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To cite this article: Mila Davids & Koen Frenken (2018) Proximity, knowledge base and the innovation process: towards an integrated framework, *Regional Studies*, 52:1, 23-34, DOI: [10.1080/00343404.2017.1287349](https://doi.org/10.1080/00343404.2017.1287349)

To link to this article: <https://doi.org/10.1080/00343404.2017.1287349>



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Proximity, knowledge base and the innovation process: towards an integrated framework

Mila Davids^a and Koen Frenken^b

ABSTRACT

Proximity, knowledge base and the innovation process: towards an integrated framework. *Regional Studies*. The proximity concept refers to types of inter-organizational relationships that are expected to facilitate interactive learning and collaborative innovation. Different forms of proximity include geographical, cognitive, social, institutional and organizational proximity. This paper argues that the relative importance of each proximity dimension depends on the type of knowledge being produced. It distinguishes between analytical, synthetic and symbolic knowledge, the intensity of which in turn varies with research, development and marketing stages of new product development. The case study of Unilever's Becel diet margarine serves as a first example of such an integrated framework.

KEYWORDS

innovation; proximity; knowledge; science-based industries; multinational enterprise; management

摘要

邻近性，知识基础与创新过程：迈向整合的架构。 *Regional Studies*。邻近性概念指涉预期能促进互动学习与合作创新的跨组织关系的类型。不同形式的邻近性包含了地理，认知，社会，制度与组织的邻近性。本文主张，各种邻近性的面向之相对重要性，取决于所生产的知识类别。本文区辨分析，综合与象征知识，它们的强度随着新产品开发的研究，发展和行销阶段而有所不同。联合利华的贝赛尔低脂人造黄油的案例研究，提供作为此般整合架构的第一个案例。

关键词

创新；邻近性；知识；以科学为基础的产业；多国企业；管理

RÉSUMÉ

Proximité, base de connaissances et le processus d'innovation: vers un cadre intégré. *Regional Studies*. Le concept de la proximité se rapporte à des rapports inter-organisationnels censés faciliter l'apprentissage interactif et l'innovation concertée. Parmi les différentes formes de proximité, indiquons la proximité géographique, cognitive, sociale, institutionnelle et organisationnelle. La présente communication soutient que l'importance relative de chaque dimension de proximité est tributaire du type de connaissance produit. Elle fait la distinction entre connaissance analytique, synthétique et symbolique, dont l'intensité varie, à son tour, en fonction de la recherche, du développement et des stades de marketing du développement de produits nouveaux. L'étude de cas de la margarine «diététique» Becel d'Unilever est un premier exemple d'un tel cadre intégré.


MOTS-CLÉS

innovation; proximité; connaissance; secteurs à base scientifique; entreprise multinationale; management

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ZUSAMMENFASSUNG

Nähe, Wissensbasis und der Innovationsprozess: auf dem Weg zu einem integrierten Rahmen. *Regional Studies*. Das Konzept der Nähe bezieht sich auf verschiedene Arten von Beziehungen zwischen Organisationen, von denen erwartet wird, dass sie interaktives Lernen und kooperative Innovation fördern. Zu den verschiedenen Formen der Nähe gehören die geografische, kognitive, soziale, institutionelle und organisationale Nähe. In diesem Beitrag argumentieren wir, dass die relative Bedeutung der jeweiligen Nahedimension von der Art des erzeugten Wissens abhängt. Hierbei unterscheiden wir zwischen analytischem, synthetischem und symbolischem Wissen, dessen Intensität wiederum in den Forschungs-, Entwicklungs- und Vermarktungsphasen während der Entwicklung des neuen Produkts unterschiedlich ausfällt. Die Fallstudie der Diätmargarine Becel von Unilever dient als erstes Beispiel für einen solchen integrierten Rahmen.

SCHLÜSSELWÖRTER

Innovation; Nähe; Wissen; wissenschaftsbasierte Branchen; multinationaler Konzern; Betriebsführung

RESUMEN

Proximidad, base de conocimiento y proceso de innovación: hacia un marco integrado. *Regional Studies*. El concepto de proximidad se refiere a los tipos de relaciones interorganizativas que se prevén para facilitar el aprendizaje interactivo y la innovación colaborativa. Algunas de las diferentes formas de proximidad son la proximidad geográfica, cognitiva, social, institucional y organizativa. En este artículo argumentamos que la importancia relativa de cada dimensión de proximidad depende del tipo de conocimiento que se produce. Aquí distinguimos entre el conocimiento analítico, sintético y simbólico, cuya intensidad a su vez varía con los estadios de investigación, desarrollo y mercadotecnia del desarrollo de un nuevo producto. El estudio de caso de la margarina dietética Becel de Unilever nos sirve de primer ejemplo para este marco integrado.

PALABRAS CLAVES

innovación; proximidad; conocimiento; industrias del sector científico; empresa multinacional; gestión

JEL F23, L66, N30, O31

HISTORY Received 22 September 2015; in revised form 17 January 2017

INTRODUCTION

In many industries, a firm's competitiveness depends primarily on its innovative capacity, which in turn relies on a continuous process of knowledge creation. Knowledge is created not only in-house, but also in collaboration with other actors, including other firms, consumers, suppliers, universities and government. Regarding its outcomes, joint knowledge production is inherently an uncertain process. Furthermore, the interests at stake can be high and often conflicting. A key question for firms thus holds how to conduct effective governance of interactive learning, knowledge transfer and collaborative knowledge production.

Boschma (2005) proposed a proximity framework referring to types of inter-organizational relationships that are expected to facilitate interactive learning and collaborative innovation. Apart from geographical proximity, Boschma mentioned cognitive, social, institutional and organizational proximity as additional factors that support inter-organizational collaboration. Empirical evidence suggests that, indeed, all forms of proximity tend to be associated with increased levels of collaborative innovation, and that distance in one dimension can be compensated by the presence of proximity in another (Autant-Bernard, Billand, Frachisse, & Massard, 2007; Balland, 2012; Breschi & Lissoni, 2009; Maggioni, Nosvelli, & Uberti, 2007; Mattes, 2012; Ponds, van Oort, & Frenken, 2007).

The theoretical contribution of this paper concerns the extension of the proximity framework with the knowledge

base framework introduced by Asheim and colleagues who distinguished between analytical, synthetic and symbolic knowledge (Asheim, 2007; Asheim, Coenen, & Vang, 2007; Mattes, 2012). A proximity-plus-knowledge-base framework is then used to explain the *changing* configuration of innovation projects as they unfold over time. The framework applies primarily to innovation processes in science-based industries, where one can appropriately distinguish between a first *research* stage, a second *development* stage and a third *marketing* stage. Different knowledge bases are expected to dominate in different stages as well as in different departments, with analytical knowledge being key to research by the research and development (R&D) department, synthetic knowledge to development where R&D, production and marketing generally work close together, and symbolic knowledge to sales and public relations by the marketing department. Our perspective on knowledge bases and proximities thus reasons from stages in product development and the respective roles of departments within the firm, rather than taking the firm as the unit of analysis when looking at knowledge-production activities in general (Mattes, 2012) or specific motivations for collaboration (Hansen, 2014).

As an explorative case study, we discuss the product development of Becel, an innovative product that multinational Unilever introduced in the 1960s. As a revolutionary diet margarine, Becel represents a key innovation for Unilever, while at the same time it serves as an example of modern, science-based product innovation. The history

of Becel shows that the ability to 'bridge distances' formed an essential part of Unilever's innovative capabilities. Indeed, in each stage of product development, the company coped with different forms of distance by creating proximity in other dimensions. We elaborate on the case findings by proposing a general theoretical framework associating the relevant proximity dimensions for each of the three types of knowledge base (which, in turn, are linked with the three stages of product development). This outline can provide building blocks for a new and integrated theoretical framework for analyzing science-based product innovations.

The paper is organized as follows. The next section discusses the main tenets of the proximity framework and the knowledge base framework. The third section discusses the methodology and the fourth section presents the case study. The fifth section then proposes a new framework integrating proximity into the knowledge base framework. The sixth section provides conclusions and discussion.

PROXIMITY, KNOWLEDGE BASE AND THE INNOVATION PROCESS

Innovative activities are highly clustered in space (Audretsch & Feldman, 1996; Paci & Usai, 2000). This observation has opened up a new field of investigation generally labelled as 'the geography of innovation' (Asheim & Gertler, 2005). The primary question holds why innovation is clustered in space and what explains the differences in the degree of geographical clustering of R&D across industries. It is commonly argued that clustering stems from the need for face-to-face interaction in the joint production and exchange of tacit knowledge. Industries primarily based on tacit knowledge would be more geographically clustered than industries based on more codified knowledge, *ceteris paribus*.

Despite the tendency for innovative activities to cluster geographically, the number of international R&D collaborations has increased markedly as well (Narula & Zanfei, 2005; Picci, 2010). Innovation projects increasingly involve partnerships that span the globe, be it within or between organizations. Though the people involved have different permanent locations, they still regularly meet face to face. Temporary interaction can be organized by travelling to meetings or short-term staff exchange. This common practice implies that permanent co-location within a cluster is not necessary for effective knowledge transfer and collaboration to take place (Boschma, 2005). Rather, what is necessary for collaborative knowledge production is to organize effective forms of 'temporary geographical proximity' at different stages of an innovation process (Torre, 2008; Torre & Rallet, 2005).

To probe the spatial logic of collaborative innovation, it is useful to distinguish between different types of knowledge. Asheim and Coenen (2005) and Asheim and Gertler (2005) distinguished between analytical and synthetic knowledge. Analytical knowledge mainly refers to (scientific) knowledge to understand and explain empirical

phenomena, that is, know-why. This knowledge is highly codified, even though tacit knowledge remains a necessary complement to understand and validate analytical knowledge. Synthetic knowledge refers to know-how and is more tacit and problem driven. Typically, it is used to design an artefact or solve a practical problem. Asheim (2007) and Asheim et al. (2007) later added symbolic knowledge to the knowledge-base classification as a third type of knowledge. Symbolic knowledge is used to produce cultural meaning, often in the form of cultural artefacts like texts, photographs, films and fashion designs as used in the media and advertising industries.

All three types of knowledge are used and produced in every industry. However, we can argue that the key type of knowledge underlying innovation processes differs markedly between industries. Analytical knowledge is key to the innovation process in science-based sectors, such as the pharmaceutical, biotechnology and nanotechnology industries. By contrast, synthetic knowledge is dominant in artefact engineering for the vehicle, electronics and construction industries. Symbolic knowledge is associated with the knowledge of cultural codes underlying cultural industries and advertising. Based on this classification, hypotheses have been derived regarding the spatial organization of collaborative knowledge production. While face to face interaction is generally required for all forms of knowledge production, the exact extent differs per industry. This depends on the degree to which knowledge is formalized – with analytical knowledge being most formalized and least contextualized and symbolic being the least formalized and most contextualized (Herstad, Aslesen, & Ebersberger, 2014; Martin & Moodysson, 2013). Hence, we can expect knowledge production and exchange among actors to be most geographically localized in symbolic-knowledge-based industries, less so in synthetic-knowledge-based industries, and even less so in analytical-knowledge-based industries (e.g., Liu, Chaminade, & Asheim, 2013).

The knowledge base concept has been used mainly to classify industries in terms of the ideal-type knowledge underlying their innovation processes. However, this paper analyzes the organization of *singular* innovation projects, rather than different industries. Once we start analyzing singular innovation processes within the context of one particular industry, it becomes clear that an innovation process typically draws on multiple knowledge types (Mattes, 2012; Strambach & Klement, 2012). The relative importance of a knowledge type, then, can shift during different stages of an innovation process (Ibert & Müller, 2015). In particular, at least in high-technology industries, the research stage of an innovation process crucially depends on mobilizing analytical knowledge to guide the search process to a useful product, whereas at the development stage, more practical, synthetic problems of large-scale production and logistics need to be solved (Moodysson, Coenen, & Asheim, 2008). To the two-stage R&D model, one can add a third stage where the final product needs to be marketed to gain acceptance by clients and, in some cases, by government and the wider public as well. Marketing entails the effective communication of

the useful properties and experiences characterizing the new product to prospective users and society at large, and forms an integral part of product innovations (Schumpeter, 1934). This stage mainly draws on symbolic knowledge to get a new product accepted in the context of the cultural codes, values and expectations held by users.

It is important to stress that associating knowledge bases with particular stages in the innovation process does not imply that these stages can be neatly separated. For example, in the research phase of new product development, analytical knowledge production focuses not only on the properties of the product, but also on the properties that render a product more or less costly to produce and distribute. That is, development considerations concerning production and distribution are already anticipated at the research stage (Frishammar, Lichtenthaler, & Richtner, 2013; Storm, Lager, & Samuelsson, 2013). And the development stage, which can be associated with synthetic knowledge, increasingly draws on analytical knowledge as well, with the ongoing codification of knowledge in the engineering sciences over the 20th century (Mattes, 2012). Furthermore, marketing considerations are anticipated in the design of product interfaces developed at the R&D stages. Indeed, the product design – as an object conveying both a functional and a symbolic meaning – mediates between production efficiency and user experiences.

More generally, the three-stage model of innovation should not be seen as a linear model (Kline & Rosenberg, 1986). Problems arising at one stage may motivate a return to a previous stage. For example, if fundamental problems occur in production, scientific research may be required to find a solution. Furthermore, innovation processes lead to unforeseen outcomes, resulting in modification of goals or even a redefinition of products. Hence, our three-stage model does not assume very distinct stages to unfold over time, but rather points to three types of activities, the prevalence of which shifts over time.

Building on the knowledge base framework, then, the association between the knowledge bases and the spatial organization of innovation is based on the degree of formalization of the knowledge that is drawn upon (Mattes, 2012; Moodysson et al., 2008). More formalized knowledge is more easily exchanged at a distance than less formalized knowledge. This explains why collaborations making use primarily of analytical knowledge are often organized at long distances, while collaborations drawing on synthetic or symbolic knowledge are more often localized within a region due to the need for frequent face-to-face interactions to transfer tacit knowledge (as in the case of synthetic knowledge) or the need to share cultural codes, values and expectations (as in the case of symbolic knowledge).

However, a too strong association between the knowledge base and the geographical distance between partners ignores the importance of other forms of proximity, which are non-spatial in nature. In this context, apart from geographical proximity, cognitive, social, institutional and organizational proximity, Boschma (2005) distinguished:

- *Cognitive proximity*: the extent to which two actors share the same knowledge (Nooteboom, 1999). Cognitive proximity does not mean that actors necessarily share one of the knowledge bases as defined above (analytical, synthetic and symbolic), but more that actors share a similar knowledge background (e.g., scientific discipline or specific technology) (Breschi & Lissoni, 2009; Hardeman, Frenken, Nomaler, & Ter Wal, 2015; Nooteboom, van Haverbeke, Duijsters, Gilsing, & Van den Oord, 2007).
- *Social proximity*: generally associated with personal relationships between actors (Uzzi, 1996), e.g., resulting from friendships or family ties. Social proximity can also be revealed through past collaborations, e.g., by looking at repeated ties (Hardeman et al., 2015) or whether two prospective partners had a common third partner in the past (Balland, 2012).
- *Institutional proximity*: high when actors share norms, practices and/or incentives. Importantly, the literature distinguishes two forms of institutional proximity: co-location in the same territory where cultural codes and economic institutions are widely shared (Boschma, 2005; Gertler, 1995); and joint participation in the same social subsystem, in particular within academia, industry or government (Ponds et al., 2007; Thornton & Ocasio, 1999). Both meanings will be used below.
- *Organizational proximity*: membership of the same organizational entity, as is the case with, for example, for two subsidiaries or departments of the same parent company (Balland, 2012).

Importantly, we take as the fundamental unit of analysis in our framework the department (or corporate unit) within a firm, as opposed to the firm as a whole as in Mattes (2012), Hansen (2014) and Ibert and Müller (2015). When analyzing a singular innovation process, the choice of department as the unit of analysis follows from the fact that the main locus of innovative activity within a firm generally shifts from one department to another. The research stage primarily involves the R&D department, the development stage involves the R&D, production and marketing departments jointly, and the marketing stage primarily the marketing department.

A key insight from the proximity framework holds that non-geographical forms of proximity can compensate, at least partially, for a lack of geographical proximity because non-geographical forms of proximity reduce the need for face-to-face interaction (Boschma, 2005; Hansen, 2015). For example, scientists collaborate easily over long distances when working on narrowly defined subjects (cognitive proximity) and under the same academic incentive structure (institutional proximity) (Ponds et al., 2007). Former colleagues exchange knowledge more frequently, and in a reciprocal manner, as their social proximity built up in the past generated the required level of mutual trust (Balland, Boschma, & Frenken, 2015; Breschi & Lissoni, 2009). Moreover, tacit knowledge transfer occurs much more easily between subsidiaries in a single multinational company or industrial group compared with alternative,

more informal inter-organizational arrangements (Kogut & Zander, 1993; Levy & Talbot, 2015). The significance of geographical proximity when drawing on synthetic and/or symbolic knowledge should therefore not be overrated. In other words, if actors are already proximate in one or more non-spatial dimensions, synthetic or symbolic knowledge can still be transferred effectively over a long distance.

For each proximity dimension (cognitive, social, institutional, organizational), one can analyze how the relative importance of proximity depends on the type of knowledge base (analytical, synthetic, symbolic), which in turn is associated with the project stage of an innovation project (research, development, marketing). To do so, we will first introduce as an exploratory case study Unilever's development of a new diet margarine. The lines of enquiry are the different stages of product development, and the focus here is on the relative importance of each knowledge base and the relevant proximity types at each of these stages. Using the case study as a first example, we then move to a more general discussion so to develop a theoretical framework for more systematic empirical studies in the future.

METHODOLOGY

The exploratory case study is an historical case study of Unilever's new diet margarine Becel launched in the early 1960s. The case is based on an elaborated investigation of publications, archival data, oral histories and interviews. We held interviews with more than 16 experts (for the list of persons interviewed, see Appendix A in the supplemental data online). With some of them we also discussed parts of the text. The duration of the interviews varied from one to three hours and were held in several phases of the research process.

The secondary sources included annual reports and earlier publications on the history of cardiovascular diseases, (health enhancing) food, the food industry and Unilever, annual reports and publications in leading (medical) journals from the 1950s onwards (including *Journal of Biological Chemistry*, *Journal of Nutrition*, *International Review of Vitamin Research*, *Journal of the American Medical Association*, and *The Lancet*). Archival research was done in both public archives and Unilever's exclusive R&D archives

(see Appendix B in the supplemental data online). The primary sources included minutes of meetings, internal reports, design notes, discussions, letters as well as Unilever publications (*Unilever Information Bulletin*, *Unilever Magazine*) and internal overviews (such as *The Colworth Chronicles: A Golden Celebration, 1947–1997*) were used. The collected data have a qualitative nature. We complemented our document search with semi-structured interviews with (former) members of Unilever R&D, among which were various former directors and cardiovascular experts. We also used the interviews with former Unilever and Unilever R&D board members that were conducted and recorded in the 1960s. Insight into the importance of the nature of relationships was based not only on document analysis, but also on the interviews and consultation of nutrition, chemical and historical experts (among which members of Unilever R&D). The opportunity to conduct interviews and discuss our working documents meant that the conclusions from the data could be confirmed or challenged. In contrast to non-historical research, the interviews and consultations were mainly to verify the information based on the primary and secondary sources. The more elaborated results of the historical study are presented elsewhere (Davids, 2016; Helvoort, van, Berkers, & Davids, 2014).

The research procedure we have followed consisted of several steps. Identifying and selecting projects, collaborations and events was the first step, and reconstructing the organization of the innovation process was the second. The outcome generated by these first two steps of the research procedure was a detailed description of the innovation project, a so-called innovation biography. The third step was the analysis of the innovation process of Becel according to the proximity knowledge-base framework.

We defined geographical proximity pragmatically as those collaborations that took place within a 25-kilometre radius. For what concerns the identification of the other proximity dimensions, we followed closely the definitions provided above. Table 1 provides the list of operational definitions.

To operationalize the three types of knowledge bases, we made use of different sources. Regarding the analytical knowledge base, we focused on scientific papers and conference presentations by Unilever researchers and by other academics upon which Unilever researchers built.

Table 1. Operationalization of proximity dimensions.

	High	Low
Geographical proximity	Less than 25 km distance	More than 25 km distance
Cognitive proximity	Similar knowledge	Different knowledge
Social proximity	Friendships, family ties or earlier collaboration	Absence of friendships, family ties and earlier collaboration
Institutional proximity	Co-location in same social subsystem (academia, industry, government) or same territory	Location in different social subsystems or territories
Organizational proximity	Intra-organizational	Inter-organizational

Table 2. Operationalization of knowledge bases and main outcomes.

	Analytical	Synthetic	Symbolic
Concept	Understanding and explaining empirical phenomena (know-why)	Product and process-related problem solving (know-how)	Cultural meaning, persuasion
Output	Scientific articles, papers and presentations on fatty acids and on the effects of fat intake on coronary heart diseases	New hydrogenation process, patents	Advertising campaigns to build trust in Becel, scientific information campaigns to medical practitioners on diet recommendations, sponsoring a quarterly journal with reviews of the most important international publications on atherosclerosis in relation to nutrition
Outcome	Analysis of fatty acids, effects of fat intake	Developing a hydrogenation process (to produce a solid margarine with unsaturated fatty acids while keeping the optimal flavour)	Stressing the health-enhancing effects of Becel diet margarine, building trust

To identify the production of synthetic knowledge, we looked at the specific engineering solutions developed by Unilever to produce Becel. Finally, regarding symbolic knowledge we looked at marketing and information campaigns as well as public relations efforts in the national food council. A summary of operationalizations and the empirical findings are provided in Table 2.

CASE STUDY: UNILEVER'S LAUNCH OF BECEL AS A DIET MARGARINE

In November 1962, Unilever launched the diet margarine Becel on the consumer market. Initially the brand name Becel was used for the dietary fat for coronary patients that could only be acquired by prescription. When a competitive diet fat named Crokvitrol was distributed via grocery shops in 1961, Unilever decided to abandon its niche strategy and produce a diet *margarine* for the retail market. Becel became accessible for everyone via high-end grocery shops and later also supermarkets. In fact, Becel can be considered an early functional food (Helvoort et al., 2014). Nowadays, Becel is still an important Unilever product. It is one of 14 Unilever brands with sales amounting to over €1 billion a year. Unilever sells it worldwide, in most countries under the name Becel. Consumers in the UK, Ireland, Spain and Australia know it as Flora, while in France and the United States it is sold as respectively Fruit d'Or and Promise.

Research stage

American research from the 1930s onwards had led to the insight that various kinds of fatty acids exist – saturated, monounsaturated and polyunsaturated (PUFAs) – with specific effects on an organism's growth and development (Holman, 2000). Not surprisingly, Unilever's research interests were closely related to the worldwide explosion of biochemical research into fats from the 1950s onwards. To be able to develop a diet margarine, Unilever needed expertise and knowledge in two different domains: the

ability to separate and analyze the various kinds of fatty acids, and to investigate the possible effects of fat intake on coronary heart diseases. Unilever Research Laboratory (URL) in Vlaardingen near the city of Rotterdam (the Netherlands) had already acquired scientific knowledge and experience in both (closely related) research fields. This knowledge was analytical in character. For the chemical analyses of fats, URL could build on the earlier work of its director Jan Boldingh. Together with his staff, he had developed new techniques to isolate flavourings which would be used extensively to give margarine a butter-like taste. URL later improved those methods for analyzing fatty acids by means of chromatography (Beerthuis, Dijkstra, Keppler, & Recourt, 1959). In addition URL could rely on other internal experts for chemical analyses of fats (Beerthuis et al., 1959; Boldingh, 1953; Boldingh, 1993).

In the process, Unilever researchers collaborated with external experts from universities and private research institutes outside the Rotterdam area in the Netherlands and abroad, especially the United States. Unilever researchers were also invited to scientific symposia and conferences and co-authored papers with university professors. The research at Unilever's laboratory, however, was limited to research on mice and rats. To rectify this, a specific collaboration was set up with Leiden University (also located in the Netherlands) and its academic hospital to access medical data on human subjects.

All the collaborations between URL Vlaardingen and research institutes, universities and hospitals suggests that there was little distance between them in a cognitive sense. Even having to bridge the oceans did not hinder discussions on research outcomes and collaboration. The experts acted as part of the same epistemic community. Additionally, collaboration was facilitated by a high institutional proximity between the Unilever researchers and the scientific world. URL researchers participated in the academic domain, visited scientific conferences and published in scientific journals, sometimes in co-authorship with university researchers. They had also a shared

perception with regard to where research should be heading, all realizing that more research was needed to get a *communis opinio* on fatty acids (in particular, how to lower the risk of vascular diseases).

The knowledge transfer and collaboration between URL, academia and other research institutes implied that organizational proximity was low. The social proximity, though, varied. In the past, Unilever's researchers had already worked closely with some scientists, while other connections with scientists were established from scratch. Geographically, processes took place at any scale, with Unilever scientists operating in both national and international research networks.

Development stage

Unilever's scientific knowledge base generated the ability to separate various fatty acids and an in-depth understanding of the effects of fat intake. However, this knowledge alone was not sufficient to develop a diet margarine. New expertise and knowledge were needed to produce a solid Becel margarine, while reducing rancidity and maintaining an optimal flavour. The proposed solutions had to be feasible for large-scale production, without losing the margarine's presumed health effects.

Although Unilever had gained substantial technological expertise in the mass production of margarine over the years, producing a new margarine with a high content of unsaturated (healthy) fatty acids challenged Unilever's development capabilities. As fatty acids are liquid at room temperature, a solution had to be found to produce a solid margarine without losing the unsaturated fatty acids. Various specialists with different backgrounds within the laboratory as well as experts from other Unilever departments had to put their heads together to find a solution. In particular, URL Hydrogenation experts came up with an unsaturated fatty acid-sparing hydrogenation process, while flavour experts from the Flavour Application Service were enlisted to assist the hydrogenation experts (Flavour Research AHK).

The development of Becel as a mass product underlines not only the role of scientific knowledge generated in the research phase, but also the importance of the synthetic knowledge required for development activities. Experts with different backgrounds cooperated to create a margarine with new properties. To develop Becel, gaps between various cognitive fields had to be bridged. To solve these production problems, geographical and organizational proximity at URL in Vlaardingen was crucial. Where cooperation was based on earlier contacts between departments, the relationships were possibly also personal. Social proximity could enhance the collaboration, but it was certainly not essential. Institutional proximity, however, played a greater role in collaborative development activities. All activities were geared towards cheaply producing a tasty margarine that would sell well on the market. The incentives were aligned with activities being purely commercially driven and the new solutions being patented. The institutional logic of the markets and expected profits prevailed.

Marketing stage

Becel diet margarine was more than just a new type of margarine. The health-enhancing effects were the real novelty. Accordingly, marketing highlighted the scientific evidence of Becel's effects on health. In this way, the symbolic knowledge produced in marketing activities became heavily grounded in the analytical knowledge stemming from research. Understanding the effects of consuming fatty acids, and especially findings that could be confirmed with scientific evidence, were essential ingredients for promoting Becel as a healthy margarine.

According to Jones (2005, p. 117), the '[k]nowledge of the marketing of branded consumer goods' had always been one of Unilever's main capabilities. Indeed, Unilever had a lot of experience in launching new products. In the case of Becel, however, Unilever did not just launch a new product, but a whole new product *category*, namely functional food. This increased the cognitive distance between Unilever and consumers rendering extant marketing strategies insufficient. Unlike product characteristics such as taste and consistency, consumers were not able to evaluate the health-improving aspects of this new margarine themselves. Hence, Unilever invested in a major marketing campaign.

The Unilever researchers were convinced that 'although there is no absolute medical proof, the evidence is such that [they] would recommend a reasonable polyunsaturated content in dietary fats' (AHK Co-ordination Foods I). The marketing staff, however, hesitated because without conclusive evidence that unsaturated fats would actually help prevent atherosclerosis, there was a risk that any health claims would boomerang against Unilever. The relationship between fat consumption and cardiovascular disease was described as a 'thoroughbred in which to enter Troy' (AHK Minutes, 12 December 1962). This inter-departmental tension between analytical knowledge per se and its problematic meaning in symbolic communication to consumers further illustrates the dominance of analytical knowledge in the R&D department and of symbolic knowledge in the marketing department.

Moreover, manufacturing a mass product that was sold in groceries and, from 1963 onwards, also in supermarkets went hand in hand with a lack of personal contact between Unilever and its consumers. Only a select group of taste panellists had contact with the industrial researchers. Thus, social and organizational proximity between the marketing department and consumers was therefore low. Consumers' trust in Unilever's message was initially backed by professionals (medical practitioners, nutritionists) as well as government bodies (particularly the Dutch Food Council, which had Unilever researchers among its advisors) who supported the notion that saturated fatty acids were unhealthy and that unsaturated fatty acids would lower cholesterol levels. This claim became increasingly important in the late 1960s when more people became worried about the health consequences of fat intake. The advice was to consume less fat, switch to products like low-fat milk and replace animal products such as butter, certain margarines and animal fat with products made from vegetable oils (Wijn, 1969). The 1973 report was even more

explicit, with the Food Council recommending that people should choose healthier industrial products like Becel (Hartog et al., 1973).

Furthermore, from the very the moment Becel was launched, Unilever addressed medical experts who were regarded as a strategic ‘cognitive bridge’ between the firm and future Becel consumers. While discussing the first Becel advertising campaign in 1962, it was agreed within Unilever that, although it would have to concentrate on polyunsaturated fatty acids ‘the methodical building of good relations with medical and scientific circles, based upon trust in Unilever as suppliers of unbiased information on dietary fats’ would be the wider task (Minutes second meeting, 12 December 1962 AHK).

When Unilever used television advertisements to promote Becel in 1967, members of the public approached medical practitioners for information. Consequently, Unilever decided to invest even more in informing Dutch physicians and to include more scientific information in their advertisements (Knecht-van Eekelen & van Otterloo, 2000). In 1967, Unilever also started sponsoring a quarterly journal with reviews of relevant international publications as well as of its own research outputs. The journal was distributed to every physician.

Later, the importance of medical practitioners in diet recommendations dwindled when the overall credibility of medical experts, and experts in general, declined in the late 1970s. This was closely related to another development: debates and controversies were no longer kept within the scientific community but became public (Davids, 2016). A too explicit use of analytical (scientific) knowledge for symbolic marketing purposes actually weakened the status of Unilever’s Becel, as absolute medical proof for the claim that Becel would have a beneficial effect in terms of preventing cardiovascular diseases was still lacking.

The launch of Becel in the Netherlands illustrates that the various marketing and lobbying activities were organized within a national institutional framework. The same applied in other countries. Indeed, despite Unilever’s international branding policy starting in the 1960s, its marketing activities for Becel remained for a long time national in character. Related to its tradition of decentralization, Unilever’s operating companies were – especially regarding food products – adapted to local circumstances. For example, while in Germany the emphasis was on the medicinal role; in Belgium and the Netherlands Becel was launched as a consumer product that was ‘healthy for your heart arteries’. Additionally, expressions in advertisements and graphics on the packaging could differ geographically (Jones, 2005), and often under different names (including Flora, Fruit d’Or and Promise).

In terms of proximity dimensions, the marketing phase can be characterized as the cognitive, organizational and social distance between Unilever, on the one hand, and its consumers, on the other. Thus, geographical and institutional proximity became even more important for creating symbolic knowledge. Especially the institutional proximity in a territorial sense was exploited by following country-specific strategies towards consumers as well as

in public relations vis-à-vis experts and professionals who functioned as intermediaries to bridge the cognitive distance between Unilever and its consumers.

INTEGRATING PROXIMITY INTO THE KNOWLEDGE-BASE FRAMEWORK

The case study demonstrates that different knowledge bases play a different role at different stages of new product development. Table 2 summarizes the main outcomes. Analytical knowledge dominated in the research stage, synthetic knowledge in the development stage and symbolic knowledge in the marketing stage. Theoretically, this is in line with Asheim’s framework of knowledge base (Asheim, 2007; Asheim et al., 2007). However, whereas Asheim *cum suis* used the knowledge-base concept to explain differences across industries, the case study shows that the distinction between analytical, synthetic and symbolic also applies to stages of development in a singular innovation project (research, development and marketing). Another finding was that, at each stage, the relative importance of proximities shifted depending on the dominant type of knowledge being used and produced. This provides us with building blocks to integrate proximity dimensions into the knowledge base framework in the context of innovation processes.

In the *research* stage, the key actor is obviously the R&D department. Researchers are generally familiar with the relevant scientific knowledge and the academic institutions governing its production, validation and exchange. Indeed, to a large extent, R&D employees operate as academic scientists, visiting specialized academic conferences and publishing in scientific journals, in order to become part of the epistemic community that advances the frontiers of science (Rosenberg, 1990). Hence, cognitive and institutional proximity can generally be expected to be high in the research stage of product development processes (cf. Moodysson et al., 2008).¹ That is to say, due to the formalized and often academically produced nature of analytical knowledge, effective transfer and collaboration are made possible by the high degree of cognitive and institutional proximity. Social proximity, however, is variable depending on the contacts that a firm’s employees already established in the past within the relevant epistemic community.

Since research draws primarily on analytical knowledge, one can expect geographical and organizational proximity to be low. Companies look for state-of-the-art knowledge that is often not found within their own organization (organizational distance) nor in the vicinity of their own corporate laboratory(ies) (geographical distance). Instead, companies tend to engage in research collaborations with other research-intensive organizations (including firms, universities and public laboratories) that specialize in the same field of knowledge, that is, they operate in the same epistemic community.

At the *development* stage of new product development, which draws primarily on synthetic knowledge, the challenge for a firm is to translate its prototype into a well-functioning product that can be produced and distributed

efficiently on a large scale. This part of the innovation process is dominated by practical problems that have to be worked through on site and within the boundaries of a company, by aligning the knowledge and routines of several departments (R&D, production, logistics, marketing) through in-house collaborative projects (cf. Moodysson et al., 2008). Hence, geographical and organizational proximity can indeed generally be expected to be rather high at the development stage of product development processes.

By contrast, cognitive proximity is lower in the development stage compared with the research stage due to the need to combine different knowledge domains in complex production and distribution process. The development stage – as the intermediate stage between research and marketing – is also the most combinatorial in nature, drawing not only on various subtypes of synthetic knowledge, but also to an important extent on analytical and symbolic knowledge (Manniche, 2012; Strambach & Klement, 2012). The institutional context is given by market criteria, as user functionality, cost efficiency and intellectual property rights become the criteria for innovation. Given these dominant criteria, one can say that institutional proximity in collaboration remains as high in the development stage as in the research stage, though shifting from academic to market logic. Again, social proximity is variable depending on the contacts firm employees already established in the past within the firm. One may expect, though, that social proximity is generally higher in smaller firms, whereas innovation projects in larger firms may involve employees unacquainted with each other.

Finally, at the marketing stage of new product development, symbolic knowledge becomes crucial as the new product has to be made acceptable and attractive to consumers – and in some cases also to government – within particular cultural, legal and other institutional contexts (Mattes, 2012, p. 1093; Wrigley, Coe, & Currah, 2005). At this stage, the relevant geographical context becomes the territory where such cultural codes are shared and territorial institutions are governed. Depending on the product in question, such contexts can be local, national (or, in some cases, even transnational). Hence, the notion of geographical proximity is less useful here; rather, what matters

is institutional proximity in the territorial sense (Mattes, 2012). Firms co-located with prospective consumers in the same territory will generally have a greater understanding of the cultural meanings that prospective consumers may attribute to their new product. Furthermore, co-location will provide the firm with more effective channels to influence government policies and regulations. The cognitive proximity between users and producers will depend on the degree of novelty of the product compared with previous products and the accompanying user practices, which – in mass markets – are generally low. Similarly, the interaction with mass consumers will also lack social and organizational proximity. By contrast, in more specialized markets, proximities may vary much more.

The theoretical framework following from the discussion is summarized in Table 3. It associates different knowledge bases and different proximity dimensions to each of the three product development stages, according to the framework outlined above.

The scheme outlines the expected proximities and distances according to each knowledge base. In future research, these expectations can be further made contingent on a firm's characteristics (Cohen and Levinthal, 1990) and an industry's technological regime (Winter, 1984). For example, firms with larger size, more knowledge and higher profits may be less bound to proximities as they can dedicate more resources to overcome them. Furthermore, multinational firms adopting a more decentralized organizational structure may be more effective in communicating analytical knowledge (scientific information) in symbolic form (marketing campaigns). Regarding the industry in question, firms operating in a regime where knowledge is typically appropriated by patents may be more prone to focus on proximate partners to secure its knowledge. A further elaboration of firm and industry characteristics, however, lies outside the scope of this paper.

DISCUSSION AND CONCLUSIONS

This paper proposes a framework that combines the proximity dimensions that support collaborative innovation and knowledge transfer with different types of knowledge bases involved in new product development. The different forms of proximity are geographical, cognitive, social, institutional and organizational. The argument is that the relative importance of each proximity dimension depends on the type of knowledge being mobilized and produced, distinguishing analytical, synthetic and symbolic knowledge.

While analytical knowledge can be effectively produced over a long distance as long as cognitive proximity is high, the production of synthetic knowledge generally requires permanent co-location and in-house project teams to overcome the cognitive distance between the disciplines that need to be integrated for operational production (Moodysson et al., 2008). The joint production and use of symbolic knowledge, however, is not so much affected by geographical proximity per se, but much more by institutional proximity of the territorial kind (Gertler, 1995); most often, though certainly not by definition, laws and cultural

Table 3. Knowledge base and proximity per innovation stage.

	Research	Development	Marketing
<i>Knowledge base</i>			
Analytical	High	Variable	Low
Synthetic	Variable	High	Variable
Symbolic	Low	Variable	High
<i>Proximity</i>			
Geographical	Low	High	High
Cognitive	High	Low	Low
Social	Variable	Variable	Variable
Institutional	High	High	High
Organizational	Low	High	Low

codes are shared among those residing in the same territory (Mattes, 2012).

Another argument we advanced holds that institutional proximity is expected to be high at each of the three stages of new product development. However, the nature of institutional proximity changes over time (cf. Stark, 2009). In the research phase, an R&D department interacts closely with academia and public research institutes, largely operating under academic norms of knowledge sharing. In the development stage, a firm's innovation process becomes organized in-house in line with market criteria (user needs, cost-efficiency, patenting) as the relevant institutional environment. Finally, when launching the product in several domestic markets, public relations and marketing departments address the relevant national public authorities and the public, using the product's content symbolically. Thus, we put forward the proposition that *the ability of a firm to innovate successfully will depend on its ability to have its departments operate and collaborate under different institutional logics*.

The proposed framework is based on the notion that a different knowledge base (analytical, synthetic and symbolic, respectively) dominates in different departments responsible for different stages in new production development (research, development, marketing). Yet, it is also clear that the three knowledge bases, though clearly distinguishable and shifting in importance across stages of product development, are also very much intertwined. That is, knowledge bases are used jointly, and in various combinatorial ways (Jensen, Johnson, Lorenz, & Lundvall, 2007; Manniche, 2012; Mattes, 2012; Strambach & Klement, 2012). Our framework leads to conclusions that somewhat differ from those derived by Mattes (2012), since we took the department as the unit of analysis, while Mattes (p. 1093) reasoned from the firm as a whole, and we took institutional proximity to mean either shared territorial institutions or shared institutional logics, while Mattes used the term strictly in the first sense. These differences explain why Mattes finds organizational proximity to be most important in analytical knowledge production with firms aiming to retain intellectual property rights over their competitors, while we find organizational proximity to be of little importance in analytical knowledge production as R&D employees collaborate with scientists under academic logic of sharing and publishing.

This study has empirical limitations. The proximity-plus-knowledge-base framework has been inspired by only a single case study. The case of Unilever is obviously not representative of most firms.² Rather, it typifies a modern, science-based multinational in consumer products. Therefore, it lends itself particularly well for a combined analysis based on the proximity and knowledge-base concepts, because it integrates all three knowledge bases and it does so on a global scale.

This leads us to conclude that the framework, which associates different knowledge bases and proximities to different stages of new product development, should be understood first and foremost as a heuristic device for future case study research. The framework seems

particularly useful in global industries developing science-based consumer products such as food, clothing, pharmaceuticals, cosmetics, electronics, vehicles, furniture and toys. Such cases will help one further scrutinize the theoretical reasoning and refine the framework at large. At the same time, the framework provides testable propositions regarding the relative importance of proximity dimensions in different stages of new product development. Thus, the hope is that there will be future attempts that systematically collect information about proximities across different product development stages, so as to test the propositions either statistically or by more case studies.

Finally, our framework can be used in the context of strategic management so as to develop a more dynamic view on how innovation networks can vary in the course of an innovation project. In so far as a lack of proximity in one dimension can be compensated for by the presence of proximity in another, alternative modes of organization can be envisaged which may be equally effective (Hansen, 2014; Hardeman et al., 2015). A fully fledged proximity-and-knowledge-base framework may then be able not only to explain why alternative organizational arrangements co-exist, but also to provide strategic implications how firms can choose and learn to bridge distances in certain dimensions while being proximate in another dimension, and to adapt this according to the underlying knowledge base. A further question holds how different types of knowledge can effectively be combined if these types of knowledge are localized in different locations of a multi-locational company. Indeed, the combined management of proximities and knowledge bases can become an organizational capability of its own, and, hereby, a key source of a firm's competitive advantage.

ACKNOWLEDGEMENTS

This article is partly based on the work of Helvoort et al. (2014). The authors owe a debt of gratitude to Ton van Helvoort for his excellent research. Preparation for this article would have been impossible without access to the archive of Unilever Research & Development Vlaardingen and the cooperation of the interviewees. Early versions for this paper were presented at the 2nd Geography of Innovation Conference in Utrecht, the Netherlands, in 2014, and at the Workshop Combinatorial Knowledge Bases at the Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University, Sweden, in 2014. The participants and Jerker Moodysson, the discussant at the workshop, provided valuable feedback. The authors also thank the editor and two anonymous referees for their insightful comments and helpful suggestions on earlier drafts of this article.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

SUPPLEMENTAL DATA

Supplemental data for this article can be accessed at <http://dx.doi.org/10.1080/00343404.2017.1287349>

NOTES

1. We depart from the definition of institutional proximity proposed by Ponds et al. (2007) that university–industry collaboration is institutionally distant. Their definition applies to firm level and the university as a whole. At these levels, firms and universities have operate under different institutional regimes (market versus academia). However, taking the department as the unit of analysis, a firm's R&D department can work closely and without conflicting objectives with a university's applied research department.
2. Similar recent case studies following a proximity framework looked at cleantech (Hansen, 2014) or biotech and legal services (Ibert & Müller, 2015). In these studies, the innovation output did not concern a new consumer product as in our study.

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