Why we do not always get what we want

The power imbalance in the Social Shaping of Technology

Universiteit Maastricht
Faculty of Economics and Business Administration
21th of August 2006, Heerlen
van Wesel, Ing. M.G.
I296511
Master of Science in Infonomics
Dunnewijk, Drs. Ing. T.J.A
Master Thesis
Version 1.0

For Sara

Acknowledgement

This thesis would not exist without help, therefore my gratitude goes out to:

- Drs. Ing. Theo Dunnewijk; for guidance and introducing me in Social Shaping of Technology
- Dr. Huub Meijers; for pushing me even further
- Department of General Practitioners of the University of Maastricht; for offering me a chance to work and thus pay for my continues studying
- Thom Eaton, BA; for test reading an early draft and friendship
- Janna Koester and Maurice Vankan; for taking the same program, and good luck with finishing your thesis to the both of you
- And last but not least Irene Habets; for all her love and attention

Abstract

While the current theories on the Social Shaping of Technology offer interesting insights in how technology changes, they do not explain why we do not always get what we want. Power relations play a role in these theories, but a lack of clearly distinguishable actor types does not help us see how this power imbalance works. We need to develop different actor types to understand these relations in a better way. We can start by defining three main categories of actors; the Political Actor, the Economic Actor, and the Social Actor.

An Economic Actor can abuse its power to force something upon the Social Actors group of Consumers that might not be wanted, when the ethics and moral of the Economic Actor fail it is the task of the Political Actors to look after the Social Actors and make sure there is no abuse of power.

Contents

List of figures

List of tables

Introduction

In a perfect, social shaped world, with perfect social shaped technology, the dominant relevant social group would always get what it wants; electricity would be free, cars would be electric (maybe even fly,) we would colonize other planets to overcome problems of overpopulation, etc. There are, however, three factors hampering this: *physical limitations*; the environment consisting of the laws of physics, meaning the real laws not the ones existing from a negotiation between scientists (Webster, 1991), resources (natural, monetary, human etc)[1], unforeseen events (earth quakes, etc.,) and the state of technology and science (*Path dependency* (Garud & Karnøe, 2001), or what Heilbroner (1994) calls *technological capacity* and *material competence*)[2]. *Ethics and moral*; political, religious, etc considerations (for example the banning of human cloning.) And last but not least a group of actors I call the Economic Actors. These Economic Actors, in the end, control the scientist and engineers and will steer the technology in a way that they see fit.

It is inconceivable that any of the, what Pinch & Bijker (1984; , 1989 (1987)) call, relevant social groups involved around the development of the cigarette[3] (the smokers, the anti-smokers, the non-smokers, the aspiring-smokers etc) beside the ones that make money from smoking (the tobacco industry) or efforts to quit smoking (producers of nicotine patches/chewing gum etc) want addictive cigarettes[4]. In the Netherlands in 2003 only 13 % of the smokers indicated they never wanted to quit, 49 % indicated they did not know if they wanted to quit (so quitting smoking should be, preferably, as easy as continuing smoking,) 24

---

[1] Or for instance the quality of our environment as described by Kemp & Soete "The present environmental problems seem to put limits to past and present paths of industrialization, transportation and agricultural development." (Kemp & Soete, 1990, p. 245)

[2] As one can see, this is variable, one actor can have access to more of one or all these recourses, and an other will have less access, and one actor can also have access to more advance technology/science

[3] We can see a cigarette as a 'technical artefact' when we use the notion that technology is applied science or that there is at least an overlap between applied science and technology (Bijker, Hughes, & Pinch, 1989 (1987)-b; Collins & Pinch, 2003 (1998); Dosi, 1982; Hughes, 1986; MacKenzie & Wajcman, 1999 (1985))

[4] For the creators of nicotine patches/chewing gum this will mean more people will need the help of their cigarettes substitutes to quit smoking.

% plan to quit within a year, the remaining 14 % indicated they want to quit, but not within a year (STIVORO, 2004). Using the tobacco reconstitution process manufacturers could remove all, or virtually all, of the nicotine found in tobacco (Douglas, 1994). Although non-addictive cigarettes seem to be the socially most desirable solution, internal documents from the tobacco industry proved their research focused on creating more addictive cigarettes (Bates, Jarvis, & Connolly, 1999; Douglas, 1994, 1998; Hurt & Robertson, 1998), instead of decreasing the addictiveness, millions of dollars were spend to increase the addictiveness (Lewan, 1998)[5]. But not only this group Economic Actors are to be blamed, surely a group of actors I call the Political Actors, like the United States' Department of Health & Human Services, should have intervened, after all they should look after the consumers welfare. The Food and Drug Administration in the United States, however, could not have intervened since cigarettes are not considered food or drugs (Douglas, 1994). "To conclude that a product is a drug, the FDA has held that a the product must not only affect the structure and function of the body; in addition, the seller (manufacturer) must intend it to do so." (Douglas, 1994, p. 3), "the FDA determined that cigarettes which are advertised and sold "for smoking pleasure only" are not drugs" (Douglas, 1994, p. 3). A change in law in 1970 allowed the use of additives in tobacco products, without these additives being approved by a governmental institute (Bates, Jarvis, & Connolly, 1999), instead the tobacco companies agreed (on a voluntary base) to supply details of proposed additives (Bates, Jarvis, & Connolly, 1999). The tobacco industry thus became self regulated and, as already stated by Gulick in 1937, "activities on drug control established in protection of the consumer do not find appropriate homes in departments dominated by the interest of the producer" (Gulick, 2005, p. 84), here the drug would be the nicotine in the cigarettes (cigarettes were seen as a drug delivery device (Douglas, 1994, 1998; Henningfield et al., 1998; Hurt & Robertson, 1998)) and the department would be the ones supplying the information.) We can only guess how long this practice of enhancing the addictiveness of cigarettes would have continued, if it was not for

[5] There are some exceptions, for instance, Philip Morris's Next, a low nicotine (80 - 90 % less nicotine) cigarette developed in the 80s (Dunsby & Bero, 2004), but we must not forget that Philip Morris's rise from the smallest of the six leading U.S. brands in the early sixties to the biggest (one out of every five cigarettes sold were Marlboro) in 1978 was based on making cigarettes more addictive using ammonia technology (Bates, Jarvis, & Connolly, 1999).

the whistle blowers, whose moral and ethical views, in the end, proved not to be for sale (or at least not for the amount of money offered.)

This will indeed almost always be the case; society might make the rough sketch or the beginning of a blueprint for the artifact, but it is the Economic actor that draws up the final blueprint. The less powerful the Economic Actor (for instance many Economic Actors in the same field,) the more the requirements will reflect the rough sketch. For instance in the case of the bicycle (Bijker, 1989, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Pinch & Bijker, 1984, 1989 (1987)) where there were many Economic Actors engineering new types of bicycles.

Beginning to read works of the many theorists in the Social Shaping of Technology does not help me explain why we do not always get what we want, there still seems to be something missing. My main critiques, at the outset of this thesis, on the existing forms of the Social Shaping of Technology can be summarized as:

1. The seeming absence of the notion that different actors have different power
2. The lack of distinction between different actor types

In an attempt to overcome this problem, I will try to create an addition to the current theories that can contain both the power relations and the distinction between actor types.

But before that I must conduct a small survey of the current theories in the Social Shaping of Technology rubric, to see if my thoughts are in fact correct. This will be done in the next chapter.

Thesis boundaries and objective

First we need to set up boundaries, since studying every aspect of technological change is properly an impossible task, and certainly out of the scope and time limit for this thesis.

In this thesis I will use the three layer concept of technology describe by Bijker (2005, p. 2):

1. "At the most basic level, 'technology' refers to sets of physical objects or *artefacts*, such as computers, cars, or voting machines"
2. "At the next level, it includes human *activities*, such as in 'the technology of e-voting', where it also refers to the designing, making, and handling of such machines"
3. "Finally, and closest to its Greek origin, 'technology' refers to *knowledge*: it is about what people know as well as about what they do with machines and related production processes"

From this I can only conclude that there are three main layers of technological change:

1. Introduction of new or modified objects or artifacts
2. Change in an activity that has been identified as a technology
3. Change in what people know, this can be on a worldwide scale, on a country scale, on a personal level, in different social groups etc

The stage that will be examined is the *development stage* (Hughes, 1983; Williams & Edge, 1996) or *invention and innovation stage* (Dosi, 1982; Williams & Edge, 1996), the first type of technological change in the listing above, what happens to the artifact in the *diffusion stage* (Bijker, 1992; Bruun & Hukkinen, 2003; Williams & Edge, 1996; Winner, 1999 (1985)), for now, will be left as it is, although this stage is certainly very interesting, its only important, for now, is the direct feed back it gives to the development stage, to help shape a new artifact, for now it does not matter to me that a farmer uses a Model T Ford to run farm equipment or even household equipment (Pinch, 1996), it becomes important as soon as it will be used as input to develop new artifacts (which happened in the case of the Model T Ford as power source,) artifacts will always be used in ways the developer has never dreamed of.

According to Jamison & Hård (2003) there are three story-lines of technological change:

1. Economic Innovation; in the "economic domain technology is primarily regarded as a process of commercial product development" (Jamison & Hård, 2003, p. 81)
2. Social Construction; in the "social domain, technology is viewed as the materialized interests of particular actors or social groups" (Jamison & Hård, 2003, pp. 81-82)

3. Cultural Appropriation; in the “cultural domain, technology is treated in relation to particular life-worlds and particle activities” (Jamison & Hård, 2003, p. 82)

The emphasis of this thesis is the second story-line, the social construction, although the economic innovation part will certainly be touched.

Further I will only focus on products developed for a wide variety of users and for use under a wide variety of circumstance. This will mainly be mass-production artifacts, not on tailor-made goods, nor on artifacts developed in house for in-house use.

The objective of this thesis therefore is to enhance the current schools of Social Shaping of Technology with separate actor types, based on their function, and to create a better understanding of the power relations between actors, based upon these separate actor types.

Current theories on Social Shaping of Technology

Looking at the current theories on the Social Shaping of Technology raises some critique on how they deal with the different level of powers that actors can have in a technological shaping situation, and the different actor types. By taking a closer look to the current theories in Social Shaping of Technology my critiques will become clearer.

Although almost every writer in the Social Shaping of Technology has his/her own unique approach, we can distinguish three main 'schools' or theoretical approaches (Bijker & Law, 1992a):

1. Social Construction of Technology (See for example: Bijker, 1984, 1989; Bijker, 1989 (1987), 1992, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Elzen, 1986; Klein & Kleinman, 2002; Pinch, 1996; Pinch & Bijker, 1984, 1986, 1989 (1987); Williams, 1999)
2. Actor-Network Theory (See for example: Callon, 1980; Callon, 1989 (1987); Law, 1989 (1987), 1991; Law & Callon, 1992)
3. Systems Theory (See for example: Hughes, 1971, 1983, 1986, 1989 (1987), 1999 (1985))

We will take a closer look to these three different theories and test my critiques on them.

Social Construction of Technology

Social Construction of Technology and power relations

Although not explicitly mentioned till Bijker used them in his description of fluorescent lighting[6] (Bijker, 1992, 1997 (1995)), "there is nothing, in principle, that prevents a SCOT approach from considering power structures and social relationships between social groups" (Pinch, 1996, p. 31/32).

[6] For instance "the fluorescent lamp was developed in the midst of power games" (Bijker, 1997 (1995), p. 260)

In the case of high-efficiency fluorescent lighting there, seemingly, was a power struggle between General Electric & Westinghouse and the Utilities (Bijker, 1992, 1997 (1995); Bijker & Law, 1992b), the Antitrust Division of the Department of Justice and the War Department (Bijker, 1992, 1997 (1995)), General Electric & Westinghouse and Hygrade Sylvania (Bijker, 1992, 1997 (1995)), etc. General Electric and Westinghouse sold a fluorescent lamp largely developed by General Electric and Hygrade Sylvania sold a fluorescent lamp of its own design (although adjusted for standardization) (Bright & MacLaurin, 1943). "The fluorescent lamp was developed in the midst of power games. Various exertions of power figured prominently, though not always identified as such: patent licensing, cartel forming, price setting, political pressure" (Bijker, 1997 (1995), p. 260). There was an abuse of power by General Electric when General Electric confined the Claude Company's market (limiting Claude Company's High-Voltage fluorescent light to outdoor use, leaving the indoor market largely for General Electric's (and licensed companies) incandescent lamps) (Bijker, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983).

General Electrics' connection to the United States Department of War was used in another display of power, when the Department of Justice set out to destroy General Electrics' licensing system in 1942, General Electric claimed this would detract them from the all out war effort, however this was first not successful. General Electric then secured the help of the Department of War (in the form the of the Secretary of War, Henry Stimson) who got the Attorney General to overrule the Department of Justices' Antitrust Division (Bijker, 1997 (1995)).

It is suggested that the combination General Electric & Westinghouse is now stranger to power abuse, when they "agreed to pool their patents in 1896, the industry became a duopoly, which probably delayed reductions in the price of electrical apparatus up to 1900" (Nicholas, 2003). There were indeed anti-trust prosecutions against General Electric in 1911 and 1926 in connection to there licensing structure for incandescent-lamp manufacturing (Bright & MacLaurin, 1943).

To sum up I will use Bijker's own words; "A description in the terms of power strategies functions as a neat summary of processes that were otherwise described in terms of interactions, closure, stabilization, technological frames, and inclusion. It does, however, allow for some extra focus and sensitivity in addressing certain issues." (Bijker, 1997 (1995), p. 266).

Social Construction of Technology and the distinction of actor types

In SCOT there is no distinction made between different types of actors (all are called (relevant) social groups,) this is a mistake, especially if we take in to account the origin of SCOT. According to Pinch it is based on an observation by Schutz (1967 (1932)) and Berger & Luckmann (1966) "how everyday reality of social institutions is actively constructed by ordinary members of society in the course of their mundane social activity" (Pinch, 1996, p. 17/18), I think we can safely state that, entrepreneurs are not ordinary members of society[7]. Do we not need to distinguish these extra ordinary members of society, have they not more power then just the potential consumers? We can wonder what would have happened if there was only one bicycle manufacturer (possibly protected by patents (Bowker, 1992; M. R. Smith, 1994 among others) and/or *tacit knowledge*[8] (Bruun & Hukkinen, 2003; Collins, 1989 (1987); Koskinen & Vanharanta, 2002; Nelson & Winter, 1982 among others)) who happened to think that women belong behind the stove, would the safety bicycle (Bijker, 1997 (1995); Bijker & Oost, 1983; Pinch & Bijker, 1984, 1989 (1987)) have been developed? My guess would be **no**, unless the amount of money the new market, the market for bicycles would more then double, not only females would be able to ride the safety bicycle but also the elderly men (Bijker, 1997 (1995); Pinch & Bijker, 1984, 1989 (1987)), could generate would be more tempting then the producer's moral and ethical views.

In this I thus partly agree with Russell (1986) when he states that have to observe the social groups in their wider context, but must also agree with Pinch & Bijker (1986) that social groups are imbedded in a endless web of other groups and structures, so a whole description

[7] Without elevating them to a state of *Power Elite* (Huxley, 1959)

[8] "Knowledge that cannot be articulated" (Nelson & Winter, 1982)

can never be given. But even through we have to accept that we must simplify, we must not oversimplify, because I worry that we lose too many details, although indeed to much details will make the model lose its function (Bijker, Hughes, & Pinch, 1989 (1987)-c).

Actor-Network Theory

Actor-Network Theory and power relations

Callon claims that the ingredients from his Actor-Network cannot be placed in a hierarchy, all actors are equally important (Callon, 1989 (1987)). "Hydrogen feeds the fuel cells that power the motor that ensures the performance of the VEL [most likely short for Voitures Électrique (Electric Car)] for which the users are willing to pay a certain price. Each element is part of a chain that guarantees the proper functioning of the object." (Callon, 1989 (1987), p. 95), the power source and user are, in Callon's view, equally important[9]. Without a working efficient power source the electric vehicle does not work, while consumers can potentially be forced to buy such a vehicle, for instance by making tax on non-electric vehicles very high (the user are indifferent between an engine powered by electricity or heat (Callon, 1980)). Forced introduction would be the key to escape the gasoline lock-in (R. Cowan & Hultén, 1996)[10]. Callon later claims that there were "power relationships (EDF brings Renault to its knees)" (Callon, 1989 (1987), p. 95) (what can also be read is that it was Renault that brought the EDF to its knees by showing that the zinc/air accumulators would require the setting up of a vast network of service stations (this would challenge the "all-powerful oil consortium on their own ground" (Callon, 1989 (1987), p. 91) and by showing that the signs of the coming of a new post-industrial age were just minor technical difficulties

[9] In the Actor-Network theory all elements surrounding the technical change are actors, the term actant is used very little.

[10] Cowan & Hultén (1996) separate the competition between the electric vehicle and the gasoline car in five phases; 1885 – 1905: no dominant technology; 1905 – 1920: Gasoline car becomes dominant; 1920 – 1973: "consolidation of the position of the gasoline car" (R. Cowan & Hultén, 1996, p. 61); 1973 – 1998: "questioning of the gasoline car" (R. Cowan & Hultén, 1996, p. 61); after 1998: forced introduction of electric vehicles.

in the current age (Callon, 1989 (1987))), a power relationship must be hierarchical, since we can order the actors according to their 'power level'.

According to Bruun & Hukkinen (2003) technological change happens when an actor has a different translation of the world (or a part of the world,) "if they [actors] succeed in silencing the voices that question that interpretation – the artifact is, in a sense, 'enrolled'" (Bruun & Hukkinen, 2003, p. 105). An actor gets more power (or grows stronger) in a network when they gain credibility as spokespersons for strategically important categories of people, organizations, objects, processes and so on, they grow weaker when established representatives degenerates, for instance as a result of being questioned by a competing actor (Bruun & Hukkinen, 2003). Callon argues that "translation is the mechanism by which the social and natural worlds progressively take form. The result is a situation in which certain entities control others." (Callon, 1986, p. 224), the describing how actors are defined is key in understanding these power relationships (Callon, 1986, 1991).

Both Callon's as Bruun & Hukkinen's view indicate power relationships, and thus hierarchy, are a recognized and important force in Actor-Network Theory, as is also clear from the more Actor-Network oriented texts in *A Sociology of Monsters: Essays on Power, Technology and Domination* (Law, 1991).

Actor-Network Theory and the distinction of actor types

Since there is a distinction made between human, non-human and hybrid (human/non-human) actors (Akrich, 1992; Akrich & Latour, 1992; Kaghan & Bowker, 2001; Law & Callon, 1992), there is a beginning of dividing actors in different types, but no further categorization than this seems to be deemed necessary by the authors. The term *actant* is also used for to describe an object that acts or shifts actions[11] (Akrich, 1992; Akrich & Latour, 1992; Latour, 1991; MacKenzie & Wajcman, 1999 (1985); Star, 1991; Woolgar, 1991), in fact "an actor is

[11] "Action itself being defined by a list of performances through trails; from these performances are deduced a set of competences with which the actant is endowed." (Akrich & Latour, 1992, p. 259)

an actant endowed with a character" (Akrich & Latour, 1992)[12]. Callon however brushes over a description of two different actor types "scientists transform texts, experimental apparatus and grants into new texts. Companies combine machines and embodied skills into goods and consumers." (Callon, 1991, p. 141).

System Theory

System Theory and power relations

Hughes does not explicitly mention power relations in his work, but from his text we can see that he recognizes their existence. For instance, from the lobbying extravaganza that pursued New York City alderman with gaslight interest, to grant a franchise to Edison (Hughes, 1983, 1999 (1985)) and the rallying, to frustrate change in the environmental policies of Los Angeles, of "institutions and persons dependent politically, economically, and ideologically on the [automobile] system" (Hughes, 1994, p. 113)

System Theory and the distinction of actor types

While Hughes stresses the importance of looking at actors in a heterogeneous way, he also

1. repeatedly refers to actors by indicating the roles they fulfill (inventor, entrepreneur, engineer, scientist, financer, manger etc) (Hughes, 1971, 1983, 1986, 1989, 1989 (1987), 1994, 1998, 1999 (1985))
2. stresses the importance of including different actors with different roles in the technical change, for instance the inclusion of a special type of scientist (the mathematician Upton) in Edison's development of the Incandescent Lamp and Lighting System (Hughes, 1983, 1989)
3. describes the differences between, for instance, the inventor-entrepreneur and inventor (Hughes, 1983, 1989). He categorizes inventor-entrepreneurs as actors "who differ from ordinary inventors in that the former preside over a process which extends

[12] This distinction between an actor and actant is not (yet) consequently used

from the inventive idea through development to the time when the invented system is ready to be used" (Hughes, 1983, p. 14), he also distinguishes between, the independent inventor and inventors working in large-companies (Hughes, 1989, 1989 (1987)) etc.

This is an indication that Hughes' Systems Theory leaves room for distinguishing different actor types that are directly involved in the technical change. However he does this only for a limited amount of the involved actors. He does it for Edison (by calling him an inventor-entrepreneur,) but not for the alderman that have gaslight interests (who could in this jargon be called political-investor, legislator-investor, or even just alderman-investor) (Hughes, 1983)). He is also lacking in the description of the actor types involved, although he gives some inside in his thoughts about an inventor-entrepreneur[13] (Hughes, 1983) and the independent inventor (Hughes, 1989 (1987)).

Summary

From the use of power strategies by General Electric surrounding the introduction of the fluorescent lamp, the power relations surrounding the development of the VEL, to the New York City alderman vital to Edison's light empire, power relations are a recognized force in the three streams of Social Shaping of Technology.

Not so for the distinction of actors, although Hughes uses some categorization of his actors (Edison the inventor-entrepreneur) he does not do this consistently (the New York City alderman or not called political-investor, legislator-investor, or even just alderman-investor, to distinguish them from their non investing Alderman colleges or from their non Alderman fellow investors.) In the Actor-Network Theory the only distinctions made are between

[13] Whether or not his thoughts about entrepreneurs are inline with the research field of entrepreneurship, in which an entrepreneur is described as "the person who creates and develops new business of any kind" (Bruyat & Julien, 2000, p. 167) or as an "an innovator, and therefore a relatively exceptional person who changes the economy in some way or another" (Bruyat & Julien, 2000, p. 167)

human, non-human, and hybrid actors, and between actors and actants (the term actant is not used extensively.) In SCOT all actors involved are called Social Actors or Relevant Social Groups (there is no need to see the difference between Relevant Social Groups and Social Groups as an important one, because the Social Groups that are not Relevant Social Groups are just that, not relevant.)

Table 1 summarizes the findings of this chapter, and compares the different approaches so a researcher can choose a combination of approaches that would best fit the technological change he is studying (although the table needed to truly compare these three schools, on every level important to a research, would greatly exceed the length of this page, this chapter, and maybe even this thesis.)

Table 1 Commonalities and Complementarities among the three schools[14]

<table>
<tr><th></th><th>SCOT</th><th>ANT</th><th>Systems Theory</th></tr>
<tr><td rowspan="2">Dealing with power relations</td><td colspan="3">POWER REALATIONS PLAY AN IMPORTANT PART IN THE SOCIAL SHAPING OF TECHNOLOGY</td></tr>
<tr><td>- Power relations can summarize the process of interactions, closure, stabilization, technological frames, and inclusion</td><td>- As actors grow more powerful their translation will become more dominant, and the artifact will be enrolled</td><td>- Power can hamper or stimulate the use of a technological system, by not allowing or allowing it to exist</td></tr>
<tr><td rowspan="2">Distinction between actor types</td><td rowspan="2">THERE IS ONLY ONE ACTOR TYPE</td><td colspan="2">ACTORS CAN BE CATEGORIZED</td></tr>
<tr><td>- Actors are categorized by their biological make up</td><td>- Actors are, sometimes, categorized by their function</td></tr>
</table>

[14] This table is inspired by Bruun & Hukkinen (2003) table 1

Although power relations are thus dealt with in the different schools, our understanding of them could be enriched with a deeper understanding of the actor types, this is where we will venture to next.

Theoretical framework

Although both the Actor-Network Theory and especially System Theory come close to my view of the world, they are both not explicit enough in describing the actors, therefore, some work remains to be done. Since my view is mostly inline with Hughes' System Theory my work and ideas can properly be incorporated within System Theory without any problem. Some of my propositions are properly also easily adopted in other (social) theories of technological change. As with every model, my framework "is supposed to be a simplification – rather than replication – of reality"[15] (Zandt, forthcoming, p. 1), this will mean that no matter how 'good' a model or framework is, reality will not always fit in the model or framework.

Introducing the actors

Actors will be used to represent the different type of humans, organizations, groups of humans, etc. involved. An actor will be defined as able to make autonomous rational decisions, it is important to note that not al the decisions necessarily have to be autonomous and/or rational.[16] At it is thus necessary that there are humans involved 'in' the actor, this in contrast with the actor-network theory that sees an actor as "an entity that takes the last generation of intermediaries and transforms (combines, mixes, concatenates, degrades, computes, anticipates) these to create the next generation." (Callon, 1991, p. 141), for Callon Chernobyl, sometimes, is an actor (Callon, 1991), for me, since it is not able to autonomously and rationally decide whether or not to cause a disaster or deliver power, it is not (Chernobyl does not have an *inner logic* (Bijker & Law, 1992a).) There will however come a time when artificial intelligence will become so far evolved that it is able to autonomously make rational decisions and thus becomes an actor in its own right. I need to emphasize that an actor can be

[15] But without oversimplification, as mentioned earlier

[16] For a (mathematical) description of a rational decision-maker see for instance Myerson (1997) or other books about Game Theory, Bayesian decision theory, etc

heterogeneous, the fact that someone/something fulfills the roll of one actor does not mean that the same person/thing cannot fulfill another role, and even further, a person that functions in an organization/group of humans, etc. can fulfill a different actor role, as an individual, or with a different group altogether. Understanding that actors are heterogeneous, and thus will have different interest sets, is key to understand why they make certain decisions. Hughes tells us, for example, that some New York alderman (Political Actor) also had gas interests (Economic Actor) (Hughes, 1983), which would, as mentioned earlier, make them political-investor, legislator-investor or even just alderman-investor, this explains why Lowrey needed to arrange a lobbying extravaganza to convince them to give a franchise to the Edison Illuminating Company (Hughes, 1983). An actor can also have different functions in different situations. For instance, an Economic Actor in one situation can function as a Social Actor (in this case a consumer) in another situation. Even further; a consumer of an artifact (a Social Actor) can further develop the artifact and sell these developments (thus becoming and Economic Actor,) as was the case with Dunlop (Bijker, 1997 (1995)).

We can assume that all actors are *utility maximizers*[17], but because of the inherent difference between the different actor types they will maximize their utility in a different way. The different actor types are still quite general, but their basic characteristics are different, if we are able to split up the three main actor types into further subtypes, sub-subgroups and so on, we will be able to attribute more and more specific characteristics to them, thus allowing us to trace parent actor types of our study subjects.

Political Actor

A Political Actor is a person/group of related persons/company/organization/institution, etc. that ought to make decisions based on what they perceive as being in the best interest for what they perceive as society. The words **ought** and **perceive** are very important here; the first because history is filled with leaders who only sought to enrich themselves, the latter because we will not always agree what is in the best interest of society. This Political Actor

[17] Pennings and Kim (2000) assume this for Consumers, which in my model are a subtype of the Social Actor

also embodies actors that make the same type of decisions based on their religious believes, in other words religious actors, for instance the Vatican.

The opinion what is best for society can differ within the same government, for instance the difference of opinion between the RAF, the Navy and the Minister of Defense during the 1950s in Great Britain concerning a new aircraft (Law & Callon, 1992) or between the Antitrust Division of the Department of Justice and the War Department after the introduction of the fluorescent light (Bijker, 1992, 1997 (1995)).

State intervention can suffocate technological development or let it accelerate (Castells, 2000), state policy can also lead to an emphasis on technical education, research and development, and industrial technological innovation (this at least was a (semi-)successful expending policy in the USSR since the second quarter of the 20th century (Gomulka, 1986a).) In countries as the Netherlands, were most people are educated at institutions funded by the government, the diffusion of existing knowledge (important for increasing the range of technical possibilities (Heertje, 1977)) can be enlarged or shrunken depending on policy. Political policies also help to battle technologies bad externalities, such as air pollution by using norm policies, which can lead to the dominance of a 'cleaning' technology trajectory (Kemp & Soete, 1990). Not only do the Political Actors have influence on the development and diffusion of technology in their own country, but also on its diffusion abroad, we have to think of British laws of the 18th century to stop the transportation of technologies in certain fields and in various forms to France (Harris, 1996).

Although it seems obvious how the political Political Actors can influence technological change (for instance by law and regulation,) the influence of the more religious Political Actors might be harder to grasp. However, there are numerous historical examples of how these more religious actors, especially the Vatican, tries to influence technology, and science, an example of this is the, attempted, banning of use of the crossbow against Christians by Pope Innocent III and the Ecumenical Council to the Lateran in 1139 (Bennion & David-Bajar, 1984; Environmental Law Institute, 1998; MacQueen & Santa-Barbara, 2000; Nicholson & Nicolle, 2005).

Economic Actor

An Economic Actor is a person/group of related persons/company/organization/institution etc that benefits economically from the development/distribution of artifacts or benefits economically from a situation that is threatened by the development/distribution of artifacts (and thus tries to stop this development.)[18] Economic Beneficiaries would also have been an appropriate title for these actors, but for consistency reasons, I will stick with the Actor rubric.

It is important to understand that 'benefiting economically' does not necessarily means profit maximization per product, an Economic Actor could choice a certain *technological path* because they hope to set up a *installed base* (Stango, 2004; Stenbort, 2002)[19] or *social prestige* (Heertje, 1988). An Economic Actor will try to maximize its utility by maximizing its total expected profit over a period, even a period laying entirely in the future.

Economic theory offers different explanations for why economic actors could decide on technological change, for instance Schmookler suggest that a potential application of a scientific discovery is explored because of latent demands (Schmookler, 1971). The creation of a (temporary) monopoly, by product differentiation is also considered a driving force (Schumpeter, 1994; Tirole, 1988).

Although determining the utility function for all the different types of Economic Actors seems the be impossible, the essential point is the same; "the incentive to make an invention, like the incentive to produce any other good, is affected by the excess of expected returns over expected costs. Scientific progress may reduce expected costs and so increase the probability that a given invention will be sought and made." (Schmookler, 1971, p. 135), this incorporates both the process and the product innovation.

---

[18] The importance of 'anti' groups as a relevant 'social' group is stressed by Bijker (1997 (1995)) and Pinch & Bijker (1984; , 1989 (1987)), among others.

[19] This could have been used in the case of the Altair personal computer and its bus architecture (Ceruzzi, 1999 (1985))

The economic theories on technological change do not exclude influences from society in the decision, for instance Allen concludes that "the creation, acceptance, rejection, diffusion or suppression of 'innovations and technical changes' cannot be considered in terms of 'economics', separated from history, culture, social structure, the ecological system and so on." (Allen, 1988, p. 95).

However Economic Actors sometimes have an opportunity, and presumably sometimes take this opportunity, to guide the technological change in a direction with no regard of what the Social Actors want. This can be a small change, for example to lower the production cost (which fists more in the neo-classical or neo-Schumpeter thought of technological change,) such an action could be preferred by the Social Actor group of Consumers, since this might lower the price of a product. The Social Actor group of Consumers could be averse to a small change in an artifact, but when the impact is small, abuse would be a somewhat strong word. However as seen in the cigarette example, this deviation of what the Social Actor groups want can result in choices of questionable moral and ethics. This kind of abuse of once power has a substantially impact on the life, and in this case also health, of the Social Actor group of Consumers. To circumvent this kind of power abuse we need strict rules and regulations, donated by the Political Actors, and strict enforcement and control of these rules, this is what evidently was lacking in the cigarette case. Although in some situations they can be very powerful I would not compare them to Marx & Engels (2001) *Ruling Class*, since governmental agencies will, hopefully and evidently not the case with the cigarette example, stop actors from becoming to powerful.

Social Actor

A Social Actor is a person/group of related persons/company/organization/institution that represents a part of society (the term *Social Group* will also be used,) included in this category, among others, are consumers, potential consumers, people for some reason opposed to the technology[20] (other then economic loss because of, for instance, involvement in

[20] Again, the importance of 'anti' groups as a relevant 'social' group is stressed by Bijker (1997 (1995)) and Pinch & Bijker (1984; , 1989 (1987)), among others.

competing technology.) A Social Actor acts on satisfaction. How satisfying an artifact is for the Social Actor predicts how the actor will react on it. Changing from manual labor to an inefficient, expensive pneumatic molding machine, in the mid-1880s to break up the National Union of Iron Molders (Winner, 1999 (1985)), was certainly satisfying for Cyrus McCormick's reaper manufacturing plant (in this case a consumer of a pneumatic molding machine), although a more efficient machine would probably have been more satisfying.

The reason why Social Actors decide to buy certain artifacts depends, according to marketing theory, on *marketing stimuli* (product, price, place, and promotion,) *other stimuli* (economic, technological, political, and cultural,) *buyer's characteristics* (cultural, social, personal, and psychological,) *buyer's decision process* (problem recognition, information search, evaluation of alternatives, purchase decision, and post purchase behavior,) and *buyer's decisions* (product choice, brand choice, dealer choice, purchase timing, and purchase amount) (Kotler, Kenkins, & Keller, 2006 (2001)). Social interaction with so called *reference groups* (friends, family, neighbors, and co-workers) influence the buyer, al be it to a lesser extend then the cultural factors (culture, subculture and social class,) which leaves a trace of the values they expose the Social Actor to in his behavior (Kotler, Kenkins, & Keller, 2006 (2001)). By ways of social interaction the Social Actor is exposed to pressure to choice a certain brand, behavior and lifestyles new to him, and influencing attitudes (Kotler, Kenkins, & Keller, 2006 (2001)). The believe a Social Actor has about an artifact (or its brand) has a great influence on his buying behavior (Kotler, Kenkins, & Keller, 2006 (2001)), for instance the believe that buying household equipment saves the housekeeper time, is an important reason to buy such an artifact (whether or not these machines, and the rules that govern their use, really save time is doubted (R. S. Cowan, 1983).)

It is clear that when a Social Actor is pondering whether or not to become a consumer, he wants to have some influence on the shaping of the artifact or its succeeding artifact. But when a Social Actor will never become a consumer, he might also want to have influence on the artifact, especially if the consumers of this artifact directly, and most likely negatively, influence him. This could be played via the Political Actor, for instance and anti-smoking lobby.

Further considerations

Since development of the characteristics for the different actor types has just begun, a lot of work remains to be done in describing their characteristics in a more correct and a more complete way.

We have to view all the actors in all the roles they fulfill, that are connected to the technological change, in order to understand what drives their actions. We will thus always have to view a governmental consumer, for instance in the case of the TSR.2 (as described in Law & Callon, 1992) we have to view the British Royal Air Force (RAF) as both consumer (a Social Actor) and as part of British defense (a Political Actor,) for us to understand their motives.

The influence a Social Actor has largely depends on the power of the Economic Actor, if the Economic Actors is one of many in the field, the Social Actor will have a greater chance of getting what it wants (otherwise he can visit the competition which might comply with his wishes.) If on the other hand the Economic Actor is power full, the Social Actor will not truly get what he wants, although if the Economic Actor diverges to much from the *use value characteristics*[21] the potential user is expecting, their might never be a user.

We may start to conceive that, although the whole actor cannot be replaced with another actor (actors are not interchangeable,) we can replace roles the actors fill by another actor fulfilling the same role, thus, in the end we can eliminate one actor by replacing him/her with other actors filling up the gaps left behind. This does not mean that if we replace a network with a different network and the same 'amount' of each actor type that we will get the same outcome. This is where individualism comes in. People interpret the same things in different ways. We cannot take out Edison as an inventor-entrepreneur (Hughes, 1983) and replace him by another inventor-entrepreneur (specialized in the same fields) and expect the same system to develop. But when the role of an Economic Actor is very limited, for instance when

[21] See Lundvall (1988) about the diffusion of these characteristics

the relevant Social Groups have a very clear idea of the direction the technology has to take and the relevant Social Groups are very powerful, then taking out and replacing some of the Economic Actor will lead to, more or less, the same artifact.

Representations of reality

When observing the actors one can choose to 'zoom in', meaning represent more detail, splitting up an actor group in its specific subgroups, for instance splitting up the 'Social Actor' involved with the cigarettes from the introduction in 'consumer' (29.9 %) and 'non-consumer' (70.1 %,) the group of the consumer can be further split into 'never quitting' (13 %,) 'wants to quit' (39 %,) 'does not know' (49 %,) the group 'wants to quit' can be split in 'wants to quit but not within a year' (36 %,) 'wants to quit within a year' (21 %,) 'wants to quit within a half-year' (23 %,) and 'wants to quit within a month' (21 %.)[22] The group of the 'non-consumer' can be split in 'potential consumer' and 'never consumer' which can be split in 'anti-smoker' and 'not anti-smoker'[23], the Build up of the Social Actor is displayed in Figure 1. We can also split it up in another way; splitting up the 'Social Actor' in 'male' (49.5 %) and 'female' (50.5 %) (CBS, 2005), which can both be split in 'consumer' (32.8 % and 27.2 %) and 'non-consumer' (67.2 % and 72.8 %) (STIVORO, 2004), this is displayed in Figure 2. Both of them are correct, they display two correct but different representations of the reality. One might say that, just like artifacts are subject to *interpretive flexibility*[24], so is the representation of the build up of the actors. How then do we know what to choose? One will have to asses for him/her self what is relevant. In the case of the bicycle it would be interesting to look at the gender buildup, since the female potential consumers were important for the development of the safety bicycle (Bijker, 1989, 1997 (1995); Pinch & Bijker, 1984, 1989 (1987)), but also a view on the build up of age (older men did not ride the bicycle) and

[22] Al percentages derived from STIVORO (2004).

[23] Attributing good names to the groups will always remain a difficult process, but the only function of this is to display their mean concern about the artifact(s) in question

[24] Some authors call it 'interpretative flexibility' (Bijker, 1989 (1987), 1997 (1995), 2005; Bijker, Hughes, & Pinch, 1989 (1987)-a; Pinch & Bijker, 1984, 1989 (1987); Williams & Edge, 1996) others call it 'interpretive flexibility' (Klein & Kleinman, 2002; Law & Callon, 1992; Winner, 1993, among others), I will try to be consistent in the use of interpretive flexibility

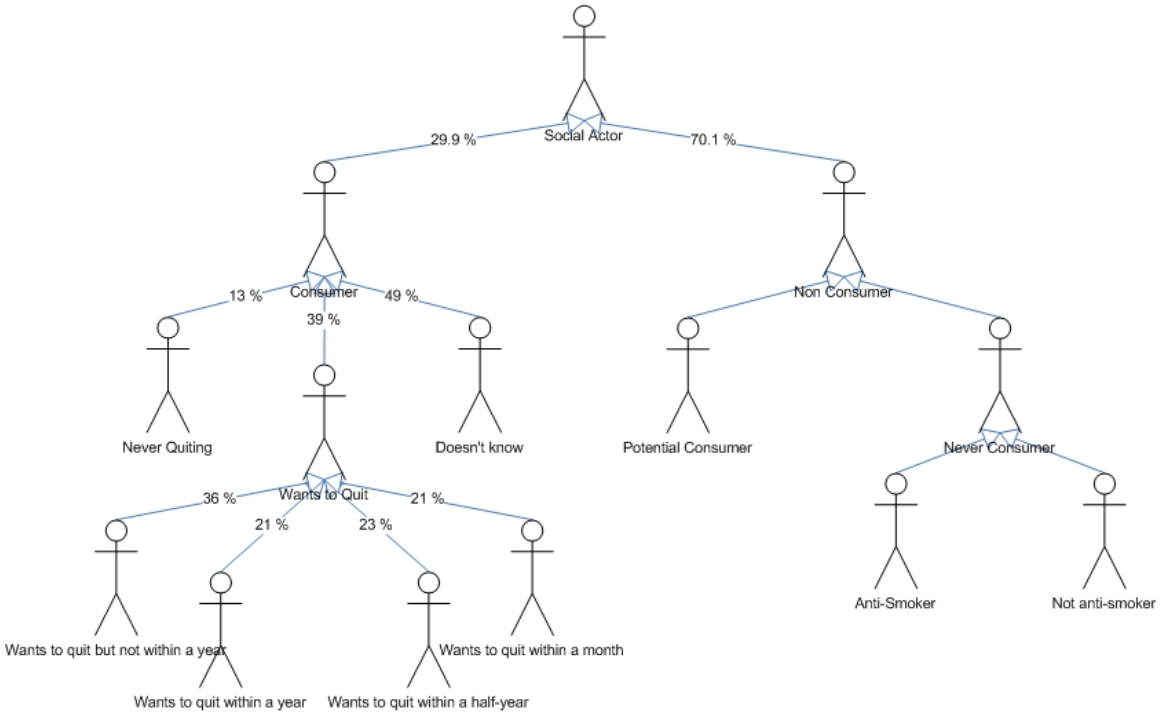

Figure 1 Build up of the Social Actor

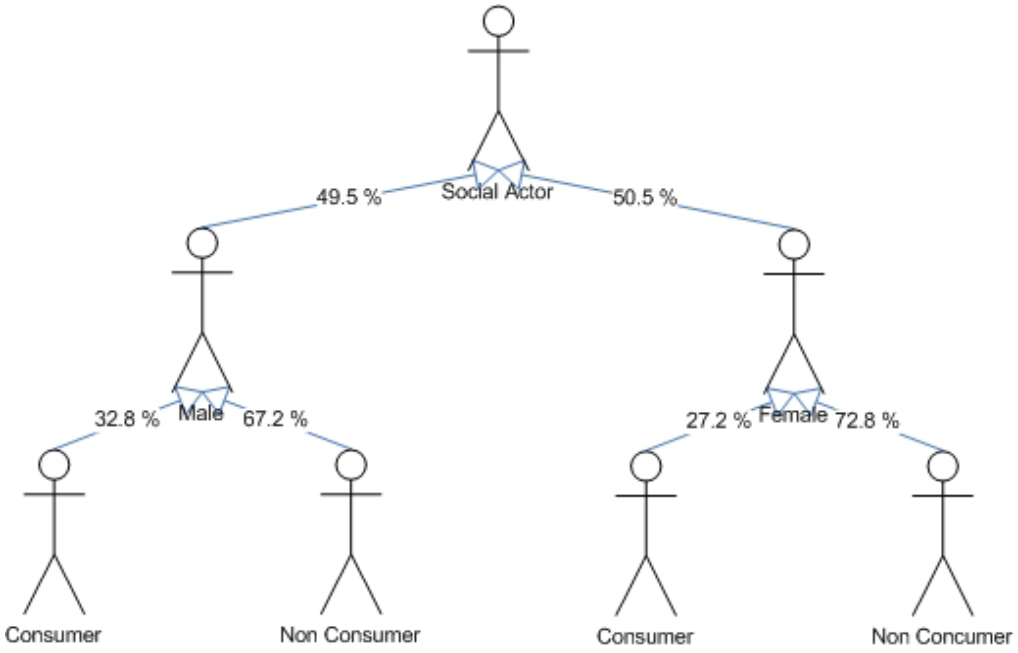

Figure 2 Build up of the male/female Social Actor

of social status (cyclists ware mostly upper-class) (Bijker, 1989, 1997 (1995); Pinch & Bijker, 1984, 1989 (1987)) would be relevant. It can therefore be useful create several different views on the buildup and origins of the different groups involved. We can,

potentially, keep zooming in until all of the individual actors are exposed, but only if this is relevant. We only need to open the *black-boxes*[25] that require opening.

The seamless web

To create a model in which there is a possibility of more powerful Economic Actors, we do not have to create seams in the *Seamless Web* (Hughes, 1986), instead we have to make the actor types visible in the existing web. Hughes tells us that we have to redefine the relationship between technology and so-called contextual factors (like political and social factors) (Hughes, 1986), or newly defined actor types can help us understand these relationships. In his work on inventors, Hughes talks about professional independent inventors who are free of organizational-constraints that face their non-independent counterparts (Hughes, 1989, 1989 (1987)), but because his work focuses mainly on independent inventors (like Sperry (Hughes, 1971, 1989), Edison (Hughes, 1983, 1989), and others (Hughes, 1989),) his model does not seem to deal with this organizational-constraint. However, the so called independent inventors also had to deal with, what I call, Economic Actors. Not only did they, themselves fulfill this function (after all the independents were inventor-entrepreneurs (Hughes, 1983, 1989),) the great inventors of that era also had to deal with financiers. Arguably, Tesla's fame, for instance, would be better acknowledged nowadays was it not for J.P. Morgan's withdrawal of investments in Tesla's Wardenclyffe Tower (Hurwitz, 2000; Roguin, 2004), apparently this is because of the financial impracticality of using the tower (Hurwitz, 2000).

The actions of the independent inventors, and the results achieved, depended on an interaction with other Economic Actors (such as J.P. Morgan (Hughes, 1983, 1989),) Political

[25] A term, referred to by many authors (Bijker, 1997 (1995); Bijker, Hughes, & Pinch, 1989 (1987)-a; Bijker & Law, 1992a; Dosi, 1982; Kaghan & Bowker, 2001; Kallinikos, 2002; Latour, 1987; Webster, 1991; Williams & Edge, 1996; Winner, 1993, among others), Latour explains the use as "used by cyberneticians whenever a piece of machinery or a set of commands is too complex" (Latour, 1987, p. 3), in this case it is just used the describe complex situations that do not require further inside.

Actors (such as the New York Alderman (Hughes, 1983),) and on Social Actors (such as the potential consumers (Hughes, 1983, 1989).)

It is questionable if the so called independent inventor does exist at all, people like Edison were far from independent, not only was his interaction as described above vital to his endeavor, but he also ran his own company at Menlo Park, working together with other inventors and experts, such as the mathematician Francis R. Upton (Hughes, 1983). The Edison Illumination Company was the real Economic Actor in the invention and diffusion of Edison's lamp.

Information imbalance

The producing Economic Actor, has "much more, and more certain, information about the use value characteristics of the new product than the potential user [a Social Actor]." (Lundvall, 1988, p. 351), but on the other hand the producing Economic Actor does not necessarily know which use value characteristics the potential user (a Social Actor) is expecting, we are thus faced with the problem of information imbalance, an *asymmetric information problem* (Akerlof, 1970).

For both the Economic Actor and the Social Actor involved there is information that they want to share and information they want to keep private. The Economic Actor wants to share the, what I would call, *positive use value characteristics* of an artifact (for instance, the fact that fluorescent lamps are more efficient (Bijker, 1992, 1997 (1995); Bright & MacLaurin, 1943),) but the Economic Actor would like the keep the *negative use value characteristics* of an artifact (for instance the fact that cigarettes are engineered to be more addictive (Bates, Jarvis, & Connolly, 1999; Douglas, 1994, 1998; Hurt & Robertson, 1998)) private. Likewise the Social Actor wants to share the use value characteristics he is accepting from an artifact (for instance, not having a vibration problem on the bicycle (Bijker, 1989, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Pinch & Bijker, 1984, 1989 (1987)),) but wants to keep the price he is willing to pay for an artifact private, in other words the value an artifact has to him.

Interaction and relationships between actors, making the web seamless

According to Schutz there are two cases of social relationship; "in the first case, the actor's subjective expectation establishes the probability of a reciprocal orientation, which by definition means that a social relationship exists. In the second case, it is the outside observer's "objective" judgment which establishes this probability and *eo ipso* the relationship" (Schutz, 1967 (1932), p. 152). What the observer sees, is not necessarily the same as what the actors experience, and visa versa (Schutz, 1967 (1932)). We are, in our seamless web, also confronted with interactions hidden from our actors. The average consumer will not have a feeling he plays any part in the shaping of new technology, just as some executives working for a producer are unaware of the interaction between the engineer and the, potential, consumer. Also are we confronted with interactions clear to the actors, but not clear to the observer (until further inspection lifts the blinds of our eyes.) We can think of the way the tobacco industry reacted on a law change in 1970, which let the self report the used additives (Bates, Jarvis, & Connolly, 1999), Philip Morris's Marlboro brand grew from the sixth biggest to the biggest cigarette brands by the use of additives, that were previously not allowed (Bates, Jarvis, & Connolly, 1999). Since the social scientist (in the broadest way of the word, thus not only the sociologist) is primarily in the position of the observer, close inspection is needed to reveal all interactions that are not immediately visible to the outside world, only in this way can a proper interaction model, a true seamless web, be constructed.

Although the interaction between the different actors involved in the seamless web will, most of the time, not be direct, this type of interaction, called *face-to-face* (Berger & Luckmann, 1966; Schutz, 1967 (1932)) or *direct social experience* (Schutz, 1967 (1932)), deserves some attention, since the *face-to-face* situation "is the prototypical case of social interaction" (Berger & Luckmann, 1966, p. 43). In a "face-to-face situation, the other's subjectivity is available to me through a maximum of symptoms" (Berger & Luckmann, 1966, p. 43). Those symptoms can, however, be misinterpret, but because of the completeness of these symptoms of subjectivity, this form of interaction is superior to any other form of social interaction (Berger & Luckmann, 1966). Also changes of a miss typification of 'the other' are smallest in face-to-face interaction, and if they do occur they are more easily recognized and fixed (Berger & Luckmann, 1966), which would be a great advantage to our Economic Actor in recognizing to which social group Social Actor belongs. But we live in an era with little to

non face-to-face interaction between (potential) user and producer, we thus have to look beyond this direct social experience to the *indirect social experience* (Schutz, 1967 (1932)) and how these experiences are used. Vital is a Socially Shaped Artifact is the skill of an Economic Actor to view past the very anonymous typification of 'potential consumer' to a more detailed typification like 'potential consumer that does not want a vibration problem on his/her bicycle', for this the degree of interest and the degree on intimacy are important, since they "may combine to increase or decrease anonymity of experience" (Berger & Luckmann, 1966, p. 47).

Most interaction between scientist in, for instance, the social construction of medicine, takes place in the form of articles and books (Woodward & Watt, 2004 (2000)). Interaction among the different actors in our seamless web can not so easily be limited to one form, interaction among Economic Actors can, for instance, take the form of licenses (as in the early American incandescent lamp industry (Bijker, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Bright & MacLaurin, 1943),) or patents (an Economic Actor is more or less saying; "This is mine and stay off it", as in the history of the bicycle (Bijker, 1984, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Milanski, 1997; Pinch & Bijker, 1984, 1989 (1987)).) The Political Actor can interact with an Economic Actor by, for instance, a law (think of British laws of the 18th century to stop the transportation of technologies in certain fields and in various forms to France (Harris, 1996).) Interaction initiated by an Economic Actor directed at a Social Actor can, for instance, be advertisement (like advertisement for an aerodynamically, Bakelite Philishave (Bijker, 1989 (1987), p. 181, 1997 (1995), p. 180). And the most clear signal a Social Actor can send to an Economic Actor is buying his artifact, by buying an Economic Actor's artifact the Social Actor seems to say; "The use value characteristics of this artifact, or at least the use value characteristics I think this artifact has, appeal enough to me to part with the amount of money I am charged". However the communication between a producer and a (potential) consumer is mostly one way (Passby, 1996), true interaction is missing.

But how does the Economic Actor know how to typificate the Social Actors? How does the Economic Actor know what the values and usefulness of this artifact have to be? How does the Economic Actor pick up the other signals send by a Social Actors, signals not send by

buying or not buying an artifact? Nowadays a producer type Economic Actor can depend on market surveys and a customer complains department to interact with the (potential) consumers (Passby, 1996). "Technology is created," says Bijker, "by engineers working alone or in groups, marketing people who make the world aware of new products and processes, and consumers who decide to buy or not to buy and who modify what they have bought in directions no engineer has imagined" (Bijker, 1997 (1995), pp. 3-4), but this can only happen if an artifact, or one of the artifacts that precedes it, already exist. Hughes supposes that "if a particular class of users is foreseen, their preferences can be incorporated in the design" (Hughes, 1986, p. 290), but also does not explain how these classes of users and their preferences would have reached the awareness of the designer in times when no modern communication tools and market research existed. For now, I am unable to answer this question myself, further research should be conducted that is out of the scope of this thesis.

The basic web

The web in its most basic form (as shown in Figure 3) functions as the starting point for the seamless actor web. In this basic web al the three main categories of actors are shown, and the connections they have with each other. All the more detailed forms can be derived from this web. A possible mistake in this, however, is showing both sub groups and the group they

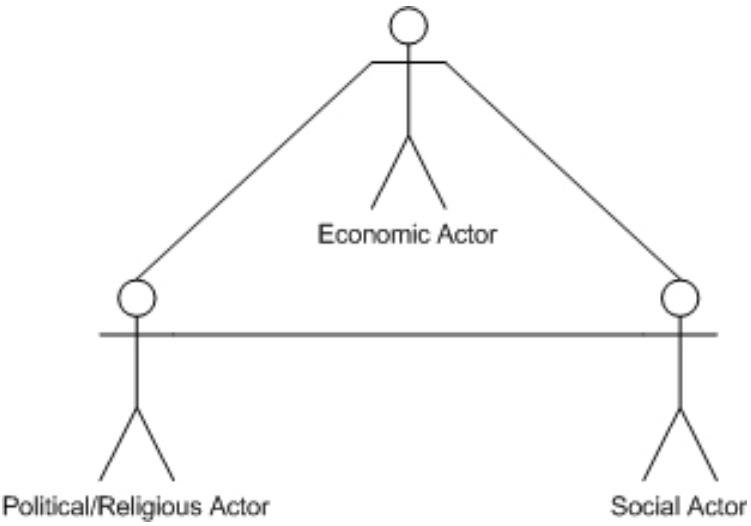

Figure 3 The basic web

form in the same web such as potential consumers, never consumers and non-consumers (where the latter consists of the other two.) When depicting the web, we should view the different actor types on the same 'zoom level'. In theory the numbers of actors in the web could be only limited by the real people in the world.

Needs to be noted that not all that every main category of actor has to be present in every web, although it is most likely a simplified view if they are not all present some how.

Interpretive flexibility

The concept of interpretive/interpretative flexibility is described as "The same artifact can mean different things to different social groups of users." (Kline & Pinch, 1999 (1985), p. 113) or "Interpretative flexibility refers to the way in which different groups of people involved with a technology (different 'relevant social groups', in Bijker and Pinch's terminology) can have very different understandings of that technology, including different understandings of its technical characteristics." (MacKenzie & Wajcman, 1999 (1985), p. 21).

As must be clear from the introduction, I agree with the notion of interpretative flexibility, Bijker views "interpretative flexibility is a crucial step in arguing for the feasibility of any sociology of technology—it shows that neither an artefact's identity, nor its technical 'success' or 'failure,' are intrinsic properties of the artefact but subject to social variables." (Bijker, 2005, p. 5). The concept of interpretive flexibility is needed to understand how new and novel uses of an artifact are found (see for instance Kline & Pinch (1996) and Pinch (1996) for novel uses of the Model T Ford,) to understand the difference in requirements (see MacKenzie, 1989; MacKenzie, 1989 (1987), 1990; MacKenzie, Rüdig, & Spinardi, 1988 for a history of two interpretations of missile accuracy,) and to understand how different actor groups see an artifact (see Bijker, 1997 (1995); Bijker & Oost, 1983; Pinch & Bijker, 1984; , 1989 (1987) for views on the bicycle). There is one other use of the concept of interpretive flexibility; it helps us to understand how more then one artifact can be developed to solve the same problem or to fill the same need.

Closure

Before we can look at how closure is achieved in this new framework we have to wonder if it exists at all. According to Bijker "closure, in the analysis of technology, means that the interpretative flexibility of an artifact diminishes" (Bijker, 1997 (1995), p. 86) in other words closure "highlights the irreversible end point of a discordant process in which several artefacts existed next to each other" (Bijker, 2005, p. 5). But does this happen, after all, the bicycle did not stop developing after the development of the safety bicycle in 1896 (Bijker, 1989, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Pinch & Bijker, 1984, 1989 (1987)), other instances of the bicycle before 1896 seem to solve problems for relevant social groups[26], and if we look around and observe the types of bicycles on roads, mountains, dirt tracks, BMX parks, and what have you today, we can satisfyingly conclude that the quest for speed, thrills, safety, comfort, etc. is not over, and most likely never will be.

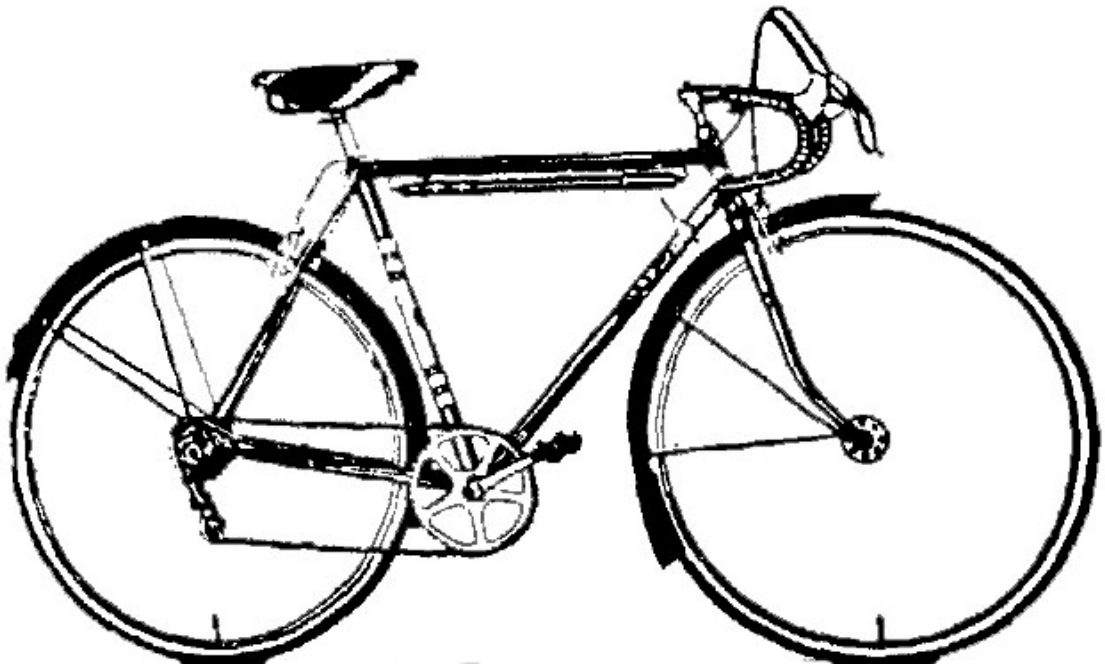

Figure 4 Bijker & Oosts' 'the bicycle' ['de fiets'] (Bijker & Oost, 1983, p. 32)

[26] This is suggested by the fact that they were produced in quantities, which can be deducted from, especially, Bijker (1997 (1995))

When talking about ‘the bicycle’ Bijker & Oost (1983) displays an image (see Figure 4) of a highly specialized bicycle, a racing bicycle, that did not exist, in the shown form, in 1896, proof that bicycle development did not stop. What is even more strange is that the development on the recumbent bicycle (not mentioned in Bijker, 1984; Bijker, 1997 (1995); Bijker, Böning, & Oost, 1984; Bijker & Oost, 1983; Pinch & Bijker, 1984, 1989 (1987)) started in 1895 (Milanski, 1997), while the development of the bicycle (the safety) ended with closure in 1896 (Bijker & Oost, 1983) or 1897 (Bijker, 1997 (1995)), the recurrent bicycle was dealt a severe blow, in 1932, when it was prohibited to use them for racing after the world record was shattered by one (Milanski, 1997). Milanski also provides us with another reason for the claimed *stabilization* (Bijker, 1997 (1995); Pinch & Bijker, 1984, 1989 (1987)) of the safety bicycle, the safety was mass-produced on assembly lines, which made switching to another bicycle type more expensive then before the use of assembly lines, on top of that the market collapsed in 1898 (there were about 500 bicycle companies in 1896 in the United States and only about 100 in 1903, Table 2 and Figure 5 for the growth in bicycle sales between 1890 and 1910,) so there was no more money to innovate and thus the form of bicycle became *frozen* (Milanski, 1997). 1896 – 1898 seems to be the period that the economic and social story line of the bicycle meet, and get interweaved. In Hughes words, the safety bicycle gained a *technological momentum* (Hughes, 1989, 1994), especially in this case because of the capital invested in the manufacturing hardware, “the machines, devices, and processes in the system are the capital, but a special kind of hardware capital with characteristics that might be called ‘system specific.’ Changes in the system might also make hardware capital obsolete.” (Hughes, 1989, p. 460).

There could be moments after the ‘release’ of an artifact that closure will temporarily exist, but once the limitations of the artifact are discovered, the requirements change or even the environment in which the artifact operates change (for someone using the bicycle as a transportation device the change from dirt tracks to concrete or asphalt roads would require less suspension on the bicycle,) the need for a new (or changed) artifact will surface again. Riding your 1896 safety bicycle down a mountain will probably be a one-time event, while now there exist specialized downhill bicycles.

Table 2 U.S. bicycle sales (based on Perry, 2003)

Year	Sales	Average Growth/year	Average Growth/year %
1890	340,000	140,000	70
1895	800,000	92,000	5.41
1896	1,200,000	400,000	50
1897	2,000,000	800,000	66.67
1899	1,182,691	-408,655	-10.22
1900	1,182,850	159	0.01
1901	1,182,850	0	0
1902	1,182,850	0	0
1903	1,182,850	0	0
1904	250,487	-932,363	-78.82
1909	233,707	-3,356	-0.27

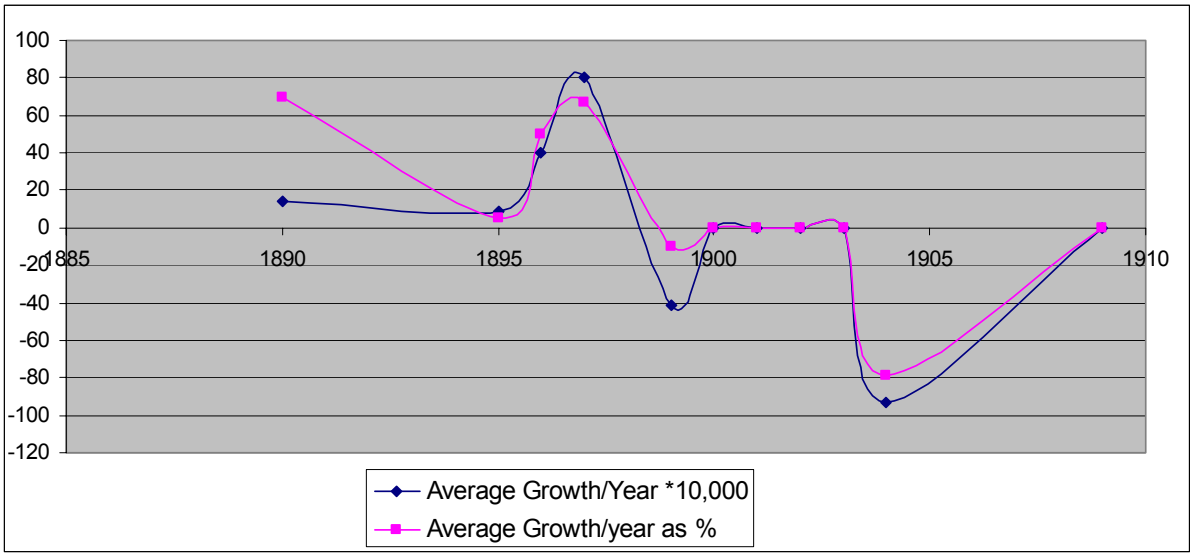

Figure 5 Growth in U.S. bicycle sales

Williams describes the process of closure as "reaching agreements about which technological path will be followed" (Williams, 1999, p. 2), he stress that this can lead to lock-in, the adoption of non-optimal technical solutions (R. Cowan & Hultén, 1996; Williams, 1999). This would make closure a dangerous and maybe even undesirable.

The only closure existing is an assumption by an Economic Actor (in this case the Economic Actor is of the Subtype Producer) that an artifact fulfills the requirements set by the Economic Actor, hopefully derived from the wishes of the Social Actors, and the Economic Actor thinks the product is marketable. To distinguish between the SCOT type of closure and the closure by the Economic Actor we will name this *producer side closure*. Of course producer side closure will solve some problems of relevant social groups, and, if the Producer Actor read market signals correctly, will (partly) replace the established artifact for more then one social group, but, since there could be a misinterpretation by the Producer Actor, the new artifact can also fail[27]. Kim & Watanabes' (2002) claim that support of relevant social groups was needed to ensure that the closure in the protocol battle for ARPANET was a long-lasting one, strengthens my case.

The power of Economic Actors, an example

Imaging a situation in which there are two firms that produce Central Processing Units (CPUs) for home computers. The two CPU lines will be called X and Y. Both CPU lines are equally compatible (are supported by the same hard and software,) and are priced in the same manner (the release price of CPUs with the same processing power will be the same and the drop in price after the same amount of time will be the same.) As in the real world, we can not go from a CPU with 2.25 thousand transistors to one with 42 million transistors[28], rather we will move in incremental steps, the "generations" in the two CPU lines will be named $X_1 \ldots X_n$ and $Y_1 \ldots Y_n$. Since innovations will be guarded by patents and different approaches will be used by different people to address similar problems, CPUs of the same generation will not be exactly the same ($X_5 \neq Y_5$) and thus the performance (P) will also differ ($PX_5 \neq$

[27] One has only to think of such examples as the Sega Saturn and the relative failure of the Sega Dreamcast (Grant, 2004)

[28] The first Intel CPU the 4004 (from 1971) contained 2.25 thousand transistors, the Pentium 4 (from 2000) contains 42 million transistors (Mateescu, Răsturnoiu, Sâman, & Buneci, 2003)

PY_5)[29]. We will assume that in the two lines CPU generations will be released in a short time span (X_5 will be released not that far from Y_5.) We will set this time span at roughly three-quarters of a year before or after. We can assume that the performance of CPUs developed in a certain period will not differ too much ($PX_6 > PX_5 > PX_4$ and $PX_6 > PY_5 > PX_4$.) Some buyers will prefer buying a normal priced CPU to buying a lower priced one with less performance. There will always be buyers for the best performing CPU on the market.

What would happen if Firm 1 would be able to produce two different generations of their CPU (say X_5 and X_6,) while they are only selling X_4 on the market? Since high-end users prefer buying a CPU with higher performance to one with less performance, they would prefer buying X_6. If, in this case, Firm 2 is still developing their Y_5 or $PY_5 < PX_5$, there will be no incentive for firm 1 to put X_6 on the market, simply because they know they will sell X_5 when it is marketed and X_6 will still sell although X_5 was marketed earlier. What the high-end users want (the best performing CPU that is available) will not be what the users get. Profit takes precedent over users' needs.

[29] We will assume one type of performance, in the real world a CPU that runs OpenGL applications smoother can be slower in encoding MP3's than another CPU

Deciding on change

Although I stated earlier that an actor that the decisions made by an actor are not necessarily rational, for this chapter we will assume they are. Also the situation we are dealing with in the beginning of this chapter will be a simple one; Social Actors will buy an artifact or they will not buy an artifact, Economic Actors will produce an artifact in an X or Y variant. To even further simplify there will be only one Economic Actor and only two Social Actors, both Social Actors have different preference concerning the artifact (the different Social Actors will be represented by SAX or SAY depending on their preference.) For the beginning we will also presume that the Social Actors know the utility an artifact variant will offer them, and that the Economic Actor is fully informed (Gibbons, 1992; Myerson, 1997; Zandt, forthcoming) and can calculate (thus know) the utility each variant will offer him. Hence the use of utility instead of expected utility. We will assume that the number of individuals in SAX is twice as big as SAY and thus will buy twice as many artifacts when the type is correct.

Social Actors decision

One faced with an artifact a Social Actor has two choices buy or not buy, whether the Social Actor buys or not depends on the utility the artifact will offer the Social Actor. If the Social Actor is SAX his expected utility when choosing to buy the artifact will be larger then when not buying if the artifact is of the X variant, if the artifact is of the Y variant the expected utility when not buying will be larger then when buying. The reverse is true for the SAY Social Actor. We will assume that buying the preferred variant offers a utility of 1, not buying offers a utility of 0, and buying the variant that is not preferred offers a utility of -1 (because of frustration for instance.) Mathematically this we can say P_{SAX}: $X \succ Z \succ Y$, where Z is not buying and P_{SAX} the preference of SAX, and P_{SAY}: $Y \succ Z \succ X$, where P_{SAY} is the preference of SAY.

A Social Actor's *decision tree* (French, 1986; Gibbons, 1992; Myerson, 1997; Zandt, forthcoming) would thus look as figure 6.

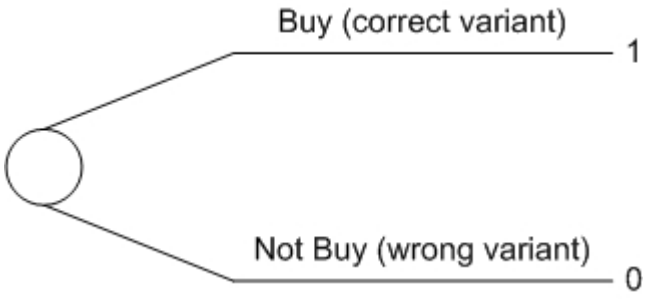

Figure 6 Decision tree Social Actor

Economic Actor decision

We will assume that the utility for the Economic Actor is direct related to the number of artifacts sold. In this case that will mean that producing the X variant of the artifact will yield a utility of 2 and producing the Y variant will produce a utility of 1.

The decision the Economic Actor is faced with in this case is represented by figure 7

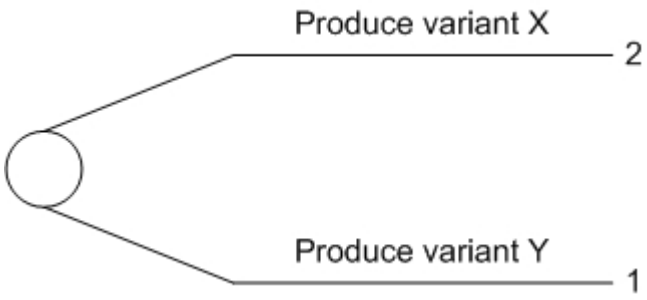

Figure 7 Decision tree Economic Actor

Combining the choices

Although it is intuitively clear what choice the Economic Actor will make in this case, figure 8 represents the complete decision tree in which all decisions are captured. The utility (or

payoff) to the Economic Actor is the total utility, while the utility (or payoff) to the Social Actor is the individual utility.

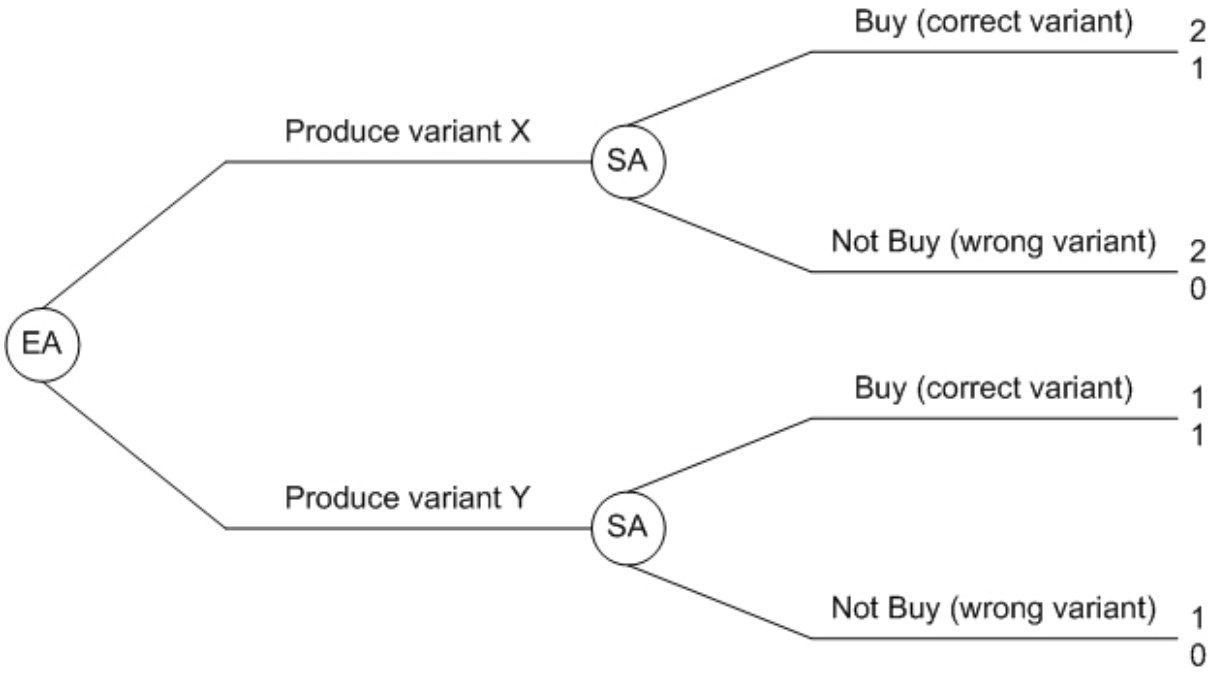

Figure 8 Complete decision tree

Figure 9 is the *extensive form game* (Gibbons, 1992; Myerson, 1997; Tirole, 1988) of these decisions. In the *normal form* or *strategic form* (Gibbons, 1992; Myerson, 1997; Tirole, 1988) the game would look like table 3. The assumption is made that when observing the SAX the SAY will act as we would expect (not buying when type X is produced and buying when type Y is produced,) and visa versa.

Table 3 Normal form game

	Social Actor			
	SAX		**SAY**	
Economic Actor	**Buy**	**Not Buy**	**Buy**	**Not Buy**
X	2, 1, 0	0, 0, 0	2, 1, -1	2, 1, 0
Y	1, -1, 1	1, 0, 1	1, 0, 1	0, 0, 0

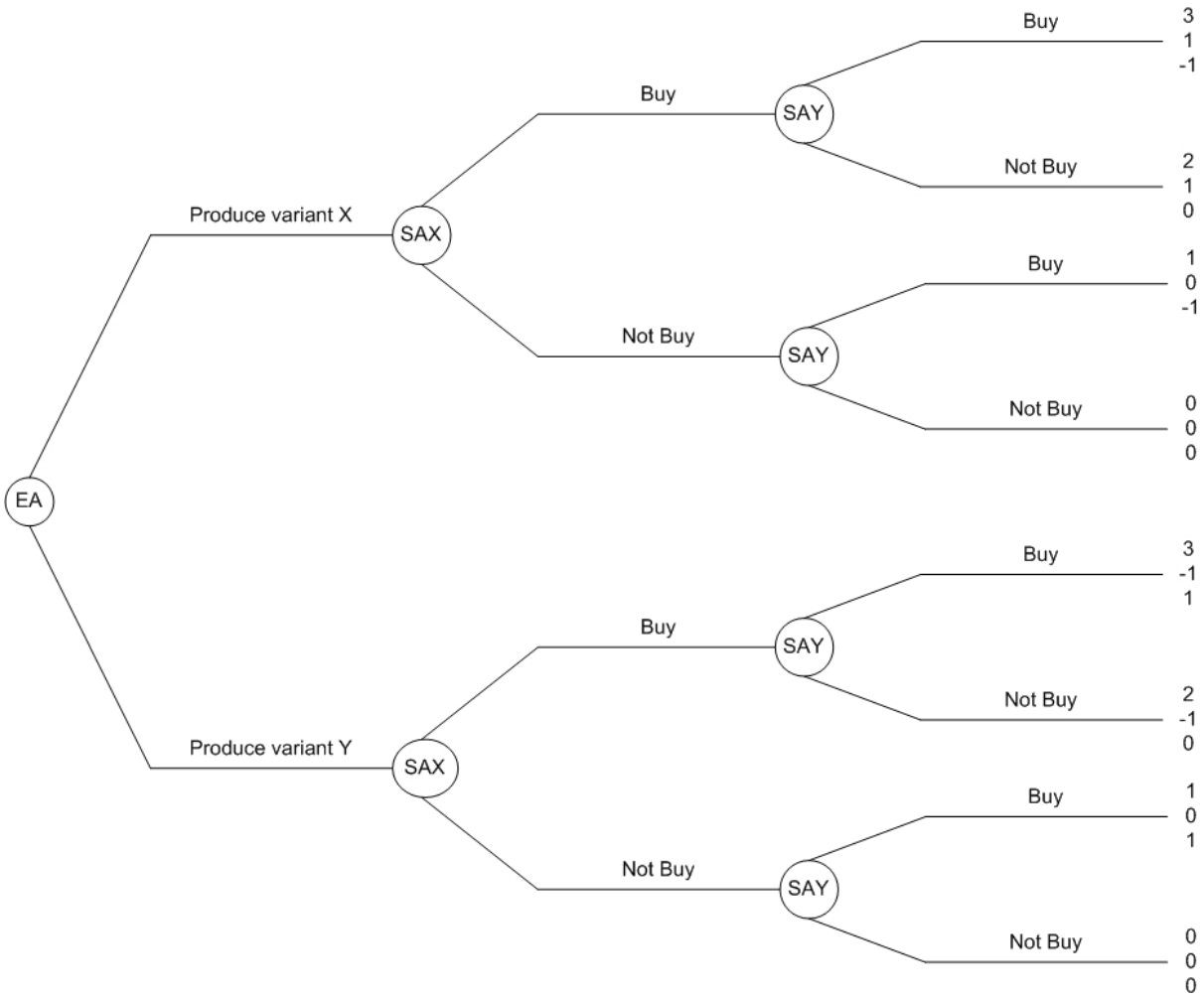

Figure 9 Extensive form game

As this is a relative easy situation the *equilibrium* (Gibbons, 1992; Macho-Stadler & Pérez-Castrillo, 2001 (1997); Myerson, 1997; Zandt, forthcoming) is the solution that we would choice instinctively, the Economic Actor will produce variant X, SAX will buy, and SAY will not buy, resulting in a payoff of 2, 1, 0 (for EA, SAX, and SAY respectively.) This would indeed be a perfectly Socially Shaped situation, since the majority of the Social Actors will indeed get what it wants.

Why we do not always get what we want

Let us change or world a bit; instead of two Social Actors there is just one, and instead of choosing to produce either a variant X or Y of an artifact, the Economic Actor will have to

choose between keep producing X or start research (at a price) and produce of Y (his factory is to small to produce both.) Our Social Actor will prefer Y over X and X over nothing (P_{SA}: $Y \succ X \succ Z$,) the utility will be 2, 1, 0 respectively. For our Economic Actor however the cost of researching for Y will cancel out all added utility, the utility to the Economic Actor will thus be 1 in both cases (if the Social Actor buys the artifact.) The normal form and extensive form of the game are captured in table 4 and figure 10.

Table 4 Normal form game

	Social Actor	
Economic Actor	**Buy**	**Not Buy**
X	1, 1	0, 0
Y	1, 2	-1, 0

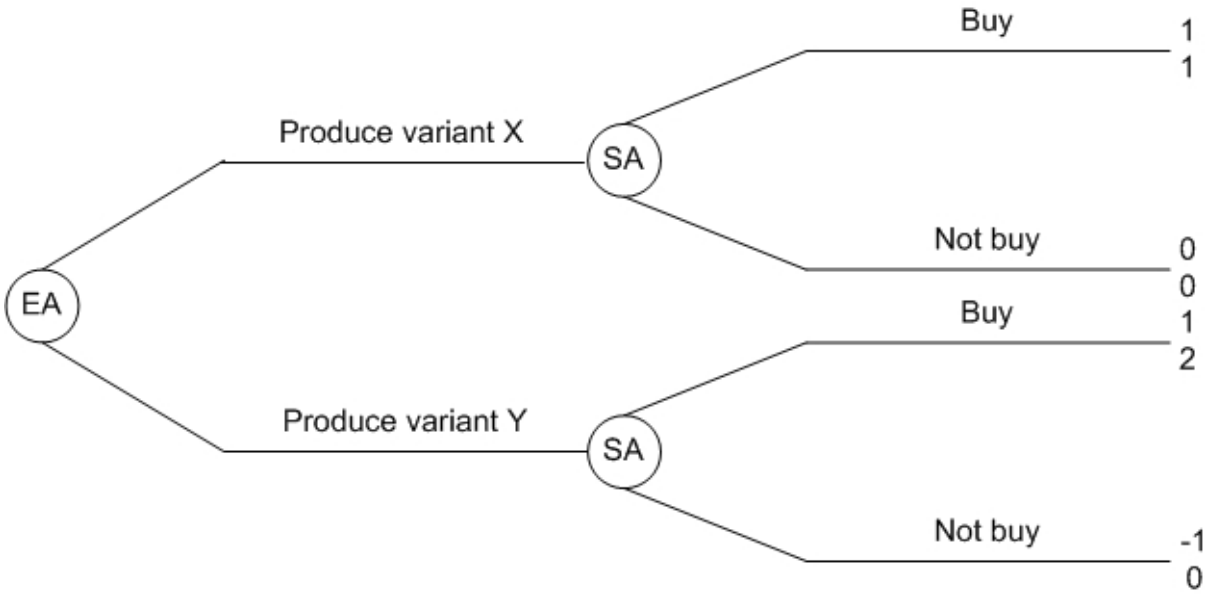

Figure 10 Extensive form game

We are now faced with a problem; there are two equilibriums, X, Buy and Y, Buy, and since the payoff for the Economic Actor is the same in both situations there is as much incentive for him to change to the production of variant Y as there is not to change.

Seeing this we can also imagine situations in which the research and development cost of a new product will be so high that the utility of the new product will be lower then that of the

existing product. In our cigarette case it is however very difficult to do this. It is very clear that the utility for the tobacco industry, the Economic Actor, will fall greatly if they would create non-addictive cigarettes (it is estimated that the number of cigarettes smoked in a year will drop from 500 billion to 25 billion (Douglas, 1994).) We can see how the Social Actor group of 'non-smokers' appreciates this. For the Social Actors that are addicted to cigarettes, even those that want to quite, the utility they receive when smoking must be very high, high enough to risk the change of developing smoking related deceases (they are faced with a *lottery* (French, 1986; Zandt, forthcoming) whenever they choose to smoke a cigarette, if we can speak of a real choice for somebody who is addicted.) Also the Political Actor comes in to play, since there are health care (currently costing about $ 68 billion in the United States of America (Douglas, 1994)) and economic factors (the exact influence on economy are hard to determine, but it is estimated that "more than 40 non-tobacco-producing states would benefit economically" (Douglas, 1994, p. 11)) that will define the payoff for the Political Actor.

Conclusion

Using simple decision and game theory it is very easy to show how actors come to a choice and why we might not always get what we want. While the models presented are an oversimplification of reality they represent a decision making in which Social Actors will not always get what they want. Modeling a real situation, even in a very simplistic way would require vast amounts of research and time, but could help out understanding of technological change.

Afterthoughts: One world, multiples theories

We live in a world with vast amounts of theories explaining many events. The existence of the Homo Sapiens is explained by theories like creationism, intelligent design and Darwinism. In this case, only one of these theories can ultimately prove be correct. Not so for technological change. Unfortunately, it will be impossible to create one theory that will cover all the different changes in technology that unfolded in the past, and that will unfold in the future. Even theories that might, to the untrained eye, seem very strange, for instance (soft) Technological Determinism (so correctly described by Marx & Smith as "Technology is a driving force of history: a technical innovation suddenly appears and causes important things to happen" (L. Marx & Smith, 1994, p. X) or ""technological determinism" is a curious phrase. This gist of it is heartbreaking in its simplicity: the belief that social progress is driven by technological innovation, which in turn follows an "inevitable" course." (M. L. Smith, 1994, p. 38)) is the correct explanation in some cases. One of the greatest discoveries by humanoids - making and tending (or controlling) fire - was probably done by accident, together with agriculture, fire techniques are also one of the most social shaping technologies for human species (it is even believed that cooking contributed to evolution of hominids, for more detail and a collecting of works see Pennisi (1999) and Hamm (2005),) and, together with language, exclusively human, unlike tool-use (Stapert & Johansen, 1999). Also some, more, recent discoveries, for instance Cyclamate, Saccharine, Acesulfame, and Aspartame (four common artificial sweeteners,) were done by accident (Walters, 2000, among others), and are thus an example of technological determinism. In these cases, the use was socially-shaped, in the case of fire, some extra uses were probably also stumbled on (for instance the preparation of food.) For artificial sweeteners there was a power struggle between the Economic Actors and the Political Actors[30].

The view of the abolitionists of the British Patent Law, around the 1850s, also had an intriguing view on technological determinism, claiming that "those men generally thought of

[30] It took G.D. Searle & Company at least 16 years to get Aspartame approved by the United States' Food and Drugs Administration (FDA) (AFSSA, 2002; Baldeshwiler, 2003; O'Shea, Unknown, among others)

as the major inventors were nothing more then the last links in the causal chain, putting the final piece into the jigsaw which others has almost completed. And if the particular individual had not been there to insert the last piece, somebody else would have been – perhaps not always at the same time, but before long. Moreover, once the final stage had been reached, there were usually many individuals seeking out the last piece of the puzzle, and so the race to the finish was often a close one." (MacLoad, 1996, pp. 145-146). "The phenomenon of simultaneous discovery is well known" (Heilbroner, 1994, p. 56), it can be illustrated by for example, the radar which was "a simultaneous invention in several places around the world" (Amato, 1998, p. 7).

In his work describing a combination of both Technological Determinism and the Social Construction of Technology, called *Technological Momentum* (Hughes, 1989, 1994), Hughes observes that "a technological system can both be a cause and an effect; it can shape or be shaped by society. As they grow larger and more complex, systems tend to be more shaping of society and less shaped by it." (Hughes, 1994, p. 112), in the open system-theory, a theory of organizational change quite similar to Hughes System-Theory of technological change, the term used for this effect is *Reinforcing Feedback* (Senge, 2005). Not only combining Technological Determinism and the Social Construction of Technology seems to be useful, Bruun & Hukkinen (2003) provide us with a combination of Actor-Network theory, Social Construction of Technology and Evolutionary Economics. Most instances of technological change will be best explained using a combination of theories, also we will be able to explain most instances of technological change using different theories. The explanation of technological change is captured in more than one storyline (Jamison & Hård, 2003). As an artifact is subjected to interpretative flexibility so is technological change.

What should be evident is that technological change works differently in different times, and different environments function in different ways. We cannot compare the way technology changed in the Soviet Union under Stalin and other Soviet statesmen (see Gomulka (1986b) for some excellent accounts of growth innovation in the Soviet Union and it's satellite states) with the USA in that same time span or medieval Europe with modern Europe (see for instance Rosenberg (1982), Law & Bijker (1992) and Picon (1996)) Also, different circumstances will change the way technological change comes about, one should consider

circumstances as the international space race ("An obvious example is electronics, especially in the fields of semiconductors and computers during the first two decades of the post-war period. Military and space programs operated then as a powerful focusing mechanism toward defined technological targets, while at the same time providing financial support to R&D and guaranteeing public procurement." (Dosi, 1982, p. 155),) World War I and II or even cataclysmic natural disasters as shaping the way technology is shaped.

Multiple theories and a short history of the bicycle

When we look at the history of the bicycle not with the Social Construction of Technology view, but with a combination of Social Construction of Technology and Systems Theory view we can see that the history of the bicycle is filled with identifying and solving *reverse salients*[31] (Hughes, 1983, 1989, 1989 (1987)). If we consider part of the historical development from the Penny Farting to the safety bicycle (Bijker, 1997 (1995); Pinch & Bijker, 1984, 1989 (1987)), we can see the emergence and solving of a couple of these reverse salients. With the Penny Farting the biggest problem was the safety problem, while most components of the technological system that is this type of bicycle are generally save, the danger laid in the giant front wheel, this was clearly the reverse salient. After the front wheel was shrunk, and thus seized to be a reverse salient, two distinctly different problems emerged, the speed problem[32] and the vibration problem, with distinctly different reverse salients, the transmission of power from feet to wheel to ground, the rigidness of the frame and the massiveness of the wheels. Using a chain driving a relatively small rear wheel, at least compared to the front wheel of a Penny Farting, and gearing the wheel up to a much larger wheel solved the speed problem.

---

[31] "A reverse salient appears in an expanding system when a component of the system does not march in harmony with other components. As the system evolves toward a goal, some components fall behind or out of line. As a result of the reverse salient, growth of the entire enterprise is hampered, or thwarted, and thus remedial action is required." (Hughes, 1983, p. 79/80)

[32] Speed seems to have always been the most important aim for a bicycle or its frontrunner the running machine, from the moment they first appeared they have been used in races (Bijker, 1997 (1995))

The vibration problem seemed harder to tackle, although bicycles with a semi-rigid frame, such as the 1885 ‘whippet’ consisting of a rigid triangular frame, some coil springs, hinges and a movable shackle (Bijker, 1997 (1995)), did solve the vibration problem, every person who has rode on a mountain bike with, especially rear, suspension knows that one not only has to power the bicycle but also overcome some of the tension in the springs, thus making the riding such a bicycle less effective. The semi-rigid frame, while solving the vibration problem, was a reverse salient in the quest for speed. When Dunlop reinvented the air tire in 1888 (Bijker, 1997 (1995)) there was a possibility to solve the vibration problem without, al be it after some modifications of the original concept, creating a reverse salient (although they originally cost £ 5 per pair, while a complete bicycle (Penny-farthing and safety,) with solid rubber tires, would have set a person back £ 20 (Bijker, 1997 (1995)).)

Even though the both frame suspension and air tires did solve the vibration problem, we can see, using or Systems Theory view, that the later was successful since it did not create additional reverse salients, while the former did create additional reverse salients. We would have missed this detail, and the reason why the air tire was chosen over the suspension frame was indeed not mentioned by Bijker (1997 (1995)), if we would have only used our SCOT view.

Conclusion

After analyzing several different theories in the field of the Social-Shaping of Technology (Social Construction of technology, Actor-Network theory and Systems Theory) I can only come to the conclusion that they cannot explain why we do not always get what we want (for instance why there are cigarettes made more addictive instead of less addictive, or even non-addictive,) and do not make enough distinctions between different actor types involved. To overcome these limitations, some additions need to be made to the field of the Social-Shaping of Technology. We must add different actor types, and understand how power relations work. These additions can be added to our current theories to make them more complete, especially so for Hughes' System theory.

We can easily conclude that in nearly all cases there will be at least one or more actors that benefit economically from the technical change, there might also be some that will get negative utility from the technical change and will try to stop it. If an Economic Actor does not abuse his power there will also be at least one Social Actor that will be positively influenced by the technological change (giving the Economic Actor an incentive for the change) there can also be Social Actors that are negatively influenced by the technological change. Furthermore, there can be Political Actors who put legal and moral constraints on the technical change. When this is not strictly enforced and controlled an Economic Actor can abuses his power when he deviates from what the Social Actors want in a way that it is substantially harmful, where the border between non-substantially and substantially exactly lays remains to be determined, but it is clear that in the cigarette and Bijkers' fluorescent light case this border has long been overshot, although the fluorescent light case is different in that there was a antitrust suit against General Electric & Westinghouse, but successful use of their connection to the War Department circumvented it.

The cigarette example from the introduction already answers the question of why we do not always get what we want: there are simply more powerful actors with different interests at heart in control. But does this mean that there is a power imbalance in the Social-Shaping of Technology? I can only answer this question negatively. Unbeknownst to me when I started

this thesis, the three Social Shaping of Technology theories looked into here; all seem to acknowledge the concept of power in one way or another. However, by attributing different characteristics to different actor types, an explanation about the distribution of this power is more easily understood and articulated. Thus instead of creating a new framework, as I originally set out to do, I created additions to the current theories to help our understanding of technological change.

Since artifacts will always be used in ways the developer has never dreamed of, the world of technology is ever-changing, and with the increasing influence that technology has over our society, it is more and more important to understand how it changes. Understanding this might help us one day devise a better way of controlling technological change and the actors that govern it. Producing more then necessarily addictive cigarettes might be one of the worst case scenarios when the actors who control technological change want to benefit economically, but it **did** happen… and as long as our understanding of what surrounds technological change is not perfect, similar events will happen again.

The way technology changes will always be a product of our state in the world (are we at war, under threat by nature etc.,) therefore they way technology changes is also dynamic. Technological change will always remain an interesting study subjects, it will help us understand past generations and it will help future generations understand us.

When we do finally truly understand technological change in al its dynamics, we can truly start to live in a Socially-Shaped Society.

References

AFSSA. (2002). *Opinion on a possible link between the exposition to aspartame and the incidence of brain tumors in humans*: Agence française de sécurité sanitaire des aliments (AFSSA).

Akerlof, G. A. (1970). The Market for "Lemons": Qualitative Uncertainty and the Market Mechanism. *Quarterly Journal of Economics, 84*, 488 - 500.

Akrich, M. (1992). The De-Scription of Technical Objects. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 205 - 224). Cambridge, Massachusetts: The MIT Press.

Akrich, M., & Latour, B. (1992). A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 259 - 264). Cambridge, Massachusetts: The MIT Press.

Allen, P. M. (1988). Evolution, Innovation and Economics. In G. Dosi, C. Freeman, R. R. Nelson, G. Silverberg & L. Soete (Eds.), *Technical Change and Economic Theory* (pp. 95 - 119). London: Pinter Publishers.

Amato, I. (1998). *Pushing the Horizon: Seventy-five years of high stakes science and technology at the Naval Research Laboratory*. Washington D.C.: Naval Research Laboratory : for sale by U.S. GPO, Supt. of Docs.

Baldeshwiler, A. M. (2003). History of FDA Good Laboratory Practices. *The Quality Assurance Journal, 7*, 157 - 161.

Bates, C., Jarvis, M., & Connolly, G. (1999). *Tobacco additives; Cigarette engineering and nicotine addiction*. Retrieved February 14, 2006 from http://www.ash.org.uk/html/regulation/html/additives.html.

Bennion, S. D., & David-Bajar, K. (1984). Cutaneous Reactions to Nuclear, Biological, and Chemical Warfare. In W. D. James (Ed.), *Military Dermatology*. Washington, DC: TMM Publications.

Berger, P., & Luckmann, T. (1966). *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*. Harmondsworth: Penguin Books.

Bijker, W. E. (1984). Techniekgescheidenis: een mogelijke basis voor theorieën over techniekontwikkeling? *Jaarboek voor de Geschiedenis van Bedrijf en Techniek, 1*, 44 - 65.

Bijker, W. E. (1989). Zonnentrillingen en macho-fietsen: social-constructivisme in the moderne wetenschaps- en techniekonderzoek. In L. B. e. G. d. Vries (Ed.), *Wetenschapstheorie - de empirische wending* (pp. 61 - 71). Groningen: Wolters-Noordhoff.

Bijker, W. E. (1989 (1987)). The Social Construction of Bakelite: Toward a Theory of Invention. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 159 - 187). Cambridge, Massachusetts: The MIT Press.

Bijker, W. E. (1992). The Social Construction of Fluorescent Lighting, or How an Artifact Was Invented in Its Diffusion Stage. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 75 - 102). Cambridge, Massachusetts: The MIT Press.

Bijker, W. E. (1997 (1995)). *Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, Massachusetts: The MIT Press.
Bijker, W. E. (2005). Why and How Technology Matters. In R. Goodin & C. Tilly (Eds.), *Oxford Handbook of Contextual Political Analysis* (Draft 8 September 2004 ed.). Oxford: Oxford University Press.
Bijker, W. E., Böning, J., & Oost, E. C. J. v. (1984). The Social Construction of Technological Artefacts. *Zietschrift for Wissenschaftsforschung, 3*.
Bijker, W. E., Hughes, T. P., & Pinch, T. J. (1989 (1987)-a). General Introduction. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 1 - 6). Cambridge, Massachusetts: The MIT Press.
Bijker, W. E., Hughes, T. P., & Pinch, T. J. (1989 (1987)-b). Introduction (to part 1). In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 9 - 15). Cambridge, Massachusetts: The MIT Press.
Bijker, W. E., Hughes, T. P., & Pinch, T. J. (1989 (1987)-c). Introduction (to part 2). In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 107 - 110). Cambridge, Massachusetts: The MIT Press.
Bijker, W. E., & Law, J. (1992a). General Introduction. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 1 - 14). Cambridge, Massachusetts: The MIT Press.
Bijker, W. E., & Law, J. (1992b). Introduction (to part I). In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 17 - 19). Cambridge, Massachusetts: The MIT Press.
Bijker, W. E., & Oost, E. C. J. v. (1983). De Sociale Konstruktie van gebruiksvoorwerpen. *Wetenschap en Samenleving, April*, 27 - 34.
Bowker, G. (1992). What's in a Patent? In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 53 - 74). Cambridge, Massachusetts: The MIT Press.
Bright, A. A., & MacLaurin, W. R. (1943). Economic Factors Influencing the Development and Introduction of the Fluorescent Lamp. *The Journal of Political Economy, 51*(5), 429 - 450.
Bruun, H., & Hukkinen, J. (2003). Crossing Boundaries: An Integrative Framework for Studying Technological Change. *Social Studies of Science, 33*(1), 95 - 116.
Bruyat, C., & Julien, P.-A. (2000). Defining the Field of Research in Entrepreneurship. *Journal of Business Venturing, 16*, 165 - 180.
Callon, M. (1980). The state and technical innovation: a case study of the electrical vehicle in France. *Research Policy, 9*(4), 358 - 376.
Callon, M. (1986). Some elements of a sociology of translation: domestication of the scallops and the fishermen of St. Brieuc Bay. In J. Law (Ed.), *Power, action and belief: a new sociology of knowledge?* (pp. 196 - 233). London: Routledge.
Callon, M. (1989 (1987)). Society in the Making: The Study of Technology as a Tool for Sociological Analysis. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 83 - 103). Cambridge, Massachusetts: The MIT Press.

Callon, M. (1991). Techno-economic networks and irreversibility. In J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination* (pp. 132 - 161). London: Routledge.
Castells, M. (2000). *The Rise of the Network Society* (Second Edition ed. Vol. 1). Malden: Blackwell Publishing.
CBS. (2005). StatLine: Centraal Bureau voor de Statistiek.
Ceruzzi, P. (1999 (1985)). Inventing Personal Computing. In D. MacKenzie & J. Wajcman (Eds.), *The Social Shaping of Technology* (2nd ed., pp. 64 - 86). Buckingham: Open University Press.
Collins, H. M. (1989 (1987)). Expert Systems and the Science of Knowledge. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 329 - 348). Cambridge, Massachusetts: The MIT Press.
Collins, H. M., & Pinch, T. J. (2003 (1998)). *The Golem at Large: What You Should Know about Technology*. Cambridge, United Kingdom: Cambridge University Press.
Cowan, R., & Hultén, S. (1996). Escaping Lock-in: the Case of the Electric Vehicle. *Technological Forecasting and Social Change, 53*, 61 - 79.
Cowan, R. S. (1983). *More work for Mother; The Ironies of Household Technology from the OPen Hearth to the Microwave*. New York: Basic Books, Inc., Publishers.
Dosi, G. (1982). Technological Paradigms and Technological Trajectories; A suggested Interpretation of the Determinants and Directions of Technical Change. *Research Policy, 11*, 147 - 162.
Douglas, C. E. (1994). *The Tobacco Industry's Use of Nicotine as a Drug: What do the recent revelations mean for Tobacco Control?* New York, New York: American Council on Science and Health.
Douglas, C. E. (1998). Taking aim at the bull's-eye: the nicotine in tobacco products. *Tob Control, 7*(3), 215-218.
Dunsby, J., & Bero, L. (2004). A nicotine delivery device without the nicotine? Tobacco industry development of low nicotine cigarettes. *Tobacco Control, 13*(4), 362-369.
Elzen, B. (1986). Two Ultracentrifuges: A Comparative Study of the Social Construction of Artefacts. *Social Studies of Science, 16*, 621 - 662.
Environmental Law Institute. (1998). *Addressing Environmental Consequences of War (Background Paper)*. Paper presented at the First International Conference on Addressing Environmental Consequences of War: Legal, Economic, and Scientific Perspectives, Washington, D.C.
French, S. (1986). *Decision Theory; an introduction to the mathematics of rationality*. Chichester, England: Ellis Horwood Limited.
Garud, R., & Karnøe, P. (Eds.). (2001). *Path Dependence and Creation*. Mahwah: Lawrence Erlbaum and Associates Publishers.
Gibbons, R. (1992). *A primer in Game Theory*. Harlow, England: Pretince Hall.
Gomulka, S. (1986a). The Incompatibility of Socialism and Rapid Innovation. In S. Gomulka (Ed.), *Growth, Innovation, and Reform in Eastern Europe* (pp. 42 - 61). Wisconsin: The University of Wisonsin Press.
Gomulka, S. (Ed.). (1986b). *Growth, Innovation, and Reform in Eastern Europe*. Wisconsin: The University of Wisonsin Press.
Grant, R. M. (2004). case eleven: Rivalry in Video Games. In R. M. Grant (Ed.), *Contemporary Strategy Analysis* (5th ed., pp. 560). Malden, MA: Blackwell Publishing Ltd.

Gulick, L. (2005). Notes on the Theory of Organization (reprint of 1937). In J. M. Shafritz, J. S. Ott & Y. S. Jang (Eds.), *Classics of organization theory* (6th ed., pp. 79-87). Belmont, CA: Thomson Wadsworth.

Hamm, K. (2005). Evidence of Anthropogenic Fire, its Uses and Roles in Human Adaptability (pp. 13): The University of Alabama.

Harris, J. (1996). Law, espionage, and the transfer of technology from eighteenth century Britain. In R. Fox (Ed.), *Technological Change; Methods and Themes in the History of Technology* (pp. 123 - 136). Amsterdam: Harwood Academic Publishers.

Heertje, A. (1977). *Economics & Technical Change*. London: Weidenfeld and Nicolson.

Heertje, A. (1988). Schumpeter and Technical Change. In H. Hanusch (Ed.), *Evolutionary Economics; Applications of Schumpeter's Ideas* (pp. 71 - 89). Cambridge: Cambridge University Press.

Heilbroner, R. L. (1994). Do Machines Make History? In M. R. Smith & L. Marx (Eds.), *Does technology Drive History? The dilemma of Technological Determinism* (pp. 53 - 65). Cambridge, MA: The MIT Press.

Henningfield, J. E., Benowitz, N. L., Slade, J., Houston, T. P., Davis, R. M., & Deitchman, S. D. (1998). Reducing the addictiveness of cigarettes. *Tob Control, 7*(3), 281-293.

Hughes, T. P. (1971). *Elmer Sperry: Inventor and Engineer*. Baltimore, Maryland: The Johns Hopkins Press.

Hughes, T. P. (1983). *Networks of Power : Electrification in Western Society*. Baltimore, Maryland: The Johns Hopkins University Press.

Hughes, T. P. (1986). The Seamless Web: Technology, Science, Etcetera, Etcetera. *Social Studies of Science, 16*, 281 - 292.

Hughes, T. P. (1989). *American genesis : a century of invention and technological enthusiasm, 1870-1970*. New York, NY: Viking.

Hughes, T. P. (1989 (1987)). The Evolution of Large Technological Systems. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 51 - 82). Cambridge, Massachusetts: The MIT Press.

Hughes, T. P. (1994). Technological Momentum. In M. R. Smith & L. Marx (Eds.), *Does technology Drive History? The dilemma of Technological Determinism* (pp. 101 - 113). Cambridge, MA: The MIT Press.

Hughes, T. P. (1998). *Rescuing Prometheus* (1st ed.). New York: Pantheon Books.

Hughes, T. P. (1999 (1985)). Edison and Electric Light. In D. MacKenzie & J. Wajcman (Eds.), *The Social Shaping of Technology* (2nd ed., pp. 50 - 63). Buckingham: Open University Press.

Hurt, R. D., & Robertson, C. R. (1998). Prying Open the Door to the Tobacco Industry's Secrets About Nicotine: The Minnesota Tobacco Trial. *JAMA, 280*(13), 1173-1181.

Hurwitz, R. (2000). Scenes from the Past: Nikola Tesla's Legacy to Modern Imaging. *RadioGraphics, 20*, 1020 - 1022.

Huxley, A. (1959). *Brave New World Revisited*. London: Chatto & Windus Ltd.

Jamison, A., & Hård, M. (2003). The Story-lines of Technological Change: Innovation, Construction and Appropriation. *Technology Analysis & Strategic Management, 15*(1), 81 - 91.

Kaghan, W. N., & Bowker, G. C. (2001). Out of the machine age?: complexity, sociotechnocal systems and actor network theory. *Journal of Engineering and Technology Management, 18*(2001), 253 - 269.

Kallinikos, J. (2002). *Reopening the Black Box of Technology Artifacts and Human Agency*. Paper presented at the Twenty-Third International Conference on Information Systems.

Kemp, R. P. M., & Soete, L. (1990). Inside the 'green box': on the Economics of Technological Change and the Environment. In C. Freeman & L. Soete (Eds.), *New Explorations in the Economics of Technical Change* (pp. 245 - 257). London: Pinter Publishers.

Kim, J., & Watanabe, T. (2002). *The Social Construction of the Internet and Emerging Problems of Internet Governance*. Paper presented at the 2991 Bugs; Globalism and Pluralism, Montreal.

Klein, H. K., & Kleinman, D. L. (2002). The Social Construction of Technology: Structural Considerations. *Science, Technology, & Human Values, 27*(1), 28 - 52.

Kline, R., & Pinch, T. J. (1996). Taking the Black Box off its Wheels: The Social Construction of the Automobile in Rural America. *Technology and Culture, 37*, 776 - 795.

Kline, R., & Pinch, T. J. (1999 (1985)). The Social Construction of Technology. In D. MacKenzie & J. Wajcman (Eds.), *The Social Shaping of Technology* (2nd ed., pp. 113 - 115). Buckingham: Open University Press.

Koskinen, K. U., & Vanharanta, H. (2002). The role of tacit knowledge in innovation processes of small technology companies. *International Journal of Production Economics, 80*, 57 - 64.

Kotler, P., Kenkins, G., & Keller, K. L. (2006 (2001)). *A Framework for Marketing Mangement*. Upper Saddle River, NJ: Prentice Hall.

Latour, B. (1987). *Science in Action : How to follow scientist and engineers through society*. Cambridge, Massachusetts: Harvard University Press.

Latour, B. (1991). Technology is society made durable. In J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination* (pp. 103 - 131). London: Routledge.

Law, J. (1989 (1987)). Technology and Heterogeneous Engineering: The Case of Portuguese Expansion. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 111 - 132). Cambridge, Massachusetts: The MIT Press.

Law, J. (Ed.). (1991). *A Sociology of monsters : essays on power, technology, and domination*. London ; New York: Routledge.

Law, J., & Bijker, W. E. (1992). Postscript: Technology, Stability, and Social Theory. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 290 - 309). Cambridge, Massachusetts: The MIT Press.

Law, J., & Callon, M. (1992). The Life and Death of an Aircraft: A Network Analysis of Technical Change. In W. E. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 21 - 52). Cambridge, Massachusetts: The MIT Press.

Lewan, T. (1998). Dark Secrets of Tobacco Company Exposed. *Tobacco Control, 7*, 315 - 319.

Lundvall, B. A. (1988). Innovation as an interactive process: from user-producer interaction to the national system of innovation. In G. Dosi, C. Freeman, R. R. Nelson, G. Silverberg & L. Soete (Eds.), *Technical Change and Economic Theory* (pp. 349 - 369). London: Pinter Publishers.

Macho-Stadler, I., & Pérez-Castrillo, J. D. (2001 (1997)). *An introduction to the Economics of Information; Incentives and contracts* (R. Watt, Trans. 2th ed.). Oxford: Oxford University Press.
MacKenzie, D. (1989). From Kwajalien to Armegeddon? Testing and the Social Construction of Missile Accuracy. In D. Gooding, T. J. Pinch & S. Schaffer (Eds.), *The Uses of Experiment* (pp. 409 - 435). Cambridge, MA: Cambridge University Press.
MacKenzie, D. (1989 (1987)). Missile Accuracy: A Case Study in the Social Processes of Technological Change. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 195 - 222). Cambridge, Massachusetts: The MIT Press.
MacKenzie, D. (1990). *Inventing accuracy: a historical sociology of nuclear missile guidance*. Cambridge, MA: The MIT Press.
MacKenzie, D., Rüdig, D., & Spinardi, G. (1988). Social research on technology and the policy agenda: An example from the strategic arms race. In B. Elliot (Ed.), *Technology and social process* (pp. 152 - 180). Edinburgh: Edinburgh University Press.
MacKenzie, D., & Wajcman, J. (1999 (1985)). Introductory Essay: the Social Shaping of Technology. In D. MacKenzie & J. Wajcman (Eds.), *The Social Shaping of Technology* (2nd ed., pp. 3 - 27). Buckingham: Open University Press.
MacLoad, C. (1996). Concepts of invention and the patent controversy in Victorian Britain. In R. Fox (Ed.), *Technological Change; Methods and Themes in the History of Technology* (pp. 137 - 153). Amsterdam: Harwood Academic Publishers.
MacQueen, G., & Santa-Barbara, J. (2000). Conflict and health: Peace building through health initiatives. *BMJ, 321*, 293 - 296.
Marx, K., & Engels, F. (2001). The Ruling Class and the Ruling Ideas. In M. G. Durham & D. M. Kellner (Eds.), *Media and Cultural Studies* (pp. 39 - 42). Malden, MA: Blackwell Publishing Ltd.
Marx, L., & Smith, M. R. (1994). Introduction. In M. R. Smith & L. Marx (Eds.), *Does technology Drive History. The dilemma of Technological Determinism* (pp. IX - XV). Cambridge, MA: The MIT Press.
Mateescu, G. D., Răsturnoiu, C., Sâman, C., & Buneci, M. (2003). A Short-Time Prediction on Romanian Personal Computers Market, based on Moore Law. *Romanian Journal of Economic Forecasting, 3*.
Milanski, J. (1997). When Bicycle Evolution Stopped: Bicycle forms that didn't make it (pp. 17): Illinois Institute of Technology.
Myerson, R. B. (1997). *Game Theory: Analysis of Conflict*. Cambridge, Massachusetts: Harvard University Press.
Nelson, R. R., & Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Cambridge, Massachusetts: The Belknap Press of Harvard University Press.
Nicholas, T. (2003). Why Schumpeter was Right: Innovation, Market Power, and Creative Destruction in 1920s America. *The Journal of Economic History, 63*, 1023-1058.
Nicholson, H., & Nicolle, D. (2005). *God's Warriors: Crusaders, Saracens and the Battle for Jerusalem*. Oxford, England: Osprey Publishing.
O'Shea, T. (Unknown). Sugar: The sweet thief of Life. *Healthline*.
Passby, M. (1996). The Ideal Marketing Dialogue; improve customer chemistry in strategic information systems (pp. 19): University of Karlskrona/Ronneby, EnerSearch AB.
Pennings, J. M., & Kim, H. O. (2000). Techonological Evolution at the Producer-Consumer Interface, *Management Science* (pp. 33).

Pennisi, E. (1999). HUMAN EVOLUTION: Did Cooked Tubers Spur the Evolution of Big Brains? *Science, 283*, 2004-2005.
Perry, D. B. (2003). *Global Bike Counts (Online resources to the book Bike Cult)*. Retrieved June 24, 2006 from http://www.bikecult.com/bikecultbook/cycle_stats.
Picon, A. (1996). Towards a history of technological thought. In R. Fox (Ed.), *Technological Change; Methods and Themes in the History of Technology* (pp. 37 - 49). Amsterdam: Harwood Academic Publishers.
Pinch, T. J. (1996). The Social Construction of Technology: a Review. In R. Fox (Ed.), *Technological Change; Methods and Themes in the History of Technology* (pp. 17 - 35). Amsterdam: Harwood Academic Publishers.
Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science, 14*, 388 - 441.
Pinch, T. J., & Bijker, W. E. (1986). Science, Relativism and the New Sociology of Technology: Reply to Russell. *Social Studies of Science, 16*, 347 - 260.
Pinch, T. J., & Bijker, W. E. (1989 (1987)). The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other. In W. E. Bijker, T. P. Hughes & T. J. Pinch (Eds.), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (pp. 17 - 50). Cambridge, Massachusetts: The MIT Press.
Roguin, A. (2004). Nikola Tesla: The Man Behind the Magnetic Field Unit. *Journal of Magnetic Resonance Imaging, 19*, 369 - 374.
Rosenberg, N. (1982). The Historiography of Technical Progress. In N. Rosenberg (Ed.), *Inside the Black Box; Technology and Economics* (pp. 3 - 33). Cambridge: Cambridge University Press.
Russell, S. (1986). The Social Construction of Artefacts: A Response to Pinch and Bijker. *Social Studies of Science, 16*, 331 - 346.
Schmookler, J. (1971). Economic Source of Inventive Activity. In N. Rosenberg (Ed.), *The Economics of Technological Change* (pp. 117 - 136). Middlesex, England: Penguin Book.
Schumpeter, J. A. (1994). *Capitalism, socialism and democracy*. London [etc.]: Routledge.
Schutz, A. (1967 (1932)). *The phenomenology of the social world [Der sinnhafte Aufbau der sozialen Welt]* (G. Walsh & F. Lehnert, Trans.). London: Heinemann Educational.
Senge, P. (2005). The Fifth Discipline: A shift of Mind. In J. M. Shafritz, J. S. Ott & Y. S. Jang (Eds.), *Classics of Organization Theory* (Sixth ed., pp. 441-449). Belmont: Thomson Wadsworth.
Smith, M. L. (1994). Recourse of Empire: Landscapes of Progress in Technological America. In M. R. Smith & L. Marx (Eds.), *Does technology Drive History? The dilemma of Technological Determinism* (pp. 37 - 52). Cambridge, MA: The MIT Press.
Smith, M. R. (1994). Technological Determinism in American Culture. In M. R. Smith & L. Marx (Eds.), *Does technology Drive History? The dilemma of Technological Determinism* (pp. 2 - 35). Cambridge, MA: The MIT Press.
Stango, V. (2004). The Economics of Standards Wars. *Review of Network Economics, 3*(1), 1 - 19.
Stapert, D., & Johansen, L. (1999). Making fire in the Stone Age: flint and pyrite. *Geologie en Mijnbouw, 78*, 147 - 164.

Star, S. L. (1991). Power, technology and the phenomenology of conventions: onbeing allergic to onions. In J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination* (pp. 26 - 56). London: Routledge.
Stenbort, M. (2002). Do We Need New Competition Policy in the "New Economy"? *The Finnish Economy and Society, 2*, 49 - 60.
STIVORO. (2004). *Roken, de harde feiten: Volwassenen 2003*. Den Haag: STIVORO - rookvrij.
Tirole, J. (1988). *The Theory of Industrial Organization*. Cambridge, Massachusetts: the MIT Press.
Walters, E. (2000). The History of High Potency Sweeteners: Tales of Discovery (http://www.rosalindfranklin.edu/cms/biochem/walters/sweet/history.html).
Webster, A. (1991). *Science, Technology and Society: New Directions*. Hampshire: MacMillan.
Williams, R. (1999). *Ict standard setting from an innovation studie perspective*. Paper presented at the 1st IEEE Conference on Standardization and Innovation in Information Technology (SIIT 1999), Aachen, Germany.
Williams, R., & Edge, D. (1996). The Social Shaping of Technology. *Research Policy, 25*, 865 - 899.
Winner, L. (1993). Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology. *Science, Technology, & Human Values, 18*(3), 362 - 378.
Winner, L. (1999 (1985)). Do Artifacts have Politics? In D. MacKenzie & J. Wajcman (Eds.), *The Social Shaping of Technology* (2nd ed., pp. 28 - 40). Buckingham: Open University Press.
Woodward, K., & Watt, S. (2004 (2000)). Science and society: Knowledge in medicine. In D. Goldblatt (Ed.), *Knowledge and the social sciences: Theory, Method, Practice* (Second ed., pp. 7 - 40). London: Routledge.
Woolgar, S. (1991). Configuring the User: the case of usability trials. In J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination* (pp. 57 - 99). London: Routledge.
Zandt, T. V. (forthcoming). *Introduction to the Economics of Uncertainty and Information* (Draft November 2004 ed.). Oxford: Oxford University Press.