The Resource-Related Embeddedness of Product Development

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Abstract

The purpose of the paper is to discuss and conceptualise how the development of a single new technical industrial product is affected by the existing structure of tangible, non-human resources controlled by the firms involved in developing and using the new product as well as how their respective resources are embedded into the resource constellation of the network.

The Theoretical Basis - the Industrial Network Approach

The main theoretical basis of the paper is the Industrial Network Approach as represented by e.g. Axelsson and Easton (1992), Håkansson and Snehota (1995) and Ford et al. (1998). The primary purpose of the Industrial Network Approach is to describe and explain interorganisational phenomena like marketing, purchasing, technical development, business relationships etc. The basic assumptions of the approach are that a single firm is regarded as being embedded in a network of other firms to which the focal firm has substantial, continuous business relationships which, furthermore, are connected to each other. Furthermore, it is assumed that the actions of a single firm must be viewed in lieu of the other firms in the network and the relationships between the firms in the network.

Some interorganisational researchers assume that "the concept of a network [...] is a construct) of an investigator who derives [...] (ii) as a part of a strategy for analysing interorganisational relations. By definition, a network is not a corporate body (Aldrich and Whetten 1981:387). However, contrary to viewing a network as an analytical tool, the point of departure for the Industrial Network Approach is that a network is a specific organisational form, and thus that industrial networks exist independently of the researchers who may happen to analyse them (Håkansson and Johanson 1993:35; Håkansson 1997:232; Ford et al. 1998:41). The existence of industrial networks has been corroborated by a large number of empirical studies of industrial structures carried out by researchers within the Industrial Network Approach as well as researchers working from other theoretical points of departure (see, e.g. Håkansson and Snehota 1995:6-10 for a summary of the empirical observations). Over time, a number of different Industrial Network Models have been proposed, e.g. Håkansson 1987; Johanson and Mattsson 1992; Håkansson and Johanson 1993; and Håkansson and Snehota 1995). The models bear relatively close resemblance to each other and each of them can be regarded as representing the 'state of the art' model of industrial networks at different points in time. The most recent model is the one proposed by Håkansson and Snehota (1995) and this model forms the point of departure.
for this paper. Håkansson and Snehota (1995) propose that an industrial network can be conceptualised as three separate, but interdependent layers: an activity pattern (comprising activity structures of single firms interrelated through activity links); a resource constellation (comprising resource collections of single firms interrelated through resource ties; and a web of actors (comprising organisational structure of single firms interrelated through actor bonds). The three layers are depicted in figure 1.

![Diagram of industrial network model](image)

**Figure 1: The Industrial Network Model (Håkansson and Snehota 1995:29-33)**

In Håkansson and Snehota (1995), the focal unit of analysis is the 'business relationship'. Consequently, their theoretical propositions and discussion primarily concern the substance of the three layers within the boundary of a relationship: activity links, resource ties, and actor bonds (Håkansson and Snehota 1995:26-27): (1) Activity links regard technical, administrative commercial, and other activities of a company that can be connected in different ways to those of another company as a relationship develops. (2) Resource ties connect various resource elements (technological, material, knowledge resources and other intangible) of two companies. Resource ties result from how the relationship has developed and represents itself a resource for the company. (3) Actor bonds connect actors and influence how the two actors perceive each other and form their identities in relation to each other. Bonds become established in interaction and reflect the interaction process.

**Technical Product Development within the Industrial Network Approach**

Within the Industrial Network Approach, technical development is assumed to be an integral part of business relationships. Ford et al. (1998:244) argue that "Relationships have become a popular way for companies to enhance their technological development and there are now many articles about the importance of co-operative relationships, strategic alliances and joint ventures. But all relationships have a technological content and companies have always worked with their suppliers, with customers and with other on issues of technology. What has changed is that the increased awareness of..."
technological co-operation.“ The extent and characteristics of interorganisational technical development is empirically documented in e.g. the cross-sectional study by Håkansson (1989) of 123 Swedish firms. Technical development is not considered the result of the efforts of a single firm or innovator but, on the contrary, the result of an interplay between a number of different firms related to the focal new product (Håkansson 1987; Laage-Hellman 1989; Waluszewski 1990; Lundgren 1995; and Ford and Saren 1996). Furthermore, the Industrial Network Approach adopts the view that technical product development is characterised by uncertainty and non-linearity. However, technical product development is also proposed to have a non-random character as it is related to the resource constellation of the network in which it is carried out (Håkansson 1987:89 and 91). Within the Industrial Network Approach, technical development has been proposed to be characterised by two kinds of processes: (1) mobilisation of business actors and (2) synchronisation of resources and activities (Waluszewski 1990 and Håkansson and Eriksson 1993). Technical development has also been proposed to consist of (1) knowledge development, (2) resource mobilisation, and (3) resource co-ordination (Håkansson 1987). Additional propositions regarding resource development are presented in Håkansson (1993 and 1994). Consistent with the propositions above, it is suggested that technical product development primarily is related to the resource layer of the Industrial Network Model (Håkansson and Snehota 1995:144; Laage-Hellman 1997:375). Therefore, the aim of this paper is to develop theory about the non-random character of technical product development due to the opportunities offered and constraints posed by the involved firms’ resource collections, and the resource constellation in which these are embedded through resource ties. In order to focus the study, the type of resources which is in focus are tangible, non-human resources2 which have been proposed by Hughes (1987) to affect technical development, in his case the development of electrification networks: "Modern capital-intensive systems possess a multitude of durable physical artifacts. Laying off workers in labour-intensive systems reduces momentum, but capital-intensive systems cannot lay off capital and interest payments on machinery and processes. Durable physical artifacts project into the future the socially constructed characteristics acquired in the past when they were designed. [...] The momentum of capital-intensive unamortized artifacts partially explain the survival of direct current after the battle of the systems" (Hughes 1987:77).

The Concept of Embeddedness

In the Industrial Network Approach, embeddedness is one of the underlying basic assumptions (Snehota 1990:123; Henders 1992; and Håkansson and Snehota 1995). The conceptualisation of embeddedness within the Industrial Network Approach is inspired by Granovetter (1985) proposing that economic action is embedded in the concrete, ongoing structure of social relations of which the actors form part. Thus, ‘embeddedness refers to the fact that economic action and outcomes, like all social action and outcomes, are affected by actors’ dyadic (pairwise) relations and by the structure of the overall network of relations’ (Granovetter 1992:33). Rejecting oversocialised accounts of economic action (where actors adhere slavishly to scripts written for them by the particular intersection of social categories they happen to occupy) as well as undersocialised accounts (in which individual actors are socially atomised from their immediate context and pursue utilitarian self-interests), Granovetter (1992:33-34)

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2 In the remains of this paper, the term ‘resource’ will refer to ‘tangible, non-human resources’.
proposes that there are three different aspects of embeddedness which are important to
consider in relation to economic actions like e.g. buying and selling, product
development etc. The three aspects of embeddedness are (1) relational aspects, (2)
structural aspects, and (3) time-related (or historical) aspects, the latter pointing to the
importance of considering how actors carry the baggage of previous interactions into
each new one’ (Granovetter 1992:34). Granovetter’s (1985) main propositions concern
the configuration of ‘social structure’ and how the structure forms the point of departure
for economic action and choice. These propositions have been further developed e.g. by
Granovetter (1992) and Grabher (1993) within the field of Economic Sociology. The
basic issue can crudely be depicted in the following way (figure 2):

Social Structure: consisting of actors’
concrete, ongoing, personal, dyadic
relations which are connected, thereby
forming a network structure

Economic Action

Figure 2: Economic action is embedded in the social structure

Comparing the propositions by Granovetter (1985 and 1992) to the Industrial Network
Approach, two differences need brief commenting: (1) the use of the term ‘episode’
instead of ‘action’, and (2) the conceptualisation of ‘structure’. Regarding (1)
Granovetter (1985 and 1992) uses the term ‘action’ to refer to ‘a single business
transaction’, whereas the term ‘episode’ is used within the Industrial Network (Lord
1980:340 and Gadde and Håkansson 1998:91). However, the meaning implied by the
two concepts appears to be similar. Regarding (2) Granovetter (1985 and 1992) focuses
on social aspects of ‘structure’ whereas, in the Industrial Network Approach, ‘structure’
is conceptualised as three separate, but interdependent, layers of a network (cf. figure
1). Granovetter’s concept of ‘social structure’ can, in general, be compared to the actor
layer of the Industrial Network Model. However, the Industrial Network Model has two
additional layers of structure: the activity layer and the resource layer. Even if
Granovetter primarily discusses ‘social’ structure, he emphasises (1992:50-51) that
other types of structures, e.g. technological, may influence economic action (in the form
of path-dependencies), and such ‘technological structures’ may be compared to the
resource layer of the Industrial Network Model. Hence, it appears that the two
approaches are partly overlapping; Economic Sociology putting relatively more
emphasis on social and cognitive aspects of structure, and the Industrial Network
Approach putting relatively more emphasis on technical and production-related aspects

Within the Industrial Network Approach, the concept of embeddedness has primarily
been concerned with the relational and structural aspects of embeddedness, whereas the
time-related aspects primarily have been comprised in the concept of episode vs.
relationship. Andersson (1997) documents different ways in which subsidiaries of
multinational corporations are embedded in networks of relations (to corporate
headquarters, sister units, and external counterparts), and the consequent different
possibilities for corporate headquarters to control and influence the subsidiaries, and
Wedin (1998) provides extensive documentation for embeddedness (according to the
three layers in the Industrial Network Model described earlier) in an industrial network
surrounding a paper manufacturer. Furthermore, as embeddedness is a basic assumption
within the Industrial Network Approach, the concept is often discussed indirectly, e.g.
by Dubois (1994) and (1998) in relation to the activity layer in the Industrial Network
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Model. However, the embeddedness of technical product development in the resource constellation has not yet be discussed and conceptualised in detail. Hence, it seems important to investigate how product development episode is affected by the resource layer of the industrial network, and this is the primary purposes of this paper: (1) to investigate and conceptualise how a product development episode is embedded in the resource constellation into which the new product is born and develops. As the paper focus on tangible, non-human resource, the 'episode' was operationalised as 'a new product related resource structure'. Thereby, the primary purpose of the paper can be depicted in the following way (figure 3):

![Figure 3: A new product related resource structure is embedded in the resource constellation of the network](image)

Concepts and Assumptions related to Resources in the Industrial Network Approach

In several theoretical traditions, resources are considered central to the functioning and performance of firms. Not surprisingly, the term 'resource' appears directly in the names of several theoretical traditions, e.g. the Resource Based View (Penrose 1959; Grant 1991 and Barney 1991) and the Resource Dependence Theory (Pfeffer and Salancik 1978). Each theoretical approach has it more or less unique way of conceptualising resources, and relating them to the different aspects of the functioning of firms, and types of explanations, which are in focus in the respective traditions. Within the Industrial Network Approach, resources are defined as elements with known or potential use. Such elements may be (raw) materials, components, systems of components, equipment, facilities, people, knowledge, financial resources, company image etc. (Håkansson and Snehota 1995:134). A number of different concepts are related to 'resources' (Håkansson and Snehota 1995:132-147):

1. **Resource collection.** A firm is assumed to consist of a resource collection comprising the vast amount of resources the firm controls or has access to.
2. **Internal resource ties.** The resources within the resource collection of a firm are related by internal resource ties, thus forming a complex mesh of resources.
3. **External resource ties.** Some of the resources in a firm's resource collection are specifically oriented to resources in the resource collections of other firms. The resources which are specifically related to each other across firm boundaries are involved in 'external resource ties'. The resource of two firms which are externally tied combine to form the resource layer of the business relationship between two firms.

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(4) Resource constellation. The resource collections of firms, related through external resource ties, form the resource constellation of a network.

In addition to these concepts, a number of assumptions are related to resources. Concepts and assumptions related to resources in the Industrial Network Approach are conceptualised and discussed in e.g. Håkansson and Snehota (1995), Dubois (1998), and Holmen and Pedersen (1999). The listing below summarises the assumptions of most relevance to the discussion in this paper:

(1) A resource is possible to develop in two ways; (1) by using the resource in a new way or (2) by modifying the resource.

(2) A resource is infinitely versatile, partly due to its ‘infinite combination potential’, and partly due to its ‘infinite modification potential’.

(3) When a single resource is used in different resource combinations, it is said to be flexible, the degree of flexibility depending on the number of different resource combinations in which a single resource is used (and between which it is possible to switch) at a particular point in time.

(4) In each resource combination of which a single resource forms part, a unique set of its properties will be utilised, the set of properties utilised being dependent on the interplay among the resources in the combination. A single resource is therefore said to be characterised by differential property utilisation and, consequently, different value in different resource combinations;

(5) At a particular point in time, a single resource may be used in different combinations in which its properties are utilised in different ways. Each combination will comprise other internal and/or external resources. Relating this to the concept of ties, discussed above, a single resource can be involved in several internal and external ties at the same time, depending on the resource combinations of which it forms part (cf. Håkansson and Snehota 1995:145). The total number of resources with which a single resource is combined (tied), due to the different combinations in which it is used, constitute the resource-related embeddedness of the single resource;

(6) A resource is assumed to acquire its overall value in relation to the number and strength of its ties: “the value of a certain resource element depends on multiple ties. It will be both better utilised and more difficult to substitute the more and the stronger resource ties there are” (Håkansson and Snehota 1995:139). When assessing the value of a single resource due to its internal and external ties, the point of departure is therefore the ‘resource constellation’ in the network, and the overall value of a single resource is thus dependent on how it is embedded into this resource constellation;

(7) Party due to the difficulties, uncertainty and costs of modifying a single resource or finding new combinations in which it can be used, and partly because firms need to utilise their resources (their capacity in fixed combinations) over a certain period of time in order to recover their costs, a single resource (and resource combinations) has to be fixed for a period of time.

Research Method

In order to empirically investigate in detail how a new product related resource structure is affected by the resource layer of the network in which it is embedded, a qualitative method was required. Using a qualitative method implies that the data originate from...
the researcher putting “brackets around a temporal and spatial domain of the social world. These brackets define the territory about which descriptions are fashioned” (Van Maanen 1979:520). This method is consistent with the underlying philosophy of the study which is Transcendental Realism as represented by e.g. Bhaskar (1975), Sayer (1984), and Tsoukas (1989). Furthermore, it is consistent with the theoretical basis of the paper, i.e. the Industrial Network Approach (Easton 1995). According to this philosophy, any particular episode is idiographic; however, it is assumed that there are general ‘laws’ or ‘generative mechanisms’ which combine to produce the particular episode which happen to be observed by researchers. Hence, ‘generality’ is claimed only to the causal group studied, not to a wider population which would require replication (Sayer 1984:224). In order to develop nomothetic statements from a case study about the general ‘laws or tendencies’ at work “We first need a story that narrates the sequence of events that unfolded as the product innovation emerged. Once the sequence or patterns of events in a developmental process is found to exists, one can turn to questions about what the causes or consequences are of the events within the process pattern” (Van de Ven and Huber 1990:214). Thus, the theorising in this paper concerns the explaining of the, empirically grounded, development of a new product related resource structure in terms of some underlying ‘generative mechanisms’ or ‘laws’ that cause events to happen in the real world and the particular circumstances or contingencies when these mechanisms operate (Van de Ven and Huber 1990:213; Tsoukas 1989). In general, the research process contained inductive (empirical) as well as deductive (theoretical) components (Pettrigrew 1997), the deductive component primarily provided a focus on important issues to be investigated based on present theoretical propositions within a particular theoretical approach, whereas the inductive component enabled further theoretical development of particular aspects of the approach.

The paper is empirically grounded in a product development project carried out among a number of firms in a ‘sewer and drainage network’. The new product is an egg-shaped concrete pipe conforming to the present requirements for the British market. The empirical part of the paper describes how the development of the egg-shaped concrete pipes was related to the structure of technical resources controlled by the different firms involved in the development process and in using and producing the new product. In total, 14 people were interviewed, representing the 4 different companies which were actively involved in the product development episode. 1-8 interviews were carried out with each interviewee, primarily depending on the degree to which the interviewee and/or the firm had been involved in the development episode. Each interview had a duration of between 1-4 hours. All interviews were tape-recorded and transcribed, resulting in approx 700 pages of transcript material. In addition to interviews, other sources of empirical evidence were used e.g. industry conference papers, technical articles, different types of company documents, official annual reports etc. A case description of 80 pages was made and subsequently reviewed by the 8 main interviewees.

Empirical Grounding - the Development of Egg-Shaped Concrete Pipes

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On the homepage of Hanson Pipes, part of Hanson Quarry Products Europe, the following description of a new product can be found:

The development of egg-shaped pipes was started up by two British companies, Yorkshire Water Services Ltd., a subsidiary of privatised Yorkshire Water PLC and ARC Pipes. Among other things, Yorkshire Water is in charge of running sewer pipelines in Yorkshire. Some of Yorkshire Water’s most important suppliers are the contractors who install the pipelines run by Yorkshire Water. When a new pipeline is to be made, Yorkshire Water puts out a tender for the pipeline which a number of selected contractors then tender for. The contractors are in charge of buying concrete pipes and other related products from which the pipeline is to be made. ARC Pipes is a manufacturer of concrete pipes and thus a supplier to the contractors who install pipelines. In addition to concrete pipes, ARC Pipes also supplies rubber gaskets (which are placed between the individual concrete pipes to make the pipeline watertight) to the contractor in charge of installing the pipeline. Normally, concrete pipe manufacturers do not have extensive relationships to water companies; however, ARC Pipes and Yorkshire Water had carried out several cooperation projects e.g. new types of concrete pipes (for jacking) and pipeline installation machinery. Furthermore, a manager from Yorkshire Water and a manager from ARC Pipes had a close relationship partly due to both of them having been on the British (BS) and European (CE) committees in charge of making standards for concrete pipes for a considerable period of time. Within the relationship between ARC Pipes and Yorkshire Water, the idea of making egg-shaped in stead of circular pipes arose. The primary advantage of using egg-shaped pipes, in comparison with ‘normal’ circular pipes, is their superior flow characteristics. Pipelines have to be laid at a gradient at which the flow of liquid will achieve sufficient (self-cleansing) velocity regardless of the quantity of liquid running in the pipeline. Due to their smaller internal cross-section in the bottom of the pipeline, an egg-shaped pipeline can be laid at a lower gradient than a circular pipeline. Thereby, the number of pumping stations, lifting the water up to a level from which it can continue to run by itself, can be reduced. The basic principle is depicted in figure 4.

![Circular Pipes and Egg-shaped Pipes](image)

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3 In January 1999, ARC Pipes changed name to Hanson Pipes (Hanson Quarry Products Europe). As the development of the egg-shaped pipe took place while the company was called ARC Pipes, the name ARC Pipes will be used in the paper.

4 From this point forwards, the name Yorkshire Water will be used instead of Yorkshire Water Services Ltd.

5 From this point forwards, the term ‘egg-shaped’ will be used instead of ‘ovid’.

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Figure 4: Self-cleansing velocities with circular pipes vs. egg-shaped pipes

If the number of pumping stations can be reduced, capital costs (due to buying and installing pumping stations) as well as operating costs (due to running the pumping stations) of water companies may be reduced. Yorkshire Water and ARC Pipes decided to start up development of egg-shaped concrete pipes. In order to facilitate development of the egg-shaped pipes, Yorkshire Water and ARC Pipes made a joint venture agreement, ensuring Yorkshire Water a percentage of ARC Pipes’ future sales of egg-shaped pipes. Furthermore, it was part of the agreement that trial installations of the egg-shaped pipes were to be made on a number of Yorkshire Water’s schemes. One each of these schemes, the contractor who had won the tender for the total scheme would be asked to install egg-shaped pipes on sections of the total scheme.

In order to make egg-shaped pipes, egg-shaped mould equipment is required as this determines the shape of a concrete pipe. Consequently, Yorkshire Water and ARC Pipes needed egg-shaped mould equipment in order to produce egg-shaped pipes. Over time, ARC Pipes had bought mould equipment from several different manufacturers. One of ARC Pipes’ mould equipment suppliers was Pedershaab. Pedershaab A/S is a Danish manufacturer of mould equipment and concrete pipe production machines. Pedershaab A/S has several subsidiaries, one of which is situated in the UK, Pedershaab Ltd. The relationship between ARC Pipes and Pedershaab went back approx 40 years. Pedershaab had manufactured most of ARC Pipes’ pipe production machines, and ARC Pipes had been among the first concrete pipe manufacturers who had bought Pedershaab machines. In addition to machines, Pedershaab had delivered some of ARC Pipes’ mould equipment. In the relationship between ARC Pipes and Pedershaab several technical developments had been made over the years and some of the features on Pedershaab’s machines had been developed together with ARC Pipes. Furthermore, a number of (primarily technical) people in each of the two companies had relatively frequent contact with each other. ARC Pipes and Pedershaab had rather extensive experience with and knowledge of some of each other’s resources. For example, Pedershaab had knowledge of ARC Pipes’ machines as well as other technical equipment which was used in combination with ARC Pipes’ machines. Both counterparts considered each other to be technically competent. ARC Pipes and Yorkshire Water decided to contact Pedershaab to get them to participate in the development of egg-shaped pipes for the UK.

As mentioned earlier, a rubber gasket is needed between the concrete pipes for the pipeline to be watertight. As the three companies knew that it is difficult to seal non-circular pipes, Yorkshire Water, ARC Pipes and Pedershaab realised that they needed a special rubber gasket. One of ARC Pipes’ suppliers of rubber gaskets was Forsheda Ltd., a British subsidiary of the Swedish company, Forsheda AB. The relationship between ARC Pipes and Forsheda had lasted for more than 20 years. The rubber gaskets

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6 From this point forward, the term ‘Pedershaab’ will be used for ‘Pedershaab A S’ as well as ‘Pedershaab Ltd.’ as the study does not focus on intra-firm aspects.

7 From this point forward, the term ‘Forsheda’ will be used for Forsheda AB as well as Forsheda Ltd. as the study does not focus on intra-firm aspects.

Forsheda delivered to ARC Pipes were among the more technically complex rubber gaskets used by ARC Pipes. In the relationship between ARC Pipes and Forsheda, no major technical developments had been made; however, technicians from the two companies had relatively frequent contact with each other. Furthermore, a manager at ARC Pipes and a manager at Forsheda knew each other rather well, partly due to the manager at Forsheda having worked for Pedershaab earlier on, and partly due to both managers sitting on the committee developing European standards (CEN) for concrete pipes. Furthermore, ARC Pipes and Yorkshire Water knew that Pedershaab and Forsheda were used to working together as a team. The relationship between Pedershaab and Forsheda had existed for more than 30 years. Pedershaab and Forsheda did not have a customer-supplier relationship; however, as the products of the two companies were frequently used together by their common customers, the pipe manufacturers, Pedershaab and Forsheda had co-operated extensively together, and the co-operation had resulted in a few major and several minor technical developments over the years. Furthermore, a manager at Forsheda had worked for Pedershaab before joining Forsheda. Pedershaab and Forsheda considered each other to be important co-operation partners and a number of (primarily) technical people from the two companies were in frequent contact with each other. The co-operation had resulted in Pedershaab and Forsheda having rather extensive experience with and knowledge of part of each other’s resources. For example, Pedershaab had knowledge about how Forsheda’s rubber gaskets could be incorporated into their designs of mould equipment, and Forsheda had knowledge about the tolerances which Pedershaab could achieve on their mould equipment. There was no customer-supplier relationship between Yorkshire Water and Forsheda; however, a manager of Yorkshire Water was the chairman of the European standards committee mentioned earlier, and a technical manager of Forsheda had frequent contact with each other.

Both Pedershaab and Forsheda agreed to participate in developing egg-shaped pipes together with ARC Pipes and Yorkshire Water. Through the joint efforts of a number of people from the four companies (with regard to e.g. the size, geometry, profile of the ends of the concrete pipes, and a rubber gasket to fit the profile of the ends of the pipes), a specific egg-shaped pipe was designed, produced, tested, and installed. In the development process, a number of technical resources which were already in the possession of these four companies, as well as other related companies, were considered. ARC Pipes had a Pedershaab machine the full capacity of which was not used. ARC Pipes wanted this machine to be used for producing the egg-shaped pipes and was not interested in investing in a new machine as there was over-capacity on the UK market. The technical properties of the machines thus formed one point of departure for the design of the egg-shaped pipes. ARC Pipes was prepared to modify the machine in order to overcome some of these problems, however, the modifications should not result in the machine not being able to make circular pipes as they did not expect the sales of egg-shaped pipes to be so large that the capacity of the machine could be used full time for egg-shaped pipes. The reason for this was that egg-shaped pipes was considered to be advantageous to use in flat areas of the UK; however in many areas the topographical characteristics made it less advantageous to use egg-shaped pipes. In addition to reusing the pipe production machine, a large number of ARC Pipes’ other resources were reused in the production of the egg-shaped pipes. Examples of such resources is an anchorages tool and anchorages testing equipment, which had been developed a couple of years earlier for circular pipes; however, ARC Pipes had never circular pipes with this feature. Some of these resources were used in new ways without the resources being modified, other resources were modified specifically for the

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production of egg-shaped pipes. In addition to reusing a lot of their resources, ARC acquired some new resources, among which the mould equipment represented the largest investment. In general, ARC Pipes' production process for egg-shaped pipes was less automated than their production processes for circular pipes.

Pedershaab’s existing production equipment and mould equipment designs were also taken into account when designing the egg-shaped pipes. In fact, Pedershaab had developed egg-shaped mould equipment for another pipe manufacturers a few decades earlier, and the tool for pressing pallets had been used on a few later occasions, the lastly in the late 1970ies. However, the requirements for type of joint (inflexible vs. flexible) and the degree of tightness on the pipeline had increased considerably since that time. Furthermore, the requirements for joints according to the British Standard differ in some aspects from the requirements for joints in the other countries for which egg-shaped mould equipment had been developed. The tools for producing one particular part of the mould equipment (the pallet) are expensive to make, and therefore, it is advantageous to use the equipment for producing the pallet for a number of customers; if a specific pallet production tool can only be used for one single customer, this customer has to pay all the costs for making this tool. Consequently, it is standard procedure for Pedershaab to reuse (and possible modify) pallet production tools. In this particular case, an old egg-shaped tool was reused. Furthermore, another part of the egg-shaped mould equipment (the spigot end former) could not be made in the same way as it is normally made because it had to be egg-shaped instead of circular. Pedershaab had knowledge about a new type of pallet production machine which might have been advantageous for making high-precision non-circular mould equipment, however, Pedershaab was not considering investing in this type of machinery at this point in time. One reason was the over-capacity on the European market, which had led Pedershaab to find new markets for their products, primarily in the Far East and in Southern America. Another reasons was that a new installation method for pipes (jacking) were becoming more and more common, and only circular pipes could be used for jacking. Furthermore, Pedershaab knew that the costs of making spigot end formers by using the new technology would increase considerably. Consequently, some of Pedershaab’s existing equipment was used for the egg-shaped spigot end former as well as for the rest of the egg-shaped mould equipment. The existing equipment was, however, used in other ways for the egg-shaped mould equipment than it was used for making circular mould equipment, among other things, requiring more manual operations. In total, Pedershaab developed one new production tool for the egg-shaped mould equipment, and, in general, Pedershaab’s production process for egg-shaped mould equipment was less automated than their production processes for circular mould equipment. Pedershaab was especially interested in learning if and how egg-shaped pipes could be made on the Pedershaab pipe production machines. Over time, Pedershaab has supplied approx 3000 pipe production machines on a world-wide basis. The pipe production machines are often used by Pedershaab’s customers for a considerable period of time, e.g. 20-30 years. Furthermore, Pedershaab organises world-wide second-hand sales of Pedershaab’s customers’ old pipe production machines, and provides guarantee and service on the second-hand machines. Almost all the machines are based on the same underlying technology, vibration-hydraulic (VIHY) technology. Even if the pipe production machines Pedershaab manufactures are specifically configured for each of their customers, there are similarities, and acquiring knowledge about how egg-shaped concrete pipes could be produced on ARC Pipes’ pipe production machine, which had been supplied by Pedershaab, would imply that Pedershaab later on would be able to use some parts of this knowledge for some of their other customers.

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In general, it is technically more difficult to seal non-circular pipes compared to circular pipes. Furthermore, the old tools and machinery used for making the mould equipment resulted in somewhat larger tolerances than normal when making circular pipes. However, a new rubber gasket was not developed for the egg-shaped pipes. Forsheeda was interested in learning how to seal non-circular pipes. However, Forsheeda did not want to design and produce a new rubber gasket die for making a new rubber gasket which was specific for the egg-shaped pipes. In general, Forsheeda does not develop rubber gaskets which are specific for one customer. One reason is that Forsheeda's production machinery is best suited for production of rather large series. Another reason is that the production of dies for production of rubber gaskets is costly. A third reason is that rubber gaskets must be approved according to the national standard for rubber gaskets in the country in which it is to be used; this makes it time-consuming and costly to introduce new rubber gaskets. A existing rubber gasket (developed in the early 1980ies) was therefore chosen as yet another point of departure for the design of the concrete pipes and thus for making the mould equipment. Only the length of the rubber gasket was adapted to the egg-shaped pipes.

In addition to taking the above-mentioned technical items into account, existing technical items controlled by other actors were taken into account. There is a large number of pipeline designers and pipeline installers in the UK. Designers of sewer systems use software packages for calculating and analysing the flow in existing and new sewer systems. The software packages are written in such a way that it is possible to carry out hydraulic analysis of sewer systems of which old 19th century egg-shaped brick sewers form part. Choosing the egg-shaped cross section of the old brick-sewers implied that most existing computer software packages could be used for design of sewers of the ARC Pipes' egg-shaped concrete pipes. Furthermore, the ‘standard’ installation equipment which contractors use when installing pipelines was taken into account; and the additional equipment which was necessary for laying egg-shaped pipes instead of circular pipes was inexpensive. Pedershaab developed and produced the mould equipment for this pipe. The mould equipment was shipped to ARC Pipes premises where people from Pedershaab and Forsheeda participated in getting the mould equipment to work together with ARC Pipes' existing machine and production equipment. During this process, a lot of minor alterations were made of some of ARC Pipes' equipment in order to facilitate the production, handling, storing and testing processes. Furthermore, a few pieces of new equipment were acquired by ARC Pipes. The concrete pipes were tested with the rubber gasket which originally had been chosen. However, this rubber gasket did not perform as expected, and another rubber gasket (developed concurrently with the development of the egg-shaped pipes for a group of German customers) was, successfully, tested in the joint. Trial installations of the egg-shaped pipes were made on schemes which Yorkshire Water had identified. All of the schemes were in flat areas where the superior flow characteristics of egg-shaped pipes could be utilised. In order to install the egg-shaped concrete pipes, ARC Pipes made a few new pieces of equipment available to the contractors; furthermore, new installation procedures were developed, thereby resulting in the equipment of the contractors being utilised in new ways. In general, installing the pipes did not present any major problems.

Thus, the concept of egg-shaped sewers was not new, however the concept of egg-shaped concrete pipes (with flexible joints fulfilling the present BS5911: Part 100 (1988) requirements) was new.


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On a number of schemes in the UK, egg-shaped pipes have been used for selected sections in which the characteristics of the egg-shaped pipes were superior to circular pipes. In addition to the superior flow characteristics, the height/width relation of egg-shaped pipes (compared to circular pipes with equivalent flow capacity) has been utilised. Later on, the rubber gasket was changed, as modifications of ARC Pipes' production process made it difficult to seal the egg-shaped pipes with the rubber gasket which had been used for the first installations. This new rubber gasket had recently been developed by Forsheda for a group of German customers. Egg-shaped pipes have not become a major product for ARC Pipes; consequently, the occasions on which they carry further experiments with production of egg-shaped pipes are relatively few. Following the development of the egg-shaped mould equipment for ARC Pipes, Pedershaab has developed egg-shaped mould equipment for a few other customers outside the UK, and an additional size of egg-shaped mould equipment for ARC Pipes. On none of these occasions has the egg-shaped mould equipment been similar to the mould equipment developed for ARC Pipes, e.g. some of the egg-shaped mould equipment has consisted of an egg-shaped inner core and a circular outer mould. On some of these occasions, ARC Pipes has been in contact with Pedershaab's other customers and exchanged ideas and experience with regard to production of egg-shaped pipes. Pedershaab and Forsheda, too, have exchanged knowledge about development of egg-shaped pipes during these projects. In general, egg-shaped mould equipment has not become a major product for Pedershaab. Forsheda has been involved in sealing and developing egg-shaped pipes on a few occasions; however, on neither of these occasions has a new rubber gasket been developed. Instead, some of the rubber gaskets in Forsheda's existing product range have been utilised for sealing the egg-shaped pipes.

Analysis

On the basis of the case description, and the basic theory presented earlier, an analysis of the case was made. Firstly, the different resources involved in the new product related resource structure were identified. Secondly, the resources were classified according to the type of activity in which they were used (i.e. design, production, testing, installation etc.) in the different firms which were involved. Thirdly, the different activities in which the identified resources were used were analysed in more detail resulting in 49 tables. Fourthly, the resources were classified according to the four categories below. (For a larger overview of resources see appendix 1).

(1) Examples of existing resources which were used as usual

- **Concrete mixing and transportation equipment** (ARC Pipes). The concrete mixing and transportation equipment could be used in the same way as it is used when producing other types of pipes.
- **Extruder machine, extruder dies and rubber** (Forsheda). The way in which these resources were used was not changed.

These resources were used in the same way in relation to the new product related resource structure as they were used for other resource structures.

(2) Examples of existing resources which were used in a new way

- **Anchorages tool and anchorages** (ARC Pipes). This equipment had been developed for circular pipes, however, none of ARC Pipes customers had been interested in circular pipes with anchorages.

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However, for egg-shaped pipes, anchorages were essential because the installation of egg-shaped pipes would else have presented problems for the contractors.

- **Concrete feeder (ARC Pipes).** The existing concrete feeder could be used for filling concrete into the egg-shaped mould equipment; however, as the concrete feeder normally rotates in circles, the use of the concrete feeder was modified in order to accommodate filling concrete into egg-shaped mould equipment.

- **Cutting equipment (Pedershaab).** The existing cutting equipment was used; however, the precision which was possible to achieve on this equipment was especially important in relation to egg-shaped pipes, because of the more complex cross section of the egg-shaped pipes.

- **The sewer design and analysis software (Yorkshire Water/Sewer designers).** It was possible to make calculations of the flow in the 19th century egg-shaped brick sewers with a specific geometrical cross section by using this software. However, in case, egg-shaped concrete pipes had a cross section similar to the one in the software program, it was also possible to use the software for designing new sewers.

The majority of resources which were used in the new product related resource structure were already in the possession of the firms involved in the development episode. However, these existing resources were used in new ways.

**3) Examples of existing resources which were modified**

- **Core vibration machine (ARC Pipes).** The pipe production machine was modified in order to overcome the problem which arise when producing egg-shaped instead of circular pipes.

- **Floor (ARC Pipes).** When producing circular pipes, it is less important that the floor on which the pipes cure is absolutely straight. However, for egg-shaped pipes, it is imperative, that the floor is absolutely straight, and the floor was therefore scoured.

- **Pipe testing equipment (ARC Pipes).** Pipe manufacturers have to test their pipes as well as the joint (pipes jointed with rubber gaskets) in order to comply with the national standards. The testing equipment was adapted to testing of circular pipes, and therefore it was modified in order to accommodate it being used for testing the egg-shaped pipes.

Most modifications of resources were made by ARC Pipes. Furthermore, the modifications were made in such a way that it was still possible to use the resources for producing other types of pipes. However, in some cases considerable time and effort was needed to make the modifications.

**4) Examples of new resources**

- **Mould equipment (ARC Pipes).** In order to make egg-shaped pipes, egg-shaped mould equipment was required. This represented the largest investment in new resources in the new product related resource structure. The egg-shaped mould equipment was specific for the egg-shaped pipes.

- **Egg-shaped steel template (ARC Pipes).** In order to test the ends of the pipes to be jointed, clock gauges are normally used. However, as an egg-shaped pipe has many different radii, a new type of equipment was required. Pedershaab therefore made an egg-shaped steel template for ARC Pipes. The steel template was specific for the egg-shaped pipes.

- **Outer set ring tool (Pedershaab).** When jointing pipes, it is imperative that the tolerances of the spigot end of the pipes are small. Therefore, set rings are used for keeping the spigot ends in a fixed position while curing. Pedershaab therefore developed a new outer set ring tool in order to produce set rings for ARC Pipes' egg-shaped pipes.

- **Fork equipment (ARC Pipes).** In order to handle the egg-shaped pipes, the fork equipment used for circular pipes could not be used. Therefore, new fork equipment was acquired. The fork equipment was acquired from ARC Pipes normal supplier of fork equipment, which had originally developed the fork equipment for wood handling purposes.

Some of these resources were new in the sense that they had not existed before this new product development episode; however, others were only 'new' to the four companies.

which were involved. The mould equipment represented a relatively large investment for ARC Pipes, the outer set ring tool represented only a minor investment for Pedershaab as a large part of the investment in development and production of production tools which are specific for one customer is normally paid by that specific customer. However, the rest of the new resources only represented small investments.

Theoretical Implications

Having identified this empirical pattern, the next step consisted of theorising about the logic which may underlie this pattern. The implications suggested in this paper regard the development of a new product related resource structure from the single firm’s perspective. According to the underlying philosophy, the implications are suggested in the form of ‘tendencies’.

Ad (1) A firm has the tendency to utilise its existing internal resources in the same way as the firm is presently doing, thereby not compromising any of the existing internal and external ties of its resources, i.e. their embeddedness in the resource constellation. However, the firm has the tendency to be interested in counterpart(s) utilising the resources provided by the firm in different ways, thereby creating new external ties for the existing resources of the firm. In that way, the counterpart(s) utilise the ‘versatility due to combination potential’ of the resources, and the overall value of the firm’s resources is thus increased (due to the new external ties). However, the firm has the tendency to be interested in acquiring knowledge about the counterpart(s)’ utilisation of the firm’s (unchanged) resources and in helping the counterpart(s) with creating the new external ties, and therefore it interacts with counterpart(s) in relation to the external utilisation of the resources, which results in the firm incurring costs due to the creation of the external ties.

Ad (2) A firm has the tendency to utilise its existing internal resources in new ways, thereby creating new internal ties among its existing resources as well as creating new external resource ties (creating a new resource (a product) which is used by the counterpart(s)). However, as the resources used by the firm are not changed per se, the existing internal and external ties of the firm’s resources are not compromised. Thereby, the firm utilises the ‘versatility due to combination potential’ of its internal resources. Furthermore, this results in increased ‘flexibility’ of the firm’s internal resources, as the firm can switch between an additional predetermined resource combination. Thereby, the overall value of the firm’s resources is increased. Due to interaction in relation to making these changes, the firm incurs both costs related to the creation of external ties as well as costs related to creation of the internal ties.

Ad (3) A firm has the tendency to modify the existing resources used by the firm in such a way that new internal resource ties, as well as new external resource ties are created (creating a new resource (a product) which is used by the counterpart(s)). Thereby, a firm utilises the ‘versatility due to the modification potential’ of its resources. If the resources being modified are not tied internally and/or externally to any other resources, e.g. if the other resources which they have formerly been tied to have been modified or died out, the value of the modified resources will be increased. The same logic applies to resources which have been acquired and/or developed by the firm on an earlier occasion, but for which neither internal nor external ties have yet been created. However, if the resources are being used in other product related resource structures, a
modification may imply that the modified resources can no longer be used in all or some of these other product related resource structures. This implies, that in order not to compromise the existing internal and external ties, a firm has the tendency to try to make the modifications in such a way that these ties can be preserved to as great an extent as possible. Due to the "versatility due to combination potential", the "flexibility" of the modified resources may increase or decrease, depending on the character of the modification. Consequently, the value of the modified resources can be preserved, increased or decreased, depending on the way in which the resources were earlier on embedded into the resource constellation and on the implications of the modification for the embeddedness after the modification. Furthermore, a modification which results in internal and/or external ties being broken will have implication for the other (internal as well as external) resources to which the resources being modified are tied. Thus, when modifying resources, both costs related to the creation of internal as well as external ties will be incurred by the firm.

Ad (4) A firm has the tendency to acquire and/or develop new resources, to be used internally by the firm, in relation to a new product related resource structure. If such new resources can be used in combination with the firm's other existing, possibly modified, resources, the value of the firm's other resources can be increased due to new internal and external ties (creating a new resource (a product) which is used by the counterpart(s)). Thereby, the value of the existing resources can be increased by utilising the "versatility due to combination potential" of the resources and possibly increase the "flexibility" of the existing resources of the firm. New resources may also be acquired and/or developed in order to create new external ties between the new resource and the resources in the resource collections of counterparts, without the new resources being tied to existing internal resources in the resource collection of the firm acquiring and/or developing the new resource. However, among the considerations on such occasions will be whether creating the new external ties will result in some of the external ties of the existing resources being broken, thereby reducing the value of some of the existing resources in the firm's resource collection. In case the new resources are developed by counterpart(s), it is also necessary that the counterpart(s) are willing to make the possibly necessary changes, which, in turn, will be related to the available resources in the counterpart(s)' resource collection(s) and how the resources in these are embedded into the resource constellation of the network. When acquiring and or developing new resources, costs will be incurred due to creation of internal and external ties as well as costs due to acquisition and/or development of the new resources.

From the case description and the propositions made in this section, the development of a new product related resource structure may be metaphorically likened to 'puzzle creation', recognising the limitations of using a metaphor for focusing on some aspects, leaving out other aspects, of the empirical world it aims at capturing. A rather similar metaphor is suggested by Gadde and Håkansson (1993:144).

The creation of puzzles. The players in the puzzle creation game are firms. Each of the players has a number of multifaceted parts (resources); however, none of them have all parts necessary for making a complete picture, and none of them know in advance which picture should appear from the puzzle. The players can change their parts by using different facets, or they can decompose or recompose the parts, although they incur a 'time penalty' for doing so. Furthermore, each firm is awarded a 'prize' according to the usefulness of their parts to a puzzle(s) and how long they form part of the puzzle. However, the usefulness depends on which other parts the other players use...
in the puzzle. By participating in more puzzles, the players can increase the total amount of 'prizes' they get. However, no 'prizes' are awarded, unless the picture has acquired a certain degree of sharpness. The 'prizes' can be used for acquiring new resources or paying for avoiding the time penalty. In general, the firms aim at increasing their respective pool of 'prizes' by participating in creating new pictures or improving on existing ones. The majority of the parts are already part of other pictures, and if they are removed from these other puzzles or modified, they may become less useful for these other pictures. Furthermore, all players are involved in several puzzles, and the players frequently meet in different constellation. The development of a new product related resource structure is tentatively depicted as 'puzzle creation' in figure 5 (overleaf).

In conclusion, firms involved the development of a new product related resource structure aim at creating an 'embeddedness' within a resource structure around the 'idea' of a new product (e.g. an egg-shaped concrete pipe) in such a way that a reasonable level of technical functionality can be achieved. Their point of departure are their resource collections, and the 'usefulness' of their resources in relation to a new product related resource structure is considered. However, at the same time, each firm aims at taking the embeddedness and the overall value of their resources within the resource constellation into account. The choice of new or old resources to be used, in existing or new ways, and in existing or modified forms, in relation to the new product related resource structure is suggested to be related to the four tendencies proposed above, i.e. on the resources in the resource collections of firms and how the resources are embedded in the resource constellation of the network. The new product related resource structure evolves from each of the different firms involved 'identifying' some resources, which may be useful for the new structure, and these resources become the point of departure for 'identifying' other resources which may be useful. As the firms need to create a new product related resource structure which has a reasonable level of technical functionality in order for their resources to acquire value from being part of the structure (by the ties in which their resources acquire), they will often be prepared to make compromises and make resources available (in different forms, c.f. the four types discussed earlier); however, not all compromises are equally likely, and the compromises may change over time. Knowledge about the resource collections of

Figure 5: The development of a new product related resource structure as puzzle creation
counterparts and how their resources are embedded into the resource constellation of the network, and thereby if and how the resources can be used for a new product related resource structure is therefore necessary (e.g. knowledge that a particular resource cannot be changed because it is being used by one of the counterparts’ important customers, knowledge about the financial resources available which counterparts can use for acquiring new resources, as well as for creating internal and external ties). It should seem obvious that knowledge of this kind can ‘best’ be acquired though extensive interaction with counterparts, over time. Furthermore, development of a new product related resource structure is circumscribed with uncertainty, i.e. it cannot be known in advance which combinations of resource are possible, the implications of making modifications etc. In addition, the process of developing new product related resource structures is non-linear, i.e. the development can come to a halt only to be picked up again later, possibly with the direction of development having changed. ‘Compromises’ which may at some point in time be tried out, may fail, and the involved firms may reconsider their participation in developing a new product related resource structure – either in the direction of increasing or decreasing their participation in developing the new structure. Inquiries into how such processes unfold concurrently over time, ‘generalisation’ of the factors suggested in this paper and/or identification of other factors influencing the considerations of firms when deciding (or choosing) to participate in (or leave) the development of new product related resource structures are interesting issues for further research.

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Appendix 1.

Design of mould equipment
- Steel plates for pressing
- Pallet press
- Pallet pressing tools
- Cutting equipment
- Standard steel plates
- Drilling equipment
- Lathes
- Bending equipment
- Welding equipment
- Grinding equipment
- Inner set ring tool
- Glass fibre material and casting equipment
- Outer set ring tool

Production of mould equipment
- Pallets with studs
- Spigot end former
- Inner core
- Interface items
- Outer mould with lifting anchorages feature and preched with a sloping face
- Inner set rings
- Outer set rings
- Experimental core vibration machine
- Concrete admixtures and cement
- Measuring equipment

Testing of mould equipment
- Production of rubber gasket extruder dies
- Rubber gasket testing equipment
- Rubber gasket manufacturer
- Production of rubber gasket extruder machine
- Rubber gasket lubricant

Testing of concrete pipes
- Mould equipment
- Pallets with studs
- Spigot end former
- Inner core
- Interface items
- Concrete admixtures and cement
- Concrete pipes

Handling and storing of concrete pipes
- Core vibration machine
- Interface between spigot end former and the machine
- Vibration dampers
- Vibration dampers check equipment
- Concrete mixing and transportation equipment

Testing of joint
- Concrete pipes
- Pipe testing equipment
- Anchorages testing equipment
- Egg-shaped steel template

Installation of sewer
- Rubber gasket
- Rubber gasket
- Rubber gasket

Usage, cleansing and inspection of sewer
- Concrete pipes
- Pipe testing equipment
- Anchorages testing equipment
- Egg-shaped steel template

Contractor
- Concrete pipes
- Pipe testing equipment
- Anchorages testing equipment
- Egg-shaped steel template

Design of sewer
- Sewer design and analysis software
- Topographical characteristics of the geographical area
- Required capacity of sewer
- Required velocity
- Required tightness of sewer
- Required durability

Water Services company
- Sewage treatment plants

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