"Paths of Developing Complex Technologies:

Insights from Different Industries"

September 17-18, 2007, Clubhaus of the Freie Universität Berlin

14163 Berlin-Dahlem, Goethestr. 49

Report on the workshop at the Free University of Berlin, September 17-18, 2007.

The concept of path dependency and the associated notion of path creation are attracting more and more researchers across different fields of study. This is particularly true regarding the analysis of developing complex technologies. Against this background, Jörg Sydow (Free University of Berlin) and Arnold Windeler (Berlin University of Technology) invited researchers to a workshop to look for a comparison of concepts that help us to understand processes of developing complex technology and to compare empirical results on these very processes across different industries. This workshop was planned together with Raghu Garud (Pennsylvania State University), Peter Karnoe (Copenhagen Business School) and Arie Rip (University of Twente), around the research project "Path Creating Networks: Innovating Next Generation Lithography in Germany and the U.S." that is sponsored by the Volkswagen Foundation. The workshop was divided into three sessions and concluded with a discussion reflecting on the central conceptual issues and empirical questions of the workshop.

Arnold Windeler made his introductory statements on concepts of paths, the theory of path dependence, and the understanding of path creation, and outlined some general questions research on paths is facing. In particular, he stressed the necessity for clarity on the concept of path used in path research and on the understanding of how paths are constituted in time-space. Jörg Sydow then took over and presented a list of ten industry properties to focus on, including, for instance, actor constellations and value chains in the industry, the role of inter-organizational networks as a form of innovation governance, emergent versus mature industries, the role of technological path dependencies, and emergent versus mindful path constitution.

The first session was chaired by Arie Rip and focused to a large extent on nanotechnology. All presenters stressed that nanotechnology is a domain that lacks coherence. Krsto Pandza (Leeds University) reported on an empirical study of three organizations in the context of nanotechnology and attempted to conceptualize the innovation dynamics in these firms through characteristic knowledge structures. After this, Arie Rip and Douglas Robinson (University of Twente) presented a paper about the multi-emergence and stabilisation of paths of nanotechnology in different industries/sectors. Conceptually, they conceived the emergence of paths as the outcomes of evolving socio-technical entanglements, which become aligned across levels. Furthermore, they stressed the need to enlarge the notion of industry structure and include different kinds of societal actors, since they play an important role in the shaping

of paths. In addition, they specified several mechanisms of entanglement. In the discussion, the concept of entanglement caused some controversy regarding its usefulness and its relation to path creation. In the third presentation on nanotechnology, Tyler Wry (University of Alberta) examined the sources of intellectual property development in the carbon nanotube (CNT) field – one of the most developed areas of nanotechnology. He demonstrated that CNT patent creation is shaped importantly by patent categories and their position in the overall knowledge structure of the carbon nanotube field. However, the process by which patent categories are created and what they mean in consequence remained unclear and there were several suggestions to explore patent-related processes with qualitative research as well. Finally, Ulrich Dolata (University of Bremen) introduced an analytic framework for studying and explaining technology-driven sectoral change and applied this to the pharmaceutical and the automobile industry, among others. The concept was based on the two interrelated influencing factors of the transformative capacity of new technologies and their sectoral adaptability; their interplay leads to distinguishable modes of transformation. A low sectoral adaptability can lead to lock-ins and path dependence, as happened in the case of the German pharmaceutical industry, which refused to consider research in biotechnology for a long time. In the discussion, the concept of sectoral adaptability was questioned as being too passive, ignoring the creativity of actors. In addition, the integration of power into the framework was suggested.

The second session was chaired by Knut Lange (Free University of Berlin) and included two presentations. Andrew Nelson (Stanford University) analyzed the diffusion of university- versus firm-origin innovations for biotechnology and digital-audio. He came to the conclusion that a technology's organizational origin alone offers little insight into institutionally-conditioned diffusion processes. He argued that interpersonal networks are the critical structures that enable the diffusion of knowledge and that personal connections shape how individual researchers in each organizational context respond to the competing demands of public science and private science. In the discussion, several participants, though acknowledging the decreasing importance of the distinction between public and private research, questioned the assumption that the organizational background does not matter per se, since the prestige of a university is most likely to influence the access to interpersonal networks, for example. Subsequently, Peter Karnoe demonstrated for wind energy and the Danish energy system how different types of non-coordinated action led to the unlocking of a locked-in techno-economic regime and its associated market architectures from a path creation perspective. A key issue in the discussion was which mechanisms connect initially non-coordinated actors. Furthermore, the point was raised that a combination of external and internal attacks on a locked-in techno-economic regime could have the best chances of success.

The third session was chaired by Guido Möllering (Max Planck Institute for the Study of Societies, Cologne) and focused on the semiconductor industry. First, Dimitris Assimakopoulos (Grenoble Ecole de Management and LINC Lab) used social network analysis for the study of inter-personal networked innovation in new product development in a large multi-national semiconductor company. Workshop participants suggested complementing the data with qualitative interviews and a longitudinal analysis in order to explore path dependencies. Second, Cornelius Schubert (Berlin University of Technology), Arnold Windeler and Jörg Sydow analysed the product specifics and industry particularities in the field of semiconductor manufacturing technology, their effect on managing technological paths and how the management of this process in turn influences the development of the products and the industry. Key issues in the discussion were how to capture and measure momentum and irreversibility as well as the difference between path constitution and institutionalisation. Finally, Markus Türtscher (University of St. Gallen) and Raghu Garud explored the processes associated with the emergence of an architecture for an extremely complex technological system and thereby focused

on the early phase of design. They showed the emergence of technological and organizational paths as different groups and technologies involved in the process interacted with one another.

The workshop ended with a general discussion on technological innovation in different industries, with Raghu Garud as a discussant. He started the session with the following questions: What is a path? Is there any value in using the term path? What is the relationship between path dependence and path creation? What do we do with all these idiosyncratic cases? How should we generalize? Answers to the questions were that by contrast to the notion of network, for example, which is static, the notion of a path has the advantage that it has a temporal dimension and implications of agency. Since networks bring individuals and collectives together, which is almost always a precondition of any path creation, an integration of path and network was suggested. One proposed conception of a path was a specific kind of order producing processes. Furthermore, two concepts of paths were juxtaposed: a 'realistic' view and a social-constructionist view. A further comment was that path creation is an oxymoron, because it generates contradiction: how can there be a path if it is being created? What is more, the question was raised whether path creation is only useful in hindsight, in real time, or if it is a concept for future projections and anticipative coordination. In addition, several concepts that are useful in relation to paths were debated, including time, entanglements and the process by which things become intertwined, reflexivity and mindfulness, anticipatory coordination, technological communities or structuration, as well as useful approaches such as narratives, social networks and actor-network theory, and structuration theory. Finally, workshop participants agreed on the necessity to highlight the ambivalence of technological paths, pointing to threats as well as opportunities, and raised further points for future research such as which different kinds of paths exist, what kinds of implications they have, and how to create "better" paths.

Berlin-Dahlem, September 2007-09-19   Knut Lange

For more information on research on path dependency and path creation please visit

www.pfadkolleg.de and www.network-research.net.