How Inter-organizational Networks Can Become Path-dependent: Bargaining in the Photonics Industry*

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Abstract

This paper investigates how path dependence may come about in inter-organizational networks. To do so, we focus our analysis on one particular type of network management practices – bargaining practices – and ask whether and how they can become path-dependent. Bargaining practices are recurrent activities through which network partners agree to identify and distribute their cooperative surplus. Targeting these practices, we first operationalize the core concepts of path dependence theory by deriving empirical indicators. We then use a 'pattern matching' approach to analyze whether these empirical indicators can be found in real bargaining practices. Empirically, we conduct three case studies of regional networks in the photonics industry. We use qualitative interviews and content analysis to reconstruct the development dynamics of their bargaining practices. A major finding is that network bargaining practices can indeed exhibit inter-organizational path dependencies. This paper contributes not only by operationalizing the theory of organizational path dependence but also by extending this theory to the network level of analysis.

Keywords: inter-organizational networks; path dependence; photonics industry; practice theory; empirical, qualitative

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INTRODUCTION

Networks have traditionally been characterised as flexible forms of organization (Powell, 1990). However, it has recently been suspected that inter-organizational networks may also become inert over time (Kim, Oh, & Swaminathan, 2006), possibly even become path-dependent (Manning & Sydow, 2011; Maurer & Ebers, 2006). Our general research question therefore asks under exactly what circumstances such networks may become path-dependent. While one source of path dependence may of course be the organizations participating in an inter-organizational network (Walker, Kogut, & Shan, 1997), we highlight the contribution of "relational practices" (Ness, 2009). More specifically, we focus on one particular type of relational or network management practices: bargaining practices. Bargaining occurs when two or more parties can jointly create a cooperative surplus but need to coordinate a way of distributing it amongst themselves (Muthoo, 1999; Nash, 1950; Rubinstein, 1982). Bargaining practices, then, are recurrent activities through which the network partners agree to identify and distribute their cooperative surplus.

Bargaining practices are especially suitable for studying inter-organizational path dependence because they – by definition – emerge from the interactions of two or more organizations and can be assumed to become inert after a while because the organizations get used to the practices, routinize them and are even likely to adopt other management practices that fit the focal bargaining practices. But under what conditions exactly do they become not only inert but path-dependent? In order to answer this research question, we first recapitulate the theory of organizational path dependence and present an operationalization of this theory with the help of indicators that are suitable to depict the development of an organizational path in general and of the path dependence of bargaining practices in inter-organizational networks in particular. After introducing the research setting – three regional networks in the photonics industry in Germany – and our methods, we present our results case by case. In the

final section we compare and discuss these results and the limitations of the study. Major contributions of this study are not only the operationalization of the theory of organizational path dependence but also the extension of this theory to the network level of analysis.

THEORETICAL BACKGROUND

Organizational Path Dependence

This paper uses a framework that is based upon the emerging theory of organizational path dependence (Sydow, Schreyögg, & Koch, 2009). Path dependence theory is concerned with explaining stable – i.e. repeatedly occurring – phenomena. The basic claim of this theory, which is based upon the seminal works by David (1985) and Arthur (1994) and more recent modifications by institutional theorists (North, 1990; Pierson, 2000), is that (some cases of) stability can be explained by a specific dynamic marked by three distinct phases: the preformation phase, the path formation phase, and the actual lock-in phase. In the preformation phase, a number of alternative organizational solutions are available and one or several 'small events' trigger the initial adoption of one of them. In the path formation phase, this initially adopted solution is used increasingly because of at least one self-reinforcing mechanism; correspondingly, alternative solutions are excluded increasingly. In the lock-in phase, the focal organizational or inter-organizational solution is rigidly replicated and alternatives become nearly – but not totally – extinct. All three phases are summarized in the following figure 1.

INSERT FIGURE 1 ABOUT HERE

In order to apply this model to specific empirical cases we need to operationalize its abstract definitions. Towards this end, we will derive three empirical indicators for each of these three phases. Indicators are an intermediary step between abstract concepts and actual evidence of practices: on the one hand, they are derived from the abstract phases of path dependence; on the other hand, they are measureable and therefore provide guidance for empirical analyses.

According to the theory of path dependence, the path formation phase is characterized by "an initial scope of choice" (Sydow et al., 2009: 692). Hence, a first indicator of a preformation phase implies that there must have been at least one theoretically available alternative to the one that developed into the organizational path – otherwise the solution would be deterministic (Indicator I1). Although the presence of such an alternative needs to hold for the subsequent path phases as well, we attach this indicator to the preformation phase because it is the precondition to starting any empirical path analysis and should therefore top the list of indicators. A second indicator is that one or several alternatives need to have been not only theoretically but also practically viable – otherwise a path interpretation is purely hypothetical (I2). The third indicator concerns the end of a preformation phase. A small contingent event needs to be discernible (I3), that is, "… an event that was not expected to take place, given certain theoretical understandings of how causal processes work" (Mahoney, 2000: 531), which triggered decisions or actions influencing the alternative to follow. An event is contingent if it is neither deterministic ('necessary') nor random.

The path formation phase is characterised by the self-reinforcing dynamic of *positive feedback*, which is at the core of the theory of organizational paths (Sydow et al., 2009: 698) and similarly possesses three theoretical features. First, the fundamental idea of 'self-reinforcement' is that "… the increase of a particular variable leads to a further increase of this very variable" (Sydow et al., 2009: 694). Hence we must be able to measure, at the very least, two consecutive increases of the same variable (I4). Second, some self-reinforcing

mechanism must explain how the first increase leads to the second increase (I5). Various mechanisms have been suggested in this context and the next section will analyze how they can be disentangled. Third, there must be some but fewer alternatives available than during the preformation phase, i.e. the number of practically viable alternatives and/or their probabilities needs to diminish (I6).

An (organizational) *lock-in* is defined as "… a preferred action pattern which gets deeply embedded in organizational practice and replicated" (Sydow et al., 2009: 694). Again, three theoretical features are implied for the lock-in phase. First, replication requires that a nearly identical solution has been used at least twice but ideally more often (I7). Second, it has to be shown that practically viable alternatives are ruled out further (I8) – i.e. that alternatives are even fewer or even less likely than in the preceding path formation phase – but also that there is still 'some scope for variation' (Sydow et al., 2009: 695). Third, the degree of inertia of the alternative reproduced needs to be distinguished (I9, Jonsson & Regnér, 2009): 'unaware' indicates that alternatives exist but are not perceived by the actors; 'unwilling' indicates that alternatives exist but that the actors involved do not want to pursue them; 'unable' indicates that the implementation of existing alternatives fails.

Altogether, this operationalization of the three-stage model of organizational path dependence yields nine theoretical features and their corresponding empirical indicators. Figure 2 summarizes the indicators.

INSERT FIGURE 2 ABOUT HERE

The most complex indicator to show empirically is indicator number five, i.e. that one self-reinforcing mechanism at the very least explains the two consecutive increases of a variable. As stated above, self-reinforcing mechanisms have the property that a 'first increase' in a variable leads to a further 'second increase' of the same variable. Self-reinforcing mechanisms drive the path-like development of an organizational solution from its inception at the triggering event to its eventual lock-in. Correspondingly, at the *start* of a self-reinforcing mechanism an organizational solution has been put into practice *at least once* – self-reinforcing mechanisms 'only' explain the continuation and expansion of a once established solution but *not* its inception.

Though heavily debated and varying from one to more than a dozen (Beyer, 2010), the literature on organizational paths suggests four main self-reinforcing mechanisms through which paths can develop: coordination effects, complementarities, learning effects and adaptive expectations (Sydow et al., 2009). In the following, we will focus our attention on coordination effects and complementarities, which seem by far the most likely mechanisms driving (inter-) organizational path dependence of bargaining practices. Coordination effects are relevant because any change to a once established distribution of the joint surplus will disfavour at least one partner, who may threaten to terminate the relationship. Anticipating such a reaction, no partner will initiate a change in the first place so that a once established solution perpetuates itself. Complementarities are likely because a successful network may see an ever increasing fit of its members' contributions to the joint surplus. *Focusing* on coordination effects and complementarities does not imply, however, that learning effects and adaptive expectations have no role to play in a potentially path-dependent development of bargaining practices. Nonetheless, we had to limit our focus to make our overall research manageable and presentable. We will now outline general, abstract definitions of both

mechanisms and translate these first into necessary conditions and then into sub-indicators that need to hold when the mechanisms are at work.

Coordination Effects

Coordination effects "build on the benefits of rule-guided behavior: the more actors adopt and apply a specific institution (i.e. an organizational rule or routine), the more efficient the interaction among these actors is, since the behavior of the actors is rule guided and can therefore be anticipated and reactions can be considered in advance" (Sydow et al., 2009: 699).

Coordination effects have been formally defined by game theorists (Cooper, 1999; Rasmusen, 1994). We will analyze a slight alteration of the standard coordination game – the 'bargaining game' – to derive two necessary conditions for coordination effects and their corresponding empirical indicators. We will then show how coordination effects contribute to the self-reinforcing stability of bargaining practices.

A simple bargaining game is depicted in Figure 3. In this example, both players are asked to share a pie of size 1. If they both make equal demands, no one will receive any payoffs so that they are left with the so-called 'disagreement point' of 0 each. If the players make corresponding demands (i.e. 'low' and 'HIGH' or 'LOW' and 'high'), the player asking for the high share receives two thirds of the pie and the other player the remaining one third. These are also the two pure strategy equilibria (Rasmusen, 1994).

INSERT FIGURE 3 ABOUT HERE

As can be seen from the payoff matrix, both players prefer *not* to deviate unilaterally *once an equilibrium is reached.* Assume we are at the top-right equilibrium in which player 1 plays 'low' and player 2 plays 'HIGH'. If – on the one hand – player 2 single-handedly *lowers* its demands to 'LOW', he would be left worse off with the disagreement point payoff of 0. If – on the other hand – player 1 unilaterally *raises* its demand to 'high' then he risks the continuation of the overall relationship and hence a disagreement point payoff of 0. Thus, we are not likely to observe unilateral deviations in any direction by any party. Instead, a once established pattern becomes self-perpetuating. This leads to the first indicator of coordination effects (I5a): *a unilateral deviation will not be attempted by either side*.

Moreover, in a bargaining game the players' strategies are strategic *substitutes* (Bulow, Geanakoplos, & Klemperer, 1985). That is, an increase of one player's demand strategy gives the other player an incentive to *lower* its demand. This can be explained as follows: assume we start from the same equilibrium in which player 1 plays 'low' and player 2 plays 'HIGH'. If player 1 raised his demand from 'low' to 'high', then player 2 should reduce his demand correspondingly from 'HIGH' to 'LOW', as this would still leave him better off than the disagreement payoff. Hence player 2 has to 'substitute' the increase of player 1's demand strategy.

The fact that strategies are strategic substitutes implies that at least one person is made worse off if we move away from any equilibrium. From this follows that a joint deviation to any other equilibrium will leave at least one party worse off. As it is likely that such a losing party would oppose this move, there should also be no successful attempts at joint deviations. Thus, a solution that is found once should be self-perpetuating, which may provide a possible explanation of path dependence. This leads us to the second indicator of coordination effects (I5b): *a joint deviation will not be attempted*.

Complementarities

Complementarities are defined as "… a synergy resulting from the interaction of two or more separate but interrelated resources, rules, or practices" (Sydow et al., 2009: 699). Thus, two activities are complementary if their output does not simply add up but additionally leads to a synergy. Thus, the fundamental property of complementarities can be expressed with the formula $k_1 + k_2 < k_{1+2}$. A synergy therefore indicates the existence of complements.

One way of measuring the presence of a synergy – and thereby of complements – is by showing that *a substitution of inputs is not advisable*. Two input factors are complements if one partner cannot compensate for a decrease of the other party's input factor by increasing his own input factor. For instance, one could run the hypothetical thought experiment about what would happen if one player removed his contribution from the partnership. If it turns out that the other player can easily replace the first player's input by his own means, then it is unlikely that they form a complementary relationship. If, on the other hand, the other player cannot replace the first player's input at all or only with great effort, then one can speak of a complementary relationship. It follows that the *absence of substitutes* is a necessary condition for the presence of synergies. It therefore represents a first measureable indicator of a mechanism operating through complementarities (I5c).

Complementarities are self-reinforcing because they provide an incentive to engage repeatedly in the same action and reap the benefits of the synergy instead of exploring alternatives. "In complementary settings self-reinforcing processes occur when routines and/or practices are interconnected in such a way that it becomes ever more attractive to exploit the synergies or—when referring to the reverse side—to save misfit costs caused by solutions deviating from the established cluster/organizational capability" (Sydow et al., 2009: 699). In inter-organizational cooperations, this leads to a virtuous cycle: the investment

of one partner in the mutual business relation provides an incentive to his counterpart to invest as well. This second investment, in turn, provides a reason for the first partner to increase his initial investment. This *"virtuous cycle"* forms the second measurable indicator of a self-reinforcing mechanism based on complementarities (I5d). Figure 4 below summarizes this discussion by showing the four indicators of self-reinforcing mechanisms, two each for coordination effects and complementarities.

INSERT FIGURE 4 ABOUT HERE

RESEARCH SETTING AND METHODS

Our empirical setting is the photonics industry in Germany. This industry provides a particularly suitable field for studying the development dynamics of bargaining practices and their potential path dependence. In this industry, joint product development in inter-organizational networks is very common, as most organizations are extremely specialised small- and medium-sized companies that need to pool their expertise and components to develop new devices for new applications. Cooperation is therefore a frequent phenomenon, and the networks are even quite heterarchical, so that the terms of mutual cooperations actually get negotiated.

While the appropriate methodology to study organizational path dependence is still debated (e.g. Koch, 2011; Vergne & Durand, 2010), we use a qualitative case-study design (Yin, 1994) with three cases, all of which show a rather stable pattern in their bargaining practices, giving us enough reason for an initial path suspicion. A qualitative research

methodology is especially suited to our purpose: “As scholars have increasingly begun to appreciate the role of dynamic processes (e.g. path dependency or evolutionary processes), rich longitudinal research is needed to provide the details of how these processes actually play out” (Siggelkow, 2007: 22). Each case – our unit of analysis – is a regional network of photonic organizations in Germany. Cases were selected if joint product development occurred frequently (so that potential instances of bargaining occurred), and all network members were willing to share business sensitive information with the researchers (which was of course anonymized for this paper).

Empirical data was collected to reconstruct the development processes of bargaining practices and to subsequently analyze them regarding their path dependence. A semi-structured questionnaire was designed and pilot-tested. In each network, the managers of either all or the most crucial member organizations were interviewed, resulting in 22 interviews. Interviews lasted between one and two hours and were later transcribed and anonymized, producing approximately 650 pages of text. Additional sources like websites, newspaper articles and meeting notes were collected to triangulate the interview information. Even more importantly, we were able to build upon previous insights gathered in this field for almost a decade.

The transcripts were analyzed using multi-level content analysis (Mayring, 2000). In a first round of encoding, descriptive codes were assigned to the text to signify the content, timing and actors involved. Subsequently, chronological thick-descriptions were written for each network (Jarzabkowski, 2008), resulting in another 300 pages of text. A ‘pattern-matching’ approach was then used to analyze the development of the bargaining practices (Yin, 1994). ‘Pattern-matching’ means that the actual bargaining practices were checked to see if they exhibited the patterns associated with each of the empirical path indicators. We encoded and tabulated all supportive and inhibitive quotes for the empirical indicators in a

second round of coding. An indicator was judged 'present' in a given bargaining practice when the events in the chronology provided supporting evidence.

RESULTS

All three inter-organizational networks create a joint surplus by coordinating the individual activities of their member organizations so that they can jointly manufacture and sell innovative high-tech products. In each network, the high-tech components of individual organizations are combined into sophisticated joint devices. The process of value creation goes hand in hand with a method of value distribution; we will take a closer look at three aspects of it. First, we look at who does what. Since members of all three networks manufacture constitutive components that are combined later, a central bargaining issue is which manufacturing tasks are assigned to which network member. Secondly, we look at network-internal transactions. To assemble joint devices, the usual procedure is that one network member sells its component to another member, which acts as an integrator company. During this network-internal transaction, so-called gains from trade are created. That is, the buyer values the exchanged goods or service at a higher price than the seller. The bargaining issue is therefore who gets what share of this valuation difference. Third, we look at the way (dis)agreements are codified. For instance, the allocation of tasks can simply be based on an oral agreement or be written down in detailed contracts. Before we turn to these issues, we will outline the genesis and development of each of the networks. We will then conclude each case with a path analysis of its bargaining practice.

Case study A: The “Surface Network”

Surface Network consists of four optical component producers located in a region of Northern Germany: Alpha, Beta, Gamma and Delta. Alpha is the biggest company with roughly 100

employees. Beta and Gamma both have about 30 employees, and Delta has seven. Figure 5 displays Surface Network, also indicating different firm sizes (as measured by full time employees (FTEs)) and tie strengths (as measured by subjective evaluations of interviewees) between the firms of the network.

The common goal of Surface Network members is to combine their individual expertise to produce devices that use components from each member company. Today, they jointly produce highly sophisticated scientific devices worth several million dollars for natural scientists wanting to analyse the physical attributes of surfaces on a nanometre level. In order to achieve this end, they have developed a sophisticated collaboration routine: Surface Network gets external requests from customers to build tailor-made devices that use components from all the network companies. Once a client places an order, manufacturing tasks for individual components are distributed among the network members by a so-called lead partner. The lead partner then continues to buy those components from the others, who act as network-internal suppliers.

INSERT FIGURE 5 ABOUT HERE

Such a practice was suspected to be self-reinforcing because as soon as the members have coordinated one way of working together, it seems unlikely that a unilateral (I5a)[1] or joint deviation (I5b) would be possible without harming at least one partner.

[1] I5a means indicator 5a as outlined in the theory section.

Genesis of the network: This practice took years to develop. Initially, the network members only worked together sporadically and without any ulterior motive. Surface Network was founded by Alpha around the millennium. At this time, international research universities were increasingly demanding complex systems that combined several specialised components in one device. As Alpha did not have all the necessary technologies in-house it initiated Surface Network as a means to "… be as big as necessary on spot – definite client, definite terrain, definite technology" (Quote from Alpha).

Alpha selected Beta and Gamma as the initial members of Surface Network; Delta became a member in 2005. Initially, manufacturing tasks were distributed according to the competencies of the network members and included one overlap: Alpha produced registration components. Beta and Gamma both produced different types of modification techniques. Delta produced a high energy component. Additionally, Alpha formulated some "ideal goals" for the network, including a distribution of tasks without overlaps and an exchange of ownership shares.

Development over time: Alpha deliberately designed the network to be "adaptive to outside circumstances" and rejected the option to establish a system of elaborate contracts between the partners. This meant that relational practices in general and bargaining practices in particular were not deliberately designed but were allowed instead to emerge from the interactions between the actors. In the subsequent 'trial and error' period, the network members tested which bargaining arrangements were working for them. For instance, the initial distribution of manufacturing tasks was once contested by Alpha when it tried to redistribute some highly profitable tasks from Gamma to Beta. Alpha justified this attempt by claiming that Beta was more capable of performing the tasks than Gamma, so that the overall network would benefit from a further specialisation of its members. This attempt failed,

however, because Gamma did not agree to it. On the one hand, Gamma disagreed regarding Beta's alleged superiority and instead insisted that their capabilities could match Beta's. On the other hand, Gamma expected a loss in profits if it gave up some tasks and no alternative compensation could be found. Regarding internal supplies during the 'trial and error' period, the network agreed on transfer prices 25% below list prices that have been reproduced in the actual prices ever since. The distribution patterns of Surface Network are not codified in contracts or other documents but instead rely on oral agreements and actual practising. All interview partners highlighted the fact that contracts are not capable of codifying the trustful relationships that Surface Network is based on. In one case, the wish to sign a contract was even interpreted as a sign of mistrust.

Surface Network has grown substantially since its inception. Initial purchase orders were small and provided a means to test the modes of cooperation among the partners. Today, Surface Network is capable of processing orders in the region of up to two million Euros. At the same time, a noticeable asymmetry has developed. While Alpha has grown by almost 400% since the start of the network, its partners have only experienced growth between 50% and 100%.

Path analysis: A path analysis of Surface Network reveals that all three phases of path development can be found. The three indicators of a preformation phase are present: as required by the theory of organizational path dependence, there used to be initial alternatives to the bargaining practice (I1). For instance, Alpha had considered an elaborate system of contracts (before dismissing the idea). Moreover, it outlined a series of "inner goals" that were later on attempted (I2). In the "trial and error" period, the network members tested which bargaining arrangements were working for them. It can thus be interpreted as a series of "small events" (I3).

Moreover, there is evidence of the indicators of a path formation phase. The bargaining practice has been applied with subsequent increases in the volume of orders that Surface Network could process (I4). Simultaneously, in the trial and error period, some alternative modes of distribution and cooperation were dismissed so that the number of alternatives diminished (I6).

Most importantly, self-reinforcing mechanisms based on coordination effects as well as complementarities can be discerned in the development trajectory of Surface Network. As outlined in the theory section, indicator I5a of coordination effects requires that no partner successfully deviates from a once established bargaining practice. Indeed, Alpha's attempt to redistribute some tasks from Gamma to Beta failed. This supports the conclusion that coordination effects had stabilized the initial distribution of tasks. Complementarities have also stabilised the bargaining practice. As also outlined in the theory section, indicator 5c of complementarities requires that no company substitutes the capabilities of their partners. All network members highlight the fact that it is necessary to cooperate with their partners in order to fulfil the clients' desires for sophisticated devices that combine several components. At the same time, the members point out that they are unable to reproduce their partners' manufacturing abilities in-house, as they lack their expertise.

There are also some indications that the current bargaining practice is locked-in: there have been attempts to make changes to the current practice – yet those failed (I7). At the same time, alternatives have continued to disappear (I8). For instance, a dissolution of the network is now almost impossible, as many customers perceive Surface Network as one entity. The partners are "unwilling" to change the status quo (I9) because they all profit from their collaborative venture. They are also "unable" to unilaterally change the bargaining practice as exemplified by Alpha's failed attempt to redistribute manufacturing tasks.

Case study B: The "X-Ray Network"

X-Ray Network consists of 13 companies and research institutes in a region in Eastern Germany (see figure 6). The network organizations have highly specialised R&D and manufacturing expertise that enables them to produce sophisticated components for X-ray devices.

INSERT FIGURE 6 ABOUT HERE

The common goal of the network is to combine their individual components in order to manufacture sophisticated devices for specific application purposes that yield high profit margins, e.g. an X-ray analysis of solar cells. Today, the network members are very successful at doing so, jointly generating an annual revenue of more than €20 mio. Thus, the network members complement each other and the resulting benefit is distributed among them. Moreover, they have devised a complex coordination process called "roadmapping" that enables them to identify, evaluate and implement joint opportunities. This successful practice was suspected to be self-reinforcing because the network members increasingly complement each other, hindering alterations to the technology promoted as well as the way the resulting benefit is distributed among them.

Genesis of the network: Again, the successful practice took years to develop. In the 1990s, the X-ray competencies in Berlin were dispersed and uncoordinated. Prior to the reunification of Germany, two separate X-ray communities existed in East and West Berlin. After the fall of

the Wall, many researchers in the former East founded their own companies or were transferred to newly established research institutes.

X-Ray Network emerged during the mid-1990s. In 1994, the still influential leader of a former East German research institute founded his own company. He orchestrated the X-ray actors of Berlin to work jointly on a project aimed at creating a revolutionary generation of X-ray detectors that could work at room temperatures, thus avoiding expensive cooling systems. For the new generation of detectors to unfold their potential, several new components had to be developed in parallel: new X-ray sources, new X-ray optics, new X-ray stimulation units, new software and new electronics. During this initial project, development tasks were allocated to network members according to their expertise. For instance, the company X-Instruments (an anonym) started the development of the detector and its electronics, Kapillarsys (an anonym) started the development of the optics and the stimulation units, and X-Tubes (also an anonym) started the development of X-ray sources. At the end of the project in 1997, substantial headway had been made on these developments, yet no marketable device had been constructed. Correspondingly, to that date there had been no need for negotiating terms for network-internal supplies or for drafting contracts.

Development over time: The first sophisticated device was engineered and manufactured in the next joint project that lasted from 1999 to 2001. Its goal was to develop a mobile X-ray device for the analysis of paintings by old masters. Initially, tasks were distributed in the same way as in the first project, with X-Instruments in charge of developing the detector and electronics, Kapillarsys in charge of developing the optics and the stimulation unit, and X-Tubes in charge of developing the sources. It was also initially agreed upon that X-Instruments would market the new device, as it was the only member of X-Ray Network that had the international sales team necessary for such a venture.

During the second project, the initial distribution of manufacturing tasks was unilaterally challenged by X-Instruments when it decided to manufacture a stimulation unit itself and equip all X-ray devices with it, thus making Kapillarsys' development obsolete. After some period of disagreement, Kapillarsys ultimately agreed to this substitution but required the following three types of compensation. First, X-Instruments had to buy all optics for the mobile X-ray device from Kapillarsys at a favourable price. Second, Kapillarsys was allowed to buy detectors from X-Instruments at a favourable rate. Third, Kapillarsys and X-Instruments were both given the right to manufacture new devices for new applications that combined the new detector with its complementary parts. All three provisions were codified in a supplementary agreement.

After 2001, X-Ray Network officially became part of OpTecBB, a from then on state-supported regional cluster of optics companies and research institutes. Within this official structure, the member organizations started to develop "roadmaps" that laid out plans of how the individual components were going to be developed and how the components could be combined to produce new devices for new applications. Roadmaps were written in 2003 and 2006, each with a five-year planning horizon. The roadmaps led to further generations of the detector and its complementary components. It was also discussed whether the whole network should form a virtual company and sell the lucrative devices jointly. However, the network stuck to the arrangement in which new devices were either manufactured by X-Instruments or Kapillarsys.

Internal deliveries between the network members were never exclusive. Even though the overall network never did recommend any discounts between the companies, the network members still decided to grant each other favourable terms bilaterally. Such terms were never fixed in framework contracts or similar written documents but instead relied on oral commitments.

Path analysis: The development of the bargaining practice of X-Ray Network provides evidence of all three phases of organizational path dependence. To begin with, the three indicators of a preformation phase can be shown. Stimulation units were first produced by Kapillarsys only and later by both Kapillarsys and X-Instruments, thus indicating that at least two alternative allocations of manufacturing tasks had not only been discussed (I1) but even attempted (I2). The supplementary compensation agreement between X-Instruments and Kapillarsys established the allocation of manufacturing tasks that has been reproduced ever since, thus forming the "small event" that triggered the further development of the bargaining practice (I3). Moreover, the official foundation of X-Ray Network in 2001 established the roadmapping process as the common framework of action.

The three indicators of a path formation phase can also be discerned. Once the supplementary agreement had allocated the manufacturing tasks, this pattern was adopted increasingly by the actors during the time of the roadmap (I4). In all projects initiated during the roadmap years, X-Instruments was in charge of developing better detectors, Kapillarsys improved its X-ray optics, X-Tubes continued to improve its X-ray tubes, and device manufacturing was done by either X-Instruments or Kapillarsys. At the same time, alternatives like the "virtual company" were ruled out (I6).

The successive stabilisation of the allocation of tasks was driven by self-reinforcing coordination effects and complementarities. When X-Instruments unilaterally deviated from the initial allocation of tasks by taking over the production of stimulation units, it could not simply go on with business as usual but had to compensate Kapillarsys for this. This indicates that a pure unilateral deviation was always impossible, which is in accordance with indicator 5a of coordination effects. Similarly, the joint deviation that both partners agreed on was not simply a zero-sum redistribution of tasks but included a compensatory deal. Hence, a “pure”

joint deviation was also impossible as predicted by indicator 5b. Instead, compensation had to be paid in order to win over Kapillarsys. After the compensatory agreement between X-Instrument and Kapillarsys was signed, no further unilateral or joint deviations have occurred, thus indicating the presence of coordination effects (I5a and I5b). Similarly, no network partner has substituted any of their partners' capabilities (I5c). This indicates that – in line with indicator 5c – complementarities have sustained the bargaining practice. Instead of substituting each other, all partners have stuck to their assigned development tasks and have been engaged in a mutually beneficial upward spiral in which the investment of one partner into his specialty component enables the other partners to follow suit with theirs, hence allowing all network members to produce another lucrative generation of devices with new fields of applications and better technical parameters. This pattern of a "virtuous cycle" indicates complementarities as outlined in indicator 5d.

Today, the bargaining practice, which has been replicated ever since the supplementary agreement, appears to be locked-in (I7). No alternatives have been attempted on a network level, although individual companies still work with other partners outside the network in different arrangements. Alternatives to the bargaining practices have correspondingly been reduced in the network, yet have not completely vanished (I8). Lastly, the partners seem to be "unwilling" to leave their virtuous cycle of new generations of product developments (I9).

Case study C: The "Photonics Network"

Photonics Network consists of over 40 companies and research institutes in a Northern region of Germany. In this paper, we will focus on only one major development of Photonics Network, the so-called "fibre-to-the-home" (FTTH) household access points. The goal of this new technology is to develop and produce modems that allow households to be directly

connected to glass fibre networks, thus omitting traditional solutions based on copper and multiplying the current rate of data transmission by several orders of magnitude. Figure 7 represents Photonics Network; the companies and research institutes involved in developing FTTH are highlighted with a gray circle.

INSERT FIGURE 7 ABOUT HERE

FTTH is still a technology "under construction", as many of its production parameters are not yet finalized. It was suspected that a technological decision might stabilise the distribution of manufacturing tasks and thus the bargaining practice. Moreover, once a supply chain is established for the manufacturing of FTTH-access points there is reason to believe that a once adopted solution will be repeated and alternative solutions will be increasingly ruled out.

Genesis of the network: The first FTTH-project started in 2005 and lasted until 2008. A cooperation agreement was signed by all members of the project team, as required by the sponsoring government body. However, this agreement was a rather loose declaration of intentions to work together. The goal of the project was to evaluate potential FTTH-access technologies for their cost-effectiveness and their potential for mass production. Several alternatives were initially debated: (1) using existing manufacturing technologies and transferring all production capacity to cheap labour countries in Asia, (2) automating existing technologies and building the manufacturing facilities in Germany, or (3) combining existing technologies with new, more efficient materials. All three alternatives were rejected in the course of the project. Instead, one member organization filed a change request that called for

a complete overhaul of the existing technologies. This new technological route affected the distribution of development and manufacturing tasks. One company was alienated by the move and left the consortium, another left because it no longer envisioned prosperous business opportunities for itself. However, the remaining partners eventually agreed to follow the new route suggested.

Development over time: Subsequently, a new project was started, specifically aimed at developing the components necessary for the new technology. The idea of the project was to develop a "toolkit" that encompassed all the component parts of the new FTTH-access technology, each developed by a specialist company or research institute. The partners drafted a cooperation contract, as required by the sponsoring government body. Again, this contract entailed rather vague terms for both conflict resolution mechanisms and distribution patterns. The leadership of the project was taken on by one of the research institutes; this institute is known for acting as the “motor” of the industry.

The allocation of manufacturing tasks represented the vertical value chain of the photonics industry. One institute designed and developed the basic platform, and another institute developed active filters. One company used the basic platform to equip it with fibre cables, thus producing so-called passive optical components. Another company would then buy those passive components and equip them with filters in order to turn them into so-called active components. According to several interviewees, this distribution of manufacturing tasks was “ideal” because there was no overlap of interests; it was intentionally designed by the leading research institute to be that way.

Details of network-internal supplies had not yet been fixed. However, generic principles were already being applied. As value generation is sequential in this industry, the output of one company is the input of the next company. In this sequential value chain, each

company can take "the margin that it needs", often between 20 and 25%. Thanks to the close ties in the network, all member organizations know what share the other takes. This provides implicit upper limits on acceptable margins.

Shortly after the second project, a third project started in 2008 in order to co-develop one especially intricate component of the new toolkit: the basic platform. Again, the core team of the previous two projects took part, supplemented by two further companies. As in the second project, internal deliveries were not yet regulated, as marketability was still a few years into the future. The distribution of manufacturing tasks resembled that of previous projects. As before, a loose cooperation contract was signed in order to fulfil the formal requirements of the sponsoring government body.

Path analysis: In this case, it is yet unclear whether there has been a path-dependent development of the bargaining practice. Signs of path dependence appear most convincingly in case of the distribution of tasks. The technological alternatives of the first project each implied a different task distribution (I1 + I2). The successful change request thus fixed the initial distribution of tasks (I3).

Subsequently, coordination effects and complementarities formed self-reinforcing mechanisms that have stabilised the bargaining practice in a path formation phase. All the partners involved have provided complementary inputs to develop the toolkit technology (I5d) at ever increasing rates (I4). At the same time, no partner could substitute another's input (I5c). After the change request, no partner has ever deviated from the bargaining practice (I5a + I5b). Alternatives to the toolkit technology are increasingly unlikely to be attempted by Photonics Network (I6).

However, it is far from clear that the technology will be successful on the market, so that a lock-in phase cannot yet be detected. It has yet to be shown whether there will be a

replication of the bargaining practice once the product is introduced onto the market (I7). Different technologies will bring along different distributions of manufacturing tasks and different internal supply arrangements. It follows that alternatives have not been marginalized yet (I8) and that the partners can still change the course of their developments instead of being "unwilling", "unaware" or "unable" (I9).

Besides the distribution of manufacturing tasks, rules for network-internal deliveries have yet to be established, both because the cooperation contracts leave these questions open and because the technology has not progressed far enough yet to answer these questions. It also remains unclear whether any future rules will be codified in contracts or not.

DISCUSSION AND CONCLUSION

A cross-case analysis shows that within at least two cases, bargaining practices have become quite stable over time. This can be accounted for by the theory of organizational path dependence, which directs attention to three phases and, in particular, to the effect of self-reinforcing mechanisms in the path formation phase. Actually, there seems to be evidence of a preformation and a path formation phase in all three networks, and evidence for a lock-in phase in two of the three networks. The subsequent discussion of the cross-case analysis is summarized in figure 8 below.

To begin with, there is evidence of a preformation phase in all cases. Initially, alternative bargaining practices are discussed and tested in all cases (I1 + I2). A small event has then favoured one solution over its alternatives (I3). As would be expected from ultimately decisive events that are "not expected to take place" (Mahoney, 2000: 531), their nature varies: a trial and error phase in Surface Network, a supplementary agreement as well as the foundation of the official network in X-Ray Network, and a change request in Photonics Network.

There also seems to be evidence of a path formation phase. Subsequent increases (I4) can be observed in all cases, as can diminishing alternatives (I6). Self-reinforcing mechanisms based on coordination effects and complementarities work in parallel in all three cases. Unilateral deviations (I5a) were not attempted (Photonics Network) or had to be compensated for (X-Ray Network). In Surface Network, we even found a situation in which an attempt to change the bargaining practice was undertaken yet failed because the network members were unable to agree to a re-distribution. Similarly, joint deviations (I5b) were not attempted (Surface Network and Photonics Network) or had to be compensated for (X-Ray Network). Internal substitutions (I5c) have not taken place since the small events in any of the three cases. Instead, a virtuous cycle (I5d) of mutual co-investments in the joint capabilities was triggered in X-Ray Network and Photonics Network.

Lastly, a lock-in phase seems to have occurred in Surface Network and X-Ray Network. In both these networks, the initially adopted bargaining practices have been replicated several times (I7). At the same time, the number of remaining alternatives has been diminishing but is not down to zero (I8), as the partners actively uphold alternative cooperation partners by occasionally working together with them. The type of lock-in (I9) seems to be "unwilling" for both Surface Network and X-Ray Network. In Surface Network, “unable” is also discernable. For Photonics Network, a lock-in cannot be diagnosed (yet), as the core technology developed by its members has not (yet) matured to marketability.

INSERT FIGURE 8 ABOUT HERE

Three conclusions can be drawn from this discussion of the cross-case analysis. First, this paper shows that bargaining practices in inter-organizational networks can indeed exhibit path dependencies; a supplementing inertia-import from organizations (Walker et al., 1997). Second, it reconstructs the temporal ordering of events that may lead to such a situation: starting from a situation in which several alternative bargaining arrangements are on a more or less equal footing, a small event – which can take various forms – sets off a self-reinforcing process based on both coordination effects and complementarities, which increasingly favours one solution and diminishes its alternatives. This process may even lead to a lock-in where one solution is replicated over and over again, making the adoption of alternatives ever more unlikely. As bargaining practices are one particular type of network management or relational practice, the third conclusion of this paper is that inter-organizational networks as such can – but do not need to – become path-dependent by a sequence of events similar to the one just described.

This paper's contribution is twofold. First, we have operationalized the abstract three-phase model of organizational path dependence with nine empirical indicators. We have also operationalized the core of path dependence by finding sub-indicators for two types of self-reinforcing mechanisms – coordination effects and complementarities. This has enabled us to directly compare our three cases and identify similar patterns across them. We suspect that such an operationalization may also enable cross-comparison between different studies, thus helping to unify the research on organizational path dependence by providing a common framework of reference for empirical analyses.

Second, our study contributes to the debate on the stability of network forms of organization (Kim et al., 2006). It could be shown that in all three cases, the network bargaining practices emerged through processes that featured small events, were stabilised by self-reinforcing mechanisms, and – in two out of three cases – resulted in inter-organizational

lock-ins. All three phases of a path-dependent development trajectory can be detected in the bargaining practices investigated, even though the individual practices differ substantially from each other. Thus, practices in network forms of organization are not flexible a priori but can become rather stable and even locked-in.

Having established some evidence of the general proposition that inter-organizational networks may become path-dependent, it seems worthwhile to ask further research questions addressing both the pre-conditions and the consequences of path dependence. First, one may explore which preconditions may predispose a network to develop in a path-dependent fashion. For instance, initially shared interpretative schemes might aid the development of commonly agreed and acted upon routines. What, in particular, might be the role of early network imprints in this process (Milanov & Fernhaber, 2007)? Second, one may explore how path dependence affects the performance of networks. Do path-dependent networks, for instance, produce higher benefits from cooperation? Answering both types of questions would require a comparison of the development trajectories of path-dependent and path-independent networks.

Certainly, the major limitation of this study is that it is focused on three cases only and has utilized purpose-built instruments to collect and analyse data on organizational path dependencies of network management practices. Nevertheless, this research – in line with other recent network studies (Manning & Sydow, 2011; Maurer & Ebers, 2006) – puts a question mark behind the alleged flexibility of the network form of organizing. In addition, it challenges recent interests in studying strategic alliance and inter-organizational networks by focussing exclusively on the formality of contractual arrangements (Arino & Reuer, 2005) while ignoring the influence of informal practices. At the very least, a focus on relational practices in general and bargaining practices in particular nicely complements former network research, which has been concentrating more on governance aspects so far (for recent reviews

of network research see Borgatti & Foster, 2003; see also Ness, 2009; Provan, Fish, & Sydow, 2007; Zaheer, Gözübüyük, & Milanov, 2010).

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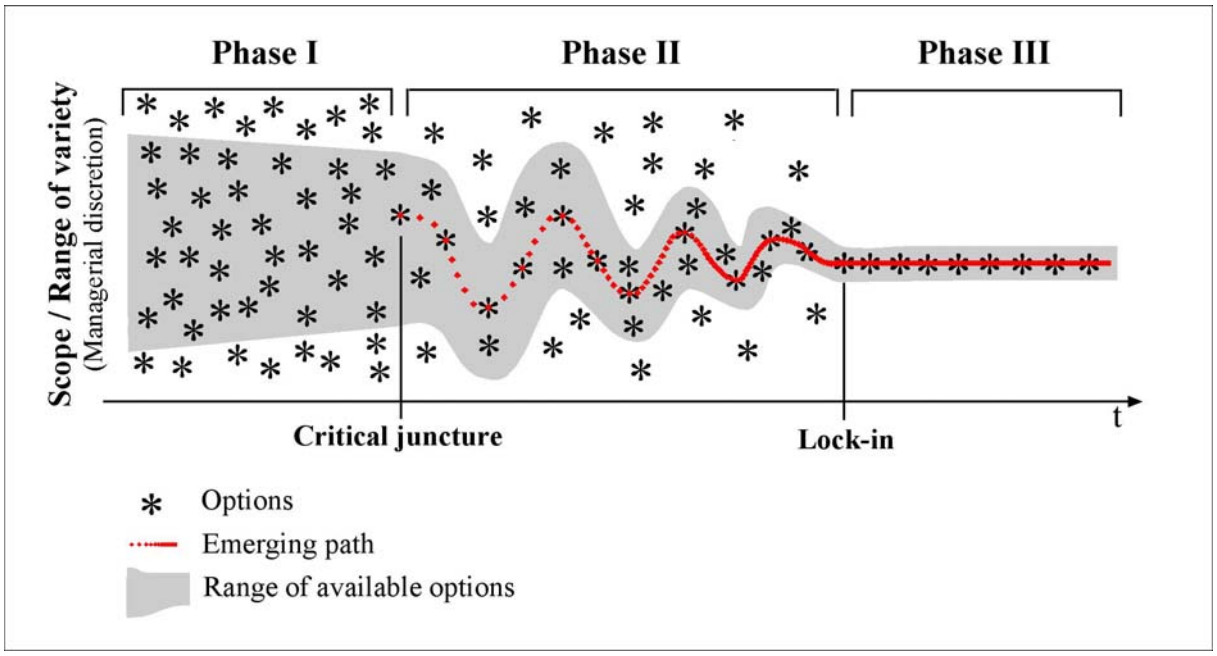

Figure 1: The Constitution of an Organizational Path (Sydow et al., 2009: 692)´

Path phase		Empirical indicators
Pre-formation phase	I1	Theoretical alternatives: at least one theoretical alternative existed to the chosen solution
	I2	Practically viable alternatives: one or several alternatives to the chosen solution were real possibilities
	I3	A 'small event' decided the path – i.e. an event that was neither deterministic nor random
Path-formation phase	I4	Subsequent increases: a first increase of a variable led to a subsequent increase of the same variable
	I5	A self-reinforcing mechanism explains why the first increase led to the second increase see the list of sub-indicators in figure 4
	I6	Fewer/Less probable practically viable alternatives than in preformation phase: the number or likelihood of alternatives narrows compared to the preformation phase
Lock-in phase	I7	Replication: the currently used option has been replicated, i.e. used at least twice
	I8	Fewer/less probable practically viable alternatives than in path-formation phase: the number or likelihood of alternatives narrows further, but 'some scope for variation' remains
	I9	Inertia: the degree of inertia of the locked-in solution can be identified: unaware vs. unwilling vs. unable

Figure 2: Nine empirical indicators derived from the theory of organizational path dependence

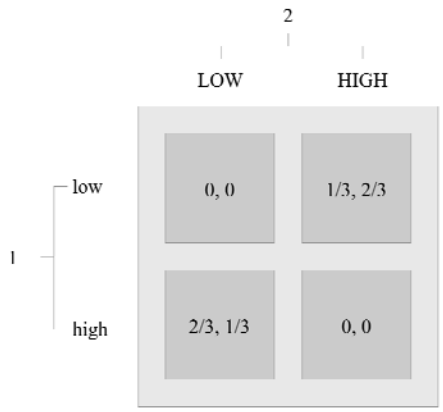

Figure 3: A simple bargaining game

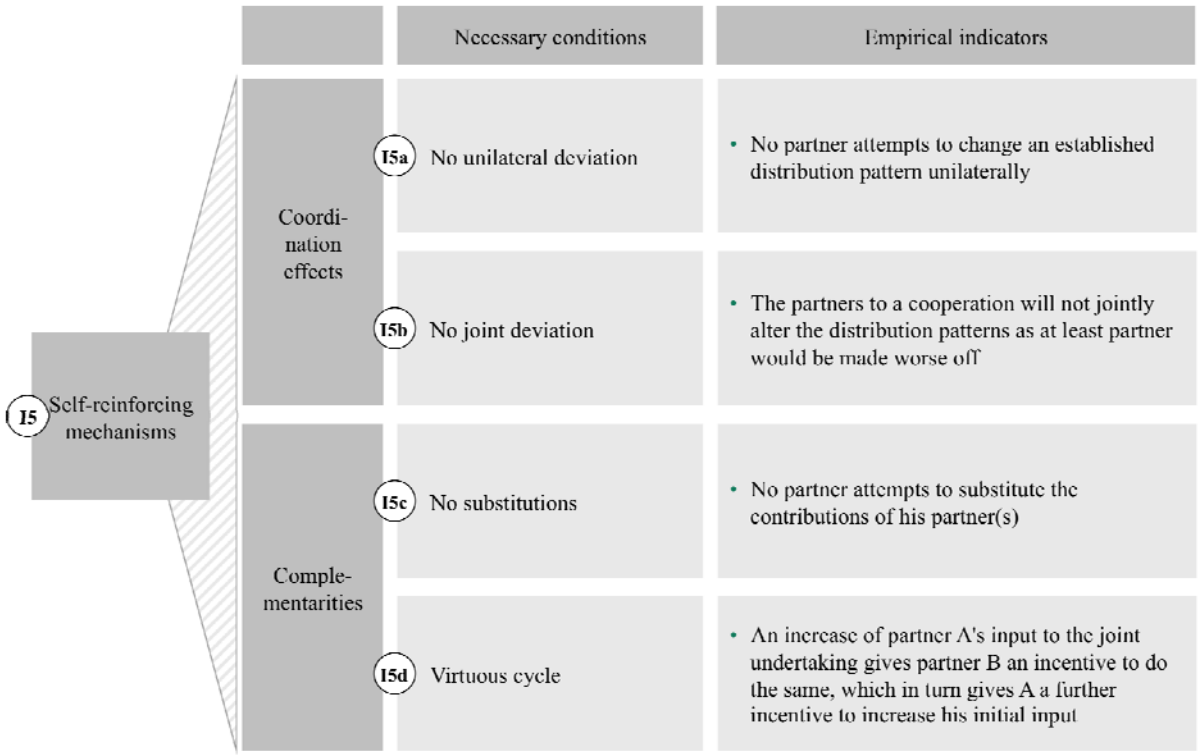

Figure 4: Indicators for coordination effects and complementarities

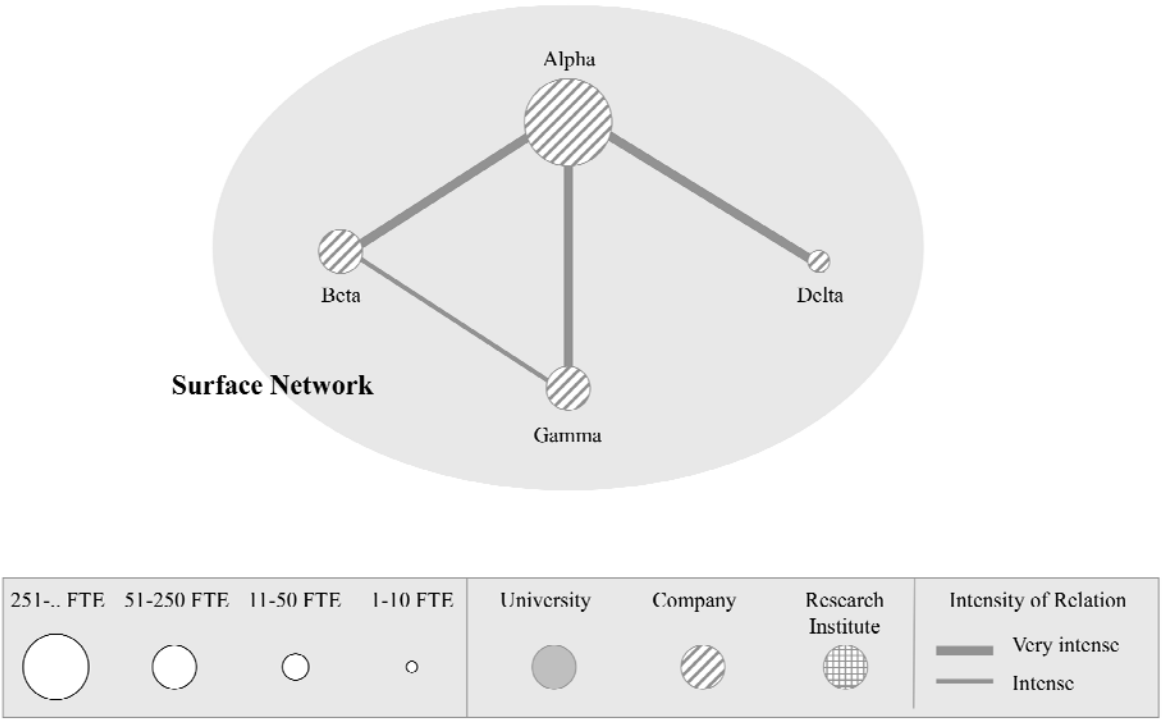

Figure 5: The “Surface Network”

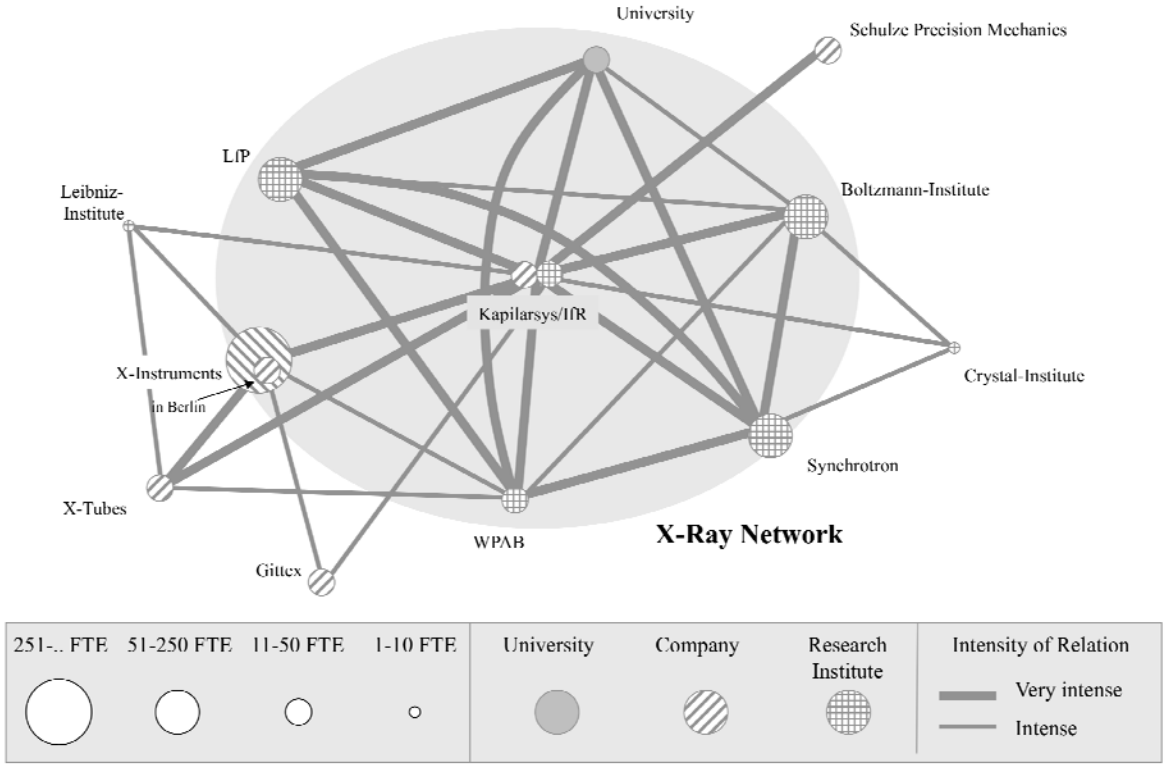

Figure 6: The “X-Ray Network”

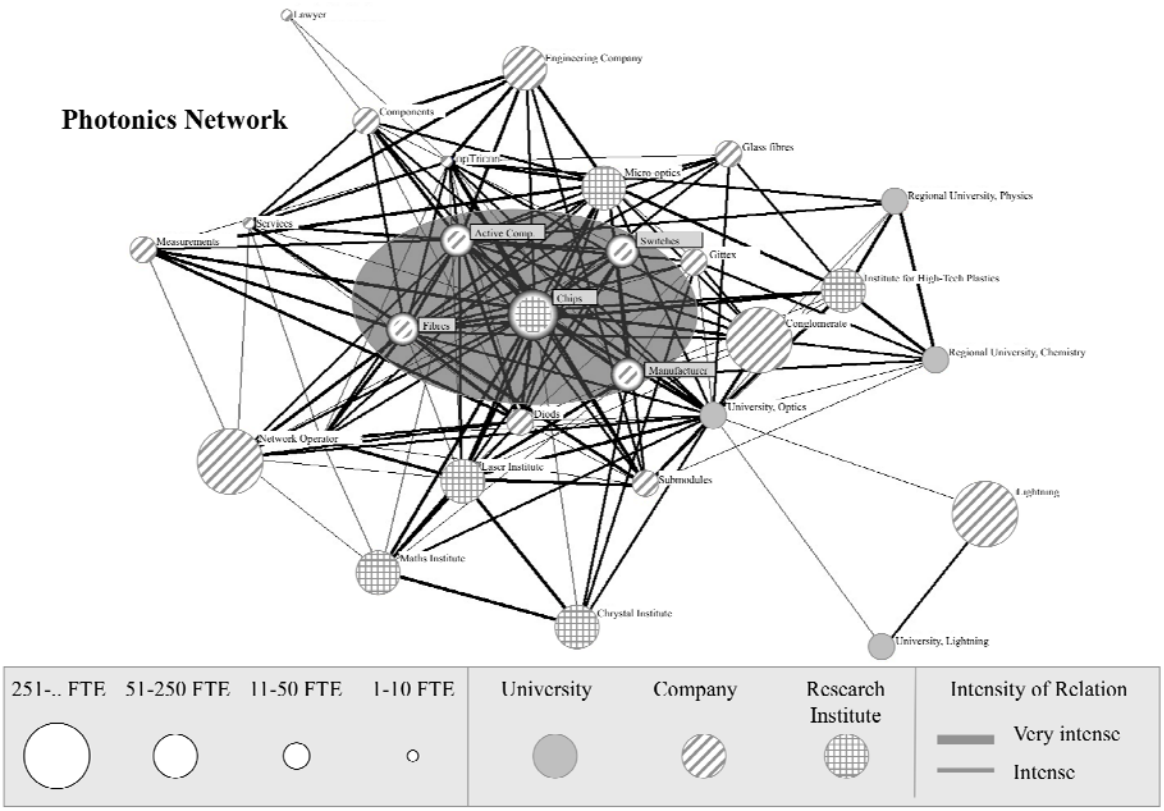

Figure 7: The “Photonics Network”

Path Phase	Path Indicator		Surface Network	X-Ray Network	Photonics Network	Conclusion
Preformation Phase	I1:	Theoretical alternatives	- Contracts between the network members - "Ideal" of the network, including joint ownership	- Alternative distribution of manufacturing tasks - Selling machines through a virtual company	- Each technological alternative would have brought about a different distribution of manufacturing tasks	- Theoretical alternatives were discussed in all cases
	I2:	Practically viable alternatives	- The alternatives were debated and tried out	- The alternatives were debated and partly tried out	- All alternatives were actively debated during the first project	- Alternatives were a real possibility in all cases
	I3:	"Small event(s)"	- "Trial & error"-phase	- The supplementary agreement established today's distribution of manufacturing tasks for the first time - The official foundation of the network initiated the roadmapping process	- The change request at the end of the first project triggered further developments	- The nature of small events differs from case to case
Path-Formation Phase	I4:	Subsequent increases	- The volume of orders that the network can deal with has subsequently increased	- All partners have increasingly invested in developing their component	- Each network member focuses on developing his component, with continuously increasing commitment	- Subsequent increases could be observed in all cases
	I5a:	No unilateral deviation	- Alpha's attempt to reallocate tasks between Beta and Gamma failed	- X-Instruments unilaterally substituted Kapillarsys' stimulation unit but had to compensate them for it - This has not occurred again after the supplementary agreement	- No unilateral deviations have been attempted	- Both coordination effects and complementarities can be observed in all cases
	I5b:	No joint deviation		- X-Instruments and Kapillarsys jointly deviated after compensation was agreed upon - This has not happened again after the supplementary agreement was established	- No joint deviations have been attempted	
	I5c:	No substitutions	- Substitutions have never occurred as each network member lacks his partners' expertise	- Substitutions have not occured since signing the supplementary agreement	- Substitutions are not possible between the network members due to their diverging specialisations	
	I5d:	Virtuous cycle		- Whenever one partner develops the next generation of his component, the other partners have an incentive to invest as well	- The R&D achievements of the partners build upon each other	
	I6:	Fewer/less probable alternatives than in preformation phase	- Alternatives were tried out during the "trial & error" phase but were dismissed	- Dismissal of several alternatives, e.g. that the whole network offers machines through a virtual company	- Due to the high investments into the "toolkit" solution, no alternatives were developed	- Alternatives fade in all cases
Lock-in Phase	I7:	Replication	- The partners have replicated their bargaining practices	- The distribution of manufacturing tasks has repeatedly been used	- It is yet unclear whether the new technology will succeed on the market - It is time too early to diagnose a replication	- Replication can be observed in Surface Network and X-ray Network - In Photonics Network, replication has not yet occured
	I8:	Fewer/less probable alternatives than in path-formation phase	- No dissolution of the network is possible today as clients view the partners as one unit	- Some alternatives remain, as the network partners occasionally collaborate with outside companies	- Implementing alternative technologies is still possible	- The number of alternatives has diminished, but not down to zero
	I9:	Inertia	- "Unwilling" and "unable"	- "Unwilling" because of the virtuous cycle	- None of the three types of a lock-in applies so far	- The type of lock-in appears to be "unwilling" in Surface Network and X-ray Network - In Surface Network "unable" also plays a role - In Photonics Network, it is still an open question

Figure 8: Cross-case comparison of path indicators