On collaboration between academia and practice for research and innovation: A pilot study for BillerudKorsnäs

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REPORT

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On collaboration between academia and practice for research and innovation

A pilot study for BillerudKorsnäs

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LUND
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Executive Summary

This report is based on pilot study conducted by the division of Innovation Engineering, Department of Design Sciences at Lund University for BillerudKorsnäs. The study, conducted in the beginning of 2015, addresses collaboration between academia and practice for research and innovation. The study takes its outset in BillerudKorsnäs' aim to take a more active stance based on its research agenda, identifying, initiating and supporting industry relevant research, addressing issues of: *How to find sharp research tasks that are relevant to both parties? How to bridge cultural differences and different demands? What kind of interaction model to aim for?*

The study is based on a literature review on collaboration barriers and success factors, interviews with experienced researchers at Lund University, and interviews with employees at BillerudKorsnäs. In summary, the authors of the report conclude that:

- Finding a good research task relevant to both parties builds on mutual understanding of different needs; combining practical problems with issues relevant for developing the greater knowledge base (theory) and is an exercise best done in collaboration.
- Bridging the cultural differences and other barriers is best done through greater "understanding of each other's worlds," spending time together, building trust. Improved communication and key person/-s with roles as "translators" or "liaison officers" – on both sides – are central.
- Finding the right interaction model requires investing time and other resources in relation to "the what" (the research task and expectations), "the who" (both internally and in academia), "the how" (the project set up, responsibilities, deliverables etc.) and "the when" (time frames). Addressing these lay the foundation for any interaction. Even though there are established formats through PhD-students, national programs, clusters etc. there is *no one* model. However, as a general rule long term strategic collaboration efforts – more or less formalized – are found more fruitful based on an equal partner approach where learning is at the core

In conclusion, despite the importance of mutual understanding, there are few suggestions in the literature on how to improve understanding beyond checklists for collaboration. We therefore suggest that an important step forward for a firm like BillerudKorsnäs is to develop a visual tool to facilitate mutual understanding. This "tool" should illustrate the very foundation for a

research-oriented collaboration, i.e. the “problem/-s” and potential research questions, based on a vision or research strategy visualising the “whole puzzle” as well as a more detailed description of research areas and levels. Drawing from previous and more recent findings, one such tool could be a further development of the so-called Technology Readiness Levels (TRL) model, or other generic models for project, process or product development. Furthermore, a checklist for managing collaboration from the perspective of BillerudKorsnäs – summarising the findings herein – is suggested.

1. Background

There is an acknowledged need to improve collaboration between academia and practice. With the aim to further improve their external R&D links, BillerudKorsnäs has approached the division of Innovation Engineering, Lund University, with the question on how BillerudKorsnäs can get more out of their external R&D from universities and research institutes.

The division of Innovation Engineering conducts research on innovation of both technical and social nature including design and development of new products (goods and services) and processes (technological and organisational). A central theme is the cross-functional interaction between individuals, groups and organisations throughout the innovation process from idea to commercialisation and application. Central to the research is to increase understanding on: divergent and convergent innovation processes (Process); cooperation and collaboration in cross-functional teams and perspectives (Team) and; collaboration and communication across different stakeholders and users (Network). Human centred and need-based research is essential to the division as is bridging the gap between academia and practice.

BillerudKorsnäs is a world-leading manufacturer of strong primary fibre-based packaging material, working with over 1500 customers in over 100 countries. Over the last decade, BillerudKorsnäs has taken part in and/or initiated a number of projects with different academic institutions ranging from PhD research, strategic research agendas and research project on different issues related to material and packaging research and more. Moving forward BillerudKorsnäs aims to take a more active stance based on its research agenda, identifying, initiating and supporting industry relevant research. BillerudKorsnäs' innovation agenda sets out clear priorities for the innovation work within chosen areas. Given that external research is a necessary part of the BillerudKorsnäs Innovation system, the purpose is to improve the effect of external research through:

- Linking the external research closer to the mission and the objectives within The BillerudKorsnäs Innovation Agenda
- Improving BillerudKorsnäs capabilities to find the best research providers in each field.
- Finding effective routes to initiate, follow up and implement collaboration projects and their results in the BillerudKorsnäs organisation

As a first step, BillerudKorsnäs is to address the broader question on how collaboration and cooperation between academia and practice could best be set up and managed, drawing from existing research and experience. The resulting

perspective is expected to be generic and applicable to different disciplines within the scope of External R&D for BillerudKorsnäs, however dominated by the technical field related to materials and production processes. Questions addressed are:

1. *How to find sharp research tasks that are relevant to both parties?* What are the characteristics of a good research task? How should a research task be obtained? How do we make sure that the Research task is adapted to the strengths of the research provider?
2. *How to bridge cultural differences and different demands?* Identify and describe the most important differences between companies and academia (e.g. time frames, stakeholders and financing) and propose changes. What changes in organisation and set up of External R&D is needed within BillerudKorsnäs to improve ability to bridge cultural differences? What kind of organisation and set up should we look for at the academic counterpart?
3. *What kind of interaction model should we aim for?* Supplier/customer approach, subcontractor approach, equal partner approach etc., or something unique? How should the different tasks in a research effort be distributed between industry and academia (programming, financing, project management etc.)? How do we ensure necessary control and influence over resources, decisions, results etc. for both parties?

The research project: a pilot study

The nature of the questions posed by BillerudKorsnäs corresponds well with the research areas of the division of Innovation Engineering. Given the broad scope of the question on collaboration between academia and practice, the research presented here is limited to the three overarching questions above (1 – 3), addressed in accordance with the research approach described below and agreed delimitations for this pilot study in the extent of data collection, focusing on the relationship with academia/universities. Research institutes or governmental bodies such as Vinnova are not in the scope for this study but have been considered where mentioned in interviews or literature.

In order to address the questions above, the research, data collection and analysis has been conducted in five steps:

I. Literature review and summary on “best practice” in research on the issue of collaboration between academia and practice in general and on innovation and engineering issues in particular (related to materials and production processes) where found.

II. Interviews with seven (7) researchers at Lund University who have in-depth experience from working with industry in different forms of collaborations.
III. Interviews with six (6) initiated individuals at BillerudKorsnäs who have experience from working with academia on different projects.
IV. Analysis of findings
V. Summary of findings and recommendations on measures for beneficial collaboration between academia and practice.

The end result foreseen and presented is a description of a generic model or best-practice for collaboration and interaction between academia and practice, drawing on existing research (questions 1 and 3), and a summary of differences and experiences (cultural and other) drawn from interviews within academia (Lund University) and BillerudKorsnäs (question 2).

2. Literature review

The role of external links – positioning the study

Collaboration and links to external partners is an important cornerstone of research and innovation for any organisational actor. Successful innovation management from a business perspective involves four major clusters of routines: *strategy*, *effective implementation mechanisms*, a *supportive organisational context* and *effective external linkages*.[1] A strategy for research and innovation (and an effective development process thereof), aligned with the overall business strategy, sets the scene and prevents "…*innovating because it is fashionable or as a knee-jerk response to a competitor*."[2]. Effective implementation mechanisms, for example, for new product development, is the second important ingredient. A common fallacy lies in not undertaking the initial 'front-end' activities in a product development process or lacking a development process altogether. The use of cross-functional teams with representatives of all relevant disciplines or departments is an important part here too. Thirdly, besides interdepartmental cooperation, an overall supportive organisational context is crucial in building an innovative organisation. A combination of clearly communicated goals together with enablers such as team leadership, a clear decision-making mandate and top management support, are important cornerstones.

Given those three central ingredients, a fourth is the routines for building effective linkages outside the organisation – to identify resources for research and development to actual implementation of innovations. Given that innovation is a process of know-how accumulation, or learning, effective linkages to customers, suppliers as well as university and research institutes are key for successful innovation management. Research shows that different types of R&D focus can enhance or reduce the performance impact of R&D collaborations with universities. However, there is much to be done to understand what kind of R&D focus inside a firm can enhance or undermine the benefits that arise from these external collaborations.[3] The type of research, whether it is basic, applied, or advanced development, does not affect a collaboration's impact.[4] That is, some researchers found no significant difference in terms of impact between projects with different missions. They

1 Tidd, Besssant, & Pavitt (1997).

2 Tidd, Besssant, & Pavitt (1997), p. 36

3 Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., et al. (2013).

4 Ibid.

argue, instead, that what is important is that the project addresses a tangible need for the company; collaborations must be aligned with their research and development strategy.[5]

Academia and industry collaboration

Academia-industry links (or UI-collaboration) and their impact on industrial innovation have been widely studied in different scholarly communities. With increasing international competition and rapid technological change, governments have been encouraging collaboration between academia and industry as a means of improving innovation efficiency and thereby enhancing wealth creation.[6] In particular, some authors have shown that around 10% of new products and processes introduced by firms would not have been developed (or only with great delay) without the contribution of academic research.[7] The actual impact of academia-industry links beyond the introduction of new products is believed to be far greater.

One understanding is that research collaboration between faculty members and firms is a market of some sort in which partners engage in exchange behaviour. According to a study[8], faculty members collaborating with industry bring with them a set of personal objectives for which they are willing to commit time, energy, and intellectual resources; likewise, firms have their own agendas for which they are willing to commit corporate resources. A summary of these underlying motivations of both actors is shown in Table 1, ranked by decreasing importance, based on a study of U-I collaborations in different industries.

Table 1. Underlying motivations of both actors in UI collaborations, ranked[9]

WHAT FIRMS SEEK FROM ACADEMICS	RANKING	WHAT ACADEMICS SEEK FROM FIRMS
Research on product development	1	Secure funds for graduate assistants and laboratory equipment
Conduct "blue sky" research in search of new technology	2	Gain insights into one's own research
Solve technical problems	3	Field test applications of one's own theory
Design prototypes	4	Supplement fund for one's own research

5 Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., et al. (2013).

6 Barnes, Pashby, & Gibbons (2002).

7 Mansfield (1998); Beise & Stahl (1999).

8 Lee (2000).

9 Ibid.

Provide seminars and workshops	5	Assist university's outreach mission
Conduct fundamental research	6	Create student jobs and internships
Support universities	7	Gain knowledge useful for teaching
Develop software	8	Look for business opportunity

Public research affects industrial R&D in a broad range of industries, though often in different ways.[10] There are different kinds of channels through which academic researchers interact with industry. Amongst the various channels available for establishing these links, the commercialization of academic knowledge (i.e., involving the patenting and licensing of inventions, as well as academic entrepreneurship) is considered a prime example for generating academic impact because it constitutes immediate, measurable market acceptance for outputs of academic research.[11]

While commercialization clearly represents an important way for academic research to contribute to economy and society, there are multiple other ways in which academic research is transferred.[12] "Academic engagement" is generally defined as knowledge-related collaboration by academic researchers with non-academic organisations. These interactions can include formal activities such as collaborative research, contract research, and consulting, as well as informal activities like providing ad hoc advice and networking with practitioners.[13] It is sometimes also referred to as informal technology transfer[14] that tends to be formalised using contracts. In Sweden, the most common ways that university and industry interact are through Master Thesis students, Industrial or full-time academic PhD students, Research programs/platforms and/or networks or in the form of assigned research projects (Uppdragsforskning).

Academic engagement represents an important way in which academic knowledge is transferred into the industrial domain; many companies consider it significantly more valuable than licensing university patents.[15] It is important to note that fewer academics are involved with commercialization than academic engagement.[16] In essence, commercialization means an academic invention is exploited with the objective to reap financial rewards,

10 Cohen, Nelson, & Walsh (2002).

11 Markman, Siegel, & Wright (2008).

12 Salter & Martin (2001).

13 Abreu, Grinevich, Hughes, & Kitson (2009); Bonaccorsi & Piccaluga (1994); D'Este, P., & Patel, P. (2007); Meyer-Krahmer, F., & Schmoch, U. (1998); Perkmann, M., & Walsh, K. (2008), as cited in Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., et al. (2013).

14 Link, Siegel, & Bozeman (2007)

15 Cohen, Nelson, & Walsh (2002).

16 Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., et al. (2013).

and by contrast, academic engagement is broader and is pursued for varying objectives. However, despite these differences, there are important links and overlaps between both types of activity.[17]

One study argues that the implicit assumption that successful UI alliances must lead to a transfer of technology from the university to the firm, i.e., "technology", as concrete creations, (new tools, methodologies, or products) should contribute to improving processes (quality) or outcomes (sales), is *too* narrow of a characterization, and that UI relationships are really an opportunity for learning[18]:

> *"Transferring a new tool or process may be beneficial to the firm, but many other types of learning might occur. Learning can impact the organization's strategic thinking, culture, problem-solving skills, and knowledge base. These changes may improve the organization's long-run viability more than any specific tool, method, or product. Thus, the focus on technology transfer limits our understanding of the real benefits of UI alliances."*[19]

In a recent study by the Swedish research institute Ratio, the authors' most important conclusion is that collaboration should be seen as a learning process and that industrial PhDs play an important role.[20]

Barriers and success factors

For a successful collaboration to occur, many barriers have to be overcome. At the core of the obstacles to academia-industry collaborations are the different institutional norms governing public and private knowledge.[21] Because of this inherent difference, collaborations are likely to be plagued with conflicts due to a weak attitudinal alignment between partners and a mutual lack of understanding of each other's practices and expectations.[22]

The following table, adapted from several studies, discusses some perspectives of possible barriers in UI partnerships and knowledge transfer projects.

17 Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., et al. (2013).

18 Cyert & Goodman (1997).

19 Ibid.

20 Lindberg, Larsson, & Karlsson (2015).

21 Dasgupta & David (1994), as cited in Bruneel, D'Este, & Salter (2010).

22 Bruneel, D'Este, & Salter (2010).

Table 2. Barriers to university-industry collaboration[23]

BARRIERS	ACADEMIA	INDUSTRY
Difference in fundamental motivation	Primarily motivated by intrinsic goals and social objectives of the university, recognition within the scientific community	Primarily motivated by the appropriation of knowledge for private, financial gain
Cultural differences	Explorative nature, oriented towards pure science Long-term time orientation "Public-domain" mentality: open source and publication approach	Applied nature, oriented towards problem solving Short-term time orientation Privacy and confidentiality: competitiveness and result protection
Exogenous shocks (related to market conditions, political, economic and legal risks)	Less susceptible to external factors, but still subject to disruptive events (e.g., administration turnover, change of direction and support of UI centres, bidding away of key faculty members)	Much more susceptible to external factors (e.g. mergers, acquisitions, reorganisations, fluctuations in economy, downsizing)
Mutual lack of understanding	Typically does not understand market forces, time demands, and the incentive structure of the firm	Typically does not understand how work gets assigned in universities or how university budgets are created, and is unfamiliar with investments in physical and human capital that preceded their relationship with the university
Administrative and organisational barriers	Bureaucracy and inflexibility Lack of mature and formal procedures for university-industry collaborations Poorly-designed incentive systems Potential conflicts related to intellectual property (IP), ownership, and exploitation	

Many authors have presented suggestions on how to improve UI relationships to ensure successful collaborations. Success factors regarding UI knowledge transfer, technology transfer, or general collaboration management have been reported in different studies.

23 Adapted from: Bruneel, D'Este, & Salter (2010); Cyert & Goodman (1997); Schofield (2013); Siegel, Waldman, Atwater, & Link (2003).

One study offer a summary of the critical success factors for *knowledge transfer* in UI collaborations, grouping them into seven main categories, as seen in the table below. Among these factors, the most cited are: (i) understanding of customer needs, (ii) common goals, (iii) a clear focus on translation, (iv) an understanding of intellectual property issues, and (v) early technical scoping of the project to ensure the alignment of mutual goals and objectives.[24]

Table 3. Success factors for knowledge transfer in UI collaborations, by category[25]

CONTEXT	CRITICAL SUCCESS FACTORS
Knowledge context	• Partners' mutual confidence • Strong translational focus • Alignment of research objectives and with partners' strategic objectives
Organisational context	• University ranking • Support at the senior level • Network assets • Policies and incentives for knowledge transfer activities • Risk taking propensity • Well-developed IP strategy
Decision-making context	• Support at senior management level • Decision on project ownership at an early stage • Framework for assessing feasibility (for international collaborations)
Individual context	• Relative academic freedom • Academic champion • Entrepreneurial expertise • Personal motivation • Personal goals
Project management	• Flexibility and adaptability • Strong project management • Industry early involvement in the process • Past experience of partners • Effective communication
Market context	• Supportive national Government • Absorption capacity and ability to learn from best practice • Strong market knowledge • Thorough due diligence analysis • Risk assessment and mitigation strategies
Relational and cultural context	• Knowledge of national culture • Trust and openness • Long-term commitment • Knowledge of local language (for international collaborations)

24 Schofield (2013).

25 Ibid.

Another study reports specific recommendations for both actors on how to improve *commercial knowledge transfer* (i.e., technology transfer) in UI collaborations:

Table 4. How to improve university-industry technology transfer (UITT)[26]

SUGGESTED UNIVERSITY-BASED IMPROVEMENTS	SUGGESTED FIRM-BASED IMPROVEMENTS
• Universities need to improve their understanding of the needs of their true ''customers,'' i.e., firms that can potentially commercialize their technologies • Adopt a more flexible stance in negotiating technology-transfer agreements and streamline UITT policies and procedures • Hire licensing officers and technology transfer office (TTO) managers with more business experience • Switch to incentive compensation in the TTO • Hire managers/research administrators with a strategic vision, who can serve as effective boundary spanners (tie to boundary spanning literature) • Devote additional resources to the TTO and patenting • Increase the rewards for faculty participation in UITT by valuing patents and licenses in promotion and tenure o decisions and allowing faculty members to keep a larger share of licensing revenue (as opposed to their department or university) • Recognize the value of personal relationships and social networks, involving scientists, graduate students, and alumni	• Be proactive in their efforts to bridge the cultural gap with academia • Hire technology managers with university experience • Explore alternative means for tapping into UITT social networks

These recommendations are quite limited to the commercialization aspect of collaborations between the university and industry, thus there is a focus on technology transfer offices and its activities. In many situations, however, a lot of improvement is still needed not just in these liaison-related activities, but in other aspects of the collaboration project, as well.

A limited number of studies offer findings from an *industry* perspective on how to best approach and manage collaboration with academia. The selected study below presents seven of the best practices that firms should implement in order to achieve competitive impact from UI research collaborations. The best practices mentioned below emphasize the importance of focusing on collaboration *impact*, not outcome; that is, how the new knowledge derived

26 Siegel, Waldman, Atwater, & Link (2003).

from collaboration with a university can contribute to a company's performance.[27]

Table 5. Seven keys to collaboration success, from a company perspective[28]

BEST PRACTICES
1. Define the project's strategic context as part of the selection process. a. Use your company research portfolio to determine collaboration opportunities. b. Define specific collaboration outputs that can provide value to the company. c. Identify internal users of this output at the working level; executive champions are not a substitute for this requirement.
2. Select boundary-spanning project managers with three key attributes: a. In-depth knowledge of the technology needs in the field b. The inclination to network across functional and organisational boundaries c. The ability to make connections between research and opportunities for product applications
3. Share with the university team the vision of how the collaboration can help the company. a. Select researchers who will understand company practices and technology goals. b. Ensure that the university team appreciates the project's strategic context.
4. Invest in long-term relationships. a. Plan multi-year collaboration time frames. b. Cultivate relationships with target university researchers, even if research is not directly supported.
5. Establish strong communication linkage with the university team. a. Conduct face-to-face meetings on a regular basis. b. Develop an overall communication routine to supplement the meetings. c. Encourage extended personnel exchange, both company to university and university to company.
6. Build broad awareness of the project within the company. a. Promote university team interactions with different functional areas within the company. b. Promote feedback to the university team on project alignment with company needs.
7. Support the work internally both during the contract and after, until the research can be exploited. a. Provide appropriate internal support for technical and management oversight. b. Include accountability for company uptake of research results as part of the project manager role.

27 Pertuze, Calder, Greitzer, & Lucas (2010).

28 Ibid.

Trust – a particular issue

Inter-organisational trust is one of the strongest mechanisms for lowering the barriers to UI interactions.[29] Trust formation between academics and industry practitioners requires long-term investment in interactions, based on mutual understanding about different incentive systems and goals.[30] Face-to-face contacts between industry and academia are also essential, initiated through personal referrals and sustained by repeated interactions, involving a wide range of interaction channels and overlapping personal and professional relationships.[31]

Trust, as an essential element in inter-organisational relationships, has been approached from numerous perspectives and levels of analysis. The general consensus is that there are two essential elements to the concept of trust: *positive expectations* and *willingness to be vulnerable*.[32] Indeed, collaborative research exposes both sides to a certain degree of vulnerability to exploitation. Many academics view funding from industry as having strings attached that negatively influence their research; likewise, many firms view universities' demand for exclusive ownership of intellectual property rights as an impediment for working with universities.[33]

The amount of trust between partners is positively related to knowledge transfer and innovation performance. According to one study on trust in UI collaborations, trust formation relies heavily on 1) transparency and flexibility of university IP policies, 2) shared governance between the actors and 3) behaviour of UI collaboration champions, although the relevance of these factors may vary between the stages of collaboration.[34] In order to enhance trust, companies should not only consider university IP policies, but also need to actively engage in shared governance with university partners. For example, UI collaboration champions can help shift the attention of company managers from formal rules set by university IP policies toward shared project planning, coordination, and implementation with university partners.[35]

29 Bruneel, D'Este, & Salter (2010); Mora-Valentin, Montoro-Sanchez, & Guerras-Martin, (2004).

30 Bruneel, D'Este, & Salter (2010).

31 Ibid.

32 Rousseau, Sitkin, Burt, & Camerer (1998).

33 Hemmert, Bstieler, & Okamuro (2014).

34 Bstieler, Hemmert, & Barczak (2014).

35 Ibid.

It has been well established that academia-industry links greatly impact industrial innovation. However, due to fundamental differences between the university and the firm, it is not uncommon for collaborations to be afflicted with conflicts and barriers, usually due to a mutual lack of understanding and alignment between the partners. Differences in motivations and expectations of each partner, inherent cultural differences, and organisational barriers are among the most cited barriers to collaboration between the university and industry. There is obviously a need to improve the understanding of how these two different organisations can more effectively interact with each other, and several studies have attempted to address this prevalent dilemma by suggesting different models for collaboration.

Models for collaboration

University-industry links, relationships, joint research, and partnerships (in general) are widely practiced as a source of innovation. One study reported a typology of the different ways university and industry interact, according to the extent of relational involvement, from low involvement (i.e., knowledge transfer) to high involvement (i.e., relationships).[36] Commercialisation of intellectual property represents an important way for academic research to contribute to economy and society, but there are many other ways that university knowledge is utilized. Within the context of open, networked, and interactive innovation, this study suggests that actual relationships between the university and industry, rather than just generic "links," play a stronger role in generating innovations.

Table 6. Typology of UI links according to extent of relational involvement[37]

EXTENT OF RELATIONAL INVOLVEMENT	TYPE OF LINK BETWEEN UNIVERSITY AND INDUSTRY	
Low: knowledge transfer	Commercialization of IP (e.g., licensing)	
Medium: mobility	Academic entrepreneurship Human resource transfer	
High: relationships	Research partnerships: Collaborative (or sponsored) research University-industry research centres	Research services: Contract research Consulting

Another study discusses the importance of various channels through which knowledge and technology is transferred between university and industry.

36 Perkmann & Walsh (2007).

37 Ibid.

They concluded that the choice of interaction channel depends on the several factors:

> (1) Basic characteristics of the knowledge in question (tacitness, systemicness, expected breakthroughs)
> (2) The disciplinary origin of the knowledge involved
> (3) (To a lesser degree) individual and organisational characteristics of those involved in the knowledge transfer process (seniority, publication record, patent record, entrepreneurship, and research environment).[38]

The same study suggests that firms are better equipped to define their own strategy of interaction with a university after having reflected on their present and future knowledge needs. They found two major patterns of interactions for firms that aim to become innovators or early adopters in the market:

> *"One strategy more focused on collaborative and contract research to support the adoption of interdependent knowledge, especially in areas such as biomedical science and computer sciences; the other more reliant on patents, licensing and specific organised activities to support access and adoption of systemic knowledge, especially in material sciences and chemical engineering. In both cases, as firms need to engage in the application of scientific published knowledge to the specific needs of their products and of the markets' needs, firms also need to rely on scientific publications, informal contacts with university researchers and students. Moreover, absorption and adoption of breakthroughs seem to depend on labour mobility, as Zucker et al. (2002) argued."*[39]

Another study suggests a process model for U-I research collaboration, which aims to provide practitioners with a "route map" of how to develop and manage research collaborations.[40] The process function of the model, as seen in the figure, is based on a linear sequence of groups of activities involving the five stages: terrain mapping, proposition, initiation, delivery, and evaluation. The sequence of activities is supported by two information or knowledge elements, the technical mission and business mission, which allow the collaboration process to be linked with the strategic management activities undertaken both within the university and the industrial firm.

38 Bekkers & Bodas Freitas (2008).

39 Ibid.

40 Philbin (2008).

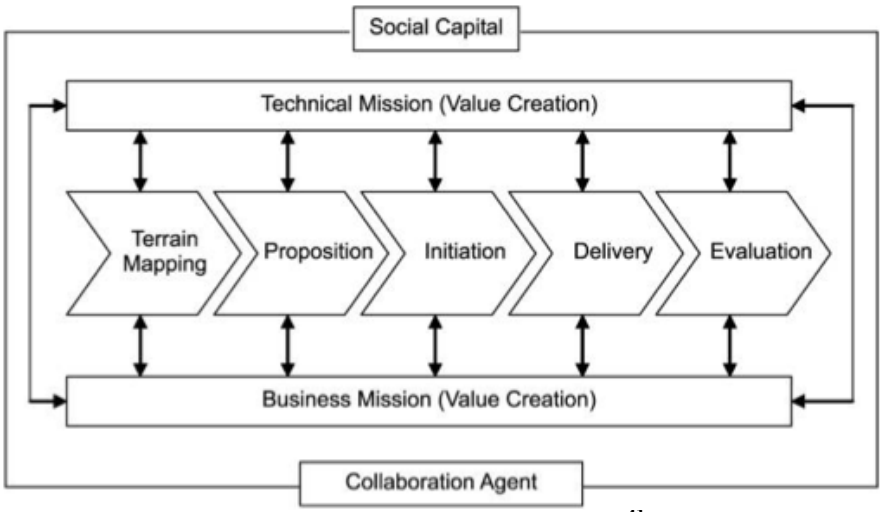

Figure 1. A process model for UI research collaborations[41]

The model also includes social capital, to capture the necessary social interactions that are required for collaboration, which in reality are difficult to manage. The final element is the "collaboration agent," an individual who personally drives forward the collaboration and is responsible for achieving the required objectives in order to initiate and deliver the collaboration. It should be noted, however, that this model is focused on contract research and not technology transfer (e.g., commercial exploitation of IP rights through licensing deals).[42]

Other studies suggest practice models, one that incorporates earlier mentioned success factors into other key areas that are important in managing of UI collaborations, such as partner evaluation method, good project management, universal success factors, flexible management processes, maintaining commitment of industrial partner, and mutual benefit.[43] The details of such a process model can be seen in the figure below.

41 Philbin (2008).

42 Ibid.

43 Barnes, Pashby, & Gibbons (2002).

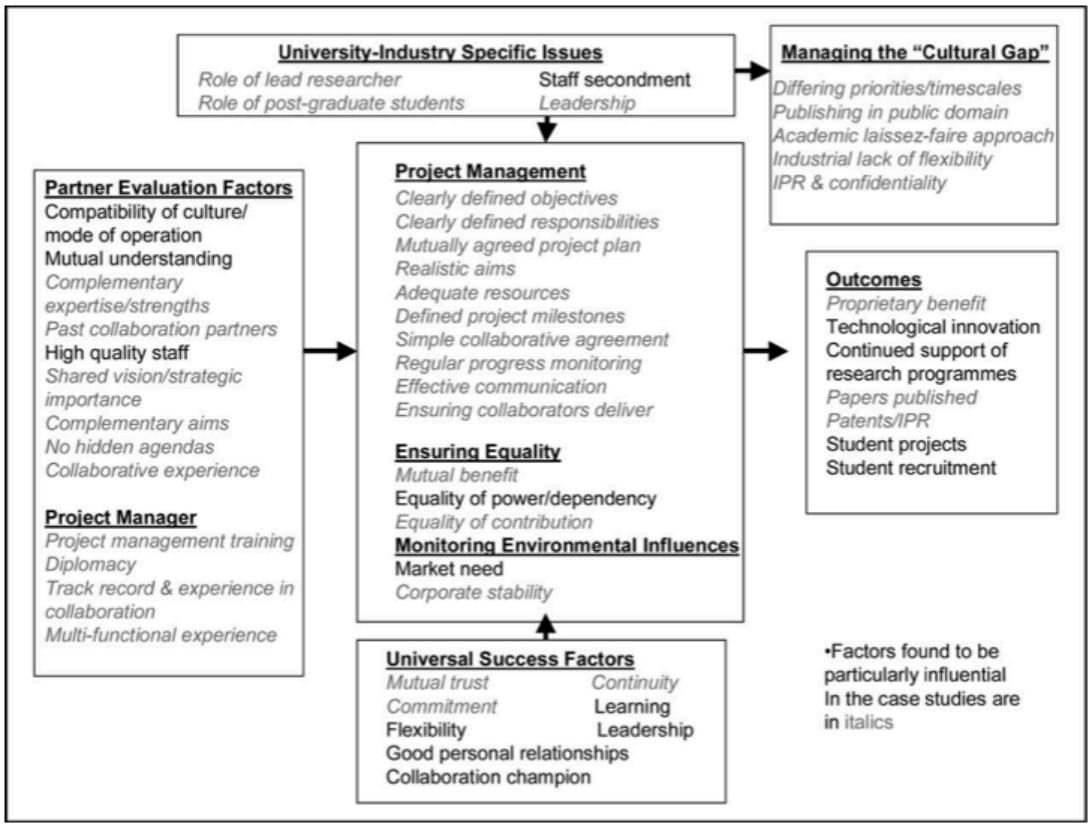

Figure 2. Practice model for collaboration management[44]

A tool for enabling understanding

Technology Readiness Levels (TRL)

An overarching barrier to UI projects is the mutual misunderstanding between the collaborators (university and the firm) in terms of each other's drivers, time horizons, expectations, the actual research scope and other differences. To effectively enable collaboration and to increase innovation efficiency between the university and industry, this should be resolved through bilateral understanding.

In order to effectively develop the research results into innovative products and services on the market, strategic planning of the research initiative is important, and one way to facilitate this strategic understanding between the university and the firm is through the use of the Technology Readiness Levels

44 Barnes, Pashby, & Gibbons (2002).

(TRL) tool.[45] TRL is a systematic measurement system, developed by NASA, which supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology.[46] A graphical TRL scale has nine criterion levels that visualize the technology readiness in increasing levels of technology maturation (e.g., from NASA's Level 1, "Basic principles observed and reported", to Level 9, "Actual system 'flight proven' through successful mission operations").

In Sweden, the TRL model can foremost be found in the defence and automobile industry and has just recently spread to other industries and the academic community. In 2014 it was introduced in the EU Horizon 2020 program to provide a common understanding of technology status, provide the scope for research and direct funding, addressing the entire innovation chain. The generic TRL set up for Horizon 2020 follows the original nine steps, defining the separation (and funding) for technologies with lower TRLs (Future and Emerging Technologies in Horizon 2020) and technologies with higher TRLs (Leadership in Enabling and industrial technologies'/LEITs).

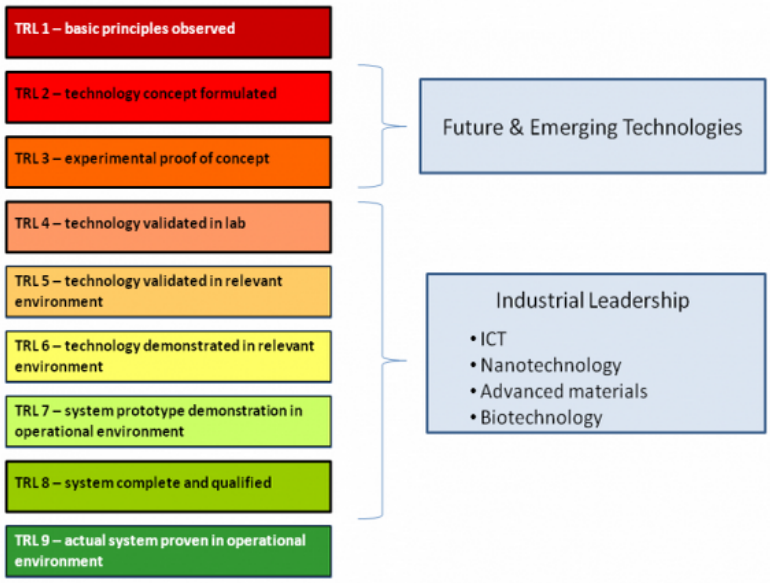

Figure 3. TRL levels according to Horizon2020[47]

In a recent study, the use of TRL as a means to create a common platform for identifying common interests and competencies has proved useful. TRL can

45 Wallin, Isaksson, Larsson, & Elfström (2014).

46 Mankins (1995).

47 Topstart (2014).

generically communicate and visualize the maturity of a technology, a methodology, or a tool, thus instantly facilitate understanding between people with different skills and in different organisations; however, it can also be strategically used to visualize the current and future state of development projects internally and externally.[48]

An example of TRL as an intuitive tool for facilitating understanding is seen in the figure[49] below, which shows how different development projects (GENx, TXWB, PW1000) can be positioned on the TRL scale over time, which is a change from the original use of TRL as an implicitly linear scale. Shown in the figure, is one company's use of the TRL tool to show their partners how their national and EU projects have, or are expected to climb the ladder of the TRL scale from basic technology projects to product development projects.

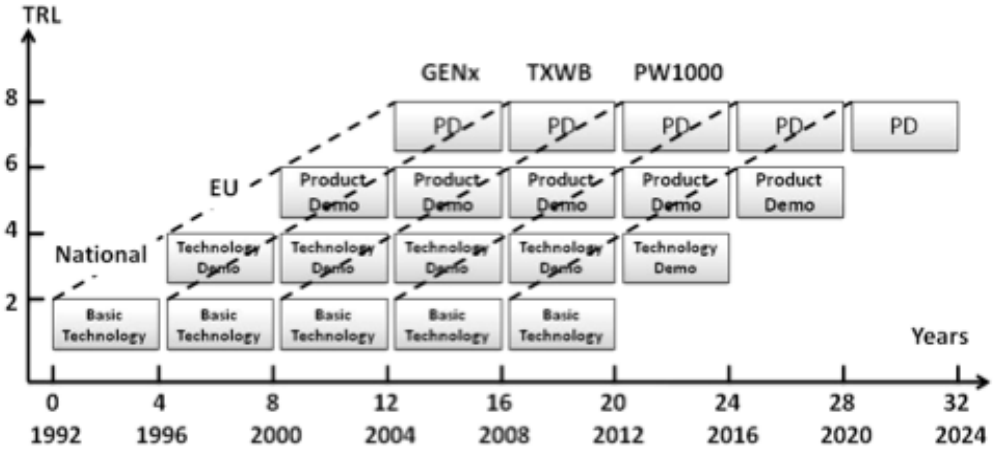

Figure 4. An example of how one company visualizes Research Projects on a TRL scale over time[50]

Communicating a company's research agenda, broken down in different projects and steps over *time*, facilitates common understanding not only on the maturity of technologies but also methodologies, tools and development projects.

It is should be noted that the TRL scale, although proven to be useful for different organisations, requires adaptation before it can be used within a

48 Wallin, Isaksson, Larsson, & Elfström (2014).

49 Ibid.

50 Ibid.

specific context.[51] Using the TRL as a tool to communicate a company's development processes and its different stages externally and in particular to academia has proved very useful, albeit not a widespread approach as of yet.

In summary, effective external linkages are important for successful innovation management in a company. A considerable amount of research has proven the relevance of university-industry links in today's increasing international competition and rapid technological change. It is essential that companies be well equipped to effectively participate in collaborations. Different knowledge transfer or collaboration mechanisms may require different support structures within the firm and the university. There have been many recommendations in literature on how to improve UI collaborations. One important example, from an industry perspective, is that a collaboration project will best impact the company if the project goals are aligned with their vision and research strategy. There is a multitude of barriers to university-industry collaborations; therefore, universal success factors such as trust, communication, and mutual understanding will always be important regardless of the kind of collaboration model used.

51 European Association of Research and Technology Organisations (2014).

3. What scientists say

From academia's perspective, collaboration with the industry is not only desirable but also viewed as a necessity on both sides, with mutual advantages including knowledge development and resource exchange, among others. Most academics agree, however, that there is a huge divide between the academe and the industry that needs to be addressed further in order to produce successful collaborations. Experienced academics from Lund University and the Faculty of Engineering, with extensive history in collaborating with industrial firms in different setups were interviewed. The interviews were conducted and structured in accordance with the three main questions on research task, cultural differences and interaction models. The interviews focused on UI collaboration in general and not on BillerudKorsnäs per se, which was not the purpose.

On research tasks

Mutual understanding of different needs

Developing and defining a research task, or research question from an academic perspective, is one of the most important steps in a research process. The research question and purpose of a study should in turn be based on an identified problem, a problem or gap found in practice *and* theory. The aim of a study should be to contribute to practice, but foremost to knowledge and theory building.

In a UI partnership, identifying the "problem/-s" and developing the research task together is perceived as especially important. Of importance is that "real" industry problems are identified (i.e. need-based), which in turn correspond with a need to confirm, reject, or fill a gap in existing theory or knowledge base. In identifying problems and a possible research task, researchers often experience that industry a) do not know what they want or b) provide a problem and research task that they *think* researchers can manage, and/or c) struggle to "aim high". A quote from one of the interviewees: "*Industry can't think big*", captures the experience that industry set the bar too low in their scope and the view that researchers are, by nature, more explorative and innovative in identifying problems and hence scope for finding potential solutions. "*We are free to think big – we are not bound by quarterly reports or the bottom line*".

Given the inherent differences in the ways of working of the university and the industry, research task and subsequent objectives should be developed

together, with the aim of having mutual understanding and alignment throughout all the stages of a project. Without joint efforts in defining research tasks the result may be unsatisfactory, especially from a firm perspective. One example is reaching an agreement for developing master's thesis or PhD topics. A company often wants to have very concrete answers connected to their business, while it is the role of the academic supervisor to make sure that the scope and results of an academic work do not only serve to answer a practical research question and purpose but also theoretical ones. As said by one of the interviewees, "*Industry needs should be aligned with academic excellence*" meaning that a UI collaboration has to build on a mutual understanding for, for example, particular industry *and* theory building related issues to advance knowledge on a broader scale. Some of the interviewed academics refer to that there are times when the academe drives the formation of the research task and objectives, particularly in large projects involving several levels of researchers and PhD students. The reason, again, being to ensure a broad research approach (i.e. considering perspectives of both practice and theory) and the need of, for example, PhD students to gradually develop knowledge for their thesis, which cannot be sacrificed for short-term project results. This aspect is often not considered by firms when they start UI projects.

Coming to a mutual agreement is believed to require openness and clarity from all actors' right from the beginning. As much as there is an experienced misunderstanding from the perspective of industry on how academia works, there is an acknowledged view that it takes two to tango. Researchers also see the need to improve their understanding of the reality of business. This is equally important in order to identify need-based problems and define research tasks not only with the view to publish a neat result, but a result that is also applicable in industry in terms of for example scalability and cost-efficiency.

Framing the task and the issue of time horizons

Framing a research task in UI collaboration is closely coupled with the time horizon set out in for example a four to five year PhD project or national research program which can be set to three to several more years. A common view in industry that academics are aware of, is that the academic processes are slow and take too long. One of the reasons for this may be the academic time frames per se coupled with the way of working. Another aspect may be the scope of research. In areas such as biotechnology, future materials and even a more socially scientific area such as innovation engineering (i.e. management) basic research may be needed to precede applied research. While faculties of engineering and universities of technology focus on applied research there is an acknowledged discrepancy between academia and industry in what that actually means. This discrepancy will affect the timeframe as well

as the end result. Hence, framing the task in a UI collaboration, i.e. really understanding differences in scope may be an important parameter to also understand the time frames. Another important aspect here is also the researcher's competence. While a PhD student may not have a thorough understanding of a problem in theory, or practice, (and has to lay the foundation for his or her research) a professor is at a different level, with more or less experience from working with industry.

Hence, for applied and particularly short-term research tasks, a firm should consider if partnering with the university is the best step forward, or if other channels (e.g., consultants) should be approached instead. However, depending again on the task, a UI collaboration may well deliver applicable results in the short-term perspective, given that both parties are on-board when it comes to defining the research task, objectives and deliverables, with an openness from both parties to re-defining throughout the project.

On cultural differences and different demands

We live in different worlds

> *"It's about making them understand who we are, what we do, what we want - and we need to do this right from the start."*

The underlying reason for most of the barriers in UI projects is that people in the university and the industry have a mutual lack of understanding about each other, in terms of their differences in environment, culture, business model, expectations, and time frames. A description of a researcher will naturally vary along age, research area etc. but a general illustration, drawing from the interviews, shows a person who is: curious, driven to find answers, a person who (in accordance with the academic career ladder) needs to publish academic articles (relentlessly), give lectures, supervise students, network and cooperate with other researchers preferably globally, contribute and interact with society – all while also being responsible for financing her studies or research projects applying for grants or answering to calls from institutions like Vinnova. The time frames are naturally long term, the university system is big and its' main task is education.

The understanding of industry and business differ among researchers and typically depend on experience. In this study all interviewees have extensive experience from working in industry and/or UI collaboration projects. Two of the main differences they point to are differences in drivers, i.e. publications vs. applicable results, and funding. On drivers, the view is that *if* there was an

open discussion right from the beginning about project expectations, demands, time frames, it will be easier for both to understand the long-term benefits of working with each other. The mutual benefits must be clearly discussed, since the university and industry have inherently different ways of measuring success. One example mentioned by an academic was about how he explains the academia's business model to the industry in a simple way: *"Publishing results is as important to academics as it is important for businessmen to sell."* While researchers are good at publishing, some believe that they are not good at commercialising their results. In general, researchers have a cloudy idea of the potential business in their results and are seldom driven by a commercial interest.

Funding is a challenge for UI collaboration from more than one perspective. While a prerequisite from universities' research funding partners increasingly is to find co-financing from third parties, i.e. industry, there is limited internal support structure on how to identify, establish or formalise such set-ups (see more under Interaction models). Funding or understanding the "business model" is not as inherent for a researcher as it may be for a person in industry with clear budgets, KPI's and a common bottom-line. On another note, given the public education system in Sweden, it is often perceived that companies view students as a "free resource" so they are more open to involving them in solving company problems through student projects. Researchers, on the other hand, are sometimes wrongfully considered under the same classification, that companies can just ask for information from them for free. This can be because of lack of knowledge of the industry on how academic researchers are involved in a different system of financing, and that they often have to compete against each other for funding.

Inflexible administrative policies (on both sides) that make it difficult to smoothly facilitate partnerships and collaborations with external actors is one barrier that might be overcome, if only both the university and industry will have better knowledge of how to approach, understand, and communicate with each other.

Trust and communication

Given the different cultures, trust (or the lack thereof) is a related theme that researchers find to be a barrier in UI collaboration. Building trust takes time and is developed through collaboration experience, openness and communication. From some academics' point of view, industry can do a lot more when it comes to trusting their university partners. A company should generally not be hesitant in sharing information from their side; in addition, they should keep in mind that academics aim to create knowledge for the society, and not "*to steal company ideas*." However, a company's expectations

on confidentiality or care in handling data should always be clearly communicated and if needed regulated. In general, it is not problematic for researchers to anonymize data.

With new partners, it is believed that one way to build a relationship is to start with small-scale projects, such as a pre-study, master's thesis, student projects, or "Skunkworks" projects, and then gradually develop the trust between partners.

Open communication channels are crucial in UI partnerships. All academics interviewed emphasized the need for a key person (or persons); although given several names (e.g., broker, translator, champion, liaison officer), to serve as the main contact person in the project. These persons from both sides may not only facilitate communication, but also be the key to bridging the cultural gap. Another name for these kinds of individuals are "hybrids". One of the interviewed academics expressed his opinion that this key person inside the company should exhibit a willingness that goes beyond their formal role, that personal motivation to collaborate is not just a bonus but almost a requirement. This is especially important because industrial firms are very dynamic and are often subject to exogenous factors that may cause reorganisations within the company. When this happens, the collaboration project may lose momentum without the presence of a responsible contact person who is supposed to keep a constant communication with the university partners. On the university side, the best people who can take on this responsibility are those that have actually experienced working both for the university and the industry, as they might have good knowledge on how to maintain these partnerships. These can be in the form of adjunct professorships and industrial PhDs, people who have forged solid relationships in the industry and in the university.

On interaction models

The researchers interviewed are accustomed to interacting with industry in the forms of Master thesis and PhD projects, Research programs/platforms and/or networks or assigned research projects (uppdragsforskning). The view on UI collaboration is positive and seen as a necessity despite the barriers. *"Collaboration is a necessity, but we always have to find a balance in the collaboration model".*

Long term

In general, long-term strategic collaborations are considered as a very important way of partnering with industry. Large companies are usually able to see the value of working on long-term, collaborative research. Although

they may want to have usable results as soon as possible, they see it as an investment with different pay-offs. On collaborative research projects, the academics believe that there should be an equal partner approach. Most especially in the beginning of a potential partnership, research tasks should be formed together, and then throughout the duration of the project, project management and communication are both clearly important. While the actual division of tasks may vary, there is a firm belief that the more that is discussed upfront the better.

On collaboration the experience is that it is important to further consider – from both parties – who interacts with whom. Some academics have found that in order to ensure that people on the company side will cooperate in the UI project, they (the academics) should know who to interact with and how to interact with different people. It is a matter of pairing the right researchers with right business people – from professors to PhD students on the one hand and top management, operations and R&D in business on the other. That is not to say that a professor is always best at talking to top management or a PhD student to operations or R&D. It is matter of matching "selling and procurement skills". From the perspective of academia there is an acknowledged challenge in the difference in explaining the goals and expected project outcomes to top management, versus people in operations, for example. Furthermore, while companies may not always know what they want when they approach academia, academics are poor at communicating that "there is something in it for them," (i.e. a company) when presenting an idea for a research project.

Pairing also comes into the different forms of UI collaboration. Collaboration, in terms of a PhD or industrial PhD, may be suitable for long-term research tasks or fit in to a larger collaboration project where particular results of a study are relevant. Another factor to consider when looking at interaction models is the importance of labour mobility. Several academics agree that spending time in each other's environments facilitate gradual and effective knowledge exchange, especially in fields that are on the front line (e.g., nanotechnology). A person from a company inside a department at the university can help drive the firm's research agenda towards a direction that it is aligned with the university's technological developments, and vice versa.

A company should also consider joining multi-disciplinary research clusters, as these are "good meeting places" wherein people from different institutions and firms regularly interact, form networks and begin potential partnerships. There is great value in learning across different domains (e.g., Material Portal at Lund University): *"I think in the intersection here is where you can learn a*

lot. Also, different domains progress at different paces, and if you can learn across, you don't have to repeat the mistakes in the other domains."

However, when a company wants to address short-term or specific research issues together with the university, it is best done through for example master's theses; student projects included in the course curriculum or through specific assigned projects (uppdragsforskning). For very applied and short-term research tasks, a firm should consider partnering with consultants or research institutes instead.

Financing

Given that funding is an important part of a researcher's responsibilities, finding financing is increasingly becoming an intrinsic part in different research projects. "*Money talks,"* as one researcher put it, referring to how funding partners like Vinnova and SFS steer the agenda and hence research focus through calls. Calls that in turn holds prerequisites for co-funding in real terms or "in kind" from industry partners based on the idea that research should be need-based and the results usable for industry. While the intention might be right it often creates challenges to researchers as well as companies having to adapt to a third party in terms of scope, collaboration set up, financing and formal agreements. While this type of funding is commonplace there are other forms such as grants, and direct financing from industry and there are different views on the pros and cons in the research community.

On a general note, the view is that short-term project (e.g., geared towards consulting) costs should be paid by the involved company. In larger projects like consortia or clusters, all actors contribute; however, there are researchers who believe that the university should only contribute with its people. *"It is not our role to invest cash. And sometimes when we do, we are made to co-finance far too much, I think. When the university joins clusters with companies, I tell them that we go into this cluster to make our knowledge available, but we don't pay money (for example, as a membership fee). I prefer not to pay this and the companies usually don't understand why. I tell them that we are not a company; we give you our knowledge. The difference between the two should be obvious."* On the other hand, there are those in areas of basic research like biotechnology who believe that for front-end, long-term research, academia should shoulder the majority of the cost.

Even though UI collaboration increasingly builds on solving financing issues, there is a fear in the academic community of being too much in the hands of industry. Referring to this issue, one interviewee compared with universities in other countries. For example, in University of Leuven, 40% of the research is funded by companies, while in Lund University that value is less than 5%. In

countries like Belgium and Holland, there are many big companies that have a tradition of financing universities, but some universities are not too happy about it because they think that the companies have too much influence on their research. "*It's interesting to see this [about Belgium/Holland] because we always say that we [in Sweden] aim to get more and more research money from companies. We should realize where the balance lies... because our role is to develop knowledge for the society in general, not for the single companies."*

Coming to an agreement

The need for agreements in a UI collaboration will differ in relation to the research task and the objectives (i.e. general knowledge, patent potential etc) and whether it involves a funding partner or is a dual partnership between a particular university department and a company. The universities, like Lund University, will have standard terms for cooperation and specific terms for contract agreements. While there is a pragmatic view and experience on how and when to use these, combined with particular company terms, there are experienced difficulties in drafting agreements that are commercially viable when for example patents may be involved. According to one experienced researcher this is due to a lack of competence and interest among researchers themselves (the commercial results per se are not in focus); there are no good standard models and Universities may lack competence in commercial law. Another potential challenge is the Swedish "teachers' exemption" (lärarundantaget) whereby it is the teacher/researcher who owns the result and not the University as in for example the USA.

Defining successful collaboration

Joint research goals should be mutually beneficial and relevant to both parties. From the academia's side, one very important challenge in UI projects is in convincing researchers that there is a benefit for them in joining these collaboration projects with the industry. They have to see that it benefits their career in many ways, and that they are not simply "selling out" by partnering with a company but they are also developing knowledge that will be useful to society at large. Success however is understood differently given the inherent natures involved in a UI collaboration.

While the end result may be publishable for a researcher, it might not be applicable in industry and hence of limited use. Criteria for success may however go beyond the actual result to involve impact in other ways. One view of what defines a successful research project is that the involved company receives inspiration and knowledge from new perspectives. One academic's personal opinion was that "*If we can impact the people working,*

rather than just [make] a specific solution, then that is the most important result, and the concrete research outputs are just secondary."

In larger research projects like national programs and agendas, when financing institutions (e.g., Vinnova) are part of the project, defining success criteria to enable evaluation has become an administrative burden rather than a beneficial factor in UI collaboration. The process is regarded to be laborious with too much time spent on documentation and paperwork, and the perspective of KPIs too narrow. A lot of improvement is believed necessary in the system of project documentation and evaluation, especially when it comes to having more actors and financing institutions in the project.

4. Experiences BillerudKorsnäs

Universities and research institutes are important partners in BillerudKorsnäs (BK) external R&D activities. External R&D with academia, in Sweden and elsewhere, take place on different levels: from master thesis student projects to engaging industrial Ph.D. researchers; collaborating with selected individuals/institutions on specific issues or participating in national and international research programs and consortiums. The experiences from research collaborations identified in this study are related to process and product development, covering areas from energy efficiency and waste treatment to development of new or improved barriers, printability, new materials etc. In the light of a BK taking a more active stance based on its research agenda, previous and individual experiences from six employees have been identified and summarized with the view to improve the effect of external research.

On research tasks

A good research task is need based

The characteristics of a good research task will vary depending on where in the BK organisation it originates or is addressed. From the perspective of operations/the mills, potential research tasks need to be short term in nature, coupled to the process development objectives such as cost savings, quality improvement, product care, test drives etc. "*It must be a problem or question where we can see a solution in a near future*". R&D on the other hand is more long-term in nature, working with a long-term perspective on issues derived from the internal research agenda under development (previously research plans) and/or the business areas. Even though R&D has a more long-term perspective the focus is on tangible results: early or parallel testing of research and lab results is important. Scaling is key and hence an important prerequisite in any research endeavour in collaboration with academia. The New Business Lab has a more long-term agenda for which inspiration and ideation are more in focus.

Even though there are different perspectives, it appears that research tasks/questions need to frame issues that are connected to products that are about to be scaled or are already in the production process. Given this scope there may be little room for research questions addressing issues in the early development phase, or at the so called fuzzy front end: *"...that will be difficult because at that stage we don't know if there will be a product or not"*. An important issue to consider moving forward is what lies in the early

development phases for BK with regard to process as well as product development.

Define or accept

There is a prevailing experience that academia is often the initiator to R&D collaboration with BK. Hence, the research questions may already be defined with little room (real or perceived) for further revision. The pre-constructed question/-s, coupled with the absence of a clearly defined internal research agenda for external R&D, has led to joining research initiatives that "sound interesting" or because other industry actors/competitors are participating, rather than being based on relevant gaps for BK: "*We spend too little time discussing the difficult questions*…" (i.e. the what and the why). The internal research agenda being developed is a step in the right direction. Operationalising the internal research agenda under development, further defining *what* questions BK seeks answers to and *why,* is seen as an important prerequisite.

Different tasks to different parties

Defining a research task is also dependent on the research partner. The general experience is that research institutes are more suitable, compared to academic counterparts, in delivering faster and more applicable answers and solutions to operational or product development issues.

In relation to academia, knowing where to put the level of the research questions is found to be a challenge: "*Should we go for what we really need, or what we think the researchers can do*?" A general tendency is to delimit the scope to academia for reasons of business integrity or trust "*We want to give away a piece of the puzzle but the researchers often want to see the whole puzzle*". However, the view is not that Institutes are appropriate partners for all research tasks. For issues that are more long term, or where input could be useful to shed new light on a problem, academia is believed to be more appropriate.

On cultural differences and different demands

The general experience from working with different actors in academia, be it through consortiums or PhD-students, is unsatisfactory. The collective view is that academic processes are time-consuming with results of limited applicability.

Differences hampering collaboration

The differences between industry and academia with a hampering impact on the collaboration process are found in issues such as: objectives

(organisational and research), time frames, financing and project management. Some illustrative quotes are:

> "*We wanted data - they wanted to publish articles. We did not get any data for two years*."
>
> "*We have probably sometimes ordered product development more than research - when we want data evaluation (mätdata) in a steady stream, it does not work".*
>
> *"If for example we would like to learn more about a certain conversion process, there is no one at a university who can take that on unless you finance a PhD."*
>
> "*If I have a bag of money with me, someone (i.e. academic) can imagine thinking about something for five years.*"

On objectives and time frames the respective nature of industry versus academia manifests itself not least in the differences in organisational drivers. Where BK needs results that can be applied and used, academia needs scientific results for publications. While these needs could go hand in hand, the experience is that they seldom do due to differences in time frames and the objectives with final results. Where expectations from industry on for example a research project on innovation is a product that is ready to launch, academia is satisfied with validated data and mock-ups: *"We get an equation not a new product"*. In general, the expected result from an internal operations- or even five-year-R&D perspective does not correspond with the result of a five-year PhD process.

The differences in objectives can also be found on a more granular level in relation to the actual research task or scope. Given the experiences from collaboration efforts it appears that there is a mismatch in the understanding what the needs are, and/or what the actual meaning is of for example innovation and product development. To BK, the need and meaning of product development is by nature different from those of actors in other industries. Compared to academia the understanding of product development and innovation (such as incremental vs. radical) is equally different, as is the starting point – early development from BK perspective may be something else than from a researcher's perspective given, again, the different arenas for contribution being business versus science. The closer the research gets to the product, the more difficult is becomes for BK to interact. "Open innovation" efforts are problematic with regard to the increasing competition.

Financing is another issue of frustration not least given the experienced lack of results in relation to the cost. Co-financing is common and often "in-kind" which in itself is difficult due to lack of time and resources internally.

On project management there is a general feeling that academia is poor at managing. Meetings are ill prepared, communication is deficient, and follow-up not commonplace. Even in projects where there are clear project plans with identified objectives, results are meagre. At the same time, the internal view is also that BK has been poor at taking its own part in effectively managing external R&D projects.

The good examples

Positive experiences from working with academia are often tied to individuals at different institutions where there is a favourable view on, and experience from, working directly with individual companies on more short term projects ("uppdragsforskning"), or PhD students in highly related areas, or, when BK has taken an active approach in defining the research task and managing the project in larger research set-ups. One such example is on functional barriers where an external intermediary/project manager was hired and the research divided in one industry group and one group for researchers. Results were delivered in parallel tracks, enabling pilot tests at an early stage. Communication remained however a main challenge throughout the project. Another example outside academia that is welcomed is the new set-up at Innventia who have organised their research projects in Application Oriented Research and Precompetitive research respectively.

The internal set-up

The internal research agenda under development is a welcomed step in guiding the external R&D activities. Building on the experiences form previous collaboration efforts a more active approach in relation to academia is sought after. This approach should be based on for BK relevant issues and different needs for both long and short-term results and solutions, considering process and product development. Coupled to this are also thoughts on the internal procurement skills, meaning identifying who and what the organisation is best at interacting with, and even understanding, the different external counterparts.

Beyond the structural set up, managing external projects in the same way as internal is believed to be an important way forward. This includes processes for digesting and applying the knowledge received "*we get incremental knowledge, but, it is always up to us to then apply it of course, however here is the challenge: we have too little time to put this knowledge into practice"*. It also entails improved evaluation of different efforts.

On interaction models

Interacting with academia offers a variety of different set-ups. From experience, there is no one model that appears better than another but is dependent on individuals and the approach from involved parties. The overall experience from large research projects such as consortiums, directed from academia or institutes are, is that they yield little results also coupled to a mismatch in the defining or understanding of the research task.

There is however an identified need to clarify and direct different research initiatives to different counterparts. Where research institutes may be an easier partner to collaborate with through a supplier/customer approach, the same does not work for academia. An internal research agenda will guide in accepting or declining different initiatives for collaboration with academia, it will also form a better base from which to take own initiatives.

Managing external R&D projects with academia more effectively is also believed to improve collaboration efforts. While there is an acknowledged need internally to take a more active stance, collaboration with academia may play another role, seeing academia as a learning partner rather than a supplier. *"The worst thing a researcher can imagine is being driven by industry – it is better if we stay in touch and talk about what interests us to create inspiration"*. There are many examples of fruitful individual contacts with senior researchers who are not necessarily involved in a particular project but know the area/issues. Furthermore, while investing in a PhD student over five years may yield limited results, it is seen as an important recruitment base.

5. Analysis and conclusions

This pilot study confirms previous findings in literature on the barriers to UI Collaboration – the lack of mutual understanding being a central theme in the conducted interviews – caused by differences in objectives and culture. At the same time, and more importantly, there is a mutual desire to improve collaboration given the benefits of knowledge exchange and other end results. There is however not one generic model for interaction given the different scopes and time frames of different research endeavours (involving different competencies in an academic institution and industry) and the respective need for more or less formalised agreements. Collaboration should be beneficial for all parties, based on a mutual understanding of what that actually means.

While the findings contribute to further improving UI collaboration efforts from a two-party perspective, the analysis and conclusions inhere focus foremost on the perspective of industry in line with the aim of the study. The analysis and conclusions are drawn from the perspective of one company, BillerudKorsnäs, wanting to improve UI collaboration through taking a more active stance, and based on the three central issues set out for the study. It should be noted that the study is limited in scope and data collection (i.e. number of interviews) why the results presented here cannot be generalized.

Taking an active stance in UI collaboration

BillerudKorsnäs aims to take a more active stance in identifying, initiating and/or supporting industry relevant research. From a perspective of innovation management, building *effective external linkage* is in turn dependent on a strategy for R&D/Innovation, effective internal implementation mechanisms and a supportive organisational context. While the three latter have not been in focus for this study, they are important to consider for any company. Research shows that a UI collaboration project will best impact a company if the research project is aligned with its' vision and research strategy. Furthermore different knowledge transfer or collaboration mechanisms may require different support structures within a firm. In brief, a company that is well equipped will more effectively participate in and draw beneficial results from UI collaborations. Hence, linking the external research closer to the mission and the objectives within the BillerudKorsnäs innovation agenda, product roadmaps and business plans is a step in the right direction. Building effective external linkages in this context, identified success factors are; investing in mutual understanding, communication and trust. These success factors are important regardless of collaboration model used however relative to the level of engagement and respected results.

Finding a good research task relevant to both parties

Finding good, or sharp, research tasks that are relevant to both parties in a potential UI collaboration, builds on mutual understanding of different needs. Where a research task has to carry relevance in relation to a research strategy or particular project development project for a firm, it *also* has to be of theoretical relevance for an academic (i.e. has to contribute to the existing theoretical knowledge base). Given the findings in the literature review and interviews with academics, the best research tasks are defined jointly based on a mutual understanding and trust. For BillerudKorsnäs this may be particularly important with regard to "Early Development projects" which may require more effort in the initial phase of defining the problem and formulating the research task. However, an important question going forward is what a similar project actually means – what is "early" in the BillerdKorsnäs development process may be positioned elsewhere in a similar academic research scope. "Early" from a researcher perspective may well be interpreted as looking beyond existing research, aiming high, and in areas where basic research is still needed. Or, taking the outset in a generic product development process even if applied to a particular business, "early" for a researcher involves the so-called fuzzy front end, where challenging existing assumptions is part of the game.

Bridging the cultural differences and demands

As found in the literature review, and the interviews, the main barriers to UI-collaboration are: differences in fundamental motivation; cultural differences; different susceptibility to external factors (e.g. mergers, fluctuations in economy etc.); administrative and organisational barriers, and possibly foremost: a lack of mutual understanding. Examples of differences are publications vs. applicable results, and funding. At the same time there is a mutual desire to collaborate given the benefits, and possibly even greater benefits, can the barriers be overcome. Bridging is best done through greater "understanding of each other's worlds," spending time together, build trust and communication. Beyond good communication of visions, problems and needs, the organisation or individuals involved in a UI collaboration are important.

Taking the outset in, and importance of, a firm's own Innovation and/or R&D strategy, there are further examples in the literature on keys to collaboration success (see for example Table 5.) One such key is the individual/-s, and project managers in a project. Given the different nature of potential research collaborations in terms of scope, time frames, parties involved etc., an

important conclusion to be drawn is to ensure that people involved have the right "procurement competence" meaning the ability to interact with academia on different levels. Finding the right people to interact with is also acknowledged among the researchers, who also point to the benefits of key person/-s in a UI collaboration taking on roles as "translators" or "liaison officers" – on both sides.

Finding the right interaction model

Finding the right interaction model involves defining "the what" (the research task and expectations), "the who" (both internally and in academia), "the how" (the project set up, responsibilities, deliverables etc) and "the when" (time frames). Even though literature and our interviews indicate the challenges with truly addressing these issues, an important conclusion is that addressing these lay the foundation for any interaction model. However, while large research projects and their expected set up etc. may be stipulated by external partners (e.g. Vinnova), it appears that going through this exercise is key as there is no *one* model.

On the one side, given the case of BillerudKorsnäs, the potential research needs are based on different objectives within the organisation, which in turn form one prerequisite for interaction. In academia there are certain pre-defined formats of interacting through Master theses or PhD projects, and different programs with more actors involved. A simple conclusion, without a more comprehensive understanding of the BillerudKorsnäs organisation or innovation agenda, is to say that R&D and the New Business Lab are more suited to interact with academia while operations are more helped interacting with research institutes. That is not to say that operations should not take part in collaborations projects with academia on more long term, early development projects.

The important thing is to find a match, and again, find solutions based on a more thorough understanding of the academic animal in relation to the internal needs (and dreams). It goes without saying that for a firm this will require time and effort, investing not only money but possibly more importantly time, in laying the foundation for successful UI-collaboration. Drawing on findings from previous research and interviews with researchers, an important conclusion is that long term strategic collaboration efforts – more or less formalized – are more fruitful based on an equal partner approach where learning is at the core. Beyond the different formats mentioned above, industrial PhDs and labour mobility set-ups – spending time in each others' organisations – have been proven successful. Matching the different academic formats with industry needs and potential benefits one could argue for

Consortium/Strategic agendas where the aim is learning and know-how, *PhDs* for potential recruitment, *Industrial PhDs* for know-how transfers, *Assigned research* (uppdragsforskning) for particular situations where there are well established individual contacts and Master theses for starting or allowing for continuity of collaboration.

In terms of financing, while being a barrier, there are few recommendations on solutions. Given that funding has increasingly become a part of researchers' responsibility we would argue that this has to be solved in each UI-collaboration and where national institutions are important financiers, it may also be a matter of opening the dialogue for more appropriate solutions not least in relation to the fundamental differences between basic and applied research. Several of the researchers interviewed question whether companies should be asked to finance areas in basic research, or early development projects, where results may not be expected for ten to twenty years. However, that is not to say that companies should not be involved.

In conclusion, despite the importance of mutual understanding, there are few suggestions in the literature on how to improve understanding beyond checklists – the TRL being an exception. The findings from interviews with researchers and practitioners from BillerudKorsnäs suggest that an important step forward is to develop some sort of visual communication tool enabling understanding of the actual and potential research task. A further developed and adapted version of the TRL model, or a generic project, process or product model is therefore suggested as a way forward. Furthermore, a checklist for managing UI collaboration from the perspective of BillerudKorsnäs – summarising the findings herein – is suggested.

6. Suggestions and recommendation

Given the barriers and success factors identified and summarized in this study, our suggestions are aimed at further improving collaboration between academia and industry from the perspective of industry, here represented by BillerudKorsnäs. These suggestions should be considered as a first step, in need for further development and adaptation by BillerudKorsnäs, and as a next step be tested on an academic counterpart.

Facilitating understanding through a visual model – The BillerudKorsnäs TRL

With the view to facilitate mutual understanding, from the perspective of industry; defining "problems" and research tasks in relation to particular areas, visualising a company's research or innovation agenda has proven effective in UI collaborations. Given that researchers prefer to see "the whole puzzle", not just one piece, suggest that a similar visual should be comprehensive (albeit simple) in illustrating different research areas, or projects, in relation to the company's corporate strategy or vision.

The original TRL model offers a structure which requires adaptation before it can be used within a specific context of the company. For instance, moving beyond its implicitly linear character, by including the *time* variable, and identifying the "x" being, for example, BillerudKorsnäs' priority research areas, positioning each area in accordance with its own TRL and thus potential research needs (see figure 5). As an alternative to the TRL model, one could imagine generic or company specific project-, process- or product development processes.

A further developed and adapted TRL should not be seen as a new way of structuring the internal innovation agenda, or potential KPIs but foremost a way of visualising and communicating ongoing research areas for an external partner.

To further develop a similar TRL for BillerudKorsnäs, it can be done according to the following steps:

- Define number and name levels for TRL or take the outset in project-, process- or product development processes (i.e., from basic technology or "fuzzy front end").

- Consider what levels are incorporated (i.e., potential levels possibly beyond the company scope – where does a BillerudKorsnäs TRL start and can this be different from another perspective?)
- Explain and exemplify meaning/content of each TR-level, or steps in a development process.
- Categorise research areas along each TRL/development staircase. (e.g., several priority research areas)
- Visualize each TRL staircase and align with timeframes (these will naturally differ)
- Identify where, within each TRL staircase, collaboration may be needed and match with potential academic processes (e.g., PhD student, national research initiatives)
    - Pinpoint research scope - what is internal and what is external (always) - collaboration can be based on both: "Where does BK work? Where does academia work? Where can we work together"?
- Include overall vision and/or strategy: the whole Puzzle in the completed visual – researchers like to see the whole picture.

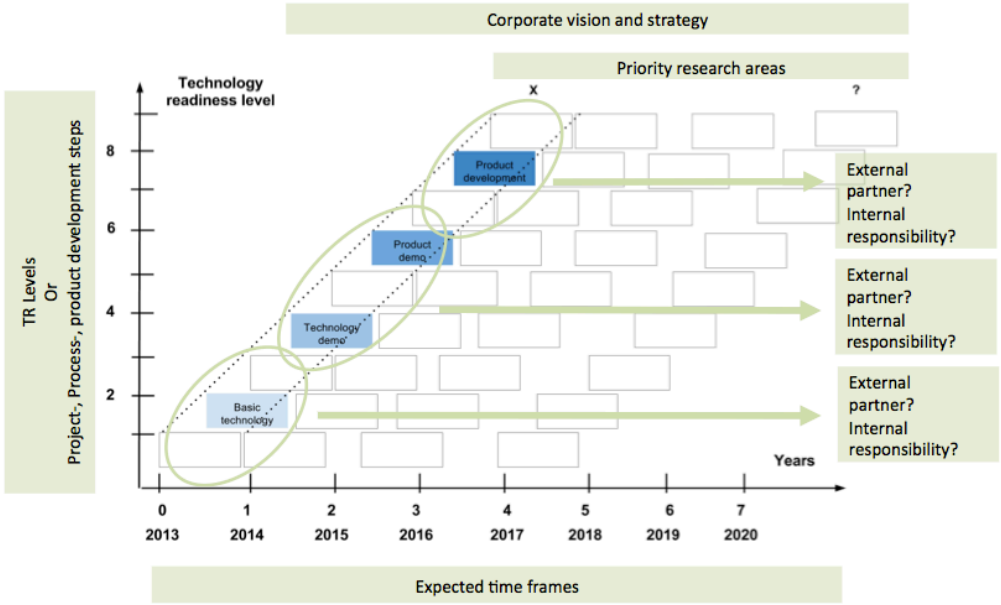

Figure 5. An adapted TRL model

Given the inherent complexity of different research areas within an R&D or innovation agenda, adapting and developing a TRL-model might not be an easy endeavour, however suggested a fruitful exercise to enable improved communication with academic counterparts.

A checklist for enabling successful collaboration

Building on the suggested success factors and checklists in literature and findings from the interviews, a generic checklist for identifying and managing UI collaboration projects has been summarized. This checklist needs to be adapted to fully suit the needs and aims of BillerudKorsnäs, but notable is the division between the different starting points – whether actively approaching academia or reacting to an invitation or proposal, underlining the benefits of the internal R&D strategy and agenda.

Active/Outgoing	Reactive/Incoming
Company R&D Agenda/Portfolio coupled with TRL visual	
Determine collaboration opportunities in R&D portfolio (i.e. research tasks and potential academic partner).	Verify proposal based on R&D Agenda/Portfolio *and* TRL. Verify if research objectives are aligned with strategic objectives.
Define the research scope (research questions and expectations) internally or with selected partner. Define output that provides value to the company.	Verify/revise the research scope (research question) and expected output. Verify if project output will provide value to the company.
Identify and select external partner (physical meeting). Consider the following: competence, track record, personal relations or references.	Verify external partner (physical meeting). Consider the following: competence, track record, personal relations or references.
Select internal project managers. Consider: expertise *and* personal motivation. Define their responsibilities.	
Formulate and agree on project plan (scope, time frame, required resources, deliverables).	
Interaction model (i.e., Learning, Partnership, IP) Formal agreements	SIO /Consortium
On-going project management. Ensure that flexible/adaptable policies and management processes exist. Provide internal support. Maintain communication channels.	
Absorption of results. Communicate to company personnel to ensure organizational learning. Promote feedback to university team.	

Opt out?

Opt out?

Opt out?

Figure 6. Proposed checklist for UI collaborations (outgoing and incoming)

Considering front-end, often long term, research areas and the advantages of building long-term relationships with academia, continuous networking and informal contacts with existing and potential university partners is key.

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8. Appendices

Interviewees

Lund University

- Anders Axelsson, Professor, Department of Chemical Engineering; previous rector of LTH
- Annika Olsson, Professor and Head of Division, Division of Packaging Logistics, Department of Design Sciences; LTH Vice rector for collaboration and innovation
- Josefin Ahlqvist, Tech lic, Project Manager, FUF – Future Urban Supply Systems & LUBIRC - Lund University Biobased Industry Research Center, LU Open Innovation Center
- Maria Andersson, PhD, Senior Researcher & Technology coordinator, Division of Biotechnology, Department of Chemistry
- Martin Stankovksi, PhD, Project Manager & Theme Leader Future Materials, LU Open Innovation Center
- Per Runesson, Professor and Head of Department, Department of Computer Science; Research director, Industrial Excellence Center EASE

BillerudKorsnäs

- Eva-Lena Strömberg, Manager Process Development and Environment, Skärblacka
- Grete Åvitsland, Manager Team R&D Skärblacka
- Johan Larsson, Certified Project Manager, R&D Gävle
- Margareta Öhrn, Manager Technology & Logistics, Skärblacka
- Mikael Ankerfors, Project manager New Business Lab
- Olle Steffner, Corporate IP manager

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