Path-dependence: restricting or facilitating technical development?

Håkan Håkansson, Uppsala University, Uppsala
Alexandra Waluszewski, Uppsala University, Uppsala

Abstract

The existence and importance of path-dependence has been observed in a number of technological studies. The main effect of path-dependence has been described in terms of restrictions, or as something that is hindering the development of new innovations and new products. In this paper based on a case where IKEA is demanding a new “green” catalogue paper from its suppliers, a complementary effect is observed and discussed: Path-dependence can also facilitate innovations. The reason is that certain resource item always is part of different resource collections, following different paths. When new cross-roads of such paths are created, there are possibilities to find new combinations. In the case, the new demanded product is distinctly different as compared to the traditional catalogue paper - it is an innovation. The development of the new catalogue paper could take advantage of earlier investments in certain production facilities and earlier experiences in specific supplying units. These resources were parts of other resource collections, following other paths as compared to the paper product. However, although the combinations of new cross-roads of path-dependence seemed to facilitate the development of a new product, it was not a smooth process, working more or less automatically. The moving of a certain resource in relation to other resources meant struggling with a lot of adaptations, including considering how these affected other resources. An important theoretical conclusion of the paper is the importance of friction in the business world.

1. Path-dependence: hindering or facilitating technical development?

The fact that so many new and clever innovations never reaches the stage of being established products, is increasingly explained by the concept of path-dependence:
The solutions that are historically built into an industrial structure inhibit the rise of certain new paths, which break with the existing structure. Or, to use David’s (1985) definition: “A path-dependent sequence of economical changes is one in which important influences upon the eventual outcome can be exerted by temporal remote events”

According to Dosi, (1988) path-dependence in terms of paradigms is due to the common knowledge base that is developed within certain area. However, path-dependence is an integral part not only of knowledge, but also, as Hughes (1987) points out, in all technical items that are developed and adapted in relation to each other. Over time such technical systems acquire a certain “momentum”, i.e. the possibilities for changing them more radical are believed to decrease: “They have a mass of technical and organisational components: they posses a direction, or goal, and

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1 Dosi, 1988, pp. 221-238
2 Hughes, 1987, pp. 51-82

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they display a rate of growth suggesting velocity." A similar view is expressed by Biejker (1987), who argues that this process of "closure" implies that the flexibility of the system decreases. Hence, path-dependence is seen as something that restricts what can be done.

The perhaps most well-known example of path-dependence is "QWERTY". The keyboard once developed for the typewriter, organised in order to make the typist write as slowly as possible. While typewriters hardly is used anymore, but has been replaced by computers, the lay-out of the keyboard is still the same. When David (1985) uses QWERTY as an example of path-dependency, it is just to illustrate how this function as a hindering force, creating "lock in" effects: "Competition in the absence of perfect futures markets drove the industry prematurely into the facto standardization on the wrong system." According to David, there are three important features behind such negative "lock in" effects: Technical inter-relatedness, or the need for system compatibility, economies of scale and quasi-irreversibility of investments. David (1985) is concluding his discussion of QWERTY with the following statement: "I believe that there are many more QWERTY worlds lying out there in the past, on the very edges of the modern economic analyst's tidy universe; worlds we do not yet fully perceive or understand, but whose influence, like that of dark stars, extends none the less to shape the visible orbits of our contemporary economic affairs."

Certainly there are a lot of empirical examples in line with David's "lock-in" and Hughes "inertia" But is then all path-dependencies "dark stars", hindering the development of innovations that brakes with the existing paths? Or is it as Smith (1993) argues, that finished artefacts always can be "recontextualized" or "redefined" due to the "rich mix of voices, the cacaphony of social processes that is embedded in each artefact like the sound of the ocean in a seashell."

In this article we want to discuss not only how it is always possible to redefine existing solutions, but also how in certain situations the existing path-dependence even seems to facilitate technical change. How solutions that are historically built into an industrial structure can facilitate a technical development that breaks with the existing path. We will discuss this by considering the idea that path-dependence can exist in several different forms. Or, as Håkansson and Lundgren (1997) argues, a path cannot exist in vacuum, it must in some way be related to other paths, other structures. "The critical issue must be: what constitutes a crossing? Given the basic definition of path, a crossing should be where actors, activities or resources meet and habit or routines are confronted or combined."

2. An interactive world full of "heaviness" and "variety"

When we apply an interactive perspective on industrial exchange, certain features of the

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4 Hughes, 1987, p. 79
5 Biejker, 1997, p. 270
6 David, P., 1985, p. 46.
7 David, P., 1985, p. 41.
The heaviness of the empirical area presented in this paper is expressed in many related facilities, including the use of different insert materials and equipment in different production processes. There is a raw material system including forestry, harvesting equipment and transportation. There are semi-finished products like mechanical pulp, chemical (kraft) pulp and different kinds of printing paper. And there are end-products like magazines, catalogues and other printed matter. There are distribution systems including lorries, trains and boats. There are advertisements, there are printing machines and packaging machines. All these items, as well as the systems to which they belong, are heavy both in a physical and economical sense. In other words, it is an industrial area that can be characterised by a very obvious “heaviness”. According to Biejker, this heaviness is easy to underestimate, including the higher level of stabilisation the items reach over time. 10

However, another, partly contradictory, aspect comes to light in an interactive perspective on industrial exchange, which also is important when the idea of path-dependency is considered. As was emphasized above, an interactive perspective focuses upon how resource items are combined. Besides an obvious heaviness, any structure of resource combinations is also characterised by a large variety: First, there is a variety of natural resources, “made up” of a huge amount of different parts, giving them different features. For example, a “simple” bacteria such as the E. coli (Escherichia coli) has at least as many different parts as there are genes in the genome of the species, which amounts to roughly 3,000 for the human and animal gut bacterium. 11 Second, the variety can also be found in the “artificial world”, where natural and man-made resources are combined and used by all these different actors, with different history, substantiated resources and relationships, as means to solve different problems: resulting in new but related artefacts. The variety of man-made resources, according to Basalla (1988) 12 has often been overlooked or taken for granted, and is not less impressing than the natural. Although it is not possible to estimate items of human manufacture with any deep precision, Basalla just reminds us of the 4.7 million US patents that have been issued since 1790. Or, to use Maddox’s
The variety of resources has at least two main consequences: First, that every single resource will have as many features as there are other resources it can be combined with. Secondly, that the possibilities for creating new resources by combining old one’s are infinite. Hence, the variety of resources implies that as soon new cross-roads of path-dependence is created, there are possibilities to combine earlier physical and immaterial resources in new ways.

The interaction that takes place between industrial actors is thus characterised by both heaviness and variety of the resources exchanged. However, only a few perspectives consider these phenomena at the same time, more often within historical than economical disciplines. We will take the “heaviness” and “variety” of resources as two important starting points in the discussion of path-dependence. Let us start by taking closer look at how the existence of heaviness and variety affect interaction concerning different resource items.

3. Interaction and substantiated resources

As was pointed out above, certainly the development of resources in relation to each other, where certain qualities are developed, invested in and embedded into larger technical systems, gives rise to heavy industrial structures. However, within these heavy structures there is also a great variety, both in terms of the existing methods of combining and activating resources, and in terms of development possibilities. The quality of a resource substantiated into this structure is never given once and for all, but is just a result of how the resource is embedded into other resources. Even if the possibility of discovering new features of resources seems to be huge, the existing space for utilising them seems to be very narrow and specific:

On one hand, there is a strong need for stability, in order to economise/utilise all the investments already made. On the other hand, within structures where the interaction between connected actors defines the value of the resources, there always seem be reasons to try to improve by developing/changing the interfaces. Such developments must always begin with the existing structure. At least some parts of the existing resource combinations must be utilised in the new solution. Hence, the development work carried out by these actors, struggling to develop existing and new resource combinations, is not only a technical process, but also a political, an economical and a social process. Or, as Biejker (1997) puts it, when he argues that any artefact includes scientific, technical, social, cultural and economical aspects: “Another way of expressing this idea is to recognise that a successful engineer is not purely a technical wizard, but an economical, political, and social one as well.”

These interaction processes, where existing and new resource combinations are related to each other, are in other words much "thicker" than assumed in market exchange. The "thick" interaction can include problem solving connected to different

26 Biejker, 1997, p. 15.
resource items, and will leave traces behind, not least expressed in artefacts of different kinds. Here we will treat it as the resources involved are given certain features. Hence, the interaction will influence and shape all the resources involved, i.e. all already “substantiated” resources. However, these substantiated resources will also influence the interaction process. We are going to discuss four ingredients in the interaction between industrial companies and how they are related to four types of substantiated resources:

a) How interaction concerning “buying/selling” is related to substantiated resources in the form of “products”.
b) How interaction concerning “producing/using” is related to substantiated resources in the form of “facilities”.
c) How interaction concerning “co-operation” is related to substantiated resources in the form of “business units”
d) How interaction concerning “networking” is related to substantiated resources in the form of “business relationships”.

Let us now take a closer look at these four:

A. Buying and selling and products
In a traditional view of economic exchange the product is viewed as given. However, in accordance with our empirical base, it is rather seldom that industrial buyers and sellers apprehend a product as given. Rather, several features of a product can be seen as the result of the interaction between the buyer and seller: The product can, for example, be adapted in order to suit the buyer, or the buyers customers, better. Hence, as soon as the buying/selling process includes thick interaction, this creates imprints on the product exchanged. These imprints reflect the product being part of both a “selling” and a “using” system: it is given some specific features from both these systems at a certain moment in time. It is embedded into other products and becomes an integrated part of the structure adding to the heaviness. However, at the same time it is given certain features that can always be used in combinations with other resource items (such as other products).

B. Producing/using and facilities
In a traditional view of economic exchange, producing and using facilities are in no way involved in the exchange. However, empirical evidence tells us that producing and using companies utilise possibilities to create both development and efficiency effects by relating facilities to each other. Hence, the construction of a facility can be regarded as an attempt to “freeze” certain features: to use a certain set of resources to perform a certain set of activities. But at the same time certain external activities and resources are assumed to be in a certain way or develop in a certain way. The underlying knowledge, substantiated in R&D activities, trials and other experiences, is certainly much deeper and wider than the visible, physical structure. Again we have the same process as for products. The facilities are embedded into each other, and their uses intertwine. At the same time they are given features - sometimes well known, sometimes more hidden - that certainly also can be used in relation to other facilities or resources. During interaction processes, where a certain facility is related to other facilities including equipment, such features can be discovered, or re-discovered, and brought to light.

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C. Co-operation and business units

Interaction is not only related to "physical" resources like products and facilities. It also affects the business units as such. The reason is that there are skills involved when the interaction is "thick". The ability to co-operate is a crucial ability. When a new business unit starts to grow, it becomes substantiated into a resource that exist in terms of certain facilities, producing certain products. However, due to its interaction with other units, the business unit is also embedding those other into the resources. This embedding includes knowledge about the others and also the ability to work together with them. Hence, the characteristics of a business unit go beyond being a combination of products and facilities. It is a social unit with the knowledge and ability to work together with certain counterparts. These features are built up over time and also exist outside the boundary of the company as they also include the abilities, knowledge and expectations of the counterparts. One important feature of this substantiated resource is that it is integral to all the people being involved, but as well as to how other resource elements are brought together: how production facilities are combined with products, with humans, with application knowledge and so on. Again we have the double process, one where the unit becomes embedded into the other, giving it features that it can use in relation to new counterparts.

D. Networking and business relationships

One important ingredient of "thick" interactions is the time dimension. This includes memories of what has taken place, and expectations regarding future activities. The involved actors will have feelings of obligations, rights, hopes and so on. In this sense, relationships have an existence in terms of a social structure. This will give opportunities to all involved actors to do networking: trying to take advantage of the existence of relationships in their actions. These relationships can be connected in different ways. It can be in the classical "political" way to get support for or against someone else, but it can also be to tie resources or link activities to each other. Relationships have way features related to how they can be used in networking activities. Some of these are already in use while others are "dormant", waiting for to be found. In this way the relationship is an element that both creates heaviness and increases the variety.

To sum up: All of the four interaction processes and related resources discussed above have important economic properties. The two first, buying/selling and using/producing, further have some very clear physical properties, while the two latter, co-operation and networking, include more social properties. However, all of them are at the same time characterised of both heaviness and variety. Every resource is thus multidimensional, and new dimensions can always be added. However, the four types of resources identified have one common feature: All are clearly defined in relation to other resources, and they can furthermore be possible to combine with just some of these other resources. This also implies that all of the four can have different types of path-dependencies: they are the result of different processes of development, where different physical and immaterial features are created.

4. An empirical example of interaction and changes of substantiated resources: IKEA’s demand for "green" catalogue paper.

In the beginning of the 1990s, one of the world’s largest users of catalogue paper declared a new environmental policy. The company was IKEA, which besides being a giant within production and distribution of furniture, also is one of the worlds’ largest

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producers of catalogues. With a circulation of about 100 million catalogues in 39 editions per annum, IKEA was purchasing about 40,000 tons of "LWC"-paper (light-weight-coated) only for the production of the main catalogues. To that can be added the production of seasonal catalogues and other printed matters. Hence, among producers of LWC and other printing paper qualities, IKEA was regarded as a very prominent customer.  

IKEA's new environmental policy was a way to handle a threat from two different, but closely related environmental issues, which affected both producers and users of pulp and paper products:

Firstly, there was an increased knowledge about the deleterious effect caused by the discharge of chlorinated compounds from pulp bleaching. Both governmental and non-governmental (NGO's) environmental organisations stressed the urgent need of reducing the discharge of chlorinated waste-water. The suggested solution was development of bleaching methods which was based on chlorine-dioxide in low levels, or, as claimed by the most demanding environmental groups, a totally excluding of chlorine as bleaching agent.  

Secondly, there was the growing "waste mountain" of Western Europe in general and Germany in particular. The latter became urgent when the Wall fell in 1989, and the export of waste to Eastern Germany no longer was possible. In order to handle the waste problem, both governmental and non-governmental organisations, NGO's, argued for an increased recycling of "post-consumer-waste", not least of paper based products. The suggested solution did in other words include both an increased collection on waste paper, and an increased insert of secondary fibre in paper production.  

IKEA's interpretation of how it was related to and could cope with these issues was revealed in its new environmental policy, presented in 1992. Or, as the head of the catalogue group, Hans Hildorsson explained: "When the public debate focuses on cutting down trees, or on the waste disposal problems, or maybe in a near future the air pollution created by our printers, it is closer at hand for the public to think of IKEA, being much more present in the minds of the people than the companies in the paper and printing industry. This tendency is reinforced by the fact that these companies choose to remain anonymous to the general public. The public opinion hits IKEA immediately and creates great damage to the IKEA image and position on the market." According to the head of the catalogue group, IKEA's environmental policy had its foundation in a genuine interest of the owners. But other, more strategic inducements were also to be found. "We must also consider the fact that IKEA is a very public and successful company - the ideal target for journalists and/or green organisations". In order to get the kind of printing paper that was considered as environmentally acceptable, the management was firmly resolved to mobilise "all necessary power". 

27 Hildorsson, H., 1993,  
20 Hildorsson, 1993, p.3.
In the environmental policy was stated that in order to be “green” the IKEA catalogue had to be based on a paper which firstly was **totally chlorine free**, i.e. no chlorine at all had to be used in the pulp bleaching process. Secondly, the paper must also include a certain insert of **secondary fibre**, i.e. pulp made from post consumer paper waste. 21

Certainly, IKEA’s interpretation of how to solve the chlorine and secondary fibre issues was not transferred to any commercial solution yet: by the producers it was simply regarded as an impossible mission to create such an LWC-paper. The LWC paper consists of a very thin base paper (about 30 gram per square metre) which is coated with clay during an average speed of 1.500 metres per minute. In this complicated on-line process, which starts with the mix of 99 percent of water and 1 percent fibre and ends up with a coated paper, no insert of secondary fibre were allowed. Since pulp made from de-inked post consumer waste always contains certain contaminants, any such trial was regarded as leading to production disturbances. Further, in order to give the base paper its necessary brightness and strength qualities, a mix of about fifty percent of chlorine-dioxide bleached kraft pulp was regarded as necessary. Since almost fifty years chlorine in any form was regarded as a must in order to create a full-bright and strong kraft pulp. 22

When IKEA presented their new environmental policy, there were however some companies carrying out trials with chlorine-free bleaching. The ordinary chlorine-dioxide based bleaching process started with a pre-treatment of the unbleached pulp with oxygen, and then it was treated with chlorine-dioxide and peroxide. There were a few producers that was working with excluding the chlorine-dioxide step, through increasing the insert of peroxide, which by environmental groups were regarded as harmless. However, no one could at this time present a bleached kraft pulp with stable quality and full brightness. In Europe, where this development originated, it was probably only the minor Swedish mill Aspa that had an half-bright chlorine-free pulp on its production programme. 23 The larger Swedish market pulp producer Södra Cell was running an extensive development project concerning "totally chlorine free" pulp, or TCF, and was building a new bleaching-facility for this purpose. Through its contacts with Greenpeace’s Pulp and Paper Campaign IKEA was informed about these projects, and also that some Finnish producers of bleached kraft pulp, among others Kymmene and Metse-Serla, had carried out tests with TCF pulp. 24

Besides the contacts with Greenpeace, IKEA did also discuss the chlorine-free and secondary fibre issue with the pulp and paper producer’s suppliers of chemicals and equipment. In order to learn more about the ability to use secondary fibre in LWC paper, IKEA established contacts with the equipment supplier Sulcher Escher Wyss, a company with several decades of experiences from de-inking technology. To gain deeper understanding of the properties of the totally chlorine-free pulp bleaching, IKEA turned to one of the dominating suppliers of bleaching chemicals, Eka Nobel.

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32 Hildorsson, 1993
23 The brightness of a full-bleached kraft pulp reaches 88-90 %ISO, while the unbleached pulp stops at about 40% ISO. Aspa early trials stopped at about 70 % ISO.
35 Håkansson & Waluszewski 1999.

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Close discussion was also carried out with the Swedish pulp producer Södra Cell, one of the pioneers in the TCF development. Through these contacts, IKEA learned that even if there were some minor quantities of full-bright and semi-bleached totally chlorine-free kraft pulp available, there was still not one single paper producer that could present a LWC paper based on TCF pulp. The de-inking of secondary fibre was certainly regarded as an established technology. However, it was adapted to the production of newsprint, were both the demands on brightness and cleanness of the pulp was not at all on the same level as compared to the LWC.

When IKEA presented its new environmental demand, the reaction from the suppliers can be characterised as “direct dismissal”. One of IKEA’s largest suppliers, the German paper producer Haindl Gmbh, refused to adapt to TCF due to both the undeveloped quality and restricted supply, and also refused to work with something as complicated as secondary fibre in LWC-paper. The severe dispute resulted in IKEA seeing no other alternative than to break up its long-lasting relationship to Haindl.

Two of IKEA’s other main suppliers, the UMP and Kymmene was however more open-minded. Both UPM and Kymmene was in the same way as their Swedish competitors exposed to the increased attention on how to create “green” paper products, from authorities, environmental groups, as well from industrial and end-users. Even before IKEA launched its environmental demands for “green” LWC paper, these mills had been exposed to a number of inquiries expressing similar interest, mainly from German catalogue producers and publishers. When IKEA started to work with these suppliers, they both belonged to the marketing organisation Finnpap. In 1989 Kymmene broke out from this, and in 1995 UPM and Kymmene merged.

UPM produced LWC suitable for magazines and catalogues in Kaipola, with a capacity of 240,000 tons per annum. Kymmenes’ LWC production was carried out on two machines in the integrated kraft pulp and paper mill Kaukas, Lappeenranta, which has a capacity of 450,000 tons per annum. In Voikka, Kuusankoski, 435,000 tons of LWC paper per annum was produced.

Despite the fact that neither UPM nor Kymmene really shared IKEA’s interpretation of how printing paper should best become environmentally adapted, a decision to meet this new customer demand was taken rather quickly. “If IKEA needs LWC based on TCF pulp and secondary fibre to become ‘green’, and if the general public agree, they shall certainly have it”, declared the product development manager of UPM-Finnpap.

In UPM’s mill Kaipola, the development of a “green” catalogue paper could benefit from an earlier investment, and from technical development carried out by their kraft pulp supplier. Since 1988 Kaipola had supplied Inter IKEA System with 51 gram LWC for gravure printing. Besides the twin wire machine producing 240,000 tons of

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25 Interview H. Hildorsson, Inter IKEA Systems, M. Rainey, Greenpeace.
27 Interview L. Tuukkanen, Finnpap, J. Tiiitonen, UPM Kaipola.
39 Interview, J. Tiitanen, UPM-Kaipola, M.S. Korpela, Kymmene-Lappeenranta.
3: Interview, L. Tuukanen, Finnpap.

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LWC in weights between 45-60 g, Kaipola had one machine producing SC telephone directory paper and one machine producing newsprint. For the newsprint production, Kaipola's manufacturing of thermomechanical pulp had already in 1989 been complemented with a de-inking plant. From about 150,000 tons of collected waste, 130,000 tons of de-inked pulp per annum was produced.

Even if the Management of Kaipola was not delighted, they were not totally negative towards using the de-inked pulp in a LWC paper. However, according to Jukka Tiittanen, technical director at the LWC mill, most did agree with the general opinion within the industry, that neither LWC nor SC should be based on de-inked pulp, due to the risk for production disturbances and negative effects on the brightness.

The cleaner the waste, the easier it became to make the pulp suitable for LWC paper. Only newsprint, magazines and advertising materials were accepted as raw material. The heart of the technology for transferring the collected waste to de-inked pulp is the cleaning of the fibres. In a mechanical de-inking stage, the raw material was disintegrated in a pulper and impurities such as ink, glue, plastics etc. were washed out. To increase the brightness of the pulp, it was then treated in several washing or flotation stages, where both chemicals and air were used.

For the application in LWC, it is essential to eliminate "stickies" in the pulp, or residues of glues, styrene, butadiene, latex, etc. from coated paper and glue banded magazines, besides to reduce the discoloring residues of ink. These adhesives left in the processed pulp could get stuck on the paper machine, creating dilution or holes in the paper and also standstills in the production process. Before the de-inked pulp was clean enough to be bleached, it has passed about 20 different stages of cleaning. However, to create a de-inked pulp with strength, cleanliness and brightness as close to the primary-fibre based pulp as possible, the de-inking process had to be so extensive that the yield did not reach more than about 75-80 %, as compared to about 90 % when used in newsprint. The use of de-inked pulp in LWC paper in other words created a larger amount of waste.

Despite Kaipola's thorough washing of the secondary fibres, the de-inked pulp had a higher degree of contamination as compared to the thermomechanical pulp. This resulted in problems with the paper machine, mainly on the wire section and during the on-line coating of the paper, with disturbances in the production as a consequence. However, when the LWC paper was finished, the insert of secondary fibre did not make any visible difference as compared to standard quality. "For the customer and the printers the use of de-inked pulp does not mean any real change, the main problems to solve end up in the paper production," underline Jukka Tiittanen, technical director at the LWC mill Kaipola.

Kaipola could also benefit from the development work carried out by their supplier of kraft pulp, Metse-Botnia, belonging to Metse-Serla Oy, to meet the IKEA demand of using totally chlorine-free kraft pulp used in the LWC paper. In the mills Kaskinen

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31 Finnpap, 1993.
32 Finnpap, 1993.
33 Interview, J. Tiitanen, UPM Kaipola. in McLoughlin, Damien. and C. Horan (eds.), *Proceedings of The 15th Annual IMP Conference, University College, Dublin 1999*
and Kemi, Metse-Botnia was producing almost one billion tons of pulp per annum. Even before IKEA came up with their request, Metse-Botnia had delivered test samples of totally chlorine-free pulp, which Kaipola used in the LWC production on customers’ orders. As a larger producer of chlorine-dioxide bleached kraft pulp, and with both internal and external customers in the hygiene product area, Metse-Botnia had been exposed to the chlorine-free demand at an early stage. Soon also customers producing SC and LWC paper, mainly located in Germany, exerted pressure on the kraft pulp supplier. It was in the early 1990 that Metse-Botnia’s Kaskinen mill, producing about 420,000 tons of hardwood and softwood pulp, started to work with TCF in co-operation with the Finnish supplier of bleaching chemicals, Kemira. In September 1991 a new totally chlorine-free bleaching process was started, based on bleaching with oxygen, peroxide and enzymes. It was not a full-bright pulp, but the brightness reached about 75-80 %, enough for production of magazine papers. The strength characteristics and the runability were intact, but the pulp had a tendency to yellow.

During 1992 Metse-Botnia took a step further and started trials to reach a full-bright pulp by adding a new chemical, ozone. Through the investment of FMK 100 million, Kaskinen in November 1993 could start the production of full-bright, ozone-bleached pulp.

For the pulp customer Kaipola, the first years with Metse-Botnia’s TCF was however not free from dilemmas, among the most difficult problems unstable brightness and negatively affected runability were the most serious. After some years, when the loss in strain characteristics had been compensated with adaptations on the paper machine, the TCF kraft pulp reached almost equal quality as compared to ECF.
IKEA’s other Finnish supplier of “green” LWC, Kymmene’s Kaukas-Lappeenranta mill, could also fulfill these demands on the basis of the existing production structure. The situation in Lappeenranta was however the contrary as compared to Kaipola, while TCF was produced within the integrated unit, the secondary fibre based pulp was delivered by a sister unit. Like several other Scandinavian producers of bleached kraft pulp, it was in 1991 that Kaukas-Lappeenranta initiated its chlorine-free bleaching process. At that time the mill was also equipped with oxygen pre-treatment of both the hardwood pulp and softwood pulp. With a capacity of 200,000 tons of hardwood pulp, and 175,000 tons of softwood pulp, Kaukas could not only supply the integrated LWC mill, but also several other internal and external customers. 38

IKEA was not the first customer to present a TCF demand to Kaukas, but followed some German magazine paper producers. At this time, the development work had proceeded so far that even if the totally chlorine-free bleached kraft pulp was not an established product, the mill could produce TCF “in an exceptional way”, according to the technical director. The quality was not as consistent as the standard pulp, but the brightness obtained with oxygen pre-treatment, peroxide and several kinds of enzymes, was good enough for the LWC production. 39

However, the insert of secondary fibre created many more problems. The use of de-inked pulp in printing paper production was an established technology since mid 1980s, with German equipment suppliers and producers at the forefront. The technology was however developed for newsprint production, with significant lower demands on both the cleanliness and brightness of the pulp. This was also true for the de-inked pulp delivered by the French sister mill, Chapelle Darblay, which had a capacity of about 115,000 tons per annum. In the first years with de-inked pulp, the technicians at Kaukas-Lappeenranta had to solve several problems due to impurities. 40

Despite all the modifications needed by the Finnish LWC producers, not least due to the insert of de-inked pulp, the quality of the LWC paper based on TCF and 10 % secondary fibre, was more or less impossible to distinguish from the traditional paper from the customers point of view. Neither did IKEA or the mills meet any negative reactions from the printers, the performance in the printers was equal to the “standard” LWC. 41 Or, as IKEA’s head of the catalogue group expressed the opinion of the IKEA catalogue of 1993: “More beautiful than ever.”

5. Utilising possibilities in path-dependence

The catalogue paper IKEA asked for and also received was certainly a new solution: the first LWC paper based on TCF, totally chlorine-free pulp, and secondary fibre. How did this new solution then into the existing resource structure? In what way did it suffer or benefit from path-dependence?

38 Svensk Papperstidning, 1996/
39 Interview, M.S. Korpela, Kymmene Lappeenranta.
40 Interview, M. S. Korpela, Kymmene Lappeenranta.
41 Interview, H. Hildorsson, Inter IKEA Systems.
Although the attention to "green" issues increased in the late 1980s and early 1990s, neither the "chlorine-free" nor the "recycling" issue was totally new for the pulp and paper producers. The interest in a new bleaching solution, in order to decrease the discharge of chlorinated compounds, started to grow as early as the late 1960s and early 1970s. However, at that time it was presented by the Scandinavian environmental authorities and the pulp mills, far away from the involvement of any paper consumers. A new bleaching solution became substantiated in the interaction between the environmental authorities and their ambitions to force the pulp mills to reduce the negative environmental effects of effluents in water and air, and the pulp mills ambitions to create a more efficient use of chemicals and energy. This process involved both equipment suppliers and suppliers of chemicals. Successively these different problems became organised into one common solution, through the development of the oxygen pre-treatment and chlorine-dioxide bleaching method in the late 1970s. Actually, before the "chlorine-free" issue came up on the agenda of the environmental NGO’s, the Scandinavian bleaching facilities’ average discharge of chlorinated compounds had been reduced by approximately 75 %, measured in AOX per ton pulp.42

Hence, there was a development of the existing resource structure which made the reduction of the "low-level" of chlorine-bleaching possible. However, this reduction was carried out without any interference from the buyers of paper products. Instead, all endeavours to decrease both the insert of chlorine and the discharge of chlorinated compounds had to be carried out within a structure that overall was adapted to the supply and use of paper products characterised by as high brightness as possible.

Consequently, the interaction behind the new solution affected only a few of the connections between the four types of substantiated resources identified above: "products", "facilities" “business units” and “business relationships”. The new solution was mainly built into the pulp bleaching facilities, including the equipment and the processes carried out there. It was also built into some business units, especially between producers and some of their supplier. The focal product, bleached kraft pulp, had still to remain the same in its main quality characteristics. The buyers of bleached kraft pulp were in the same way very little involved in this process. Since the demand for decreased discharge of chlorine did not interest the paper producers and users, there was no interest in adapting the different products based on bleached pulp to such solution. In general, however, this was not regarded as an advantage in the interface with other resources, for example with the printing paper in paper production, or with the resources activated in the production of magazines and newspapers. In other words, the knowledge and experiences gained from the efforts towards "low-level" chlorine-bleaching remained a matter between the producing units and their co-operation with suppliers of equipment and chemicals. These insights were generally not utilised in the relationships with publishers, printers and their advertisers. Hence, the resource types “facilities” and “business units” where developed through different paths as compared to “products” and “business relationships”.

A similar pattern characterises the demand on an insert of secondary fibre in the paper production. The use of secondary fibre was something that started with the growing

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42 AOX = adsorbable organic halides

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environmental awareness in the early 1990s. For producers of "simple" paper products, recycling had long been a solution in situations with lack of primary fibre, restricted pulp production capacity or a need to reduce energy consumption. And, for the industrial consumers of certain paper products, there was the need to get rid of waste paper. Thus, several different problems had successively been organised into a recycling solution. But, this development did not at all start out as a "green" issue. Further, it was a solution that was restricted by relationships to the customers. In principle secondary fibre was only used when it could not be observed by the customers, i.e. when the quality characteristics of the different paper products were not affected.

In the same way as with the low-level chlorine bleaching, the use of secondary fibre became an issue between the producers and their suppliers of equipment and chemicals. And, the solution had to fit into a structure adapted to the use of primary fibre. Again, this meant that the secondary fibre solution was mainly built into the production facilities. The relationships affected were those connected on the supply side, while the user side had to be kept in the dark as much as possible. In the interface with the resources activated by industrial converters and users, the insert of secondary fibre was rather seen as a drawback. Here, as well, de-inking knowledge was kept inside the business units producing pulp from secondary fibre and their cooperation with equipment and secondary fibre suppliers. Bringing these experiences out open in the relationship with for example printers, publisher and advertisers was more or less out of the question. Hence, in the same way as the chlorine-issue, the resource types "facilities" and "business units" where developed through some other paths as compared to "products" and "business relationships".

To sum up, long before IKEA made their interpretation of how to create a "green" LWC, based on chlorine-free bleached kraft pulp and secondary fibre, "embryos" to similar solutions existed, built into certain parts of the structure. However, both the "chlorine" and "recycling" solutions were restricted to the supply of pulp and paper products, and included neither the industrial users, nor the end-consumers or the general public. Both were solutions that were mainly built into the resource types "facilities", including raw material, equipment and production processes used here, and into the "business units" engaged in process and equipment development.

What was happening then in the late 1980s and early 1990s, just before IKEA presented their new demand, was that both a low level or a total reduction of chlorine and a certain insert of secondary fibre became perceived as tools to create "green" pulp and paper products. And, in contrast to the "first wave" of substantiating these solutions, the green demand was presented by actors who had hitherto been negative or neutral towards them: the industrial users and converters, the distributers and end users of paper products.

Hence, new cross-roads of path-dependency were suddenly created: By combining certain solutions that already existed as "embryos" in the "facilities" and "business units" with new demands on the "products", it became possible to create several different types of "green" paper products, including the TCF and secondary fibre-based LWC that IKEA was asking for.
If we start with the "chlorine-free" or TCF bleaching solution, both UPM’s mill Kaipola’s external supplier, Metsä-Botnia, and Kymmenes’ Lappeenranta mill were already established producers of chlorine-dioxide bleached pulp. Further, both were already carrying out experiments with totally chlorine-free bleaching processes, although there was no established TCF pulp yet. The process was not stable enough to produce a full-bright TCF kraft pulp at about ISO 88-90%, but the brightness was acceptable for LWC paper, where the insert of mechanical pulp limits the highest possible level to about ISO 80%. It was the already existing investments in chlorine-dioxide bleaching that laid the foundation for further trials with a decreased insert of chlorine. Without any new innovations in terms of equipment, but due to a lot of trials with different process adaptations, it became possible to develop a TCF kraft pulp to fulfil one part of IKEA’s "green" demand.

The "secondary fibre" solution could also be built upon earlier endeavours and existing resource combinations. Both UPM’s mill Kaipola and Kymmenes Lappeenranta’s supplier Chapelle Darblay were engaged in de-inking of secondary fibre for newsprint production. Through their investments in de-inking equipment and the knowledge developed in this technology, it became possible to develop a secondary fibre based pulp for a completely new application. Again there where no new innovations in terms of new equipment carried out. The secondary fibre solution for IKEA’s LWC-production did instead rest upon the existing equipment combined with an increased sorting of waste paper, and not least, a lot of process adjustments.

Hence, IKEA’s demand for an LWC solution including both chlorine-free or TCF pulp and secondary fibre, could benefit from the creation of new cross-roads of different path-dependencies: Solutions already existing in the resource types “facilities” and “business units” were picked up and further developed, and, not least, combined with “products” and “business relationships”. This utilisation of different path-dependencies was an important ingredient in the successful creation of a "green" LWC product.

6. Path-dependence as a possibility – or how to cope with "substance" and "friction".

The empirical example above draws our attention to what can actually be created, not despite, but because path-dependence. The fact that path-dependence sometimes occur as a hindrance and sometimes as a driving force in technical development can be understood by considering the parallel existence of heaviness and variety.

The existing path-dependencies in an industrial structure, in accordance with our empirical example, can be of different kinds for different types of resources. We have seen that the path-dependencies characterising the resource type "facilities", can be rather different from those characterising the "products" produced. In the same way, different kinds of path-dependencies in "business units" and "business relationships" are possible.

A new situation can create, as it did in our example, a new cross-roads where different kind sof path-dependencies meet, creating new possibilities for utilising resources.
The parallel existence of heaviness and variety of resources means that specific kinds of features or qualities can be combined in new ways.

Due to their heaviness, substantiated resources are attributed with certain features, which are often regarded as given, but should instead be seen as the result of certain interfaces. At the same time, the variety of resources makes them infinite sources of hidden qualities. The total content of any resource will thus always be unknown. We can use the concept of "substance" to indicate that we will never have complete knowledge of any resource in terms of all its features. Clearly substance has physical dimensions. However, although they are physical resources interacting with other physical resources, they also have social and economical dimensions. Every resource is multidimensional in this way, and new dimensions can always be added.

One of the major reasons behind the obscurity of a resource, is that its features are a result of "interaction" with other resources. Combined with one or several other resources, a certain feature or quality is brought forward. As was pointed out above, such a "collective" quality is often regarded as a fixed feature, or a restriction, of a certain resource. However, new features might appear, both if a focal resource is combined with resources with which it never has been used before, and if it is combined with well-known resources in a new way. Such changes in how a resource interacts with other resources can create features never thought of before. Certainly, these never activated features exist as potentials in any resource: it is a part of the substance.

But what then happens when such features are activated, when resources are related to each other in a new way? We have seen in the empirical example that even if it is possible to utilise certain path-dependency to create new solutions, this is not a smooth and easy process, working more or less automatically. Any substantiated resource has its own path-dependence, but it is also embedded into other resources. Any attempt to utilise a certain feature of a resource in a new way will affect other, related resources. For example, when the possibility of bleaching kraft pulp with no insert of chlorine was presented, this had negative effects on other substantiated resources: The unstable strength characteristics created disturbances in the LWC paper production process. The lower brightness characteristics had a negative impact on the printability and readability of the finished paper in certain applications. Similarly, the insert of secondary fibre in LWC meant that the de-inking process had to be improved, at the expense of a decreased yield. Further, the impurities that still remained in the pulp created disturbances in the paper production process.

*Hence, even if possibilities always exist in any industrial structure to take out new qualities or features from a resource, this cannot be done without work.* In order to create any change, there has to be movement. And, whenever there is a movement of a resource in relation to other resources, there will be friction. Or, as Äkerman

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43 We have taken the idea of substance from Aristotle: "The substance of anything is that in it which gives it continuous and independent existence, which makes it more than a passing quality or quantity or other characteristic, that may exist in something else but never alone. Substance is then what is, the permanent core or substratum underlying the fleeting qualities" (Loomis 1943, p xxii). However, we would like to make one important change. We do not see the qualities as "fleeting", but as imposed on the resource from the interaction with other resources. They are the interface between the resource and another (or several) resource(s).

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(1993)\(^4\) expresses it: "Without friction, no movement whatsoever." Hence, to change, to give something a new feature, can only occur to the prize of some type of deformation. This process of friction is probably one of the economic processes we know least about, and we believe that an interactive perspective can teach us much more about it.

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**Appendix**

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