Success Factors Powering Industry-Academia Collaboration in Software Research

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Abstract

Collaboration between industry and academia supports improvement and innovation in industry and helps to ensure industrial relevance in academic research. This paper presents an exploratory study of factors for successful collaboration between industry and academia. A survey was designed for data collection and was firstly conducted in Sweden then replicated in Australia. The context for the two studies is different thus forming a starting point for potential generalizations in the future. From the two studies we conclude that the industrial side of collaboration is the key element for successful collaboration, with key factors being "Buy in and support from company management" and "Champion at company". Context-specific factors were also identified based on differences in the context between the two studies. These findings may help industry and academia to set up successful collaborative ventures.

Keywords: Technology transfer, success factors, industry, collaboration

1. Introduction

Software development organizations are continuously seeking new technologies and new processes to ensure their global competiveness. For example, at Ericsson, one of the largest providers of telecommunication systems, 80% of their R&D is devoted to software. To address these challenges organizations look beyond their industry partners for greater opportunities and more efficient innovation (Barnes et al., 2002) and collaboration between university and industry partners is seen as increasingly essential. Successful collaboration does not just happen; it has to be carefully planned and nurtured, it is therefore important to understand what is needed to make such collaboration a success, without this understanding, collaboration is likely to fail. This paper provides insights into the factors identified as being important for successful collaboration between industry and academia. Findings are based on two exploratory studies: one conducted in Sweden and the other in Australia.

This paper provides a comparative analysis of findings with a view to identifying potential common success factors, which could form the basis for future generalization.

Previous research has looked into success factors of collaboration between university and industry partnerships in technology transfer projects. Barbolla and Corredare (2009) completed a study interviewing 30 researchers in different areas, with the majority of them involved with information and communications technologies. Analysis was taken of the projects themselves, the experiences, and a determination of what made them successful or unsuccessful. This resulted in a set of

important factors for collaboration covering areas such as project, people, industrial organization, coordination and trust.

Barnes et al. (2002) completed a large research project that involved six case studies. The main objective was to identify factors that would increase the probability of successful collaboration between industry and academia. The result was a "Good Practice Model" for effective management of collaborative R&D projects, and covered areas such as partner evaluation, project management, trust, management processes and mutual benefit.

The studies presented in this paper contribute by extending the research on success factors for industry-academia collaboration into the development of software for software-intensive systems. Furthermore, it makes the relative importance of each success factor explicit by allowing the participants in the study to prioritize the different factors with respect to importance. The studies include participants from industry and academia, hence making it possible to compare and contrast findings. The factors studied are well aligned with the areas identified by Barnes et al. (2002).

2. Context

The companies represented in the studies originate from a number of different application domains: professional & personal services; pharmaceutical; telecommunications; automation; banking, finance & insurance; health & aged care; and bottler & distributor. The size of the companies ranges from a couple of hundred employees to large multinationals, industrial stakeholders include the following roles: product managers, project managers, developers and testers. From academia, the stakeholders include professors and students on different levels.

2.1 Sweden

The Swedish study was conducted within a large six-year collaborative project (BESQ, 2008) between industry and academia; matching funds from industry were required and were primarily in terms of in-kind funding. Five companies participated for the whole duration of the project. PhD students, each of whom had one main industrial partner, conducted the majority of the collaborative work. Many of the PhD students had electronic access cards, a work place and computer logins at their main industrial collaborator. The Swedish study was conducted under a stable and ongoing collaboration between Blekinge Institute of Technology and its industrial partners - after four years of collaborative work. The main collaborative process between industry and academia is described in Gorschek et al., 2006. The senior researchers, primarily involved in the role of advisors of the PhD students, and industrial respondents most likely contributed both with their experience from this collaborative project and from previous experience from other collaborations. The latter may include other smaller research projects, student projects and masters theses conducted.

2.2 Australia

The Australian study was conducted in a more general context and was primarily related to information systems research (Phillips, 2009). It included respondents from more than one university and did not have its main focus on one long-term collaborative effort. Thus, the respondents in the Australian study had a more diverse experience base. The senior researchers in the Australian study had similar general experiences as the Swedish senior researchers. Industry participants in the study

had varying experiences from different forms of collaboration between industry and academia. The experiences include different types of student research projects, joint research projects, students undertaking industrial training, consultancy and development projects. The students participating in the study came from different levels including both masters and PhD levels and had different experiences, including different thesis projects typically with data collection in industry.

3. Method

3.1 Research Questions

The objective of this research was to leverage and collect experiences and lessons learnt from successful collaboration between industry and academia across two different settings. The aim was to investigate both the industrial and academic perspectives on factors that were perceived as most important in leading to the success of such collaborations (success factors). Based on ongoing research collaborations between Blekinge Institute of Technology in Sweden and University of New South Wales in Australia, it was decided to replicate the Swedish study in Australia. Some changes were made to the research method and this is addressed in Section 4.2, however, it was perceived as valuable that the actual context for the two studies differed as it enabled a greater possibility for generalization of the findings.

Based on the above, the following research questions were investigated in both studies:

RQ1: Which success factors are considered most important in collaborations between industry and academia?

RQ2: What are the differences between industry and academic perceptions of the important factors to the successful collaboration between industry and academia?

Based on the two studies, the following additional research question was formulated:

RQ3: What are the differences between the Swedish and the Australian studies when it comes to the identified factors to the successful collaboration between industry and academia?

3.2 Survey

Both exploratory studies were conducted in the form of a survey. Participants were provided an Excel file with success factors believed to be important for successful collaboration between industry and academia. The factors in the Swedish study were based on literature [Barnes et al., 2002] and a brainstorming session with three researchers at the university. Two industrial representatives experienced in industry-academia collaboration were asked to review the list to ensure reasonable completeness from their point of view. Both confirmed the usefulness of the 14 factors they were presented with, they are as follows:

1. Champion at company
2. Champion's network within the company
3. Buy in and support from company management
4. Buy in and support from industry collaborators

5. Short term results and impact on industry
6. Organizational stability (industry partner)
7. Researcher has a visible presence in industry
8. Regular meetings
9. Relevant expertise of researcher (main person in the collaboration)
10. Attitude and social skills of researcher
11. Researcher's commitment to contribute to industry needs
12. Well-organized collaborative research project
13. Research environment at the university
14. Prior experience of industry-academia collaboration

The participants were asked to prioritize the importance of different factors for successful collaboration. Each participant was given 1,000 points to separate between the 14 different success factors. This method is often referred to as either cumulative voting or the $100-method (Leffingwell and Widrig, 2000). Each participant is allowed to distribute the 1,000 points based on the perceived importance of a success factor, resulting in a prioritized list with a relative distance representing the difference in importance between success factors.

The survey was sent to students, senior researchers and practitioners. Initially the intention was to cover different roles on both the industry and academic sides. However, it turned out that there were no statistical differences between different roles in industry and different roles in academia respectively. Thus, only industry compared with academia is reported here.

The Swedish study included 9 doctoral students, 6 senior researchers and 24 practitioners; the latter represented four companies, where one was over-represented with 15 respondents. All responses were checked to ensure that the industrial data was not biased by the dominance of one company over another. Respondents in the Australian study included 15 students, 18 senior researchers and 17 practitioners.

It should be noted, that two additional success factors were added to the Australian study: (15) Trust and (16) Short term results and impact on university. In the individual analysis, all the factors identified from this study were used and in the comparative study, only the 14 common factors were analyzed.

3.3 Statistical Analysis

Due to the bounded nature of success factors (assigning values whose sum should be 1,000), the normality assumption for parametric methods (like ANOVA and t-test) is violated. To be able to apply parametric methods for the comparison of roles, the data were transformed, using Blom's transformation (Blom, 1958), which utilizes the ranks of the values and the inverse of the cumulative Normal distribution function. The resulting data were normally distributed and standardized (mean=0 and standard deviation=1), and therefore an ANOVA or a t-test could be applied. Results with a p-value lower than or equal to 0.05 are considered statistically significant. The nonparametric Kruskal-Wallis and Mann-Whitney tests were applied on the original values of the factors to confirm the results.

4. Results

4.1 Swedish Study

4.1.1 Rankings of success factors (RQ1)

Using the survey, individual responses from the Swedish study were merged and the top three factors identified as:

1. Buy in and support from company management
2. Champion at company
3. Attitude and social skills of researcher

and the bottom three factors were:

12. Well-organized collaborative research project
13. Research environment at the university
14. Prior experience of industry-academia collaboration

It must be noted that all 14 success factors were used since they were all perceived as being important. Thus, although the success factors at the bottom are not regarded as critical as the higher ranked factors, they should not be neglected. This is one of the major points differentiating this study from others in this area. The objective of the current study is to identify and review the relative importance of success factors. From the analysis, it is clear that it is primarily the factors at the company-side that will enable the success of collaboration. However, given that it is the researcher who will go out into industry, another important factor is the researcher's ability to fit into the organizational context. The factors that ranked lowest were primarily focused on the situation at the university, providing further motivation for getting the company-side well-organized.

4.1.2 Industry vs. academia (RQ2)

The next step was to try to identify if there were any major differences between the views of the industry and academic participants. To study the differences it was decided to look at the success factors where the differences in ranking was 4 or higher, for example one factor may be ranked 1st by industry and 6th by academia in which case the difference in rank would be 5. The difference does not imply that one view is more correct than the other; it simply illustrates that the two groups have differing opinions about the importance of the success factors.

Industry believes:

- Researcher's commitment to contribute to industry needs (diff. 6 in rank)
- Buy in and support from company management (diff. 4 in rank)
- Researcher has a visible presence in industry (diff. 4 in rank)

are more important than academia.

Academia believes:

- Champion's network within the company (diff. 6 in rank)

- Buy in and support from industry collaborators (diff. 4 in rank)

are more important than industry.

The differences show that industry is more concerned with a company's management and the researcher's commitment to contribute and help them, whereas academia is more concerned with the actual collaborators, including the main champion at the company. A comparison of top 3 factors is provided when comparing the results between Sweden and Australia.

A t-test for all factors (applied to normalized values) with respect to the two-level variable (Industry/Academia) was undertaken. The independent samples t-test showed significant difference for "Researcher's commitment to contribute to industry needs" with p=0.035, and it was perceived as more important by industry. Significant p-values were also obtained for "Research environment at the university" with p=0.007 and "Prior experience of industry-academia collaboration" with p=0.007. The same differences were also found by the Mann-Whitney test (p=0.050, p=0.015 and p=0.016 respectively). For these two variables academia perceived them as more important than industry. The Mann-Whitney test gave an indication of significant difference for one more factor, namely factor 2 ("Champion's network within the company") with p=0.050. Academia perceived this factor as more important than industry

4.2 Australian Study

4.2.1 Rankings of success factors (RQ1)

As with the Swedish study, individual responses in the Australian study were merged and the top three factors identified as:

1. Buy in and support from company management
2. Shared second between: a) Champion at company and b) Short term results and impact on industry

and the bottom three were:

14. Researcher has a visible presence in industry
15. Research environment at the university
16. Short term results and impact on university

Once again, the 2 top success factors related to the company's management and the champion at the company. Researchers' presence was different across the two different contexts. The Swedish study was conducted as part of a continuous collaboration involving the same people, while the Australian collaboration was mostly based on shorter visits obtaining data from industry.

These findings indicate that industry's commitment to the collaboration is paramount and ultimately will lead to its success. Additionally, short term results and impact on university is the lowest rated factor, adding strength to the view that it is more important that industry obtains value and results from the collaboration than the university. The value on the academic side is often for the individual researcher or student involved in the collaboration, while industry expects value for the organization as such and not for individual employees. It is worth noting that one of the two new success factors

included in the Australian study (Short term results and impact on university) ended up in the last position, whilst the other factor (Trust) ended up in the middle.

4.2.2 Industry vs. academia (RQ2)

As with the Swedish study, differences in ranks between industry and academia in the Australian study were studied to capture differences in viewpoints.

Industry believes:

- Champion's network within the company (diff. 4 in rank), in particular in relation to students (diff. in rank 8)
- Short term results and impact on industry (diff. 5 in rank)
- Regular meetings (diff. 6 in rank)
- Trust (diff. 8 in rank)

are more important than academia.

Academia believes:

- Buy in and support from industry collaborators (diff. 4 in rank)
- Relevant expertise of researcher (main person in the collaboration) (diff. 9 in rank)
- Researcher's commitment to contribute to industry needs (diff. 9 in rank)

are more important than industry.

Academia is more focused on the actual researcher and the collaborators than industry is, although industry prioritizes the network of the collaborator. Furthermore, industry is more focused on the results, meetings and trust. Some of these findings are actually the other way around than when observed in the Swedish study. It points to the need to perform statistical analysis to identify the significant differences.

The same analysis was applied for both the Australian and the Swedish study with all factors (normalized and standardized) and having role taking on two different values (Academia/Industry). The independent samples t-test showed significant differences for "Buy in and support from company management" with p=0.009. It is industry that views this factor as more important. In addition significant differences were found for "Relevant expertise of researcher" (main person in the collaboration) with p=0.016 and for "Researcher's commitment to contribute to industry needs" with p=0.004. The two latter factors are perceived as more important by academia than industry. The same differences were also found by the Mann-Whitney test (p=0.016, p=0.022 and p=0.005 respectively). The Mann-Whitney test gave an indication of significant difference for one more factor, i.e. "Research environment at the university" with p=0.048. Once again, it is a factor that is viewed as more important by academia than industry.

4.3 Comparison between Sweden and Australia (RQ3)

As stated above, no statistically significant differences were identified between students and senior researchers across either the Swedish study or the Australian study, and hence the comparison of the two studies is only based on two variables: origin (Sweden or Australia) and role (Industry or

Academia). First the top 3 factors in both countries are shown in Table 1 and then a statistical analysis of the differences is provided. The table shows all top 3 success factors overall, for industry and for academia.

Table 1: Success factor ranking comparison

Success factor	Sweden	Australia
Buy in and support from company management	Overall: 1 Industry: 1	Overall: 1 Industry: 1 Academia: 2
Champion at company	Overall: 2 Industry: 2 Academia: 1	Overall: 2 Industry: 2 Academia: 1
Attitude and social skills of researcher	Overall: 3 Academia: 2	
Short term results and impact on industry		Overall: 3 Industry: 3
Researcher's commitment to contribute to industry needs	Industry: 3	Academia: 3
Champion's network within the company	Academia: 3	
Buy in and support from industry collaborators	Academia: 3	

From Table 1 it is clear that in general there is quite a high percentage of agreement. The key success factors identified were "Buy in a support from company management" and "Champion at company". In Sweden, "Attitude and social skills of the researcher" ended up being ranked 3rd. This is most likely due to long-term collaboration where it is particularly important that the researchers (in the Swedish study the PhD students) are able to work together with industry and hence attitude and social skills become particularly important. When we look at the 3rd ranked success factor, more differences appear. However, the factors which ended up being ranked 3rd were all related to the company side of the collaboration. To study the differences further, a statistical analysis was conducted.

The statistical comparison between the two countries was based first on a two-way ANOVA being applied to the normalized and standardized values of the 14 factors, which were common across the two studies. The variables in the Australian study were first rescaled to sum up to 1,000 (NB the Australia study originally had 16 factors). Each success factor was considered as a dependent variable while the two independent variables were the origin (Sweden/Australia) and the role (Academia/Industry). The success factors for which the effects of the independent variables were found significant were:

1. “Buy in and support from company management”: only an effect of role (industry/academia) was found significant ($p=0.011$) – it was more important for industry.
2. “Research environment at the university” both the main effects of origin (Sweden/Australia) and role (Academia/Industry) were found significant ($p=0.01$ and $p=0.001$) – it was more important for academia in both Sweden and Australia.
3. “Researcher has a visible presence in industry”: only the effect of origin (Sweden/Australia) was found significant ($p<0.001$) – it was more important in the Swedish study.
4. “Attitude and social skills of researcher”: only the effect of origin was found significant ($p<0.023$) – it was more important in the Swedish study.
5. “Researcher’s commitment to contribute to industry needs”: only the effect of interaction of role (industry/academia) and origin (Sweden/Australia) was found significant ($p=0.001$) – it was more important for Swedish industry and Australian academia.

Findings show that industry stresses the need for “Buy in and support from company management” more than academia. Given the importance of the industrial side in the collaboration, it is important for academia to understand the need to have management support when launching collaborative projects. Industry does not view the actual research environment as important as academia does. This is probably due to the fact that the person actually collaborating with them is more important than the research environment as such, since industry is normally on “home ground” in the collaboration. In other words, it is the researchers/students that go into industry and not vice versa. The 3rd and 4th observation is most likely due to the differences in context between Sweden and Australia. In Sweden, it is a long-term collaboration with the same PhD students being regularly and frequently in industry for several years. The participants in this long-term collaboration realize that presence, attitude and social skills are important elements in helping to make a long-term collaboration work. Finally, the 5th observation is more difficult to interpret, and hence the explanation becomes mostly speculation. Swedish industry and the academic respondents from Australia agreed that the researcher is committed to contribute to industry needs. A potential explanation is that Swedish academia perceives this as part of the package with a long-term joint project. At the same time, Australian industry may view the more short-term collaboration as a basis for recruitment rather than focusing on the actual contribution and impact, while the academic respondents in Australia like to see a contribution to industry needs.

4.4 Validity threats

Four different types of validity threats are considered: construct, internal, external and reliability threats. Construct validity is related to obtaining the correct measures for the concept studied. In the current studies, participants were people who had prior collaboration with us, or one or several of our colleagues, thus trying to ensure construct validity. As a consequence, the sample was smaller than without this requirement. Internal validity is mainly related to causal and explanatory studies. Given that our study was primarily exploratory, internal validity is not considered a problem. External validity is concerned with the ability to generalize the results. As this study has been run in two contexts and in two different countries, which is insufficient to claim generalizability as such; although it is promising that the results are similar despite the different settings for the studies in Sweden and Australia respectively. Finally, reliability is concerned with replication, i.e. if the same results would be obtained if the studies were done all over again. Given that the results are similar

between the two studies, and hence if the studies were to be undertaken once again – with the same partners – it is likely that similar results will be generated.

5. Conclusions

Two studies across two different countries with different contexts have been conducted to identify and further explore factors that should be in place to ensure successful collaboration between industry and academia; despite the different contexts, several common factors were identified. This is a very positive result as it illustrates that the findings are not only valid across one context and also points to some potential generalizability of findings, and hence the results could form a basis for future generalizations.

It is clear from the studies that the most important factors rest with the industrial side of the collaboration. This is not really a surprise, since it is normally the researcher or student that goes out into industry and not the other way around. The most important lessons learnt are:

- Buy in and support from company management is crucial.
- There has to be a champion at the company, and not only a person assigned the responsibility.
- There are different understandings between different categories of people, for example, industrial people, senior researchers and students.
- Social skills are particularly important in a long-term collaboration.

Following up on this, it also implies that the least important factors are those related to the research environment at the university. This is most likely due to the fact that it is most often academic individuals (researchers or students) that work with a company, and hence the individual is more important than academia as an organization.

Finally, the two studies also point to some differences, which are probably due to the differences in context between the Swedish and the Australian studies. In the Swedish study, it is a long-term collaboration where the same individuals collaborate with a company over several years; whilst in the Australian study, the nature of the collaboration is more short-term.

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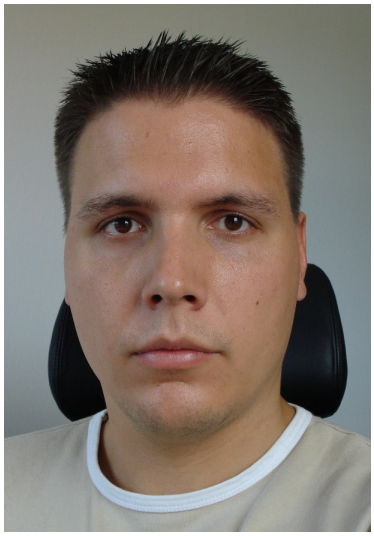

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