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Managing Paths: How Shell Pursues the Development of Alternative Fuels[1]

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Abstract

This paper develops an understanding, how incumbents of technological paths pursue active path management, i.e. the creation, extension, or termination of paths by cultivating their increasing returns. This understanding combines the concepts of path dependence (Arthur 1989; David 1985) and of path creation (Garud & Karnøe 2001) with the help of insights from the 'actor-centred institutionalism' (Mayntz & Scharpf 1995) and results in a heuristic framework. The usefulness of this framework is demonstrated by analysing the activities of the mineral oil company Royal Dutch/Shell regarding the alternative diesel Biomass-to-Liquids (BtL). It is revealed that Shell becomes active in the area of alternative fuels due to external pressures for cleaner and greener fuels. These pressures as well as the increasing returns of the existing fossil fuel path are addressed with the help of the technological design of BtL. Taken together; the activities reveal that Shell is pursuing simultaneously the extension of the fossil fuel path and the creation of a new product path.

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1 Introduction

The concept of path dependency, i.e. the stabilisation of a status quo by reinforcing mechanisms (Arthur 1989; David 1985), has gained increasing attention in the area of innovation taking path dependency as a restriction for innovation (e.g. Kemp et al. 2001; Foxon et al. 2005). This antagonistic relationship between path dependency and innovation was challenged by Garud and Karnøe's (2001, 2003) concept of path creation. In this concept agency is reintroduced in the form of (collective) path entrepreneurship. However, since path creation focuses on path entrepreneurs, the old path and the actions of the path incumbents are left out of sight. This is astonishing insofar as these actors have much to lose and therefore can be suspected to prosecute their own kind of 'path management'.

This gap, common to 'entrepreneurial' approaches (e.g. Leblebici et al. 1991), is addressed in this paper, investigating how incumbents of the old path can engage in active 'path management' in regard to both the old and the potential new path. Thereby, this paper can be located in the wider area of 'exploitation-exploration'-topics (March 1991; Smith & Tushman 2005) considering that path management focuses on *external* factors such as technology, regulative institutions and actor environments instead on internal difficulties to innovation in incumbent organisations (Koza & Lewin 1998).

The activities of the mineral oil company Royal Dutch/Shell in the alternative diesel fuel Biomass-to-Liquids (BtL) is taken as an illustrative case of active path management (Yin 1994). Reasons for this choice are that (a) Shell is without any doubt an incumbent in the area of automotive fuels; (b) the infrastructure necessary to provide fuels can easily be identified as a path dependent 'great technological system' (Hughes 1989) including specific reinforcing mechanisms. Finally (c), Shell performs a wide range of research in the area of alternative fuels including BtL.

Considering the interest in active path management the research question of this paper is "*Why and how does Shell pursue the development of sustainable fuels in the face of its involvement in the technological fossil fuel path?*". This question contains three components: First, the existence of the technological fossil fuel path and its reinforcing mechanisms have to be proven. Second, the 'Why?'-question targets the institutional, technological, and actor-environment in which Shell becomes active. Finally, the 'How?' addresses the crucial issue of path management. These questions are analyzed in the context of the German market since Germany is the location where Shell's BtL-activities take place. Furthermore, the choice of the German market keeps the discussion of the regulative and the actor environment on a reasonable scale.

The proceeding to answer this question is as follows: The paper starts with the development of a heuristic framework for studying 'path management'. Using this framework, second, a case study is conducted on the strategies of Shell in the area of sustainable automotive fuels between 1990 and 2006. Finally, conclusions are drawn and future research areas are pointed out.

2 Managing technological paths

This paper defines 'path management' as an active management of the old as well as potential new path(s) by cultivating their respective increasing returns. In order to develop an understanding of this kind of activity and a heuristic framework for investigation, this paper rests on three approaches: First, the classical concept of path dependence as developed by Arthur (1989) and David (1985) is used since it provides an understanding of how paths are reproduced and strengthened by their increasing returns. Second, the idea of path creation of Garud and Karnøe (2001; Sydow et al. 2005b, 2004; Windeler 2003) brings agency back into the focus by pointing towards the recursivity between structure and agency. Finally, the 'actor-centered institutionalism' of Mayntz and Scharpf (1995) suggests how actors and their interests can be conceptualized vis-à-vis *exogenous* structures. These three approaches are integrated into and discussed under the development of the heuristic framework for investigating path management. This framework takes up the differentiation of the analytical subject into a structural and an agency sphere.

2.1 Considering structure

Previous research often integrated technological paths with their associated institutional environment and the involved actors into one complex, e.g. Unruh's (2000) "*techno-institutional complexes*" (ibid. 825; Hughes 1989:51). Contrary to that, this paper subdivides the structural environment into the regulative, the technological, and the actor-environment. The reason for this is that only the fossil fuel technology is considered to represent a technological path while simultaneously the regulative as well as the actor environment play a crucial role in its maintenance and change (Hughes 1989; Leblebici et al. 1991; Vleuten & Raven 2006). So, all three parts serve as a "*stimulating, enabling as well as restricting* context *to agency*" (Mayntz & Scharpf 1995:43; italics in the original;own translation).

2.1.1 Institutional and actor environments

Following the narrow definition of Mayntz and Scharpf (1995), the institutional environment of an organisation consists of regulative aspects (ibid: 45). Thereby, institutions are limited to political regulations and economic standards, leaving out of sight social norms and cognitive frameworks (e.g. Scott 2001). The effect is the avoidance of a "*crypto-determinism*" (Mayntz & Scharpf 1995:45) and a significant reduction in complexity. Nevertheless, Mayntz and Scharpf re-integrate norms and cognition as the basis for the decisions of the actors (ibid: 52-57). Accordingly, they are

not part of the institutional framework but intrinsic to the actors. Since this paper has a narrow focus on a commercial organisation only, the main interest of this collective actor is to gain resources (ibid: 54-55). Thus, perceived business opportunities and threats to the existent business are the central incitements (ibid: 58; McAdam & Scott 2005:18).
A second structural aspect is the 'organisational field' respectively the other participating actors (Mayntz & Scharpf 1995:62; Sydow et al. 2005b; Leblebici et al. 1991; Smith & Tushman 2005). Such actors are competitors, suppliers, customers, as well as societal, political and research organisations or individuals. In that regard, the opportunities and threats also derive from the mode of interaction between the field-participants as well as from the entrance of new actors who provide new products and / or question the existing ones (Leblebici et al. 1991; Hoffman 1999; Porter 1992). The third structural 'input' factor to be considered in the next section is the technological path.

2.1.2 Technological paths

The component 'technological path' is theoretically covered by the classical concept of path dependency (David 1985; Arthur 1989). Under the popular rubric of 'history matters' this concept explains the lasting effect of technological choices. Following David's (1985) famous example of the QWERTY keyboard, technological path dependency contains three components: First, an initially contingent choice. This choice is, second, amplified by increasing returns in the form of economies of scale and sunk costs (ibid: 334-336). Further positive feedbacks can stem from different sources such as learning effects, coordination and complementarity effects, adaptive expectations, power-relations, and high set-up costs of new alternatives (Beyer 2005:7; Sydow et al. 2005a:6-8). Obviously, these different causes of increasing returns are not only located in the technological path itself but as well in its embedding structures– e.g. power-relations and adaptive expectations. Driven by increasing returns, third, the technology gets locked-in and potentially more efficient alternatives do not success (Arthur 1989:117). However, focussing on increasing returns alone leads to a change-resistant and deterministic model of path dependence.

2.2 Considering agency

Agency in the face of path dependency is possible for two interrelated reasons: First, there may be 'structural holes', contradictions in the structural framework or structural changes over time (Crouch & Farrell 2004:8; Clemens & Cook 1999:448-449). Second, paths and their mechanisms are not established by a law of nature but are socially constructed (Sydow et al. 2005a:22; Hedström & Swedberg 1996). Accordingly, the missing actor-perspective of the classical concept has to be filled enabling the researcher to investigate agency as it is done in the concept of path creation (Garud & Karnøe 2001:8-9). This concept uses Giddens (1984) structuration theory to reconcile path dependent processes on macro-level with the 'enactment' of paths on the micro-level:

> “*Path dependence assigns too much weight to history; it inadequately characterizes the fragility of any path as it is produced and reproduced through microlevel practices where social rules and artifacts are enacted …*” (Garud & Karnøe 2001:8).

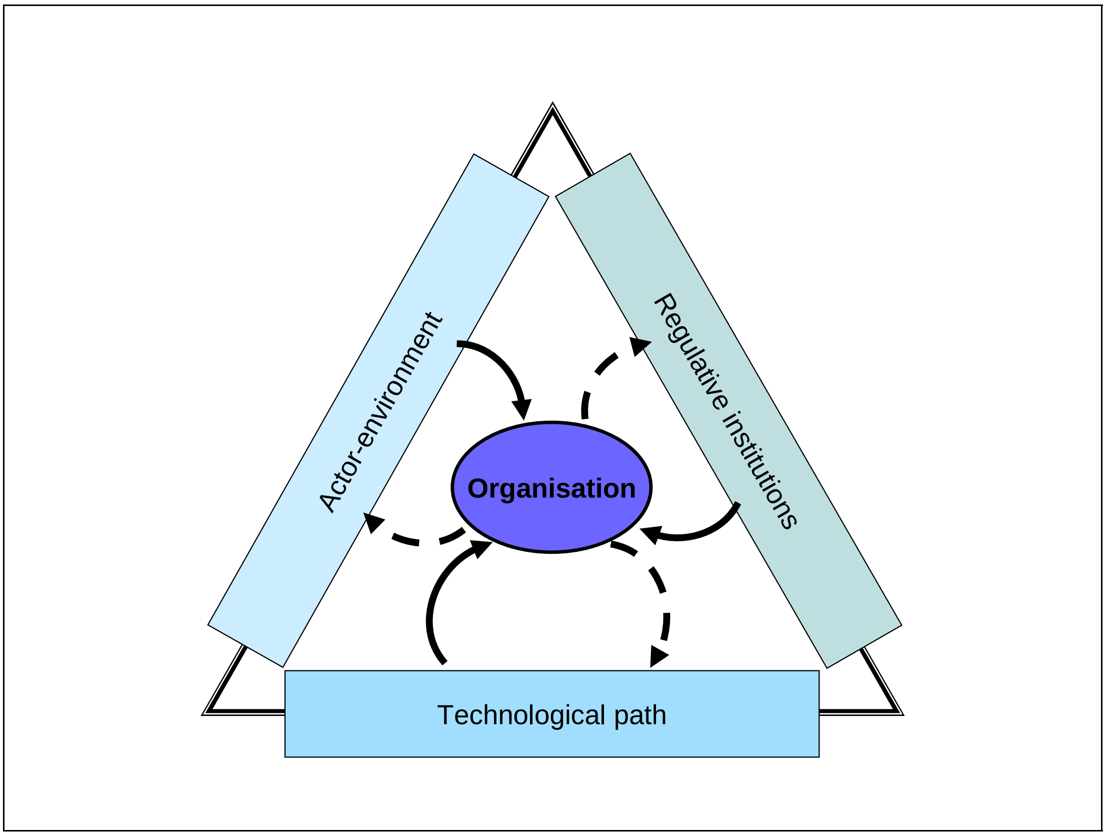
However, Garud and Karnøe – in the aftermath of Giddens – postulate that the actors *endogenize* the structure (ibid. 9). Contrary to that and in order to avoid analytical difficulties from conflating structure and agency (Archer 1982), this paper regards structures as being *exogenous* to the actors. Therefore, agency is seen as restricted, enabled and incited by the structure and influences it.

Regarding the content of path management – i.e. *how* the actors can pursue path creation, path extension, and path deviation (Sydow et al. 2005b:5) – this paper follows Arthur’s (1996) call for an “active *management of increasing returns*” (ibid:105; italics in the original). Consequently, it is stipulates that since path dependence ‘works’ on the basis of increasing returns the management of increasing returns is at the centre of path management. Thereby the corner-stone of path dependence is the object of path management. Consequently, actors can not only intentionally strive for the generation of increasing returns and enact them thereafter as Garud and Karnøe postulate (2001: 17-18). Moreover, the actors can “*cultivate*” (Deeg 2001:12-13) increasing returns striving for their strengthening, their expansion or their interruption. Following these insights, the management of increasing returns and the types of path management nicely fit together. Accordingly, this paper defines path management as ‘*the creation, extension or termination of paths by the generation and cultivation of their increasing returns*’.

2.3 Concluding on structure and agency

In order to map path management in the defined way, the discussed aspects of the structure and agency are combined into the heuristic framework as it is presented in figure 1. On the one hand this framework encompasses the structural elements of the technological path, the institutional and the actor-environment as well as their stimulating, enabling, and restricting effect on agency. On the other hand the framework pictures the organisation and its agency, i.e. how the organisation addresses and reshapes the incentives and restrictions posed by the embedding structures. This detailed recursive relationship between structure and agency will be tested on the basis of the empirical case.

Figure 1: The heuristic framework



Source: Own drawing.

3 Research design, method and sources

For demonstrating the heuristic framework and the ability of path management, a longitudinal single-case study on the activities of Royal Dutch Shell in the area of sustainable automotive fuels is conducted as a 'exploratory device' (Yin 1994:41; Pettigrew 1995; Siggelkow 2007). From the broad range of Shell's alternatives Gas-to-Liquids (GtL), Biomass-to-Liquids (BtL), cellulose ethanol, and hydrogen, BtL is chosen as an advanced 'green' and high valued alternative (Lahl & Knobloch 2006:4). Therefore, the level of analysis is Shell's activity in BtL in Germany and not its portfolio strategy in alternative automotive fuels or the company as a whole. These activities are mainly located on the level of Germany since they take place at the German start-up and BtL-developer CHOREN Industries GmbH, which is partly owned and financially as well as technologically supported by Shell.

For the analysis of Shell's BtL-activities as path management the heuristic framework delivers the categories to be filled in. Information regarding these categories from 1990 onward was gathered from a broad range of sources: (a) Semi-structured interviews (Gläser & Laudel 2004) with actors from the "*issue field*" (Hoffman 1999:351) 'automobile fuels', (b) speeches and conference presentations, (c) press releases, business as well as sustainability and technology reports, (d) newspaper, internet and business press articles as well as (e) secondary literature.

4 The empirical case: Why and how Shell pursues BtL diesel

Following the heuristic framework the empirical analysis is divided into two main steps: First, the development of Shell's structural environment is analyzed comprising the regulative institutions, the actor environment as well as the technological path. Second, it is investigated why and how Shell addresses the technological path, the regulative and the actor environment in its BtL-activities.

4.1 Shell's structural environment: Towards new fuels

Generally, fossil automotive fuels are politically and socially challenged for four reasons: (1) The finiteness of fossil fuels; (2) the security of supply, (3) air pollution caused by carbon monoxide (CO), hydrocarbon (HC), nitrogen oxide (NOx), and particulate matter (PM) emissions, and (4) CO_2-emissions contributing to the greenhouse effect. A fifth aspect is the desire to open up a new market for domestic agriculture. These problems are no 'newcomers' on the political agenda but have been discussed since 'The Limits to Growth' (Meadows et al. 1972), the oil crises in the 1970s, the release of the first Intergovernmental Panel on Climate Change (IPCC) report in 1990. Taken together, these changing environmental conditions called for the development of alternative fuels.

4.1.1 The development of the regulative institutions

Since the regulation of the German fuel market is heavily influenced by European legislation and programmes, also the latter one in its influence on the first one has to be considered. This holds especially true for ***emission regulation*** which started in 1970 and which is part of the duty of the European Community to enhance the environmental protection and quality (Taminiau 2006; Müller-Graff 2004). In the investigated time-span emission regulation was spurred by two Auto-Oil-programs (1993 to 1996 and 1997 to 2000) involving car manufacturers and the oil industry to improve among other things the fuel quality. These research programs were combined with a gradually tightened regulation of automobile's exhaust gases (EURO I-V) and rising standards for fossil fuels. I.e. lead was prohibited as a knock suppressant from 2000 on and the content of sulphur was restricted to 50 ppm in 2005 and 10 ppm in 2009 (Taminiau 2006; Dixson-Decleve 2007; EurActiv 2007). This development was supported by establishing corresponding CEN fuel standards.

On the German level, the regulative framework of the 1990s was marked by rising ***taxes*** on fossil fuels in the aftermath of the German unification (ADAC 2007). On the other hand an 'informal' exemption from mineral oil tax was granted to pure bio-diesel and plant oil. In 1999 the ecological tax further increased the price of fossil gasoline and diesel. Shortly thereafter, in 2003, the directive 2003/96/EC (2003b) of the European Commission enabled the German federal government to codify the tax exemption and to expand it to other alternative fuels as well as to the shares of blended Biofuels in conventional fuels (Thuijl & Deurwaarder 2006:15; Brand 2005:33-34). However, as the tax exemptions led to rising tax deficits – up to 2 billion Euros in 2006 –, they were withdrawn for blended Biofuels in 2006. Moreover a stepwise rising taxation on pure biodiesel, ethanol, and plant oil was introduced. On the other hand, tax exemptions were granted until 2015 to the so called 'second generation biofuels' including BtL (Bundesgesetzblatt 2006a, 2006b; BMF 2007). Simultaneously, the German government introduced new ***regulatory measures*** as a substitute for the financial incentives and in order to secure the biofuels market. These measures took the form of an obligation to blend biofuels (4,4% bio-diesel and 1,2 to 3,6% ethanol)[2] into conventional fuels since January 2007 (Lahl & Knobloch 2006).

Moreover, the ***CO_2-regulation*** included the refineries in the CO_2 trading system since 2005, and motivated the European automobile-industry to commit itself to the target to reduce the average CO_2-emissions down to 140 gram per driven kilometre until 2008 (Reinaud 2005; Müller-Langer et al. 2006:177). However, in 2006 it became obvious that the automobile industry, especially the German one, would not reach the target. This made regulatory measures likely (Lahl & Knobloch 2006). Finally, the European Union as well as the German government intend to guide the development by proclaiming ***policy goals*** for the use of bioenergy and Biofuels. This process started with the directive 2003/30/EC (2003a) which declared the aim to reach a 2% share of biofuels in 2005 and of 5,75% in 2010 (IEA 2005:29-30).

To sum up: The regulative framework for fossil and alternative fuels provided mineral oil companies with six incentives: First, the mineral oil companies had to search for a new knock suppressant substituting the lead. Second, they had to invest heavily in the refineries in order to remove the sulphur (CONCAWE 1999). Third, while the tax incentives made Biofuels attractive between 2003/2004 and 2006 as a blending component, their removal changed nothing in praxis since the companies were obliged to blend. In both cases, the ability to blend required changes in procurement, logistics, reporting and so on. Fourth, the CO_2-regulation makes efficiency measures in the refinery profitable as long as the price for CO_2-certificates is high – which it was not (Deutsche Bank Research 2007). Fifth, the CO_2-self commitment of the European automobile industry and its troubles with it represented a potential threat to the mineral oil industry since biofuels could be used to ease the pressure on the automobile industry (Lahl & Knobloch 2006). Finally, the declared policy targets function as a signal that the European and the German policies will continue to work towards a higher share of Biofuels in the market.

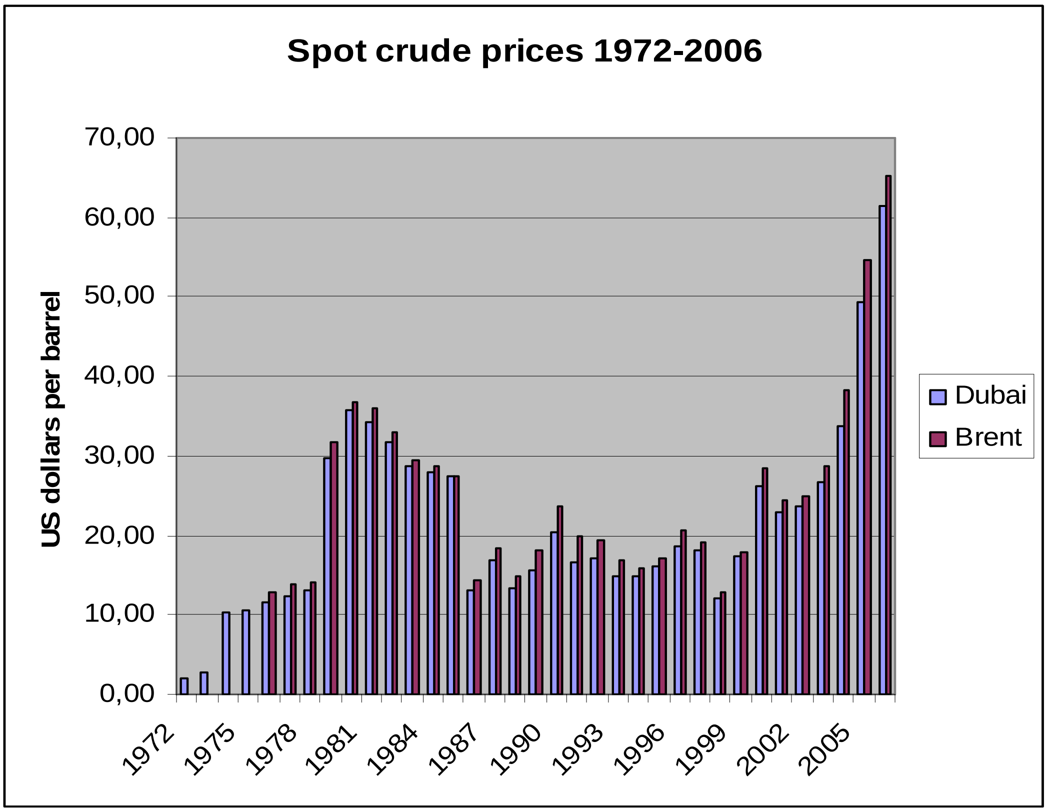
[2] The numbers are related to the energetic content of bio-diesel and ethanol and not their volume. The varying numbers for ethanol result from a rising obligation between 2007 and 2010.

4.1.2 Shell's actor environment and its' competitive position

The actor environment of Shell is analysed with the help of Porter's (1992) five forces. Taking this perspective the following trends are observable between 1990 and 2006:

On the ***supply side*** – i.e. Shell's ability to explore and exploit conventional mineral oil deposits – was weakened. This was mainly caused by two developments: Until 1998 mineral oil prices declined which aggravated the exploration and exploitation of new deposits due to the low margins. Since 1998 mineral oil prices – among other things due to the rising demand of China – sextupled (see figure 2). As a consequence the basis for negotiation vis-à-vis the non-OPEC and OPEC countries was weakened. Additionally, notably Russia, Venezuela, and Nigeria – for different reasons – turned into very insecure host countries.

Figure 2: Spot crude prices of Dubai and Brent crude 1972 to 2006



Source:BP 2007:16.

Shell's ***competitive position*** compared to the other major mineral oil companies Exxon and BP was weakened by two mergers and two scandals: The mergers concerned Exxon with Mobil in 1999 and BP with Amoco in 1998. As a consequence, Shell, previously the number one for decades, became second in class behind Exxon, battling with a growing and 'greening' BP for that position.[3] Additionally, Shell's competitiveness was weakened by the scandals around Brent Spar in 1995 and the 20% devaluation of its proven

[3] In 2000 BP acquired ARCO as well as Castrol and in 2002 the German market leader Aral. BP became 'greener' by being the first oil company recognizing the problem climate change in 1997 as well by its re-branding into 'Beyond Petroleum' in 2000. Shell followed suit regarding climate change and introduced similar to BP an internal CO_2 trading scheme (Levy & Kolk 2002).

reserves in January 2004. Furthermore, on the German market Shell was hit by the merger of BP with the German market leader Aral in 2002. This was partly compensated by Shell's simultaneous acquisition of the other leading German oil company DEA.

Regarding ***new products***, biodiesel was extremely successful on the German market reaching 4% market share in 2006 (Kliem 2007:2). This represented a partly substitution of fossil diesel. Similar developments occurred in other markets such as in the U.S., Brazil, and Sweden – but on behalf of the gasoline substitute ethanol (IEA 2005). Fourth, the biodiesel (as well as the ethanol in the other countries) was provided by ***new market entrants*** from the agrarian sector and sold via cooperative and SME's petrol stations. Otherwise, these petrol stations would have bought fossil diesel from German refineries or imported it. Furthermore, numerous start-ups were looking for other alternative fuels with higher replacement-potentials.

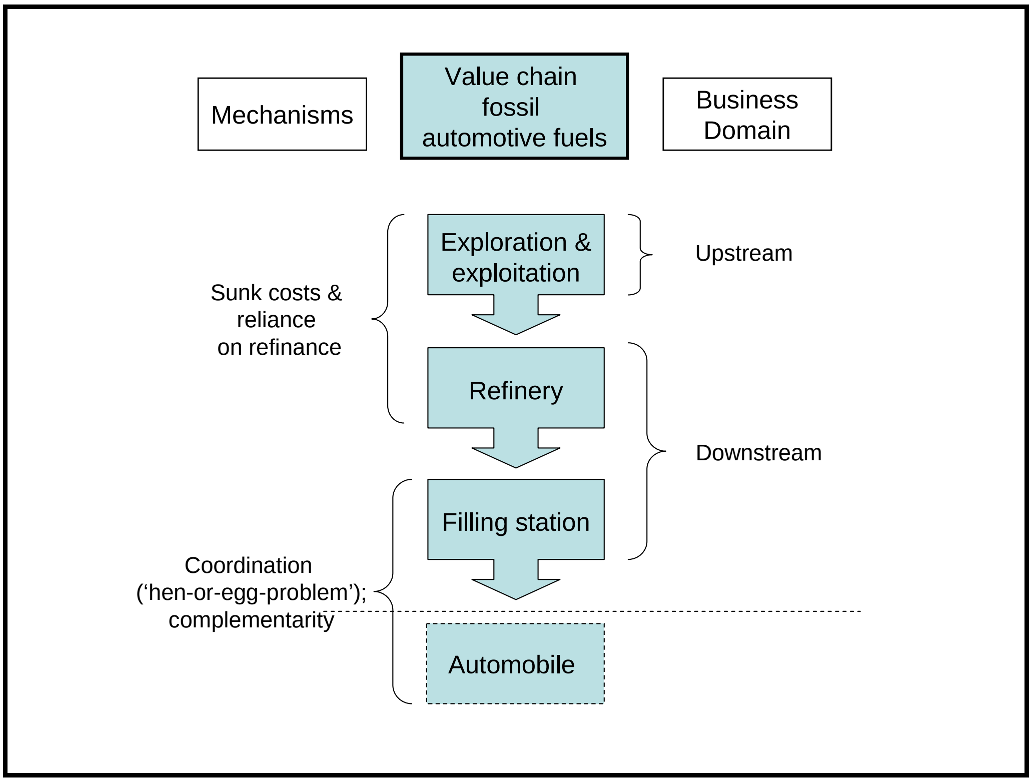
On the ***demand side*** the automobile industry increasingly required qualitatively better – i.e. 'cleaner' – fuels and 'greener' fuels. The demand for cleaner fuels was stimulated among other things by the tightened European emission regulation. The aspect of greener fuels was partly image-driven, partly the question of future mobility (Volkswagen 2005). In that regard the repeated postponement of fuel cell cars driven by hydrogen necessitated the automobile industry – notably Volkswagen and Daimler – to investigate other solutions such as Biofuels.

Taken together, Shell's actor environment and Shells competitive position enclosed the following incentives on and restrictions for agency: The room for manoeuvre was tightening regarding the supply side, especially regarding conventional mineral oil deposits. The direct competitor Exxon was leading in efficiency, while BP – also presenting good results (Pettigrew & Whittington 2003) – was building up a green image. Additionally, the market was more and more invaded by green alternatives and new market entrants on the refinery level. Last but not least, the demand side required for better and greener fuels.

4.1.3 The technological path 'fossil automotive fuels'

In order to investigate the technological path 'fossil automotive fuels' its increasing returns have to be identified. For that purpose the well-to-wheel value chain of gasoline and diesel in connection with the corresponding capabilities of Shell are investigated (Yergin 1991:503; Levy 1986; Helfat & Teece 1987). In a stylized form this value chain entails four steps (see figure 3):

Figure 3: The value chain of fossil automotive fuels:



Source:Own compilation.

In the ***exploration and exploitation business***, the so called upstream business, the mineral oil deposits are located and exploited. These long-run activities require high amounts of infrastructure, time, and money as well as a highly developed know-how regarding planning, implementation, and financing. E.g. in 2005 Shell's fixed assets in its upstream activities amounted billion 56,9 US-dollars (Shell 2006:14).

In the ***refinery*** step, mineral oil on a large scale is converted into gasoline and diesel as well as many other related products such as heating oil, etc.. The possibilities to change the shares between these products are limited and costly once a refinery is built. Since mineral oil companies are organized in profit centres and since the companies themselves do not extract enough mineral oil themselves, the refinery step includes a buying department. Similar to the exploration and exploitation business also the refinery business is expensive and a long-run enterprise which requires among other things highly technical and financial know how.

The other part of the downstream business are the ***filling stations***, the last step belonging to the mineral oil companies. The filling stations as the distribution system for gasoline and diesel are the 'face' of the companies to the consumer. Since they are distributed all over the country, they require logistical capabilities. The last step of the gasoline and diesel chain is the ***automobile*** respectively the components tank, engine and emission treatment. These are designed for special fuel qualities. Accordingly, the automobile is heavily dependent on the right fuel. In order to secure the functioning of this interface, therefore, CEN and DIN fuel-standards are set up.

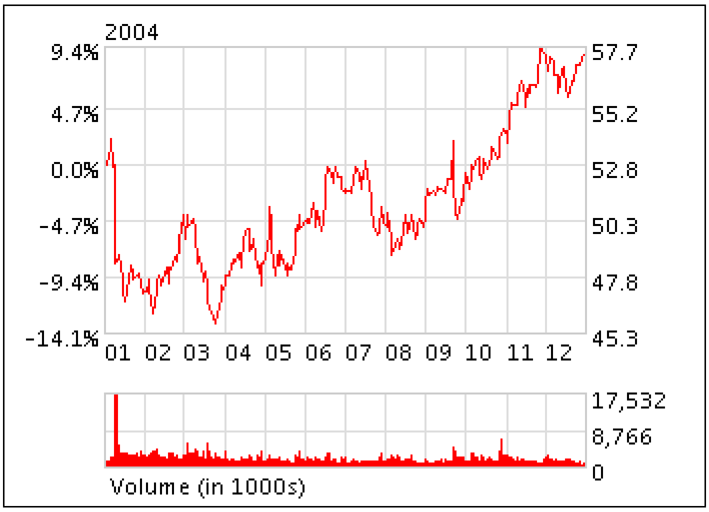
This value chain reveals four sources of increasing returns: First, there is a ***complementarity*** between the fuel and the combustion engines which co-evolve over time. Tightened emission regulations as the EURO-norms further this co-evolution since the engine and the fuel increasingly have to be adjusted to one another. As a consequence, quality standards and their compliance are of increasing importance for automotive fuels (ACEA et al. 2006:i).

Second, a ***co-ordination*** effect exists between the supply and demand of fuel all over the country, enabling a country-wide un-restricted mobility. The other way around this implies that new products concerned by the fuel-engine interface are confronted with "*hen-or-egg-problem*" (Guderjahn 2007-01-22). I.e. new fuels require new engines and new engines need new fuels. This problem is amplified by the costs for a new infrastructure (Döhmel 2006:5).

The third source of increasing returns is that the major mineral oil companies face very high ***sunk costs*** due to of the exploration and exploitation and in the refinery business. These are costly long-term investments and prone to become stranded investments.

Fourth, the ***expectations*** of the capital market are a source of increasing returns as well. These are important since the high costs further a high reliance on refinancing the active business at reasonable costs. In that regard the success of the upstream business – in the terms of the resource replacement ratio and the held proven reserves – is central since the capital market takes this as an important indicator for how creditworthy the company is. This aspect becomes obvious in figure 4 which shows the reaction of the capital market towards the announcement of the 20% devaluation of Shell's proven reserves in January 2004 (Handelsblatt 2004-01-12):

Figure 4: Development of Royal Dutch Shell A shares in New York in 2004



Source: Shell 2007.

4.2 Shell's path management

As discussed above, Shell faced mounting changes in its German and European institutional and actor-environment from 1990 onwards. Simultaneously the technological fossil fuel path enclosed strong incentives for reproduction. The following investigation of Shell's activities starts with the analysis why Shell became active. Then it is examined how Shell addresses the technological path and the regulative and actor environment in its activities.

4.3.1 Why Shell became active

In 1991 Herbert Krumm, member of the Shell Global Solutions Laboratory in Hamburg questioned alternative fuels arguing that: "*The better an alternative fuel conducts to the environment the greater are the contemporary unresolved disadvantages regarding suitability, availability, economics, and infrastructure*" (Handelsblatt 1991-09-09; own translation). Consequently, Shell recognized but did not react to the early changes in its environment.

However, by the introduction of the German tax incentives Shell became a blender of biofuels in 2003/2004.[4] This extrinsic motivation was accompanied by the high margins of SME petrol stations with pure bio-diesel and the established norms for a blend of bio-diesel[5] in fossil fuels up to 5%. With other words: There was an economic incentive, a political long-term framework, thriving competitors, and the possibility to include bio-fuels with only marginal changes into the value-chain – i.e. the built-up of a procurement and logistics. Accordingly, biofuels became an attractive business option for Shell in the short as well as in the middle and long run as a consequence of external changes.[6]

Becoming a blender of biofuels nicely lived up to the external pressures. However, Shell did not stay at the level of being a 'mere' blender. The willingness to invest in alternative business as well was stressed by the later CEO van der Veer stated in 2001:

> *"In the long-term, this industry will need to do more to adjust to new economic, environmental and political challenges. … Technical advance, government and stakeholder pressure at least in the developed world, and the emergence of new cleaner alternatives will inevitably lead to fundamental changes in the energy mix in the 21st century. This means that successful energy companies will need to pay more attention to what I have termed the 'licence to grow'."* (van der Veer 2001-04-25).

However, while this statement as well as the changes in the institutional and the actor environment explain *why* it was convenient to become active, the reason to do so also depended on the possibility to become active. With other words: Shell had to find the right product to become involved. This question of finding the right product is closely

[4] However, Shell had been a blender of bio-ethanol e.g. in Brazil for the last 25 years due to the early ethanol-programs of this country and the obligation to blend (IEA 2005:27-28).

[5] This number is related to the volumetric content of bio-diesel in fossil diesel and is equal to the above mentioned obligatory 4,4% energy content.

[6] Eventually but not necessarily this was also related to the 'greening' of the company in the aftermath of the Brent Spar conflict in 1995 and the withdrawal from the anti-Kyoto Global Climate Coalition (GCC) in 1998 (Greenpeace 2002).

related to the question of *how* Shell became active since this new activity had to address and fit into the changing regulative and actor environment as well as the technological path.

4.3.2 Choosing BtL – addressing the technological path

In 2005 Shell acquired a share beneath 25% in the BtL developer CHOREN Industries GmbH. Part of the deal was that Shell not only supports the development financially by its investment but also technological cooperation: While CHOREN owns the technology for the first step, the gasification of biomass, Shell provides the catalyst for the Fischer-Tropsch-Synthesis. Shells Fischer-Tropsch-technology – an area covered heavily by patents – already proved its functionality in Shells Gas-to-Liquids (GtL) project in Bintulu, Malaysia. BtL is produced – at least in the current state of the project – from wood, which is gasifyied and converted into a synthetic fuel. This fuel can be used as a substitute for diesel and contains – similar to the other synthetic fuels GtL and Coal-to-Liquids (CtL) – very few carbon-chains and no sulphur, aromatics and the like (Blades 2007-01-22). Accordingly, CHOREN's BtL technology offers five advantages to Shell: First, the chemical properties of BtL make the compliance with the EURO-emission regulation significantly easier for the car manufacturers. Moreover, BtL enables the car manufacturers to develop new combustion engines (Volkswagen 2005:6). Thereby, BtL diesel is very attractive for the 'customers' of Shell's fuels. Second, the BtL process and product is akin to the production of Gas to Liquid (GtL) and Coal to Liquid (CtL) diesels – two technologies already owned by Shell. Thus, Shell could become a "*(l)eader in conversion technologies*" (Bravo 2006) for synthetic fuels. Third, BtL can be sold as a blend to a higher price as the usage of GtL as an additive in the premium fuel V-Power demonstrates (Blades 2007-01-22). Fourth, BtL does not need any adjustments in the fuelling infrastructure (Döhmel 2006:5). Fifth, the cheapest way to produce BtL is to incorporate the plant into a refinery-site (dena 2006:12). Finally, BtL plants are extraordinary expensive (above 450 million Euro), requiring the financing know-how and capabilities of a big company such as Shell – and representing a significant market entry-barrier.

Relating these advantages to the fossil fuel path it becomes obvious that Shell with the choice of BtL accounted for the above identified causes of the technological path dependency: First, the ***co-ordination*** aspect is not affected due to the smooth fit of BtL into the existing fuelling-infrastructure. Second, the ***complementarity*** effect is not violated and potentially further strengthened since BtL does not complicate and potentially enhances the symbiosis between the combustion engines and the fuel. Third, ***sunk costs*** in the refinery business are avoided since the BtL-production can be integrated into refinery sites.

These three aspects are clearly related to the technological design of the fossil fuel path and the design of BtL. Nevertheless, there are also managerial issues regarding BtL which address the increasing returns of the old path. The first one is that BtL enhances the technological leadership of Shell in the area of synthetic fuels by adding knowledge and securing the technology and know-how of the early on BtL-developer CHOREN. This technological leadership is not mistaken by rating agencies:

> *"If one reads the reports of the* [biofuel; J.C.S.] *whole market of for example Merrill Lynch, then the large part of these reports deals first of all with the first generation of biofuels. But then comes the future and that is the second generation. There Shell is emphasized as a visionary and as somebody who invests far-sighted. In this respect this* [engagement in CHOREN; J.C.S.] *brings a valuable reputation among the right experts."* (Blades 2007-01-22; own translation).

Accordingly, the positive image targets the ***expectations*** of the capital markets and thereby eases the question of refinancing the day-to-day business. Second, by blending BtL with GtL in premium fuels, these become 'greener'. Thus, BtL could serve as a legitimation in the GtL-business which is very close to the traditional oil and gas upstream business of Shell. Thereby, the upstream business is indirectly supported and potential ***sunk costs*** in that area are avoided.[7] Finally, the way how BtL is marketed plays an important role as well for at least two reasons: By blending it with conventional diesel and GtL, BtL does not conflict with the current marketing of the fossil fuels. On the contrary, the conventional diesel is converted into a premium fuel. The other reason is that the potential of BtL is limited due to biomass-restrictions up to 2 to 4% until 2020 (Müller-Langer 2006:167). Accordingly, in the middle run BtL would not be more than a valuable additive instead of a substitute. Consequently, there are no ***sunk costs*** in the upstream and refinery business which still will be needed.

In sum, the technological design of BtL and its arrangement support the current fossil fuel path and make it even better. What is striking is how choice of Shell in favour of BtL was directed by the increasing returns of the old path.

4.3.3 Addressing the changing environment

Shell's choice of BtL also considers aspects of the institutional and the actor-environment: Regarding the actor-environment, second-generation biofuels offer the opportunity for the mineral oil companies to regain the prerogative of interpretation in its own branch. Furthermore, BtL is 'what the customer wants' – at least Daimler, Volkswagen. This is expressed in a broad range of joint activities kicked off by Volkswagen and Daimler in company with Shell such as the founding of the 'Alliance for Synthetic Fuels in Europe' (ASFE) in Brussels, the European research project RENEW (www.renew-fuel.com), and BtL-conferences in Germany. Regarding the latter ones

[7] It has to be mentioned that GtL itself works in favour of the upstream business since its future area of application should be to convert stranded gas. This gas obtains as a by-product in oil-fields and which is so far burned off at the field due to missing application possibilities. This worsens the CO_2-balance of such oil fields.

Volkswagen and Daimler joined forces with the Agency of Renewable Resources (FNR) a registered association closely related to the German Ministry of Agriculture (BMELV). These joint activities lower the level of uncertainty for all parties, address potential co-ordination problems[8] and could lead to a significant common competitive advantage later on if the complementary products are realized. Taken together, these activities clearly target three increasing returns directly and indirectly; First, the co-ordinated introduction of BtL and synthetic fuels secures the ***complementarity*** effect and the ***co-ordination*** effect between future fuels and engines. Secondly, this alliance tries to draw the attention of the public and external experts towards their preferred alternative. This clearly addresses the ***expectations*** of the capital market and the actors involved in the field and thereby as well the possibility for Shell to re-finance its day-to-day business. Finally, the alliance also addresses the legislator and the execution on the German and the European level in order to gain a favourable legislative framework. With other words: Shell et al. strive for political sponsoring of their alternative.

The latter aspect was achieved in the last legislative round in Germany where Shell's preferred alternatives BtL diesel and cellulose ethanol received a tax exemption until 2015 – while e.g. BP's alternative bio-butanol did not. So, it can be assumed that the coalition with the automobile industry 'paid off' in the legislation process and that Shell by successful lobbying in alliance with the powerful car industry[9] succeeded in securing future economic returns and a future competitive advantage also vis-à-vis the interests of the new market entrants.

Comparing the activities regarding the actor and the regulative environment with the ones targeting the technological path a significant difference becomes obvious: The technological path is addressed by the ongoing usage of its technologies and capabilities and by the incorporating of the new technology into the old path. Therefore, these activities could be called path extension. In contrast, the activities concerning the actor and the regulative environment are primarily directed towards the development of business opportunities for BtL in the form of a supportive regulative framework and related products. Hence, these activities must be termed path creational efforts.

5 Summary – Incumbents as path managers

To sum up: Shell's activities in the area of biofuels are primarily motivated by external changes. These external changes enclosed aspects of governmental regulation, new competitors, new technologies, new demands, and branch internal competition. On the other hand, the incentives from the old technological path are stable. These incentives are potential sunk costs, the need to live up to the capital market expectations in order

[8] Mainly for the car manufacturers as became evident in the part on the technical characteristics of BtL.
[9] One reason for the political importance of the German car industry is its share of the German employment and value creation; e.g. in 2006 the industry employed approximately 770.000 persons (VDA 2006:16).

to re-finance the cost-intensive day-to-day business, the compatibility between fuel and engine and the co-ordination between supply and demand all over the country.

These heterogeneous incentives had to be addressed by Shell in its activities. The incentives of the old path are 'appeased' by the alternative BtL. E.g. the sunk costs in the upstream and refinery businesses can be avoided due to the compatibility with the refinery sites and the upstream product GtL. The combination with GtL also supports the refinancing of the fossil business. The questions of compatibility and co-ordination are solved by the superior product characteristics of BtL. Due to this incorporation of BtL into the old path, Shell follows a capturing strategy. Moreover, by capturing and developing BtL, Shell complies with the external pressures for alternative and CO_2-efficient fuels.

However, Shell is compelled to pursue proactive measures as well, if BtL should become reality – or if Shell's version of BtL should become reality. These proactive measures take the form of path creation and target mainly the actor and the regulative environment. A salient point in these activities is the coalition with Volkswagen and Daimler. The composition of the actors seems to be a 'winning coalition' – at least in the last legislative round in Germany where Shell the preferred alternative BtL was one of the beneficiaries. With these measures, Shell clearly supports path creation on the *product*-level, striving for complementary engines, co-ordinated market introductions and a supportive regulative framework. As a consequence, Shell moves from being a reactive incumbent of the old path towards exerting influence on the structural environment as a potential path creator.

In sum, the overall strategy of Shell therefore needs to be labelled a 'proactive path extension' using measures such as the pursuit of linked innovations, building coalitions and networks around these innovations and lobbying for a beneficiary legislation. On the product level these activities can lead to a 'sub-BtL-path' which does not harm the fossil fuel path but which nevertheless has the inherent potential of becoming part of a new synthetic fuel path. Hence, Shell's activities oscillate between the exploitation of the old path and the exploration of new possibilities. The central link between the exploitation on the path level and the exploration on the product level is the technological design of BtL which makes it fit into the old path. This choice of 'technological fitness' is the critical difference between mere path creation on the product level and Shell's path management on two levels.

Conceptually this ambivalent two-level-story of Shell and BtL reveals the following points: First, path management by incumbents differs from path management by mere path creators in two ways: (a) depending on the level of analysis, path incumbents can oscillate between path creation and path extension. (b) Path incumbents can use technological designs in order to reconcile the old path and the new alternative. Second, the developed heuristic framework turns out to be very helpful in order to map the causes and consequences of the actor's activities as well as to differentiate between exploration and exploitation activities. Third, the analysis of path management as an active management of increasing returns is needed if path dependence and innovation should be combined with each other.

Regarding future research two aspects promise to be fruitful: First, what role does the character of the new technology in question play (radical or incremental) for the choice of the incumbent? E.g. in the examined case BtL does not imply a ‘paradigm shift’ e.g. as the hydrogen option would be. Second, what kind of strategies can the actors pursue in order to cultivate the increasing returns? Choice of technology, networking and lobbying are the ones used in the present case, but certainly there are further ones out there.

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