

Internationalization constraints due to path dependent innovation systems. R&D networks in the wake of a Norwegian corporate acquisition in Germany

Work in progress

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Abstract

This paper discusses the innovation system (IS) concept and whether IS are object for internationalisation in the globalizing industrial world. The attention is put on a sector characterized by an autarkic industrial order. The paper presents the case of a Norwegian transnational company acquiring a German transnational company of a corresponding size, complementing each other within the aluminium sector. The paper illustrates the lack of integration of the R&D function and limited changes in R&D networking in the wake of the merger. The case study draws a picture of the respective national innovation systems marked by inertia as they follow a path with strong historical roots. Consequently, parallel to a development of increasing international activity in companies the innovation systems remain very marked by their national origins. The case study is partly based on recent interviews of researchers and other key personnel and partly based on secondary sources.

Introduction

For some decades there have been scholarly debates on innovation system on the one hand and on economic globalization on the other hand. In spite of these lasting debates, they appear quite separate to each others. On the one hand economic geographers such as Dicken (2007) and Gertler and Vinodrai (2005) have stressed the convergence limits of business cultures and industrial practices due to differences in national institutions. On the other hand economists such as Lundvall (2007) and organizational sociologists as Whitley (2006) have discussed national innovation systems in the context of a globalizing economy. These scholars have, however, paid less attention to the internationalization of innovation systems (Carlsson 2006). We know that R&D is among the last functions leaving the mother country in transnational corporations, but we know less about how this stickiness is reflected in the innovation systems which the respective companies is a part of. As companies gain increasingly stronger foothold internationally, there is a need for extending the support of R&D in order to be able to serve international production network becoming more complex on a international level. Also, increased competition stimulates companies to search for new bidders of R&D competence (World investment report 2005). Increasing international activity in transnational companies has implications for the organization of R&D activity in the company, and further for affected actors in the innovation system. A more international range of production units that are served by R&D as well as possible extensions of R&D networks that may follow mergers or acquisitions challenge the existing networks.

This paper will contribute to the debate on innovation systems and fill this knowledge gap between the innovation systems approach and economic globalization as phenomenon by offering novel insights from a promising case study. It will argue that there are limits to internationalization of innovation systems due to their national distinctiveness and their path dependence. The encounter of two national innovation systems is analyzed trough a case study of an acquisition. Networks are considered to play a vital role, but as or focus in the article is on the systems at an institutional level, the networks will be considered as a feature in the innovation systems approach. Consequently the paper is more oriented towards innovation system theory than network theories. The article is organized in a design where the

acquisition is considered a turning point with regards to internationalization of innovation systems. This must be seen in connection with the character of the acquisition as such. In that respect the case this article is based on is rather atypical, the acquired company is of a corresponding size to the acquiring company. The power balance in most acquisitions is clear, as the acquired company is of a considerably smaller size than the buyer. Potential synergies of this merger were expected as the two companies complemented each other along the value chain. The phenomenon is analyzed in the light of the historical evolution of two distinctive innovation systems. Distinctive innovation systems are formed within the frames of a company, however such systems must also be evaluated as part of a larger system. A comparative institutional analysis of two nations' innovation systems will help us to understand the limits to their internationalization. The innovation systems respectively in Germany and in Norway are embedded in national cultures and institutions that share many characteristics. The study still identifies significant distinctions which delimit an expected increase in bilateral interaction in the wake of the significant international acquisition. On this background, the following research questions will be taken into consideration:

Which implications have a considerable international acquisition for R&D networks and the corporate integration of the R&D function?

How could the limited change in R&D networks and lack of R&D integration be explained?

The rest of the article is structured into four further sections. The following section gives an account for the notion of innovation systems (IS) and different understandings of this concept, with particular attention to sectoral and national systems. This section will also discuss the path dependency of innovation systems. It discusses internationalization of R&D and demands further attention to the innovation systems these R&D functions are part of, as well. In the third section, the empirical case is introduced, followed by how it is approached methodologically. This constitutes the background for the fourth and fifth section. The empirical material is here used as basis for analyzing the implications of a considerable international acquisition for the R&D functions of a company; further this analysis makes the basis for an explanation of a limited change in R&D networks and lack of R&D integration. Finally, the paper is summarized in a concluding sector.

Distinctive innovation systems and their path dependence

Firms do not innovate in isolation, but are dependent on other organisations as they collaborate with them (Fagerberg 2004). This is the starting point of the innovation systems (IS) approach. The function of innovation system is to create, develop and diffuse innovations. As systems, IS consists of components and the relations between them (Edquist 2004). The components are organisations and institution constituting respectively the production structure and the knowledge infrastructure. The partners are industrial companies on the one hand and universities, other R&D laboratories, and technological institutes on the other hand. Innovation systems are more institutionalised compared to networks that could be more flexible and changing over time. IS are thus a set of partners who enjoy close and long-term relationships.

The literature of national innovation systems has addressed the national level as a significant framework for interaction between knowledge institutions and industry striving to learn and innovate (Lundvall 2007). The concept national innovation system (NIS) was originally introduced by Freeman (1987), but became further recognized through two seminal books

(Lundvall 1992, Nelson 1993). Lundvall (1992) had a theoretical approach as he highlighted the interaction between the participating organisations. Focusing on learning through interaction between users and producers, he included incremental innovations as well. As learning and innovation activities could take place on diverse arenas and in different settings, his concept is broader than that of Nelson (1993). The case studies in the anthology of Nelson (1993) identified NIS primarily as R&D systems and characterised their institutional set up. It pays attention to nation-specific innovation patterns. The argumentation for the national framework is not explicit, but the studies point at national institutions, culture, language and sectoral politics.

Lundvall (2007) pays attention to the historical role of national systems. Recent literature on innovation systems stresses the co-evolution of structural and institutional characteristics which produces distinct national systems of innovations: the interdependence between economy, technology and institutions (Murmman 2003, Nelson 2005). As such, the scholars are influenced by institutional theory. Edquist and Johnson (1997) define institutions as norms, habits and rules. Such institutions point at inertia in social life and economy as well. Evolutionary economics is a related source of inspiration (Nelson 2002). Evolutionary economists suggest that industry develops along certain technological trajectories. In order to explain the institutionally specific nature of national systems of innovation the concept path dependence is particularly relevant (Feldman, Gertler and Wolfe 2008). A path dependent system is a system which evolves as a consequence of its own history (Martin and Sunley 2006). Much of the literature mentioned above places emphasis on the role of routines, institutions and networks shaping the evolution of systems.

Inspired by the literature of NIS, sectoral innovation systems (SIS) are also added to this academic vocabulary. The sectoral innovation model is partly launched as an alternative to the national innovation model. SIS are composed of those forms that are active in the innovative activities of a sector (Breschi and Malerba 1997, Malerba 2004). National economies are, however, characterized by their industrial specialization. This sectoral composition is usually reflected in sector-specific knowledge bases. Sectors dominating the national economy will particularly demand a knowledge infrastructure, institutions and policies. The national innovation system will subsequently influence the national economy, including its sectoral composition. There is thus an interface between NIS and SIS – they influence each other respectively as they co-evolve (Fagerberg, Mowery and Verspagen 2009).

We recognise that systems of innovation may be considered as overlapping systems evolving around a *national system of innovation*. The SIS-model takes into account that industries and institutions exchange knowledge across national borders. For companies this means that their creation and realisation of new technologies and innovation is dependent on a network of organisations and institutions, more or less nation based. As mentioned by Carlsson (2006) the *nation* might not always be the most adequate framework when studying innovation systems. Aiming to study innovation systems from *transnational companies (TNC)* point of view, this is obvious. Especially when it comes to multi- or high technological products, there is a growing mismatch between what companies need and what can be provided through a company and related innovation systems (Narula and Zanfei 2004). The inertia in the institutional path dependence makes the system slow to follow up the pace of technological development. As a consequence of this, companies search for innovation help abroad.

Empirical studies suggest that NSI are less national today than 20 years ago (Niosi and Bellon 1994, 1996). However, there are reasons why the NSI concept still has a high relevance.

Despite their international extension, TNCs are formed by and related to their home country and respectively a national innovation system. Even very large corporations perform most of their R&D at home, consequently their innovative activities are heavily influenced by the NSI (Pavitt ?).

Internationalisation of R&D

However, facing a growing internationalisation of economic activities and a competition that takes an increasingly global form, companies are forced to organise a global production system. R&D seems, however, much less internationalized than other corporate function such as production. In this regard, R&D is in most cases the last functions to leave the home base when a company goes global (Pavitt and Patel 1999, Dicken 2004). As such, it is reasonable to maintain that the R&D function is particularly marked by path dependence. The tendency of R&D internationalisation has, however, been strengthened over the last decade (Cantwell and Santangelo 2000). In TNCs, R&D activities tend to follow internationalisation of production, especially when it comes to major markets. Another important trend is that TNCs tend to keep the core technology and strategic projects within the home country, while the adaptation to foreign markets (final design and development) is made outside the country (Dicken *ibid*, Cantwell and Santangelo 2000). This stickiness of R&D set of course the conditions for the exploitation of innovation as a competitive advantage:

As a consequence [of the R&D stickiness], companies' innovative activities are significantly influenced by their home country's national system of innovation: the quality of basic research, workforce skills, systems of corporate governance, the degree of competitive rivalry, and local inducement mechanisms, such as abundant raw materials, the price of labour and energy, and persistent patterns of private investment or public procurement (Pavitt and Patel 1999:94).

According to Pavitt and Patel (1999), the country effects even outscore company effects in this regard. As we see, we know a little about internationalisation of R&D. What is more unclear, however, is: how are these processes affecting the *systems of innovation*? The amount of studies regarding internationalisation of *innovation systems* is considerably low (Narula 2002, Carlsson 2006).

Studying some of the worlds largest firms patenting in the USA during the 1980's, Pavitt and Patel (1999) found that the amount of innovative activity performed in foreign countries correlates with the *amount of foreign production activities*. As pointed to by Niosi and Bellon (1994, 1996) there is also a correlation between the *country size* and degree of foreign located innovative activities, as smaller countries show a higher level of flows of scientific and technological knowledge crossing borders. Regarding Europe, the smallest countries stand for the highest percentage share of innovative activities performed outside the mother country, foremost in other European countries, and as location for foreign innovative activity Germany stands out. This is interesting seen in line with the discussion of internationalisation of innovation systems, as Germany stands for a severe amount of technological activities in Europe (40 % in 1999 according to Patel and Pavitt 1999). Consequently, Germany is a favourable location site for R&D activities abroad. As a small country Norway is expected to have higher R&D interaction across her borders. This match of the two countries is also interesting in the light of Europeanization (Sandvik 2008), and the formation of a European research policy. Withley (2006) maintains, however, that national institutions constrain the development of a European innovation system. Furthermore both Germany and Norway is

among the least open economies with regard to imports and FDI, in Europe (Fagerberg and Srholec 2008).

From another perspective could FDI be linked to the strategies of firms with respect to technology acquisition, diversification and exploitation (Cantwell, 1995, 1997 in Carlson 2006). Corporate mergers and acquisitions (M&A) could have corresponding motivations as well. Clodt, Hagedoorn and Kranenburg (2006) make a distinction between non-technological M&A and technological M&A on innovative performance of the acquiring firm, where the first type appears to have none or a negative impact. The latter has a positive impact as far as the firm is able to integrate this knowledge and alter the existing routines in the organization of its research (Capron and Mitchell 2000). However, the distinction between non-technological and a technological M&A is discussible. Even though the primary motivation for a M&A is more related to organizational structure (e.g a strategy of vertical integration), exchange of technology is to a higher or lower degree following in the wake of the acquisition. This is an extensive debate on its own and will not be taken further in this article, as the acquisition here is just constituting the point of departure for discussing the main theme: internationalization of innovation systems.

Anyway will cases of technology transfer, knowledge exchange and collaboration across borders depend on national specific contexts (Gertler and Vinodrai 2005). Below we take a closer look on characteristics of the German and Norwegian innovation respectively in order to compare them.

Distinctions between Norwegian and German innovation systems

The national system of innovation concept has its roots in the work of Fredrich List (1841) who developed the basis for a German ‘catching-up’ strategy (Lundvall 2007). He includes education and training, infrastructure in his model. Compared to Britain and Belgium, Germany was relative late industrialized (Herrigel 1996) and turned to the former countries for new machinery and skilled workers to bring advanced technology to her industries (Kech 1993). At the turn of the nineteenth century Germany was able to catch up and take the lead until the nation was set back by national socialism. Compared to Norway, however, Germany was far ahead. In Norway industrialization started in the nineteenth century, but large scale industrialization took off not until the 1960s, particularly within the aluminium sector.

The economic organization of businesses is however diverse in both countries. In Germany two distinctive kinds of economic organization had emerged at a regional level. These contrasting industrial orders have their own patterns of institutional arrangements. It is the ‘autarkic’ industrial order that prevails in the Ruhr Valley and other regions. All aspects of production and government are internal to the single firm. This is often a capital intensive industry marked by mass production and vertical integration. This order is contrasted by the decentralized industrial order in Baden-Württemberg, Saxony etc. which is a pre-industrial heritage (Herrigel 1996).

This dichotomy has its parallel in Norway. Here there is a divide between small-scale decentralized development on the one hand and large-scale, centralized enterprise that seeks to exploit economies of scale and scope on the other hand. The latter capital-intensive industries started by foreign investments exploiting Norway’s natural resources, such as hydro power as a source of electrical power. The energy intensive production was localized in quite remote parts of Norway close to water power plants. After WW2 and in recent decades the

state has given large scale industry priority. Besides the large-scale industry the small-scale industry that do not perform R&D, has existed. The latter was supported by government during limited periods, but dominates certain parts of Norway (Wicken 2009).

Germany represents a special case in high export performance – ‘the world champion’. The nation has prominent sectors such as automotive, machinery and metal fabricating industries. Germany is also a leader chemical industry such as synthetic dyes, pharmaceutical industries, synthetic fertilizers and in mining and metal processing (particularly iron and steel) and electrical machinery. Compared to Norway, Germany has less favorable endowments of natural resources. The small economy of Norway is specialized in industries based on natural resources such as fish, timber, metal ores and energy, where the latter has become the most important. This includes oil and gas and energy intensive industries based on low and stable energy prices, manufacturing particular metal production such as aluminium. As such it is very much concentrated on upstream activities, adding value to resource-based sectors. So whereas the small Norwegian economy is concentrated on upstream production, large German economy is rather based on fabrication downstream.

There is a long tradition for natural sciences at German universities (Beise and Stahl 1999). Even if the Humboldt ideas of individual personality were influential, this idealism was soon moderated by utilitarian considerations. Already in the nineteenth century German universities started to combine education with advancement of scientific knowledge and the science-based firm established in-house R&D laboratories separated from production. Polytechnical schools gradually improved and Germany was soon recognized for its strong engineering professions (Kech 1993).

Whereas universities emerged quite early in Germany, Norway was a latecomer in higher education. The University of Oslo was established in 1811 as Norway’s ‘Humboldt University’ (Gulbrandsen and Nerdrum 2009). A technical university (NTH) was established in 1910 (in Trondheim), later than in most other European countries. As the national industry was weak, NTH had a slow start. Since the 1960s NTH became a more proactive university. The teaching and research agenda has been influenced by the industrial champions such as Hydro. This culminated in a user-driven strategy for industrial R&D in the 1990s (Gulbrandsen and Nerdrum 2009, Narula 2002).

Norway achieved strength in disciplines such as chemistry, metallurgy and electricity in line with parallel stronghold in German science. German knowledge institutions have though a broader orientation. In mechanical engineering there are close interaction between application-oriented university departments and industrial firms (Meyer-Krahmer and Schmoch 1998).

Technical universities have a long tradition of industry-related research and the well recognized RWTH Aachen University is particularly oriented towards industrial innovation. Polytechnics have a special role in applicable engineering (Beise and Stahl 1999). In addition there are exists a range of other institutions and laboratories performing applied and basic research. In the second half of the twentieth century the Norwegian universities were complemented by public research institutes, such as SINTEF which is a parallel to the German Fraunhofer institutes. Research Council of Norway (RCN) is a dominating public provider of R&D funding. There is a long tradition of government intervention in industry, and education and research sector. Since the 1960s the state took charge with regard to R&D. In general the R&D system dominated by the NTNU and SINTEF and RCN, is quite monolithic in Norway, compared to the more diverse and decentralized research system including public research institutions, universities, polytechnics and non-university research

in Germany. Furthermore this diverse set of R&D institutions is funded by a multiplicity of sources both at a state level and at a federal level (Meyer-Krahmer and Frieder 2001).

Both in Germany and Norway technology transfer occurs through qualified academics in firms R&D laboratories using the knowledge they received at public research institutes (Beise and Stahl 1999, Karlsen 2008). Knowledge exchange between R&D institutions and industry rely on the latter's internal R&D capacity. Technological linkages include both formal collaboration and informal networks (Meyer-Krahmer and Schmoch 1998). In Scandinavia organizations are by tradition devoted for collaboration (Gustavsen 1998). Norway has thus a higher score on share of innovative firms with cooperation arrangements on innovation activities compared to Germany (Fagerberg et al 2009). In Norway researchers both at institutes and in industry perform R&D in proximity to the industrial operations (Stensheim and Karlsen 2008). This research has thus a quite applied character as production units themselves become a laboratory. The line between industrial labs, the research institutes and universities is diffuse (Wicken 2009).

Whereas Germany is among the most R&D intensive economies in the OECD Norway is among the less (Fagerberg, Mowery and Versspagen 2009). Private industry is far the most important actor in the German system and finance the major share of national R&D (Meyer-Krahmer and Frieder 2001, Kech 1993). The manufacturing industry of Norway was slow to develop in-house R&D and private sector has still a relative low share of R&D. The domestic industry has rather relied on external sources of new technology (Fagerberg et al. 2009).

There are different causes for the Norwegian low scores of private expenditures on R&D such as the large proportion of SME: the reliance on natural endowments and dominating companies operating in low tech or medium tech industries (Grønning et al. 2005). In Germany the turnover from products with innovation has a particular high share. R&D intensive goods are metal machine tools, mechanical handling equipment, printing machinery and railroad vehicles (Meyer-Krahmer and Frieder 2001). Both countries perform better in process innovations, that usually have the character of continual incremental innovations, than in radical innovations (Lane 2000, Fagerberg et al 2009).

The German, Scandinavian and Japanese business systems are classified as a 'collaborative' by Whitley (2000). The phenomenon of cross-shareholding, including bank and allied companies as shareholders, has been widespread in Germany. The German financial system has traditionally provided "patient" capital. Investments decision and labor market practices has a long-term horizon. Due to the lack of a Norwegian wealthy middle class early in the twentieth century, the capital intensive industrialization relied on foreign capital. After WW2 the Norwegian state had a compensating role as it was both a driving force for further industrialization and a dominant owner of core companies (Seiersted 1993). Even if the state recently has played a more passive role due to pressure for privatization, the state is still in the early twenty first century, the main shareholder of industrial champions, such as Hydro and Statoil. This phenomenon is very much related to the oil economy. After the reunion, the German economy was under pressure. Economic policy was to some extent inspired by the Anglo American model with regard to deregulation and a break with the traditional long-termism in the economy is noticed. More portfolio investments and more mergers and acquisitions by foreign capital, were to come as we will see in the case of EON the owner of VAW, later to become acquired by Hydro.

Aluminium between a SIS and NIS

As NIS is characterized of the domestic specialization of industry, there will be an intersection between NIS and SIS. The relationship between sectoral and national innovation systems is co-evolutionary (Fagerberg et al 2009). Sectoral characteristics influence the development of the national knowledge infrastructure, institutions and policies. In turn, these factors influence the sectoral composition of the national economy.

In Norway, the NIS is dominated by resource based innovation, in an innovation system clearly marked by path dependence. According to Fagerberg et al (2009), this path dependency is as much political and institutional phenomenon as economic.

To which degree an industry is embedded in NIS and SIS, respectively, will vary over periods. The aluminium industry has been shaped between processes at the national level and processes of internationalization. The early inventions in electrolysis and the Bayer process in the 1880s represented breakthrough for the aluminium industry. After a decade when four major companies controlled the patents, it became accessible for other companies. Capital, technology, markets soon became international, but the sector was regulated by cartels at an international level. Technology transfer took place across the borders, within the multinational aluminium companies. After WW2 this capital intensive international aluminium industry was dominated by six companies, which controlled the complete value chain. We could talk about a constrained sectoral innovation system operating on an international level.

As aluminium was regarded as a strategic metal, the aluminium sector became a state concern in Germany during the interwar period and WW2. In Norway the sector, however, became an object for state led industrialization in the postwar period. Since the 1980s the aluminium industry was integrated and became a central component of the Norwegian NIS. In the diverse economy of postwar Germany, aluminium did not achieve a corresponding position and iron and steel were the significant metals for industry. The last decade the innovation systems have had a setback, as the large aluminium companies have developed company internal systems of knowledge exchange (Stensheim og Karlsen 2008). Aluminium industry is still dependent upon the support of NIS as well as global flows of technologies and knowledge (Moen 2009).

By tradition process innovation has been the focus in upgrading the aluminium sector. The typical aim has been to reduce costs by efficient exploitation of energy and raw materials. Since the 1980's there have been process innovations to reduce emission of fluoride. Since the radical innovation at the start, most innovations have been incremental. There are also innovations with regard to alloys and within material science. The latter have also the aim to improve product qualities in downstream production and customize the products. There have also been major organizational innovation and most organization has become flat, with a high degree of shop floor autonomy among skilled workers. They are also influence by the Japanese models such as lean production.

An international acquisition as point of departure for a comparative approach

In 2002, the largest acquisition performed by a Norwegian company took place when the aluminium company Hydro bought the German aluminium company VAW. This was a major step for the company not only when it comes to organisational growth, but also in the extension of the knowledge base following a stronger vertical integration of the company. The

launching of a new main strategy for the company in 1999 implied a renewed focus on aluminium and an ambition to become among world top 3 aluminium producers. R&D and technology development was not always a top focus in Hydro's aluminium division. Hydro started its aluminium activity based on imported technology and for a long time the company was strategically oriented towards being "best at finding appropriate technology", a strategy characterising Norwegian companies at the time (Andersen and Yttri 1997, Lie 2005, Fagerberg et al 2009). Few investments in internal R&D were done. However, the link to the Norwegian Technical University in Trondheim (NTH) was early established in providing the company graduate engineers. Regarding technological development, the company really strengthened its position through the 1986 merger with the state owned aluminium company ÅSV. ÅSV was particularly resting its technological fundamentals on people educated from NTH, as well as in symbiosis with existing research community there (Karlsen 2008). Therefore a solid basis for Hydro as a technological developer was laid in the marriage between ÅSV's dowry of own developed technology and academic network (especially within electrolysis and metallurgy) and Hydro's more market oriented production experience. This merger marked the beginning of a new technological era for Hydro and an urge to build up its own technology base. The next big achievement in terms of extending the competence base/technology development came to be the 2002 acquisition.

In order to master global competition, a stronger focus on downstream production/fabrication was needed. Primary production constituted a major part of the company's domestic activities, whereas most of the fabrication was localised close to the markets abroad (Karlsen 2009). To be sure, Hydro had a strong position within the extrusion sector, but had limited competence on rolling. A series of candidates for acquisition was considered to fulfil this strategy; however the choice finally fell on the German company.

Hydro's R&D function pre acquisition was as a product of the company's history quite decentralized (Årdal: electrolysis, Sunndal: metallurgy and casting, Karmøy: strip-casting and extrusion?). As described by Karlsen (2008), the patterns after two companies with their distinct industrial traditions and cultures are still traceable. As the company has been internationalized it inherited a pattern of laboratories and R&D activities taking place in proximity to production in quite remote parts of Norway. At the same time, Hydro's acquisitions and new establishments in fabrication (extrusion) close to the European markets craved for a dynamic R&D organisation (Stensheim and Karlsen 2008). All in all, this decentralized R&D organisation marked a noticeable contrast to VAW's R&D organisation. Pohl (1998) mentions that the VAW's Lauta works in Saxony had a large research department in the mid 1920s that brought technical inventions and economic success to the German aluminium industry until the economic crisis of the 1930s. Since the WW2 until the privatization 1988 Pohl can barely find any innovation in VAW or economic success worth mentioning. From then on changes were to come. VAW had its R&D function to a large degree concentrated to the research centre in Bonn quite close to fabrication plants. The R&D center was established in 1964 as an integration between the research activities of VAW and its subsidiary Vereinigte Leichtmetall Werke (VLW) (Schneider, undated).

VAW was originally a subsidiary of Vereinigte Industrie-Unternehmungen Aktiengesellschaft (VIAG) that was established by the German Reich in 1923 (Pohl 1998). Quite similar to ÅSV and Hydro, VIAG was based on vertical integration of power generation and energy intensive production of aluminium and nitrogen particularly for fertilizers. In the mountainous Bavaria and Austria water power plants provided the smelters with energy, while the smelters in North Rhine-Westphalia and Saxony were supplied with energy from the local brown coal plants.

Due to the armament policy during national socialism, the production of aluminium expanded progressively. VAW lost, however, smelters in East-Germany and Austria after WW2.

Due to increase in electricity prices since the late 1970s VAW was radically restructured. In the 1980s several smelters were closed and new ones were established firstly in Germany, later on abroad such as in Australia. This was also a chance for implementing innovations in primary production: As crust breaking and oxide refilling was regulated by micro processors, the melting furnace could be closed. From now on working condition of noise and dust was history. Due to cleansing fluorine emissions were reduced to a minimum (Pohl 1998) – similar to the measures taken in Norwegian aluminium industry.

VAW had also rolling and extrusion particularly as it controlled the Vereinigte Leichtmetallwerke GmbH in Bonn and more downstream activities was to come. From the 1970s, fabrication had got priority. In 1988 rolling, extrusion and castings amounted twice as many tonne as primary production. Flexible packaging (foils) for food industry became a priority area. As VIAG was privatized in 1988, it paved the way for expansion through overseas acquisitions. VAW grew steadily to the end of the 1990s when the company's owner EON decided to move out of aluminium production. At the time of take-over, VAW had operations in over 20 countries. It was to a high degree a fabrication company, with less competence upstream.

The acquisition of VAW was not the first encounter between the Norwegians and the German. The companies had a common arena in the European Aluminium Association (EAA) mirroring a sectoral aluminium innovation system on a European basis. But also, already in the beginning of the 1990's, the management from both sides had a couple of meeting "discussing the future". The meetings were in that respect fruitful considering that two industrial companies of a corresponding size had a lot to offer each other, still it did not lead to new investments then. The divide between the Norwegian and German economy as given account for earlier in this article provides an explanation why an investment from the German part was unlikely to happen: as a publicly owned company, Hydro was no candidate for acquisition. Hydro as a multidivisional corporation at that time had a strong orientation towards the oil and gas sector, and investments were to a high degree canalized in this direction. Still, it was the engagement in this sector that finally gave Hydro the financial power to acquire VAW as it was for sale.

From a common industrial departure, Hydro and VAW had evolved in diverging directions. Hydro expanded and improved in primary production and invested in fabrication abroad. Due to restructuring the primary production of VAW was reduced in Germany, while the company expanded downstream domestically. Thus at the turn of the century, Hydro and VAW was able to complement each other along the value chain. HAL's main advantage was primary production while VAW had specialised in fabrication. HAL's speciality downstream laid in extrusion and VAW in rolling. VAW had an especially strong competence on rolling, and was market leading on some areas. The company also owned half of Alunorf, Europes biggest rolling mill. In the wake of the acquisition this international division of labour between was reinforced.

The case is carefully selected in order to study the encounter of two distinct innovation systems, from a company point of view. The article is organized in a comparative design where Hydro's 2002 acquisition of VAW is considered as a momentum in the company's internationalization of innovation systems. This design must be seen in relation to the atypical

nature of this specific acquisition, as it is the story of the company who bought its peer, which had even more competence at significant production areas than the company itself. Consequently: Later in this article this event is referred to as “the inverse takeover”. At the same time, the discussion regarding internationalization of innovation systems has a larger field of fire than the mere acquisition, as will be reflected in the presentation of the innovation systems the respective companies are involved in.

The article rests on interviews with researchers and key management personnel related to Hydro’s R&D organization. Represented in the interviews are as well researchers from Bonn as from different Norwegian plants; Sunndalsøra, Karmøy and Holmestrand.

As this case study is part of a larger study of R&D in international companies with Hydro as the superior case, the article is also supplemented with secondary data material such as data from earlier interviews and written unpublished material (memos) from managers in Hydro.

Limited changes in R&D networking and lack of integration of the R&D function

Internal R&D organization: inverse takeover

The inverse takeover resulted in a new big company where the pool of technological resources was dramatically extended. At the same time, there was need for integration between partly overlapping functions. In the wake of Hydro’s new main strategy in 1999 the project *Light Metals Organization* was established in order to prepare the organization for a possible future acquisition. In this process rolling was considered an independent division, all prepared for strengthening this part of the company. Hydro’s takeover of VAW was in technical terms an acquisition, but the buyout rather proved to be a merger in procedural terms. The acquisition was primarily part of an organizational growth strategy, and as such not a technologically oriented one. Still, a considerable strengthening of the technological competence was a consequence. The responsibility for the rolling division was laid in German hands. The parity of company sizes as well as VAWs technological range and dominating competence within the rolling division was the background for Hydro’s philosophy in this process, as they wanted to secure that valuable resources from the VAW system was taken care of and kept within the new company. Hydro’s research covered a wide range, but in contrast to VAW, competence on the rolling process was scarce. Further, VAW had a considerably larger span of rolled products. VAWs ownership by a German energy corporation must as well be taken into consideration in forming the relationship between the parts, as explanation for a relatively autonomous aluminium division:

VAWs owner EON had minor competence on aluminum industry. The management in VAW therefore stood out as very self contained.

Norwegian manager 1, Hydro

For VAW, finding a suitable partner for a management buyout was therefore a more preferable solution than being victim of acquisition by investors splitting up the company. The integration process of R&D functions was treated as a separate process, but it was postponed in order to get the new operative system established in the merger between two organizations. As the competences in Hydro versus VAW to a high degree were complementary, there was an intention that the two parties should come together in R&D projects. Obviously there were potential synergies within the R&D on casting, alloys and rolling, as the coupling of different types of knowledge is associated with increased

innovative performance (Fagerberg et al 2009). Understandably, however, as the acquiring organization was placed in a subordinate position the power balance was somewhat different from minor acquisitions. The VAW competence on rolling was clearly more wide-ranging than the corresponding Norwegian one. The acquisition process with focus on the rolling division can be seen as an “inverse takeover”; the new rolling division was to a high degree built on German building bricks, within a German system. Researchers at the Norwegian plants recognize that this inverted takeover process also came at sight in the integration process in practice, leading to challenges in the encounter between two different companies. In the Norwegian system, the overall experience was that the German company fully dominated the integration process, ignorant of the organizational principles that the new parent company was built on. Whereas there was a tradition in Hydro for a close involvement between management and operational units, the hierarchy was more distinct in the German system:

We were witnessing a “railroad construction process”, as if they spent a lot of time building the track before they would allow any train driving, whereas we were used to more “hands on” management that was not afraid of some dirt underneath their finger nails, and gradually found solutions that way.

Norwegian manager 2, Hydro

Clearly, the German company operated on the basis of other guiding lines than the Norwegian. What made the distinction from the parent company even more visible, was the reservation of management positions in rolling to former VAW employees:

Maybe the integration challenges could be subscribed to the lack of Norwegians in the new rolling management after the acquisition. There were no bridge builders between the Hydro and VAW tradition.

Norwegian manager 3, Hydro

After the acquisition, there has been registered a range of new cooperation constellations that were formed in the arrangement of projects involving both German and Norwegian competence. However, it is not possible to say that a full integration has taken place. Firstly, still eight years after the acquisition the new company proves to be a mixture of project constellations, where some are formed in integration between Norwegian and German research whereas other are more localized in either Norway or Germany. Consequently, Hydro’s R&D post acquisition is not standing out as one assembled organization, but rather a fragmented and partly overlapping system as there is not a full integration between the German and Norwegian competence. Second, as it was decided that the rolling R&D function in the new Hydro should be placed in Bonn, the rolling R&D competence at Karmøy was downsized considerably. The consequence proved to be a lapse of what had functioned as the uppermost recruitment centre for the strip-casting rolling system at Karmøy, as most of the competence function is moved to Bonn. Consequently, the examples of new links of recruitments from R&D in Bonn to entering operative functions at Karmøy (or vice versa) are few. What we can see here is that parallel to what actually *has* taken place regarding integration, a dividing process has also taken place. The lines of demarcation in this process are found in the geographical distance as well as the path dependency of the respective institutions in the two countries. Hydro personnel at Karmøy also identify another path creating mechanism in the personal relationships in the local communities of practice.

Moreover, as the Norwegian parts of the company's rolling division were subordinated to a central unit in Bonn their constellations in a Norwegian innovation system are clearly affected. As the contact with external R&D goes via Bonn the Norwegian plants freedom to go directly to their contacts in e.g. NTNU and SINTEF is removed. This break is significant for the Norwegian part of the innovation system regarding rolling, the next section provides an explanation why.

Relations to external R&D

Studying the relationships constituting the respective innovation systems reveals some remarkable differences between them when it comes to Hydro and VAWs links to universities/external research institutes. As indicated earlier in the article Hydro's link to the academic milieu in Norway is first and foremost reflected in the relationship with NTNU and the research institute SINTEF. The symbiosis between NTNU and Hydro has been strong and has had a heavy influence on the development on each of these parts. Firstly, the link to the academic milieu NTNU provided for Hydro the possibility for research of a more fundamental character. Second, NTNU's pool of competence especially within metallurgy and chemistry was *the* recruitment base that fed Hydro with new graduate engineers on a continuous basis. New students were formed in the path of tradition created by the pioneers of Hydro. Later the relationship to SINTEF with its basis in Oslo and Trondheim arranged for project based R&D, more adapted to the continually changing needs for R&D in the industry (Karlsen 2008). In this way, the different Norwegian Hydro plants have through the years established a close link to these external institutions, as supplementary to the decentralized internal R&D.

The symbiosis in the Norwegian innovation system in the axis between Hydro, NTNU and SINTEF has resulted in a rather transparent knowledge transfer system. The cooperation tradition has given NTNU and SINTEF employees considerable access to the technological competence Hydro is built on, as these parts to such a degree has taken part in the company's technological development process. This is divergent from the practice in the German company:

VAW had cooperations with the universities in Dortmund, Darmstadt and Stuttgart, but the cooperation with the nearby universities of Rhein-Sieg in St. Augustin near Bonn and University of Aachen (RWTH) was the most extensive of VAWs links to the academia. This was especially visible in Aachen as base for the recruitment of metallurgists. The relationship between Aachen and VAW is parallel to Hydro's link to NTNU, where industry employees at both sides were involved in both research projects and teaching. The German system has taken a more distant character than the Norwegian:

What I have learned about the cooperation between Norwegian relationship between university, institute and industry is that the physical cooperation is closer. There are less barriers for a person from the institutes to move into the company and do work inside the industrial structure and get access to areas where at the opposite we in Germany would have clear borders.

Hydro researcher 1, Bonn

The background for this is faceted. As mentioned earlier in the article Hydro had a remarkably decentralized structure of R&D in Norway. Consequently each plant had

established close links to NTNU. In the VAW system on the other hand all R&D was channeled through the centralized R&D unit in Bonn where the decision should be taken as to whether external actors should be involved. The links at plant level as we saw in the system around Hydro was therefore not as pronounced in VAW. Further, with a broader German network of (technical) universities, the assortment of cooperation partners and recruitment bases were more varied than in Norway. Much of the explanation for Aachens status in the innovation system supporting VAW then could be found in the physical proximity:

Well, there is only one technical university in Norway so it was very obvious this link, in Germany we have ten-fifteen... When it comes to Aachen: First: we are located very close, that helps, it is closer than Munich, second, we recruited several people from Aachen, including my self. It has actually decreased the last to-three years, it used to be more Aachen-people working here”.

Hydro researcher 2, Bonn

However, the respective innovation systems pre acquisition, were not constrained to the countries separately, both VAW and Hydro took part a sectoral innovation system on a European basis. Through this network, also Norwegian actors were involved in R&D projects with VAW before acquisition. These bonds were primarily built up through common participation in large, supranational collaborations such as EU projects (Karlsen 2008):

If you look at our network; one of our big contact partners is SINTEF in Oslo and Trondheim and the Institute for Energy Technology. These people we have known long before we were Hydro. Because we had a collaboration, European project, several projects

Hydro researcher 3, Bonn

The European Aluminium Association was another arena in the European sectoral innovation system where Hydro was a driving force. The existence of a European based sectoral innovation system had paved the ground for innovation systems more far reaching than national borders. What is also interesting when it comes to the sectoral system, is that much of the networks in the innovation system already were established through this system. The acquisition as such did therefore not represent a considerable encounter between partners new to each other. Still, it touched the foundation stones of the parent company, as we will see in the next section.

Innovation systems at hold in the wake of an acquisition.

The acquisition as a historical milestone for the company has placed the close links in the Norwegian innovation system in another position than in earlier years. As part of the integration process, Hydro had to keep a low profile and keep R&D projects internal. This was considered a necessity in order to protect valuable competence in a process of restructuring of the company and work force, as earlier recognized as a general tendency within the aluminum sector (Karlsen 2008):

In a period, we did more R&D ourselves and less at SINTEF, keeping things internal until we knew the full configuration of the new company.

Norwegian manager 1, Hydro

Underlying was the enduring fear of knowledge leakages to other cooperation partners and customers, especially of SINTEF as an independent organization. Related to this process is what is termed a “generation shift” by Hydro employees; both in the industry and academia bonds are weakened as central personnel leaves for retirement. Important knowledge elements saturating relationships built on year long cooperation is of course difficult to transfer to the new employee taking over a position within the company’s R&D milieu. Another dividing factor was as mentioned the centralization of rolling R&D following the removal of the rolling division out of the mother country Norway. This represented a weakening of earlier close links. A consequence of the acquisition and the integration process in the wake of it was therefore a “cooling down” of the relationship with external actors, at least for a period. Cooperation partners of VAW in Aachen reports on an analogous process in Germany. Consequently; the temporary encapsulation of Hydro related to the acquisition process was marked in the whole new company, not only in Norway. This was a threat to the continuity of the technological development process of the company.

Nevertheless this encapsulation has proved to be a necessity of a temporary kind, and maybe constricted to the rolling sector. What comes up to the surface in Hydro post acquisition is especially the survival of the strong NTNU links from the past. The path created with NTNU as a historical recruitment base for Hydro should prove to survive the major encounter of innovation systems. This is both confirmed by Norwegian researchers, as well as notified by the new (by 2002) Hydro employees in Germany commenting on the relationship between Hydro and NTNU:

I said why don't we communicate in the same way with some key universities outside Norway? This would be a good signal! I received some positive response immediately, but it didn't happen. So, no Hydro manager is showing up in a German university as they do in the NTNU. Why?!

Hydro researcher 4, Bonn

Apparently, though the acquisition has weakened some bonds, the parent company is still devoted to its historical roots. This comes to sight both in the persisting NTNU and Hydro relationship regarding recruitment and networks in general. This path dependency will be elaborated more in the next section.

The significance of distinctive innovation systems and their path

Consequently, the history has created strong paths that survive even an acquisition of considerable circumference. Firstly, we saw no full integration in the internal R&D. Even if the examples of Norwegian-German projects and integration efforts are many, they are not erasing the overlap between the systems. Second: neither in the links to external institutions are major implications of the acquisition to be found, even though the acquisition was of a circumference that of the highest degree had implications on the knowledge base of the company. Another thing is that the acquisition per se was not representing any revolution in new acquaintances; the bonds were already there in terms of the European based sectoral innovation system of aluminium. Internationalisation of innovation systems is in this case a non-dramatic process marked by inertia and strong path dependence.

Path dependence is by first notion related to economic aspects, but Fagerberg et al (2009) underlines also path dependency as a political and institutional/cultural phenomenon. However, as we have illustrated with this specific case, another distinct feature of the path dependence in the Norwegian innovation is to be found at the individual level. The relations, here especially between participants in the industry and university, plays an important role as the life long careers of individuals constitute and have constituted main pillars in the Norwegian innovation system. A common educational background seems significant in creating professional networks. These networks have paved the way for knowledge travel, sustained through the roles of individual competence. Consequently, such main connections are weakened in the situations of generation shifts both at the industrial and academic level. The value of key knowledge carriers must therefore not be underestimated in the path dependency of the innovation systems.

Moreover, another feature of the paths at this actor level has a wider span than the national level. This is reflecting the intersection between the NIS and sectoral innovation systems as elaborated earlier in the article. This intersection comes at this level at sight in the profession based networks which the actors are part of. Researchers both take part in sectoral based networks as well as the ones within a national scope. Consequently, before the acquisition between two companies networks were already established across the two organization as they both take part in a sectoral innovation system that exceeds the national level. In this specific case we recognized that the acquisition is rather a formalisation of existing networks than an encounter of two separate innovation systems.

The implication when it comes to internationalisation of innovation systems is at least twofold. First: the intersectional feature of innovation systems, reflecting a mixture of profession based sectoral bonds and organisational bonds following national paths, indicates that innovation systems necessarily *are* international in shape, to a smaller or larger degree. Consequently, an acquisition involving two companies taking part in the same sectoral systems may not represent any turning point with regards to innovation systems.

Second, and on the contrary, the national paths of the tradition bearing pillars of relations in the innovation systems are clearly vital also in the international company. This continued relevance represents a constraint to a further internationalisation of innovation systems. When it comes to recruitment orientation, the national paths is not only a consequence of tradition, but is rooted in profound institutional features such as labour mobility for instance. Consequently: even when encounters between companies from different countries lead to new organisational structures, there is no such thing as a unified international work force. There are still forces separating the respective parts of the company, sustaining borders primarily of national kind.

Concluding remarks

As this article has shown, internationalization of innovation systems seems to be a complex and versatile process, and must also be considered a contradictory phenomenon.

On the one hand; Innovation systems cannot be said to be closed loops, but rather dynamic configurations with intersections at different geographical levels. Consequently, even an innovation system with a clearly national centre of gravity has pipelines out to the international community through intersections with sectoral innovation systems and

profession based networks. In this article the question of internationalization has been investigated with a major international acquisition as point of departure, considering this event a momentum for the geographical extension of the innovation systems supporting the acquiring company. The empirical evidence however, shows that also an event of this size, even when representing an encounter between companies of a considerable size from two countries, did not represent a “magic turning point” when it comes to internationalization of innovation systems. International links are inherent in the innovation system as such as the latter refers to a complex mixture of networks on both organisational (company specific) and professional level.

On the other hand, even when recognizing that innovation systems necessarily have inherent international moorings, this is not to say that we speak of *international innovation systems* in practice. The innovation systems literature has already called attention to the path dependence characterising innovation systems, an historical heritage that comes to sight both as an economic phenomenon and as an institutional/political one. Path dependency is especially considered important in the constitution of the Norwegian national innovation system (Fagerberg et al 2009). Still, there is another dimension of path dependence in innovation systems that has achieved less attention. This dimension is coming to sight as important in this paper, namely the individual bonds between colleagues and cooperation partners in industry and public/semi-public institutions. Such bonds, sustained through year long careers may constitute in themselves important connecting points in innovation systems. Further, as illustrated in this article, the innovation systems are threatened by the vulnerability of these bonds, exemplified through a generation shift current the last years both in the company and related public institutions. The value of individuals as tradition bearers and pillars through relations in innovation systems must ergo not be overseen. On the other hand, maybe such breaks as represented by the generation shift opens up for more integration with new generations. Still, an implication of the path established in relations, is that there is inertia in the internationalization process. It follows that the post-acquisition integration process is an evolutionary process, where close attention has to be paid to its participants in order to build new networks in addition to the well know paths.

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