e. Invitations to workshops, seminars and joint project proposals.

Q2: Barriers to start collaboration with HEIs

a. Lack of trust.
b. Limited or lack of inter-company specialists, i.e. industrial supervisor to support a PhD student.
c. Too big focus on long term research projects and/or projects at too low TRL levels (Technology Readiness Level).
d. Too little relevance in PhD studies for the SME needs.
e. Lack of financial capacity to support a PhD project.

Q3: Best practice of PhD student employment

a. A PhD student employed at the University devoted mainly (>80%) to the SME research project. External funding.
b. An SME employee registered as a PhD student at the University devoted mainly (>80%) to the SME research project. External funding.
c. An SME employee registered as a PhD student at the University devoted part time to the SME research project, allowing a prolonged project duration. Internal and/or external funding.
d. Working on a scholarship devoted full time to the SME project.

Q4: How to encourage knowledge transfer between HEIs and SMEs?

a. Contracts (HEI-SME) for sharing knowledge and intellectual property between individuals and/or organisations.
b. Foster mentoring environment by dedicated and qualified mentors.
c. Organise regular seminars and discussions on how to implement, invest and further stimulate knowledge creation.
d. Build long term confidence and trust by regular personal contacts between researchers and specialists at SMEs.

Q5: Research collaboration outcome and results with SMEs

a. One or more examined doctoral students (PhD exams).
b. Detailed contracts throughout all project collaborations.
c. Effective knowledge transfer in both directions.
d. Exchange of specialists in both directions (adjunct positions) - building trust.
e. New innovations/products/processes.

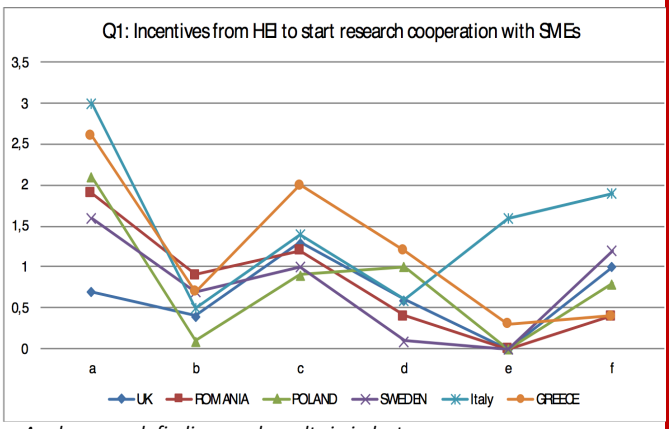
Q6: Needs for customized PhD studies with SMEs

a. No or minor need for PhD studies with SMEs.
b. No specific PhD studies specifically for SMEs, but a mentor to support a future (research) career within an SME.
c. Customized PhD studies dedicated to SMEs, i.e. different programs for doctoral students employed at university or large industry and employed by SME.
d. Partly adapted studies and requirements if the student sees a career within an SME.
e. Same requirements for all PhD students but partly customized PhD courses for SMEs
f. A half-time exam; 50% of a full PhD to see if the student and/or the SME considers it relevant to go all the way to a PhD exam (like in Sweden a licentiate exam (Techn. Lic.)), which means that the studies will at least result in one exam

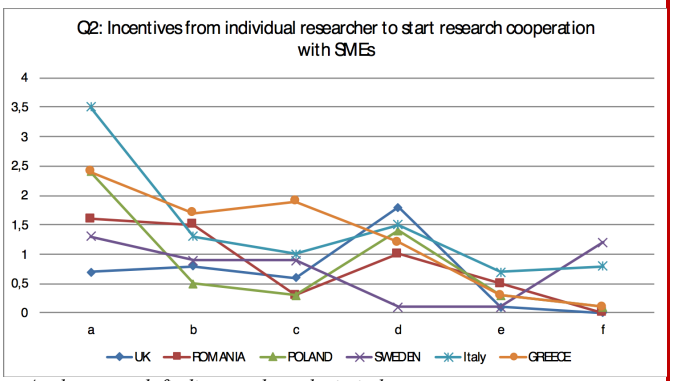
4.4. Similarities and dissimilarities between HEI and SME responses

To be able to compare the answers from HEIs and SMEs, the questionnaires were designed to be as similar as possible. In figures 3-6 the responses from the HEIs and the SMEs are grouped into blocks, where the questions are interrelated to allow simple comparisons.

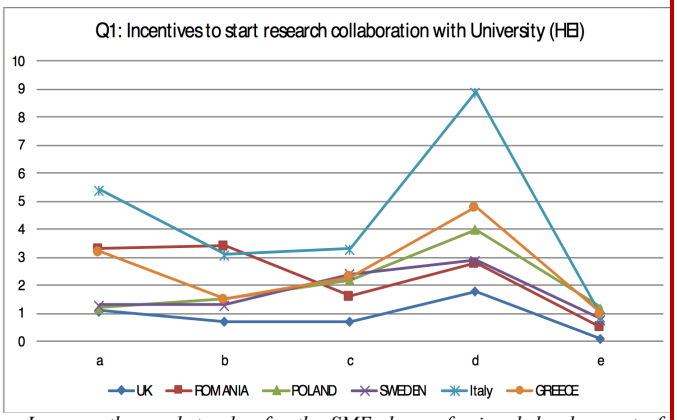
HEI perspective	Group 1: INTERESTS/NEEDS	SME perspective



a. Apply research findings and results in industry
b. Test validity and maturity of research results
c. Widen the application field of ongoing research activities within the university
d. Get access to specific technologies a/o equipment
e. Widen the network
f. Encouragement from government



a. Apply research findings and results in industry
b. Test validity and maturity of research results
c. Widen the application field of ongoing research activities within the university
d. Get access to specific technologies a/o equipment
e. Widen the network
f. Encouragement from government

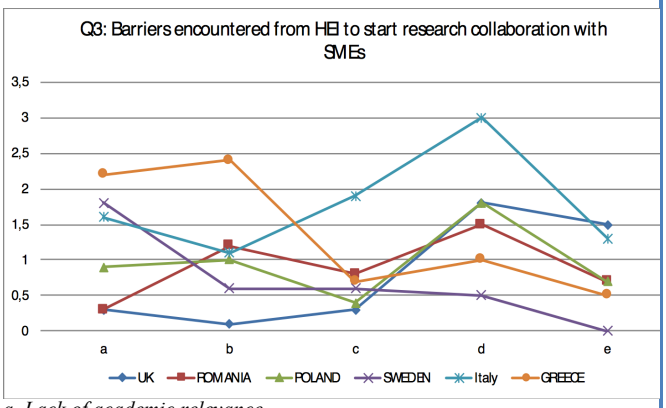


a. Increase the market value for the SMEs by professional development of employees via industrial PhD programs.
b. Strengthen relationship through better communication with HEIs.
c. Opportunities to cooperate with students and diploma thesis workers.
d. Build and enhance scientific skills and deeper knowledge in certain areas.
e. Invitations to workshops, seminars and joint project proposals.

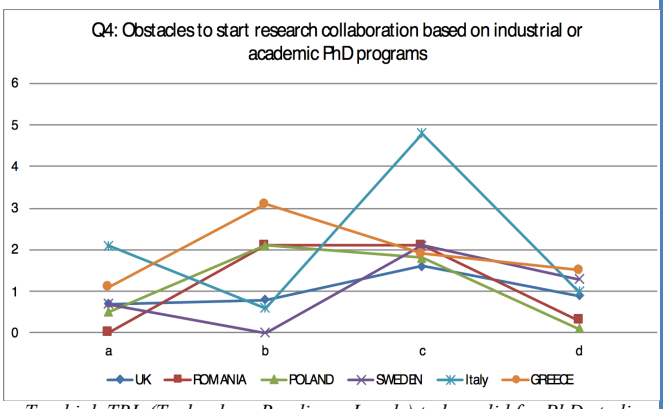
Fig. 3: Comparisons of the HEIs' and SMEs' answers under the questionnaire block: Interests/Needs (normalised data).

There is usually a large difference between the answers among the countries. In some cases, most of the countries have about the same answer but with some outlier. From both HEIs and SMEs, the main interests or needs are to increase the scientific skills, deepen knowledge and apply the existing knowledge in industry. The HEIs see collaboration potential in sharing infrastructure, while the SMEs see opportunities in getting in contact with students and diploma thesis workers and increasing the market value through the professional development of employees (figure 3).

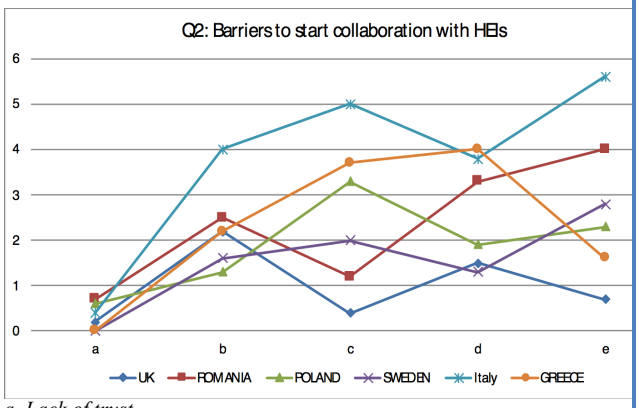
HEI perspective	**Group 2: OBSTACLES**	**SME** perspective



a. Lack of academic relevance
b. Limited university supervision resources dedicated to support a PhD student
c. Lack of administrative resource
d. Inadequate understanding of the business model of SMEs
e. Legal aspects



a. Too high TRL (Technology Readiness Levels) to be valid for PhD studies
b. No appropriate application areas for university needs among possible SMEs
c. Short-Term or commercial results expected from SMEs side
d. No possibilities to fund costs for supervision and other costs at the university

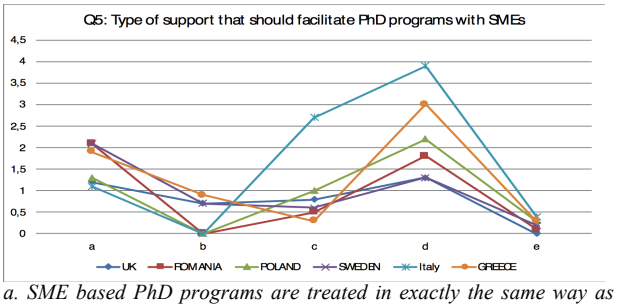


a. Lack of trust.
b. Limited or lack of inter-company specialists, i.e. industrial supervisor to support a PhD student.
c. Too big focus on long term research projects and/or projects at too low TRL levels (Technology Readiness Level).
d. Too little relevance in PhD studies for the SME needs.
e. Lack of financial capacity to support a PhD project.

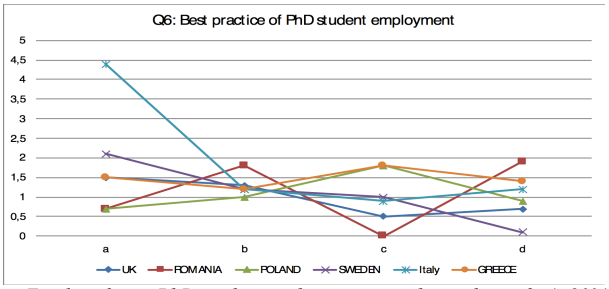
Fig. 4: Comparisons of the HEIs' and SMEs' answers under the questionnaire block Obstacles (normalised data).

In regard to obstacles or barriers for collaboration, there are both similar and opposing opinions. Both sides see a lack of resources as an obstacle to be able to support PhD projects/studies. The HEIs don't understand the business model and think that SMEs look for short-term commercial results. The view from the SMEs is that HEIs have too great a focus on long-term research. Furthermore, the SMEs consider PhD studies as having too little relevance to the industry (figure 4). For some of the questions there is a tendency to clusters among the countries, e.g. the HEIs from Greece, Sweden and Italy consider that there is a lack of academic relevance in collaboration with SMEs. Greece, Romania and Poland find that there are no appropriate application areas for universities among SMEs. From the SMEs perspective Greece, Italy and Romania are more sceptic about the relevance in PhD studies for the SME needs than those from the other countries.

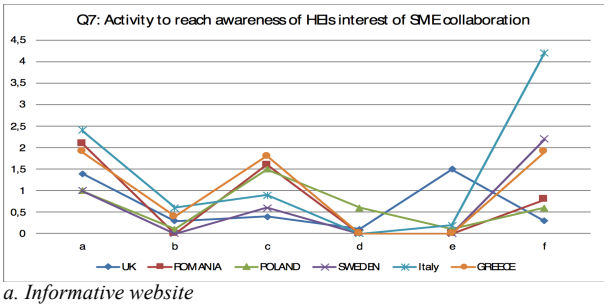
HEI perspective	Group 3: CONDITIONS for COOPERATION	SME perspective



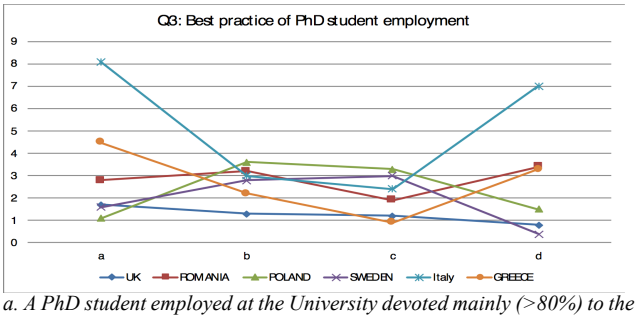
a. SME based PhD programs are treated in exactly the same way as academic based PhD
b. At the HEI centrally based team in charge of SME collaboration
c. Staff located at the dept. level to specifically support SME collaboration
d. Available funds at univ. a/o government to stimulate SME PhD programs
e. Academic Mentors



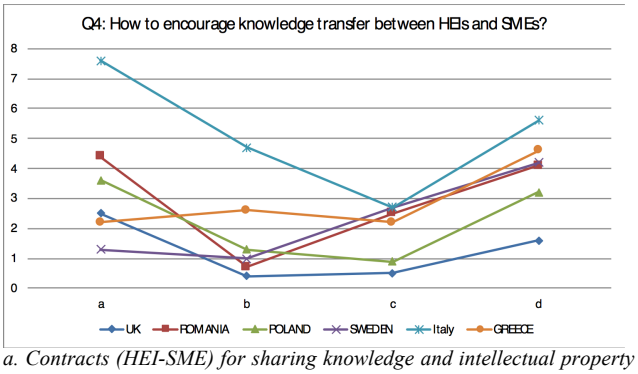
a. Employed as a PhD student at the university devoted mainly (>80%) to the SME project
b. An SME employee registered as a PhD student at the university devoted mainly (>80%) to the SME project
c. An SME employee registered as a PhD student at the university devoted part-time to the SME project
d. Working on a scholarship in the SME project



a. Informative website
b. Brochure (print /electronic)
c. Conferences
d. Printed advertising
e. Online advertising (other than own website)
f. Word of mouth, "open house", or presentation. for SMEs about research and collaborations



a. A PhD student employed at the University devoted mainly (>80%) to the SME research project. External funding.
b. An SME employee registered as a PhD student at the University devoted mainly (>80%) to the SME research project. External funding.
c. An SME employee registered as a PhD student at the University devoted part time to the SME research project, allowing a prolonged project duration. Internal and/or external funding.
d. Working on a scholarship devoted full time to the SME project.



a. Contracts (HEI-SME) for sharing knowledge and intellectual property between individuals and/or organisations.
b. Foster mentoring environment by dedicated and qualified mentors.
c. Organise regular seminars and discussions on how to implement, invest and further stimulate knowledge creation.
d. Build long term confidence and trust by regular personal contacts between researchers and specialists at SMEs.

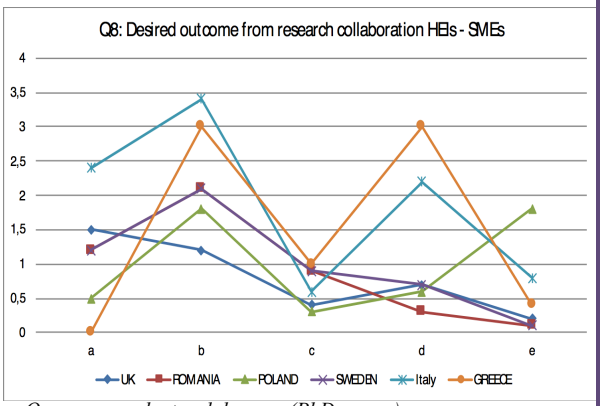
Fig. 5: Comparisons of the HEIs' and SMEs' answers under the questionnaire block Condition for cooperation (normalised data).

HEIs need funding to stimulate SME PhD programs. Furthermore, they claim that there should be the same requirements for the academic as for the industrial PhD programs. There is no clear view from

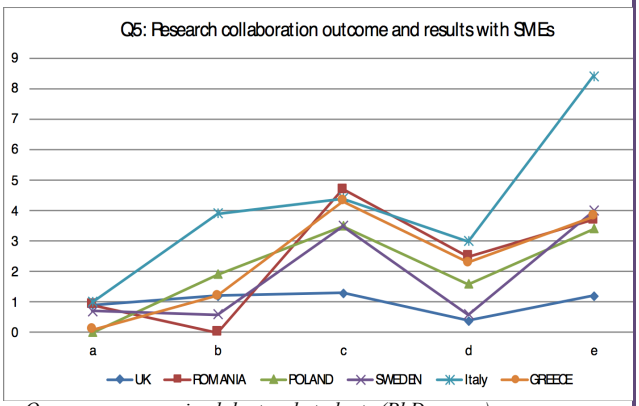
either side on where the student should be employed, if it should be at the university or at the SME, but both sides agreed that they should be working >80% with the project.

Both sides agree that there is a need to stimulate knowledge transfer between HEIs and SMEs, and appear to share similar views on how to achieve this. Regular personal contacts and networking are found to be essential for building long-term confidence and trust (figure 5).

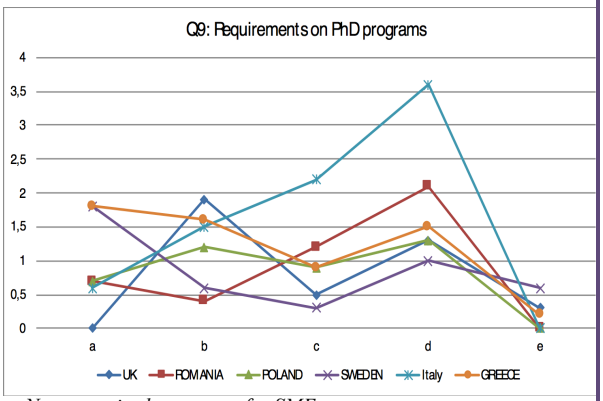
HEI perspective	**Group 4: SUCCESSFUL PRACTICES AND INDICATIONS**	**SME** perspective



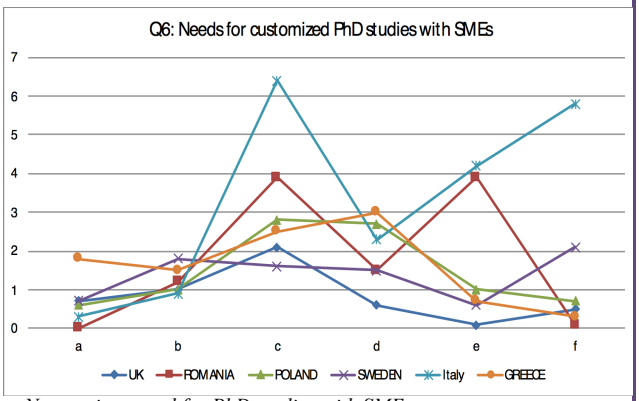
a. One or more doctoral degrees (PhD exams)
b. Effective knowledge transfer in both directions
c. Exchange of specialists (adjunct positions)
d. New innovations/products/processes/methods
e. More publications giving impact for the HEI



a. One or more examined doctoral students (PhD exams).
b. Detailed contracts throughout all project collaborations.
c. Effective knowledge transfer in both directions.
d. Exchange of specialists in both directions (adjunct positions) - building trust.
e. New innovations/products/processes.



a. No customized programs for SMEs
b. Customized programs for SMEs with other requirements on the PhD exam
c. Partly adapted programs if the student see a career within an SME
d. Same requirements for all PhD students but customized PhD courses for SMEs
e. A half-time exam; 50% of a full PhD (like in Sweden a licentiate exam (Techn. Lic.))



a. No or minor need for PhD studies with SMEs.
b. No specific PhD studies specifically for SMEs, but a mentor to support a future (research) career within an SME.
c. Customized PhD studies dedicated to SMEs, i.e. different programs for doctoral students employed at university or large industry and employed by SME.
d. Partly adapted studies and requirements if the student sees a career within an SME.
e. Same requirements for all PhD students but partly customized PhD courses for SMEs
f. A half-time exam; 50% of a full PhD to see if the student and/or the SME considers it relevant to go all the way to a PhD exam (like in Sweden a licentiate exam (Techn. Lic.)), which means that the studies will at least result in one exam

Fig. 6: Comparisons of the HEIs' and SMEs' answers under the questionnaire block Successful practices and indications (normalised data).

The results show that there must be an effective knowledge transfer in both directions and that the outcome of the collaboration results in new products, processes or innovations etc. Regarding PhD programs, there are certain differences. The HEIs feel that the requirements must be the same for all PhD students, perhaps with customised PhD courses for the SMEs, while the SMEs would like to see entirely, or partly customised, PhD studies dedicated to SMEs. The SMEs also see a value in a half-time exam (Lic. Engn.) (figure 6). From the HEIs perspective Greece and Italy have a more pronounced view than the other countries to get new innovations, products etc. as a result of the collaboration with SMEs. Greece and Sweden have a stronger opinion than the other that there shouldn't be any particular PhD programs for SMEs. From the SMEs perspective Italy and Romania are more in favour to have the same requirements for all PhD students but instead partly customized PhD courses for SMEs.

5. Discussion/Conclusion

Several studies report on collaboration between universities and industries, but only a few specifically focus on HEIs-SMEs. This study, as part of the EU-financed GIENAHS project, focuses on HEI-SME collaboration, specifically on research education and innovation. It is based on questionnaires sent out to HEIs and SMEs.

The data was analysed using the WSM analysis method and compared with the frequency analysis method. The two methods resulted in a similar outcome. There was one difference however, in that the WSM analysis gave valuable information about the strength of the response for each alternative compared with the lower ranked alternatives. The WSM was found to be useful in drawing relevant conclusions from the questionnaires and the results. The conclusions are based solely on the WSM method.

In-depth statistical analysis was not considered relevant and thus not performed, as the data doesn't allow it due to several factors such as sample size, different types of SMEs and HEIs, country-specific circumstances etc. The conclusions have thus been focused on finding trends and ideas relevant to the outcome of the GIENAHS project.

Besides the fact that the data differs to a great extent between the countries, there is also a variation within the countries. There may be several reasons for these differences, for example pre-existing SME-HEI relationships and collaborations, whether the university/department has a focus on applied or fundamental research, staff from SMEs already in the network and an already ongoing collaboration. Several studies (Gulbrandsen and Larsen, 2000; Thune 2007) appear to be very much in line with the findings in this study, in that it is difficult to create productive interaction processes in cases where there are no prior ties between the partners as there is a need to create familiarity, trust, common understanding and language, and a long-term commitment to the collaboration. Several other studies point out the need to build trust between HEIs and industry as this is vital in mitigating any barriers to collaborations (Santoro and Saparito, 2003; Bruneel et al, 2010), but this study in the GIENAHS project showed that lack of trust was no issue.

For both HEIs and SMEs, utilisation links were considered as essential for achieving the final goal and having an impact. This also proves to be an obstacle in some ways, as the HEIs want more long-term scientific projects while the SMEs prefer to look for shorter projects at higher TRL levels. The latter might explain why SMEs are more interested in getting in contact with master students and thus getting help with shorter projects, e.g. ones that could fit in to a diploma thesis.

Apart from direct utilisation links in industry-university collaborations, there are also broader utilisation routes towards achieving impact, some of which are linked directly to use in industry. The question is how to locate and visualise these routes. Traditional research tends to focus on inputs, activities and deliverables, sometimes related to outcome (short-term effects for society/industry). Impact from research has a timeline of 5-15 years and planning a research project for such a long period is difficult. However, when funding bodies increase their demand for impact, a planning process of this nature must be sought. The key point is that impact with such a time horizon is hard to achieve through research within the collaboration process. The scientific process merges into the impact process (figure 7) and the collaboration process will lead into the innovation process and ultimately generate outcome or impact in industry and society.

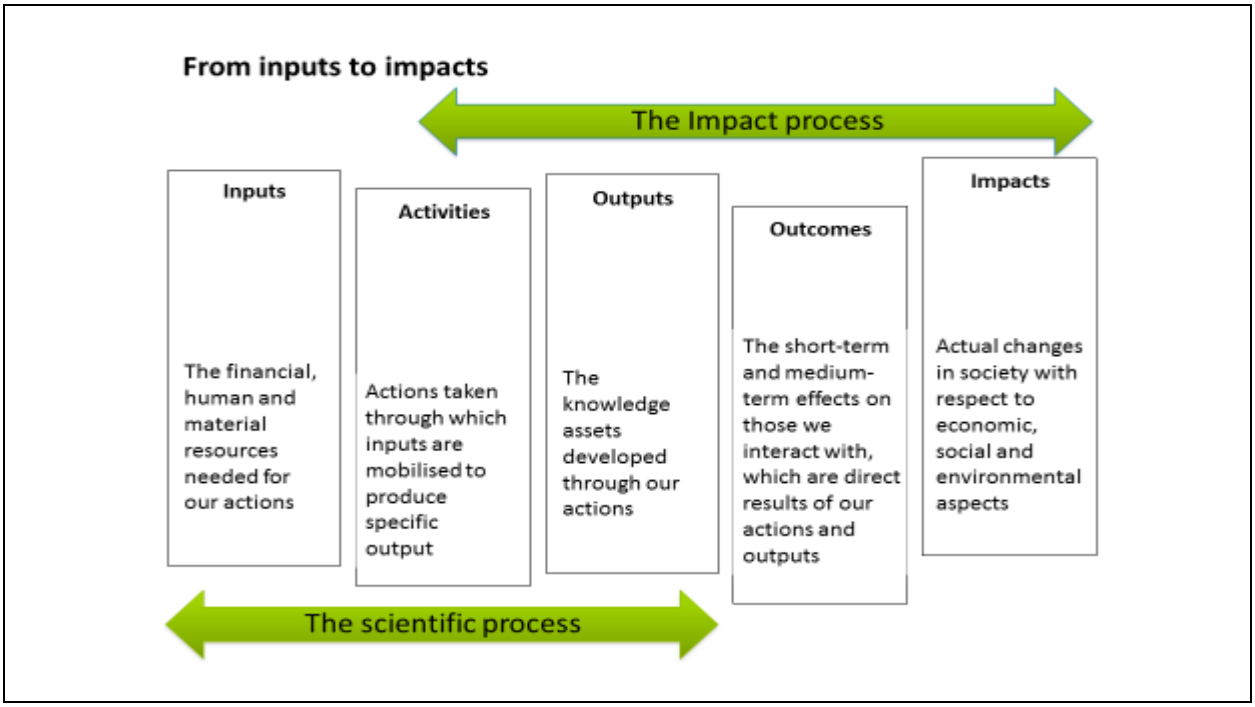


Fig. 7: From inputs to impact. The scientific process, also referred to as the collaboration process, merges into the innovation process, including the impact process (Hillemyr et al, 2016).

5.1. Conclusions specifically for HEIs

There is no doubt that there is an interest from HEIs to collaborate with SMEs and apply research findings and results in industry. Furthermore, there is an interest in achieving a knowledge transfer in both directions, for example via meetings and workshops where the groups can get to know each other. HEIs usually claim that projects with SMEs are of short duration. There is an expectation from

SMEs on commercial results and that the application areas are not in line with the university's needs. There is however a strong wish from HEIs to apply research findings and results in industry. All this points to the fact that there are opportunities to make clear improvements in favour of improved relationships between HEIs and SMEs. There is a need to get to know each other, for example through regular meetings, and to start collaborating via smaller projects e.g. with diploma thesis workers, followed by larger and/or long-term projects such as PhD projects. Of course, there might be other possibilities to start building a creative climate through a variety of innovative ways of putting HEIs and SMEs in touch with each other.

The answers from the questionnaires showed both common views and big discrepancies between the partner countries when questioned about PhD programs and PhD studies. This is probably based on long-standing and deep-rooted academic traditions in different countries and parts of Europe. A common, and important, view is that there must be some sort of support funding to cover the costs of the supervision time spent within the HEIs and in many cases to support the SMEs for their costs. Regarding requirements for PhD studies, there are different views that might be hard to handle, e.g. the duration of the studies, the amount of PhD courses and requirement on teaching activities. Some HEIs claim that the PhD programs and the requirements should be the same for both academic PhD students and industry PhD students, while others claim that there should be different programs and requirements. This is likely to be very difficult to change, as the requirements and procedures within the academy, both nationally and at different universities, are so wide and broad. A possible starting point could be to develop focused courses that meet the needs of the SMEs, which was also mentioned frequently in the questionnaires. The industrial PhD courses could be similar to those of the academic PhD path or could replace or be integrated into some courses. The predominant answer in the questionnaires is that the industry PhD students should work at least 80% with the project and be primarily employed at the university, but some responses also suggested that they should spend most of their time in industry. This might be possible to resolve, but efficient and relevant supervision of a student with a low attendance at the university is complicated and not wanted by most HEIs. Depending on the type of project and the scientific environment, the ideal time distribution between the HEI and the industry might differ. In many cases the studies would be more effective if the student spent most of their time in the academic environment. This is also in line with responses from HEIs in a recent study by Grimm (2018) regarding industry PhD programmes.

5.2. Conclusions specifically for SMEs

The SMEs' responses show big differences depending on countries, which are comparable to the aforementioned HEIs' differences. A number of parameters influence these results and might explain the differences in responses from the SMEs' side, such as the size and time of existence, experience in collaborations with HEIs, established in-house PhDs addressed to their own staff, and R&D or product development orientation.

A very positive result, from GIENAHS' perspective, is that there are no issues in regard to trust, which is an important prerequisite for extending or starting collaborations between HEIs-SMEs. Moreover, there is a willingness to collaborate, to create new networks and knowledge transfer in both directions and no less importantly, to gain access to students both as diploma thesis workers and for recruitment purposes. Some results suggest that there is a preference towards working with

diploma thesis workers, as this is more creative and in some cases, they can continue with their PhD studies. The preferences from the SMEs are in line with their own benefits, such as new products, processes and knowledge. All this indicates that there is rich potential for increasing the level of cooperation with HEIs.

Some of the problems SMEs see as barriers are the same as those mentioned by the HEIs, e.g. budget issues and resources. They also see the same problems, but with opposing views compared with HEIs, such as too much focus on long-term research projects and too little TRL. This latter could to some extent be solved if there were more chances and opportunities to get to know each other and to get a modified mindset towards more long-term R&D. Several SMEs claim that there is too little relevance in PhD studies on their needs, which are often very applied and short-term. Both these obstacles might be solved by more interaction and better understanding of the SME's needs from the HEIs' perspective, which would benefit the skills development of the SME employee, as well as provide new opportunities for improved innovation processes.

The SMEs prefer to build competence that can be used to develop new innovative products quite rapidly, therefore most SMEs had not considered PhD studies until now, when they got this survey. In the case of industry PhD students, they should be employed by the SME and work >80% with the project and with a preference for customised SME courses or programs for industry PhD students.

From some of the questions, there are simply no clear conclusions to be drawn. One finding, however, shows that there is a mutual interest in interaction with HEIs for the acquisition of new knowledge. It could be fruitful to start building a collaboration with HEIs via diploma thesis workers. The diploma thesis workers might later become PhD students, but this didn't appear to be of major interest for many of the SMEs, as it hadn't been considered before the questionnaire.

5.3. General conclusions

The results show that there are both similarities and dissimilarities in the answers from HEIs and SMEs. However, there is a common view from both HEIs and SMEs that they are open to collaborations in order to create knowledge transfer in both directions. There is however often a lack of funding for creating arenas and networks that could potentially lead to growing collaborative projects. A more specific interest in starting PhD programs had generally not been considered before this study among the SMEs, as most of them have neither research units of their own nor the financial or staffing resources. The SMEs show a common interest in obtaining higher competencies for their staff through collaborations with HEIs. There is thus a real basis for establishing and stimulating contacts and hereby initiating long-term, fruitful research collaborations and enhancing research competence. This could be done for example by building a common European standard for interaction between HEIs and SMEs using one or more of the methods below:

5.3.1. How to initiate contact and relationship

- Invite to "open houses"
  - SMEs get in contact with students and diploma thesis workers
  - Communication from HEIs about possibilities and competences
- Work with "matchmaking"

- Newsletters with positive examples
- Education for specialists in industry (continued education for professionals)

5.3.2. How to build and develop a long-term relationship and trust

- Build on already established collaborations
- SMEs and HEIs collaborate on infrastructure at one of the sites
- SMEs invited to seminars/workshops at HEIs
- Research project collaborations, via seniors, diploma thesis workers and PhD students
- Industry PhD projects and customised industry PhD courses
- Seek money for common research and PhD projects

The success in building and developing relationships and partnerships has a great potential for improvement, according to this study. However, there are big differences between countries, for various reasons. The choice of method used in each country needs to consider its specificity and also different views on research from HEIs and SMEs respectively, PhD studies and not least, industry PhD students.

Another conclusion of this study is that it is in line with several published reports and the goal to increase innovation capacity in the EU. It could generally be summarised as: university-industry collaboration is a win-win experience for both parties as well as for society. It helps to close the gap between industry/SMEs and HEIs. A successful partnership involves strategies and goals for both HEIs and SMEs and for achieving an impact and direct implementation as well as advanced research. The GIENAHS project builds the foundation for this through both a common research and education in general and industry PhD education in particular.

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