Building an Open Innovation System

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Abstract

The ability to access sources of knowledge external to the company and incorporate these into internal knowledge processes is understood to be a key enabler of innovation. While this has been addressed in general terms, the means to achieve it have remained uncodified. In this paper, we describe a three-step method that allows a firm to achieving open innovation, particularly with regard to knowledge in academic and research settings, starting with what it needs to know, determining which external knowledge sources will help it create a competitive advantage, and designing a system that allows it to continuously harvest the innovation ingredients from these sources, and details this with regard to the case of Arla Foods.

Keywords: innovation, open innovation, research

1. Introduction

The ability to access and exploit external knowledge is a critical component of innovative capabilities (Cohen & Levinthal, 1990) and many companies have responded to the call to open up their innovation process to research networks and seen advantages in doing this (Chesbrough, 2017). Established firms such as *Procter & Gamble*, with its "Connect & Develop" program (Dodgson, Gann & Salter, 2006) or *Deutsche Telekom* with its network of Innovation Centers on academic campuses, have become inspirational examples (Rohrbeck et al., 2009). Others use open innovation platforms to reach out to global innovators (Allio, 2004; Rohrbeck et al., 2010).

When following this path, firms may wonder what the right set of open innovation tools and practices for them are, and how to set themselves up to create open innovation systems. In this paper, we describe a three-step method that allows a firm to start with what it needs to know, determine which external knowledge sources will help it create a competitive advantage, and design the open innovation system that allows it to continuously harvest the innovation ingredients from these sources. We address open innovation with regard particularly to relationships with academic institutions and research institutes, and bring the case of Arla Foods to demonstrate how this may be done in practice.

1.1 Orientation to External Research Knowledge

Since the 1970s, a growing number firms have been interested to incorporate knowledge and technologies outside their own R&D labs (Wolff, 1992). Such initiatives have traditionally been driven by the interdisciplinary activities of boundary-spanning individuals, who have been directed more by personal curiosity than by employers request (Allen et al., 1971). Over time, firms started to direct such activities and establish more formal "listening posts" (Daheim and Uerz, 2008), and as part of this companies have looked to tap into external academic and allied knowledge bases (Koschatzky and Stahlecker, 2010; Rohrbeck, 2010).

When sourcing external knowledge in an industry-university collaboration, it is a challenge for a company to locate gaps in its information stream and identify the most pertinent and valuable sources of information to close these gaps. In particular, identifying sources for advance knowledge or early warning is key. Early idea-generation and conceptualization has been called the "fuzzy front-end" of innovation (Koen et al., 2001) and it is here where we can expect that trend-directed search and strategic foresight methods play a role (Farrington et al., 2012; Rohrbeck, 2014). Some firms use automated systems to track patenting and publication activities for this purpose, but the downside of this is it tracks knowledge domains the organization already knows of, or knowledge within the frames of change that the organization is expecting. For example, it is straightforward to search for patents a competitor is filing in the technological field in which your products are located. A company like Intel could, for example, track patenting activities of IBM in the field of microprocessor engineering. However, might Intel spot whether IBM or any other rival was developing capabilities in the field of neuroscience, for example, which enables artificial intelligence applications? Here it is likely the sensory system directed at research in microprocessor advances would fail. A better solution, in this case, and as described in the case below, would be to scan the entire patenting and associated publishing activities. This is a technique is known as "weak signal scanning" and it builds on monitoring of various fields of activity external to the firm, including centers of knowledge excellence to advance open innovation.

2. DESIGNING EFFECTIVE OPEN INNOVATION SYSTEMS

The following section outlines the three-step process of acquiring open innovation, described with case study from the firm, Arla Foods. The steps are:

1. Identifying centers of knowledge excellence
2. Mapping access to centers of knowledge excellence
3. Enacting an open innovation system

2.1 IDENTIFYING CENTRES OF KNOWLEDGE EXCELLENCE

A center of knowledge excellence may be defined as an organisation leading within its field of science, that has unique intellectual capital which may be value-creating for the industry. In the case of Arla Foods, we used Thomson Reuters publication databases to find the organizations that were centers of knowledge excellence within Arla's knowledge-relevant areas (farming, formulation, manufacturing, product improvements, next generation products, packaging, and consumers.) The aim in this step is to reach a comprehensive coverage of the knowledge output, therefore one can also include sources such as patent databases, industry magazines, and specialized scanning services.

The next step is to identify the organizations that which are active knowledge centers, which in the academic environment this can be approximated through research output intensity. In our case we selected based on the number of publications in our focal field, i.e. dairy related research. From the dataset, we identified 16 “tier one” organizations which had more than 70 publications within the last six years.

Figure 1 shows the result from the mapping of the knowledge centers against the list of academic collaborations from the focal company, Arla Foods. By way of a color code, where red signals no access, yellow a limited access and green a good access, we derive a first assessment of geographical gaps in access to the latest knowledge.

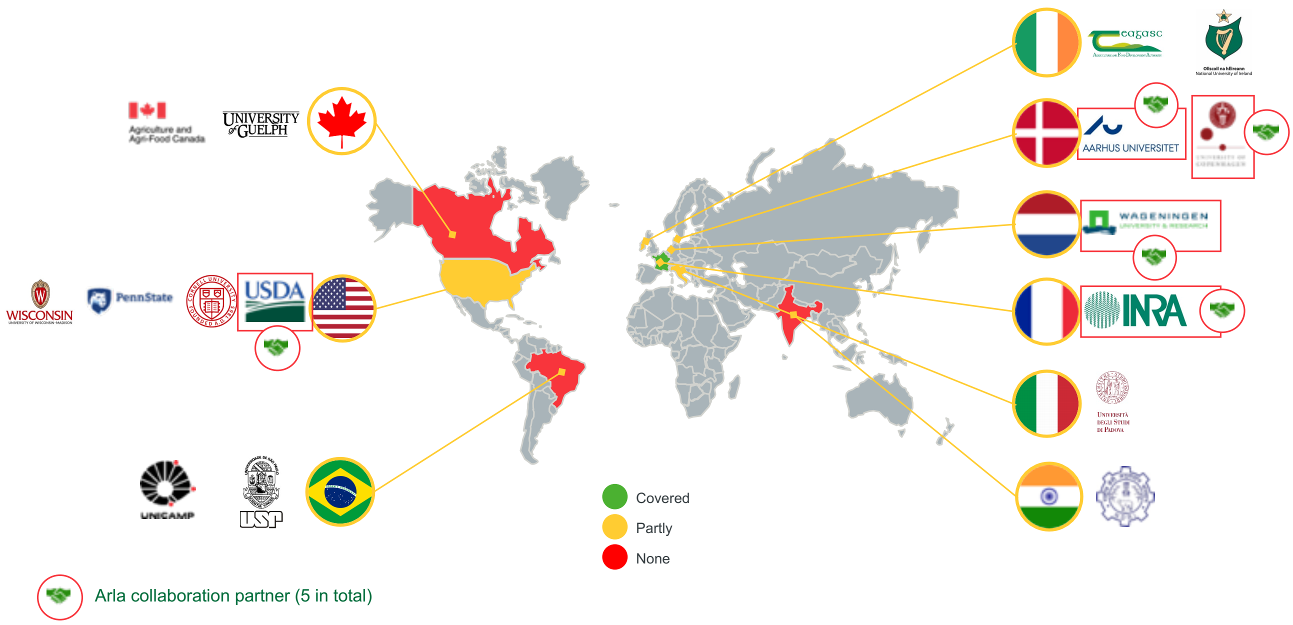

Figure 1: Knowledge centers and existing collaborations (illustrative)

The following step is to identify the centers of excellence. Here we analyze the knowledge-domain-specific strengths of each top-tier organization. In **Figure *2***, the knowledge domains or categories of research are listed across the top and the 16 centers down the leftmost column. The chart further provides a “heat-map” of where the strongest centers of knowledge excellence within the dairy industry are located, within each knowledge category. The heat map, created from 1,577 publications in total, show the leading knowledge centers crossed with which knowledge categories they are active in. The heat map is created as a set of color codes where each color represents the percentage of the total publications the center of knowledge excellence has published in that category, the darker color the more activity. It is important to notice that publications are not bound to one category. Publications can have multiple dimensions and may therein span across categories. Taken altogether, such a map gave Arla Food guidance as to which knowledge pools it could tap into. Further to the chart in Figure 2, the white "1" in a green circle represents the most prolific publishing organization within the topic category, and the green "handshake" symbolizes an organization which Arla Foods has an existing relation to. A total count of the publications within the category is stated below each category.

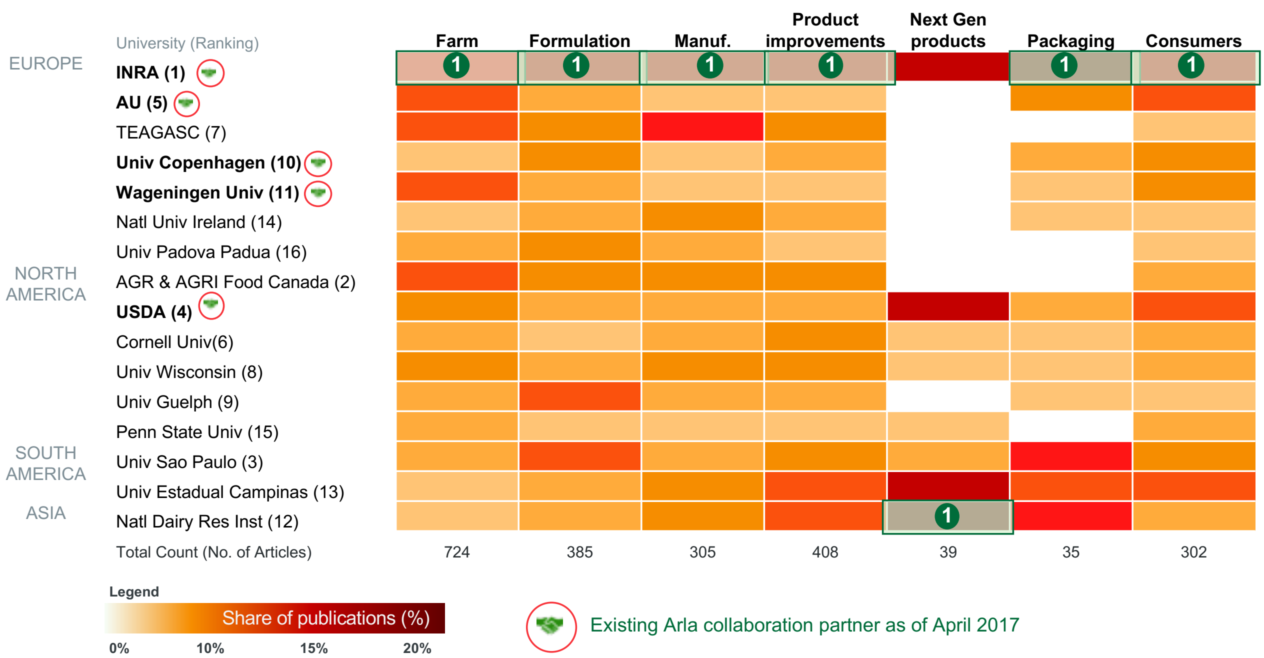

Figure 2: How a heat map identifies the centers of excellence (illustrative)

The knowledge categories and publication activity within them may be further understood, for example as follows in the Arla Foods situation:

Farming: This category contains publications that concern everything that happens with regard to the product before it leaves the farm, including farming practices, animal health, environmental footprint. Farming was the most researched field within the categories, with a total of 723 publications found within the topic. The publication within farming is fairly even distributed between the tier-one institutes, with INRA having 97 publications or 13.4%. Most publication was found in Europe, with 381 publications of the 723. Outside Europe it was found that Agriculture and Agri-Food Canada (AGR & AGRI Food Canada) had the most publications, with 77.

Formulation: The formulation category contains publications that concern the raw material, after it has left the farm, but before it is processed to the final product. Potential topics are: enzymes, cultures, fermentation systems, ingredients, and compounds. In the current case, a total of 386 publications were given within formulation. As with farming, also here INRA was dominant, with 15.3% of the publications. Beside INRA it was found, that relatively large percentages of publications were produced by the Brazilian Universidade Sao Paulo (10.1%) and the University of Guelph (9.3%)

Manufacturing: The manufacturing category contains publications that concern the processes applied to the raw material to arrive at the final product. Potential topics are: blending, mixing, storing, or pasteurization. A total of 308 publications were classified within manufacturing, with INRA again having the majority share of 17.2% of the publications. Agriculture and Food Development Authority (TEAGASC) had 12.7 %. The rest of the publications on this topic are fairly evenly spread.

Product improvements: The product improvements category contains publications about elements or processes that can potentially improve the product. Potential topics are: texture, taste, or healthiness. This was the second largest category within the publications provided in the Thomson Reuters dataset. A total of 411 publications were found to belong within this category, 18,8 % by INRA. Two organizations contributed with 9,5 % of the publications each, which were Universidade Estadual de Campinas in Brazil and NDRI in India.

Next generation products: This category contains publications that concern research that might lead products with health or nutrition-benefit claims. Potential topics include Skyr (yoghurt-cheese), lactose free products, and new use of bacteria cultures the provide health benefits. Next generation products were one of the least publicized fields of study, with only 38 publications in total. In this category, NDRI India had a 34% share of the research articles, followed by Universidade Estadual de Campinas with 21%.

Packaging: The packaging category contains publications that concern research on topics such as sustainable packaging, new materials, healthy packaging, frustration-free packaging, and shelf-life extension. Here only 28 publications were found and once again INRA had the most publications, with 21,4 %, followed by NDRI and Universidade Estadual de Campinas.

Consumers: The consumers category contains publications in consumer behavior, for example behavioral insights or nutrition and health knowledge. Consumers had a total of 304 publications where INRA led with 17.8%. It was also found that the span between the number of publications were relatively small, so that both USDA, Aarhus University, and the universities in Brazil had a relatively large share of publications.

2.2 Mapping Access to Centres of Knowledge Excellence

After identifying the centers of excellence, we assess to what extent our firm's open innovation system can access these knowledge pools. Here we first need to decompose the open innovation system into its individual tools. There has been multiple studies and conceptual papers looking into how firms can collaborate with and get access to scientific knowledge (Igartua et al., 2010; Koschatzky and Stahlecker, 2010; Rohrbeck et al., 2009). The emphasis in open innovation systems, as we discuss them here, is to not only to scan in publicly available information, but to gain privileged access or foresight into what is under development, to gain a lead-time and competitive advantage (Rohrbeck and Kum, 2018). From previous publications we identify five generic tools, which we map on two dimensions, see **Figure** *3*. The first dimension gives an approximation about how well equipped the different tools are in providing deep access, relatively to each other. The second dimension is providing information about the relative investment/resources required to build and operate the tool.

Figure 3: Generic open innovation resources

The *sponsored professor* is the most resource intensive but one can also expect that a professor can provide deep access to knowledge in his/her domain across institutions and in other domains within his/her institution through inter-professorial networks, making a professor a valuable resource to gain deep and broad knowledge access to scientific knowledge.

Collaborative innovation projects are also resource intensive but also offer a deep access to knowledge. When compared with the sponsored professorship they however are limited in their access being typically to one knowledge domain and are thus a tool for gaining access in a focus field. *Sponsored PhD fellowships* allow a similar focused access to a knowledge domain and are much less resource intensive then sponsored professorship. In comparison to professorships the other downsides are the more limited personal network of the fellow, and a lesser ability to see development patterns over time, and the time limitation (often 3-4 years) which might mean that the PhD fellow moves to a new position and the knowledge flow is terminated. An interesting alternative is the establishment of *scouting networks*. Scouts can be own employees who liaison with a center of excellence, or consultants or academics who report often in a standardized form back to the firm (Rohrbeck, 2010). The required resources might differ but are often tied directly the amount of useful information that is reported. Most firms will also use *memberships in associations and think thanks*, which can vary greatly in usefulness. The information is typically less deep, less exclusive, but also less expensive to gain access to (Daheim and Uerz, 2008; Rohrbeck et al., 2009).

At Arla Foods we used this taxonomy to map the existing tools onto our center of excellence heat map, see **Figure *4***.

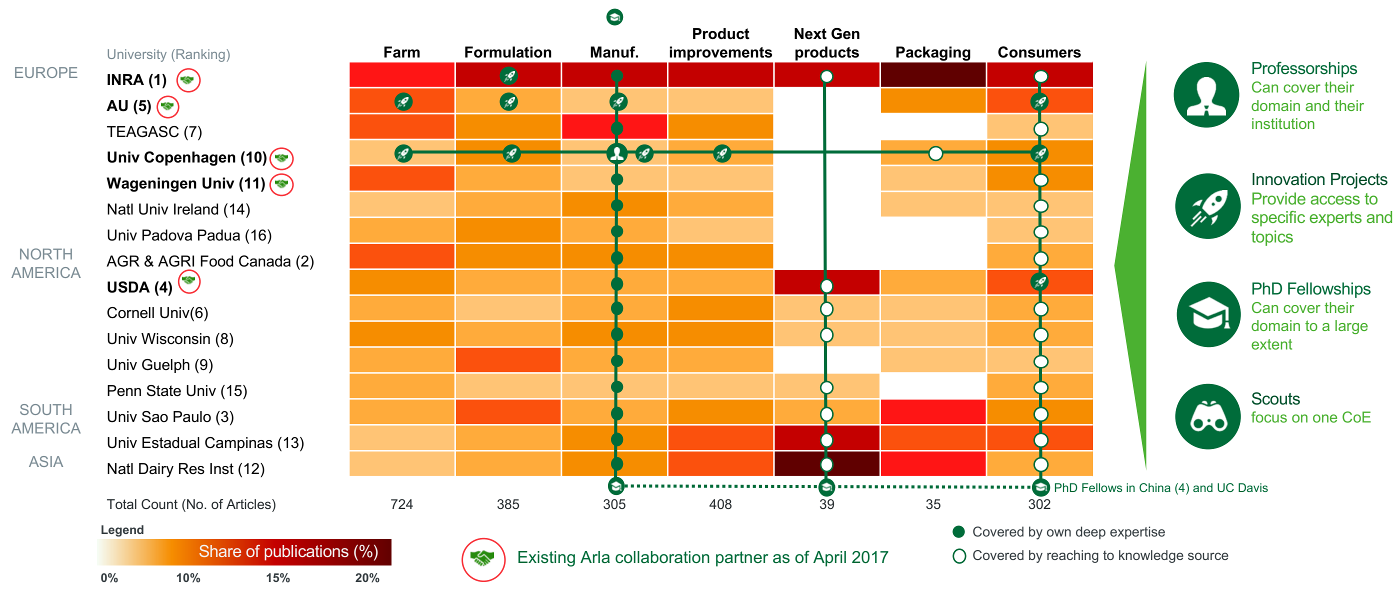

Figure 4: Current access of Arla Foods to the centers of excellence (illustrative)

Arla Foods currently has one professorial association, a professor from the University of Copenhagen, in 'Dairy Process Technology' (KU, 2017), who is supported by a five-year period grant (KU(a), 2016). The professor mainly covers next-generation manufacturing, though she does have touchpoints within formulation. The company paid DKK 5 million (US$ 800,000) for the professorship over three years.

The *professor* is located on the chart along the horizontal line where the professor has her field of research. The line represents the reach of the professor, including awareness of new publications and research of interest to Arla Foods. The circles are represented as either white or green, where green represents the professor's own expertise, and white represents where the professor can reach knowledge sources. Further, as the professor's own work is in the manufacturing category, it is assumed Arla's network can be extended to cover awareness of publications from all centers of excellence within this category (covering the vertical manufacturing axis), based on the expectation that professors in a certain field will stay updated on new research within their field and can build access to colleagues from other universities and research centers.

Innovation projects are research projects which Arla Foods funds and collaborates on with centers of knowledge excellence. These are widely used: at the time of study, the company was involved in 51 such projects. In Fig. 4 the "white rocket" symbol shows the category of research where Arla has at least one sponsored innovation project and which research institute it is with. In some categories the company may have more projects with the same university, for example it has five projects of this type with the University of Copenhagen. (Only one rocket is placed to mark the collaboration.) Overall, these ties to research organizations through innovation projects also contribute to Arla Food's reach into centers of knowledge excellence in other ways. An innovation project is often an immersion which stretches over years which leads to deep expertise through the knowledge exchange over time. Further, an innovation project may be a source where Arla Foods acquires informal network ties, which have the potential to lead to further development of the network (Ponomariov and Boardman, 2012).

The last two types of networks Arla has are *PhD fellowships* and *scouts*. In this particular case, no PhD fellowships or scouts are on the heat map because no PhD fellowships or scouts are currently placed by Arla Foods at any of the 16 tier-one knowledge institutions. (The company currently sponsors five PhD students. One is located at UCDA, USA, the other four in Hong Kong, Shenzhen, and Guangzhou, China.) The reach of the PhD fellowships is assumed to be the same as that of a professor, in the vertical line, i.e. the knowledge domain, but not on the horizontal dimension. A *scout* seeks out information which is very purposefully selected for the company, (Wolff, 1992) and is primed to select actionable information from within their field of expertise. Therefore, a scout might supply Arla Foods with deep expertise within a specific category or within the particular organization in which the scout works. In this particular analysis it was found that Arla was not using scout networks.

The access analysis (**Figure *4***) revealed that even though Arla has already a good footprint (i.e. scope of access) in the centers of excellence, there is still room for improvement.

3. ENACTING AN OPEN INNOVATION SYSTEM: HOW TO ACCESS THE SOURCES

The two steps above, (1) identifying important and relevant centers of external knowledge excellence by way of a knowledge category–to–institution heat map, and (2) identifying a company's access to these centers via access nodes such as professorships, innovation projects, scouts, etc. together set out the path a company can follow to source open innovation from research knowledge resources. What remains is to enact this, which is done by a gap analysis and strategies to close the gap.

In Arla's case, the gap analysis reveals a lack of access at the center of excellence within the domains farm, product improvements, and packaging. In addition, the important domains of next generation products and consumer research, Arla is only linked through PhD fellowships, which would be considered as worth strengthening.

The building and enhancing of the open innovation system takes the gap analysis as a starting point. Here a first measure would be to create a network of scouts that can in the short-term tap into the centers of excellence to which Arla has no access. A prioritization exercise could further reveal which centers of excellence need to be accessed with even more powerful open innovation tools, such as sponsored professorships. Such a prioritization typically addresses the innovation focus field, that is areas where a firm expects to important opportunities for differentiation or cost advantages.

In the dairy industry many expect knowledge from consumer behavior research and research into next generation product to be particularly promising. Hence the network of scouts, that can be build-up quickly might over time be complemented by PhD fellowships or even sponsored professorship. In addition, collaborative research projects could be part of the tool mix to increase access.

An alternative to external scouts can also be internal scouts, often organized in boundary spanning or foresight units that tap into knowledge pools via key individuals. They often operate not through scanning systematically across a broad scope of databased, but through a technique called pyramiding. Pyramiding uses the technique of sequentially contacting experts and asking each for a reference expert that they look towards for guidance, that is, which they see as being a more knowledgeable expert than themselves. This allows, as shown in **Figure 5**, to progress from interviewing an average knowledgeable person to the leading expert in the field. Pyramiding has been associated with higher information quality and shorter search times than systematic searches in databases (von Hippel et al., 2009). Today's Internet can further enhance pyramiding by targeting early influential authors of blogs on the topic or using online social networks.

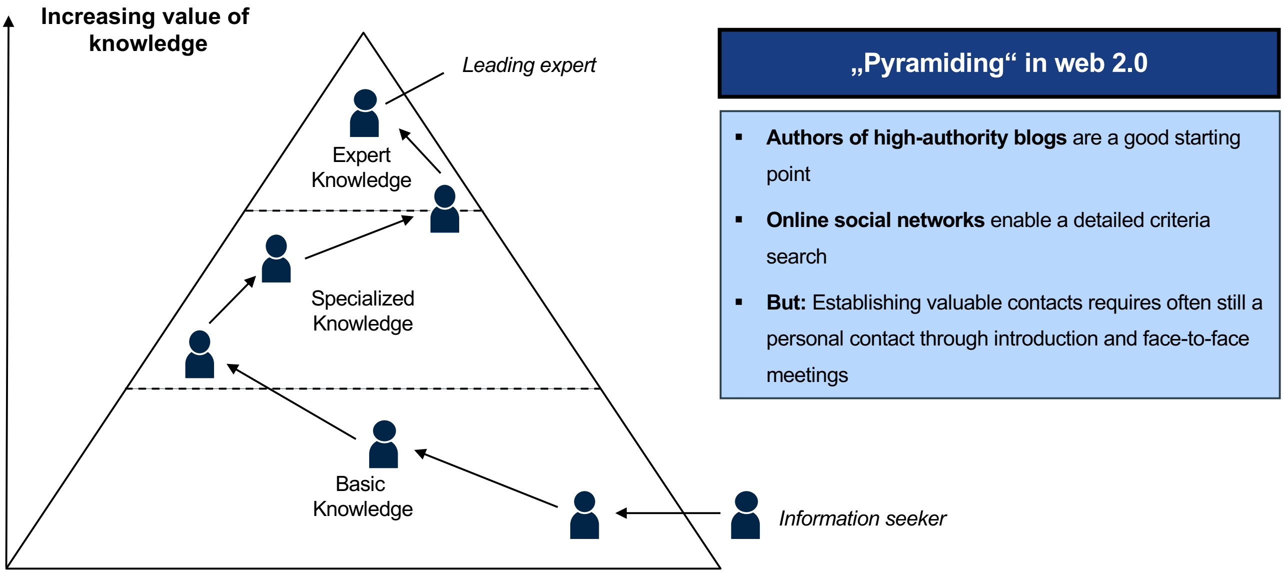

Figure 5: Pyramiding to find leading experts in fields of knowledge

Another notable point is that the open innovation tools highlighted in **Figure *3*** are all involving high degrees of human interaction. The advantages of humans are their ability to build the search taxonomy (i.e. the keywords and concepts used to identify and assess a given technology or innovation) while searching and their ability to create compelling future outlooks in an innovation field through storytelling (Crews, 2017; Rohrbeck, 2010). In addition, we can expect that humans will be instrumental to transform the academic knowledge from outside into innovation outcomes (Dahlander et al., 2016).

4. CONCLUSIONS

In conclusion, the design of the open innovation system can thus be systematized through the identification of centers of excellence, the mapping of open innovation tools onto a head map of scientific excellence, a gap analysis, and the selection of open innovation tools that tap into the knowledge pools where the firm lacks gaps. In a final step, a commercial assessment would inform about what can be achieved within given resource constraints and/or inform a prioritization exercise.

With the Arla Foods case, we have shown how a basic version of the approach has generated actionable recommendations on how to enhance and enact an effective open innovation system. The approach can be further refined by

- using *more databases* to assess a broader scope of knowledge generation activities (e.g. including patents, industry magazines, and specialized scanning services).
- using *additional criteria* to qualify the 'excellence' by moving beyond the number of publications and towards impact of publications (e.g. by measuring the citations of publications and patents)
- using *more tools*. While we have illustrated the main categories of tools there are variants like the internal scouting units that can perform a similar job as networks of external scouts)

Our three-step approach allows firms to systematically identify and access global centres of knowledge excellence, and to channel the knowledge into the organization and facilitate open innovation by way of this process.

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