Paper no. 2012/09

The European Spallation Source (ESS) and the geography of innovation

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This is a book chapter whose final and definitive form will be published by Nordic Academic Press (forthcoming).

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This version: October 2012

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WP 2012/09

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ABSTRACT

The design and construction of ESS is portrayed as an enormous injection of scientific infrastructure in the (innovation-based) economy of Lund, Skåne and the Øresund region. Innovation processes are however, inherently uncertain, unanticipated and non-linear, where investments do not directly and predictably lead to successful outputs. This chapter presents the theoretical underpinnings of localized knowledge spillovers, and demonstrates that the prospected local benefits associated with ESS are tied to the degree of embeddedness of the facility in regional knowledge networks that facilitate localized learning. This future scenario is challenged by the level of absorptive capacity of university and industry partners in the region, the presence of institutions that support an innovative milieu, and the multiplicity of ambitions set for ESS by the local, multi-national and global bodies. If actors in the regional economy are to take advantage of the opportunity that is associated with the technical design and construction of ESS in Lund, organizational and institutional features of an innovation milieu need to be prioritized.

Keywords: Large research facilities, big science, agglomeration economies, knowledge spillovers, European Spallation Source (ESS)

JEL Codes: O31, R11

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I. Introduction

The European Spallation Source (ESS) represents major investments in scientific infrastructure. 17 European countries and partners take part in the construction, financing and operation of this large research facility, which is currently estimated to cost 1.4 billion euros. This is an immense undertaking in terms of scale and complexity, and in a time of economic uncertainty. In the process of justifying such investment decisions, assessments of future impacts of various kinds – economic, social, environmental, political, scientific, etc. – are prevalent and persistent. A number of reports published by government agencies at various levels (ESS/MAX IV in Southern Sweden - TITA 2012, Styrelsen for Forskning og Innovation 2011), consultancy agencies (PWC 2009) and academic institutes (Hallonsten et al. 2004; Valentin et al. 2005) provide ample examples of the impacts ESS is expected to have on the city of Lund, the Øresund region, and European science.

There are many different points of view, concerns and tensions surrounding ESS, as is also demonstrated by the range of topics found in this anthology. This chapter focuses on the impact of ESS on innovation activities, and approaches this theme from a perspective rooted in industrial and economic geography. Stimulating technological innovation is an ambition expressed by local, national and international stakeholders alike, as shown by various government commissioned reports (for example, PWC 2009). Research facilities are expected to perform as a hub from which knowledge 'spills' into the economy, leading to technological innovation and economic growth – particularly in the region immediately surrounding the facility. This ambition places a large-scale research facility such as ESS in the context of an increasingly open and global knowledge economy, where economic competitiveness rests not on low-cost activities, but on the generation and combination of knowledge. The 'innovation' economy is thereby a powerful construct and provides a seemingly obvious justification for investment.

However, claims of this nature obscure deeper processes that underpin localized knowledge processes, and assume a linear relationship between investments in scientific infrastructure, innovation, and subsequent economic growth (which may be measured as new products, patents, sales, exports, new firms, employment, etc.). This can be problematic, because without the additional investments that are needed to support the underlying processes, ambitions are unlikely to be fulfilled. A more nuanced understanding of the geographical foundations of innovation activities is needed. To start, knowledge spillovers, or externalities, can be defined as the benefits that are generated by one organization that invests in knowledge creation, but that facilitate the innovation activities of external parties (Dicken 1990). A critical finding in the body of research on the subject is that knowledge not only spills between economic actors, but that these spillovers are spatially 'sticky', meaning that they decay with increasing distance (Jaffe et al. 1993, Audretsch & Feldman 1996). Localization theory rooted in industrial and economic geography helps to explain this pattern.

This chapter contributes to a discussion on the role of ESS in the innovation economy, by considering the underlying processes that underpin the existence of synergies between the facility and actors in the surrounding region. It begins with an overview of the theory behind the benefits associated with the co-location of different economic actors in the same region. Which mechanisms are behind the anticipated localized knowledge spillovers from the research facility? What (pre-)conditions are necessary for these processes to function properly? Section III considers how these processes could unfold in the case of ESS and surveys the opportunities and challenges for ESS to impact regional economic development. The concluding section reflects on additional impacts of ESS that could contribute to regional economic development, independent of knowledge spillovers and synergies.

II. Agglomeration theory and localized learning

This chapter is essentially about location, and how the economic and social characteristics of 'place' shape the performance of actors in that place. Contrary to images of 'the end of geography' fuelled by the advances in communication technologies, a great body of research in economic geography continues to document that 'place matters' (Dicken 2007). Economic activity tends to be concentrated, and it tends to be concentrated in particular places that could be described as industrial districts (Harrison 1992), clusters (Porter 1990), learning regions (Morgan 1997), regional innovation systems (Cooke et al. 1997) and creative cities (Florida 2002). (Arche-)Typical examples of such places that were studied in the 1980s and 1990s include Silicon Valley, the Third Italy, and Baden-Wurttemberg (for example, Saxenian 1994). Identifying the driving forces behind the agglomeration of economic activities remains at the core of this field. Organizations benefit from being located in close geographic proximity to one another, but the precise nature of these benefits has shifted over time. Whereas low transportation and transaction costs were seen as primary drivers in the 1980s (Amin and Thrift 1992), they are today trumped by conditions that support localized learning processes and innovation activities (Malmberg & Maskell 2002). Before focusing on the latter, a brief discussion of agglomeration economies will provide the essential context and overview necessary to appreciate how localized economic and social conditions shape the innovation performance of organizations, and vice versa.

Agglomeration economies

Agglomeration economies are defined as advantages that may accrue to firms that are located close to other firms, rather than in isolation. The source of these advantages is therefore external to each individual firm, but internal to the site in which they are co-located. Agglomeration economies can be divided into two main categories (see Dicken & Lloyd 1990). The first, referred to as 'urbanization economies', are advantages derived from the co-location of organizations engaged in similar and dissimilar activities in an urban setting. Firms benefit from a large urban market and the diverse supply and demand conditions that support the development of new goods and services. This diversity is an important ingredient to economic development and innovation, as is forcefully argued by Jacobs in her book *The economy of cities*:

> [Our remote ancestors] expanded their economies by adding new kinds of work…The new goods and services being added may be irrelevant to what customers of the older work want" (Jacobs 1969: 60).

The nature of demand and the ability of potential adopters to recognize and absorb new goods and services are important to innovative success. The second category of agglomeration economies is referred to as 'localization economies', which are advantages derived from the co-location of organizations in a similar or closely related industry, where each individual organization benefits from the enlarged industry as a whole at that location.

In *Principles of Economics*, Marshall (1920) devotes a chapter to 'The concentration of specialized industries in particular localities' (Book IV, Chapter X), in which he writes about "the advantages which people following the same skilled trade get from near neighbourhood to one another", where "the mysteries of the trade become no mysteries; but are as it were in the air" (Marhsall 1920: IV.X§3). Traditionally these advantages are described in terms of three categories (see Malmberg & Maskell 2002). First, the increasing scale of total activity leads to cost-savings and gives rise to (and sustains) a wide range of specialized resources. Agglomerated firms are able to share the cost of collective resources such as infrastructure and training institutions that are specially adapted to the needs of this industry. Second, a localized industry supports a localized labour market for specialized skills, which benefits both firms and workers:

> Employers…are likely to find a good choice of workers with special skill which they require; while men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market (Marshall 1920 IV.X§3).

This not only serves to improve the quality of matching firms to workers, but it also helps to share and mitigate risks faced by employers and workers. Third, co-location with other firms yields advantages for interaction and learning. Not only are the transactions between different organizations simplified and reduced in cost when they are in close proximity (including search and information costs), but this also forms the basis of a local milieu that may stimulate innovation:

> Good work is rightly appreciated, inventions and improvements… have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the course of further new ideas (Marshall 1920: IV.X§3).

As Malmberg and Maskell (2002) argue in their knowledge-based theory of spatial clustering, the flow of industry-related information and knowledge is generally more abundant, to the advantage of all firms involved: "A local culture with specific norms, values and institutions (formal and informal) makes it possible to transfer tacit forms of knowledge from one actor to another" (433). The remainder of this section will focus on and unpack the last of these advantages.

Knowledge exchange, localized learning and innovation

Our contemporary economy is often referred to as a 'knowledge-based', 'innovation' or 'learning' economy, "economies which are directly based on the production, distribution and use of knowledge and information" (OECD 1996: 229). This knowledge based economy shows no tendency of becoming any less concentrated in particular places. Rather, there is substantial evidence that knowledge spillovers are remarkably geographically localized (Jaffe et al. 1993). How can we explain such findings in the face of globalization processes, where information travels the world with relative ease? Agglomeration economies that attract the bulk of research interest concern the way in which economic and social characteristics of locations facilitate innovation. In this economy, "knowledge is the crucial resource and learning is the most important process" (Lundvall & Johnson 1994, 23), and we will unpack each of these in turn.

The concept of knowledge can be defined, classified and problematized in various ways. Sidney Winter (1987), in his chapter "Knowledge and competence as strategic assets", sets out four dimensions of knowledge that are directly related to the ease of transfer, of which the distinction between tacit and articulate (or codified) knowledge has had the greatest impact. Here Winter draws on Polanyi's work to argue that skills may be highly tacit in the sense that "the aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them" (Winter 1987: 171), as opposed to fully articulate (or codified) knowledge, which can be communicated from the possessor to another person, and the recipient becomes as much 'in the know' as the originator. A related classification of knowledge 'types' makes a distinction between 'know-what' and 'know-how'. A firm's knowledge 'assets' for example, can be seen as consisting of both information or 'know-what', knowledge which can be transmitted without loss of integrity once the rules for deciphering are known (Kogut & Zander 1992), and 'know-how', the accumulated practical skill or expertise that allows one to do something smoothly and efficiently (Von Hippel 1988), which implies know-how must be 'learned'. Lundvall and Johnson (1994) build on these types of knowledge in order to identify channels and mechanisms through which learning different types of knowledge takes place.

A core implication of these distinctions is that tacit (in contrast to codified) knowledge is much more difficult to access and imitate, and therefore a crucial source of competitiveness. Tacit knowledge is, however, considered spatially 'sticky' as it is primarily accessed through direct interaction and cannot be accessed easily from afar. In short, the tacit-local argument goes as follows: Geographic proximity facilitates face-to-face interactions between actors, which, when occurring repeatedly, form the basis of strong and stable relationships based on trust, which in turn enhance tacit knowledge sharing and learning (see Gertler 2003, Storper & Venables 2004). Moreover, geographic proximity also tends to generate other forms of proximity, such as a shared knowledge base, social relations, shared values and habits; in other words, shared understandings which smooth communication.

These ideas can be summarized by saying that the characteristics of (valuable) knowledge make its transfer between actors challenging, and requiring a set of social and spatial conditions that promote interaction and the development of relationships. These social dynamics have been of great interest to scholars in (relational) economic geography (Malmberg & Dicken 2001, Boggs & Rantisi 2003, Bathelt & Gluckler 2003), but also in innovation studies (Nelson & Winter 1977, Kline & Rosenberg 1986, Lundvall 1988). Here the argument is that organizations do not innovate in isolation, but rather in collaboration with other economic actors, including other firms (their suppliers and competitors), but also their clients, universities, financial organizations, public agencies and supporting infrastructure (Lundvall 1992, Nelson 1993). Innovation is considered an interactive (Kline & Rosenberg 1986) and 'open' process (Chesbrough 2003), with increasing levels of collaboration between diverse but complementary sets of economic actors. Sources of innovation are socially and geographically dispersed and do not all result from research and development activities (Von Hippel 1988), or from within firm boundaries. Innovation is a non-linear process and in order to access these external sources, an organization needs to interact with other organizations. The relationships and mechanisms of coordination between (rather than within) organizations, and their 'untraded' interdependencies (Storper 1995) such as trust, are therefore of key importance in knowledge exchange, learning and innovation. "Indeed", argue Boggs and Rantisi (2003) "rich empirical research…has illustrated that the quality and nature of ties are critical determinants for economic prosperity" (109, also Bathelt & Glückler 2003).

The body of research on localized learning clearly suggests that knowledge does not necessarily spill over between economic actors who happen to be located in the same area, but is more often than not the result of 'active' and intended interaction. The ways in which this interaction is organized (in networks, communities, projects, teams) is an active area of research in regional studies, economic geography and innovation studies. However, despite this emphasis on buzz and localized learning, there is also a growing body of work on the importance of extra-regional sources of knowledge, or 'pipelines', to a region's competitive advantage, continual renewal and dynamism (eg. Grotz & Braun 1997). In some industries, such as biotechnology, access to new knowledge is often acquired through 'network pipelines' of strategic partnerships, and not just from 'local broadcasting' (Owen-Smith & Powell 2004). Global pipelines offer connections to other organizations, networks and regions that are a source of fresh and diverse knowledge. One could argue that "the more developed the pipelines between the cluster and distant sites of knowledge, the higher the quality (and value) of local buzz, benefiting all firms in the local cluster" (Bathelt et al. 2004). (Life-)Science-based industries in particular, demonstrate a dual local-global knowledge flows pattern. As Coenen et al. (2004) illustrate in their investigation of the Danish-Swedish life science cluster "Medicon Valley", this sector is characterized by strong spatial concentration around nodes of excellence that are interconnected through a global network (also Gertler & Levitte 2005, Moodysson 2008). Other authors argue that basic research and a university-rich environment are the propulsive element of science-based clusters (Cooke 2002) and that universities and research activities carried out at (medical) schools serve as a magnet for biotechnology firms (Lawton-Smith 2004).

As this theoretical review illustrates, the 'mysteries' Marshall refers to are not literally in the air, accessible to anyone passing by. Knowledge also does not literally 'spill over' the edge of the large scientific research facility, and flow into the minds and offices of university researchers and entrepreneurial firms. Instead, knowledge must be actively transferred into the local economy. The advantages derived from agglomeration that pertain most to the discussion surrounding ESS involve the mechanism of localized learning, which is a process that has particular requirements in terms of network partners and a local milieu that stimulates interaction. Additionally, innovation, now a central feature of regional economic growth and development strategies, is not a linear process, but highly iterative, social and open, requiring interaction between a variety of firm and non-firm organizations. The role that large knowledge organizations such as ESS is expected to play in this innovation process and in regional economic development, is therefore much more tied to the synergies that can be achieved with other organizations inside and outside the region, than the image of a 'knowledge factory' suggests.

III. The European Spallation Source and regional economic development

We have learned that technological innovation does not automatically follow investments in research and development activities, not even in the region immediately surrounding the site of investment. Instead, spillovers follow the structures of relationships between organizations, because the effective transfer of tacit, know-how knowledge and learning takes place through interaction. How could these processes unfold in the case of ESS, and what are the opportunities and challenges for ESS to impact innovation in the local and regional economy? We can identify three distinct ways in which ESS could contribute to regional dynamics: as a knowledge pipeline, linking the local region into global scientific networks; as a magnet for highly educated individuals, which enlarges the pool of specialized workers in the region (recall Marshall's words on page 3**)**; and as a partner engaged in knowledge exchange and localized learning, contributing to local 'buzz'. In this section we will concentrate on the last of these, for such knowledge synergies have attracted the bulk of attention in the impact-on-innovation ambitions surrounding the ESS facility, and come back to the other two in the conclusion.

In order to achieve knowledge synergies, ESS must have appropriate and able partners to interact with. This raises at least three issues that need to be considered. First, who are these partner organizations likely to be and do they have the capacity to interact with and use what they could learn from ESS? Here we could think of university and industry partners, whose capabilities rely heavily on investments in skills and organizational design. Second, which norms, habits and regulations will guide these relationships? Research facilities, universities and industry each have their own institutions and ways-of-doing things, and the transition towards increased collaboration requires internal transformations (Etzkowitz and Leydesdorff 2000). And third, why would these relationships be localized, given that investments are multinational, and the scientific community is global in nature? Whose interest and responsibility would it be to invest in organizational design and institutional arrangements that support a localized innovative milieu? We will briefly consider each of these in turn, with reference to the particular context of ESS and initiatives at other large scale research initiatives for illustration.

Partner organizations and absorptive capacity

The establishment of ESS presents a major learning opportunity for other economic actors in the region, such as firms in material science and related areas of application, and university researchers. In order to realize this opportunity however, this 'demand-side' needs the ability to recognize the value of external knowledge, assimilate it, and apply it to commercial ends – or what Cohen and Levinthal refer to as "absorptive capacity" (1990). These abilities are largely a function of the level of prior related knowledge, which include skills as well as knowledge of recent technical and scientific developments.

The first aspect of this demand side that needs to be considered is the level of capabilities in neutron science and material science application areas that are currently present in the region. ESS is in a relative 'greenfield' position in Lund with little direct feed of existing skills and related industries. Building technical competence and capacity lies at the core of activities that can prepare the regional economy (see for example, CATE, TITA, ØMIC and Nano-Connect[i]). However, in addition to the technical, there are also organizational aspects to this capacity, where there need to be “bridges” between research environments, companies and ESS (Styrelsen for Forskning og Innovation 2011: 27). The close geographic proximity of regional university researchers to the facility yields several advantages, including access to beamtime when there are last-minute cancellations, and the opportunity to build relationships with instrument scientists that can be of support in pre-proposal planning for example. When we look at other large research facilities such as the Institut Laue-Langevin (ILL) in Grenoble, or Oak Ridge National Laboratories (ORNL) in Tennessee, we can identify several strategies to build such bridges and synergies. Examples at ORNL include faculty cross-appointments with the University of Tennessee and the establishment of the Joint Institute for Neutron Sciences, aimed to create a synergistic consortium. In Grenoble, ILL is one of the founders of the GIANT Innovation Campus (Grenoble Innovation for Advanced New Technologies), a partnership between universities, research institutes and laboratories, to provide a hub for collaboration with industry[ii]. The experiences at other large research facilities demonstrate that in order to support the absorptive capacity of organizations around ESS, there need to be investments in both the technical competence of university and industry partners, as well as organizational design that facilitates interaction.

Institutions and innovative milieu

In addition to these organizational features, localized learning processes rely heavily on the rules, constraints and norms that guide interaction between different organizations. In the study of innovation systems (Lundvall 1992, Nelson 1993), these are referred to as ‘institutions’, which are “sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organizations” (Edquist & Johnson 1997: 46). Institutions tend to be stable and durable, and routines are often retained even when circumstances change and they gradually become outdated. They can therefore pose real challenges to the emergence of new industries and regions in transition. A vibrant area of current research on this subject investigates the process of institutional change, the obstacles and strategies to overcome them, and the role of leadership in this process (Rodriguez-Pose & Storper 2006, Gertler 2010, Sotarauta & Pulkkinen 2011).

On this issue, ESS might actually be able to benefit from its relative 'greenfield' position and have the opportunity to start with 'fresh' institutions: to do it differently. One example internal to the facility is the system by which beamtime is allocated, which has not really changed since the peer-review system originated in the 1970s. However, as the user base of neutron facility is steadily changing, from physicists to engineers and biologists and increasingly include ‘occasional users’, the current proposal system might no longer be “the best method to produce the best science” and would benefit from strategic allocations (McGreevy 2011). Similarly, technical advances have led to enormous increases in data volume which necessitate investments in new paradigms in data analysis and visualization software. This is costly and complex, providing new opportunities for intercontinental coordination (McGreevy et al. 2004). Other institutions that can reflect ‘new paradigms’ in big science, include those that shape the relations between the research facility and partners at the university and in industry. Scott’s research on the rise of post-Fordist flexible production systems in the US in the 1980s shows that such new organizational forms emerged at great social (and geographical) distances from the established centres and institutions of the industrial heartland (Scott 1988). A similar scenario could set the stage for ESS and the transition to so-called ‘new’ big science that is considered more open and collaborative. New laws on innovation that made it easier for academics in universities and research institutes to capitalize on their intellectual property and be entrepreneurial were introduced in France in 1999, and laboratories in England were able to own their IP from 2001 onwards (Lawton Smith 2003). These changes in regulation prompted changes in practice and culture at research facilities ILL and ISIS. ESS, in contrast, is able to start fresh and set up clear and contemporary protocols for IP protection from the start. Such a regulation is an example of so-called 'hard institutions', but this opportunity extends to the crafting of a culture, or 'way of doing things', in the form of internal seminar series for example. Investments in ‘soft’ aspects of the scientific environment are important in addition to technical competence, so that institutions match with contemporary practices in science and support an open, collaborative role for new big science.

Local innovation, multi-national financing, global science

One of the biggest challenges associated with the project of designing an innovative milieu, is that the ESS is not merely a localized knowledge hub, but also a multi-nationally funded facility that serves a global scientific research community. As a local research environment, it is therefore highly integrated in continental and global networks. When assessing the (potential) impact of ESS, it is important that the multiple interests in and motivations behind ESS are considered, and differentiated. Put simply, we could phrase the aspirations or ambitions surrounding ESS at two separate scales as follows. The goal from a *European* level is to attract the best neutron users and their research projects to this facility. Based on reading the political discourse in support of establishing ESS, we can assume that there is a fair degree of competition, between facilities and between world-regions, to host future path-breaking discoveries. European leadership in neutron science in the 1990s was used as a justification for US investment in SNS in1998: “Given the medical, scientific, economic and environmental benefits available through neutron science, it would simply be irresponsible not to reclaim world leadership in this critical field. Our national interest demands it” (then US vice-president Al Gore, in RidgeLines 1998). Facilities such as SNS and ESS compete to attract highly skilled staff, top notch scientists and their cutting edge research projects that will lead to oft-cited papers in prestigious journals and perhaps even a Nobel Prize. On a European level, the benefits of hosting such a facility are therefore characterized primarily in terms of scientific reputation, measured through the number of highly cited publication in prestigious journals.

The goal from a *regional* point of view however, is not only to get a large share of the world’s best neutron experiments, but also that these ‘spill’ knowledge in the local research environment and contribute to economic development. Openness, innovation and collaboration with university researchers, industry partners and the generation of spin-off companies are therefore part of a regional ambition, but not a priority at the European level. When only the local state provides the main source of funding, as is the case in Japan’s J-Parc for example, there can be a more pronounced interest in ensuring the facility has positive economic impacts. However, when more than a dozen national governments co-fund the facility, these spillover ambitions at the local and regional level are more contentious and of much lower priority. In other words, the facility is embedded in (and dependent on) larger contexts and wider geographies such as national and continental funding frameworks for science, and global scientific networks. The prospected local benefits are therefore inextricably dependent on global dynamics.

IV. Conclusion: going beyond knowledge spillovers

The design and construction of ESS is portrayed as an enormous injection of scientific infrastructure in the (innovation-based) economy of Lund, Skåne and the Øresund region. Innovation processes are however, inherently uncertain, unanticipated and non-linear, where investments do not directly and predictably lead to successful outputs. This chapter presented the theoretical underpinnings of localized knowledge spillovers, and demonstrated that the prospected local benefits associated with ESS are tied to the degree of embeddedness of the facility in regional knowledge networks that facilitate localized learning. This future scenario is challenged by the level of absorptive capacity of university and industry partners in the region, the presence of institutions that support an innovative milieu, and the multiplicity of ambitions set for ESS by the local, multi-national and global bodies. If actors in the regional economy are to take advantage of the opportunity that is associated with the technical design and construction of ESS in Lund, organizational and institutional features of an innovative milieu need to be prioritized.

However, what if the localization of ESS in Lund does not lead to knowledge spillovers and benefits to innovation (as suggested by Horlings 2012 for example). In other words, if university researchers, firms, and other economic actors in the region are unable to establish relationships with ESS and if the facility does not contribute to local 'buzz' and instead becomes the dreaded "international enclave that is relatively cut-off from society" (PWC 2009), does this constitute a 'failure'? Not necessarily. ESS contributes to regional dynamics in two additional ways: as a magnet for highly educated individuals, which enlarges the pool of specialized workers in the region; and as a knowledge pipeline, linking the local region into global (scientific) networks.

Highly skilled people will locate where other highly skilled people are, where the most interesting work is being done, and where there is 'buzz' (Florida 2002). This, in turn contributes to the 'stock' of tacit knowledge in the local economy, as well as to the depth of the local labour market. Not only does this mitigate risks for both employers and workers in the area, but this also promotes the mobility of workers between different organizations. This leads to greater professional and social network connectivity, and soft infrastructure such as social capital. Furthermore, informal knowledge flows via social (and 'gossip and rumor') channels are demonstrated to be critical pathways of knowledge circulation (Henry and Pinch 2000).

As a 'network pipeline' (Owen-Smith and Powell 2004), ESS links the region to different sites of knowledge. This is especially important for science-based industries such as life science, one of the areas of application for neutron research that is growing in importance. This sector is spatially concentrated in nodes of excellence that are linked into global networks. A large research facility such as ESS performs a signaling mechanism that puts Lund, Skåne and the Øresund region on the global map.

Lastly, although it is yet to be seen how and how much the ESS facility in Lund will benefit the regional innovation-based economy, its size and complexity is likely to make this a major event in the region's future development trajectory. That is to say, in addition to the argument that 'place matters', 'history matters' too. Seeds of localized clusters can often be traced to historical 'accidents' (David 1985), which are then sustained by the cumulative processes described in this chapter. Although the construction of ESS does not guarantee Lund's innovation economy in the future, it will undoubtedly influence its path. It also makes for an illuminating study of the facility as it develops over the coming years. ESS is characterized by extreme geographic complexities: although the neutron user community is globally distributed and their output circulates globally in the form of publications in international journals, scientific advancement relies heavily on very large, capital intensive and extremely localized facilities such as the planned ESS. What can this global-local duality tell us about new forms of localization economies? What remains a localized strength or emerges as an opportunity in a globalizing world?

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[i] CATE, Cluster for Accelerator Technology, www.cateproject.org/;TITA, Region Skåne, http://essmax4tita.skane.com/en; ØMIC, Øresund Materials Innovation Community, www.oresund.org/materials; Nano Connect Scandinavia, www.nano-connect.org/

[ii] Joint Institute for Neutron Sciences, http://jins.tennessee.edu/about/, Grenoble Innovation for Advanced Technologies, http://www.giant-grenoble.org/en/about-giant

Acknowledgements: Support from the Pufendorf Institute and members of the theme "Legitimizing ESS: Big science as collaboration across boundaries" is gratefully acknowledged.

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