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Interlocking patent rights and modularity: Insights from the Gillette Fusion razor

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Abstract
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Jelcodes:O32,O34

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Keywords: Value appropriation, complexity, modularity, intellectual property rights

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1. Introduction

The analysis of firm value appropriation is a field that has received considerable attention in the management literature (Arundel et al., 1995; Cohen et al., 2000; Levin et al., 1987), with value appropriation through intellectual property as one sub-field. However, despite patent protection, the position of patenting innovators is frequently deteriorated through imitation of their products (Mansfield et al., 1981). Firms are therefore motivated to better protect their intellectual property. Prior literature has pointed towards patenting strategies which all make use of multiple, related patents to better protect the underlying technology, making imitation inherently difficult (Granstrand, 1999; Knight, 2001; Rivette and Kline, 2000a). Among them, patent fencing has received the most scholarly attention so far (Cohen et al., 2000; Reitzig, 2004), potentially creating interlocking patent rights.

Recently, research started looking at how patent fencing strategies in discrete product industries are implemented in detail. Sternitzke (2012a), for instance, showed that fences are created based on substance patents which are complemented by various application patents over time. Little is known to date how such interlocking patents emerge in complex product industries. There, many products comprise multiple components fulfilling a variety of functions, with potentially complex relationships among each other. In order to manage complexity, Simon (1962) suggested breaking down such complex systems hierarchically. This leads us to the literature stream on modularity (Salvador, 2007, Campagnolo and Camuffo, 2010, for a review), where complexity is expressed through coupling of components (e.g. Stevens et al., 1974). According to Pil and Cohen (2006), the relationship between modularity and intellectual property has not fully been investigated yet. This leads to the following two research questions: (1) How are interlocking patent rights created in complex technologies, going beyond the approach of filing e.g. application patents around a basic patent as a centerpiece? (2) What is the impact of modular and integral systems on filing interlocking patent rights?

I use an inductive case study design to explore interlocking patents and modularity. I investigate a famous patent case, namely the Gillette Company and its razor business, featured for the first time for its superior patenting approach in Rivette and Kline (2000a). More specifically, I analyzed in detail the patents of the Gillette Fusion razor which was launched in 2006. Studying such a razor enables me to observe modular and integral components at the same time, providing insights into modular systems as triggers and boundaries for generating interlocking patents.

I found that Gillette utilized three approaches to achieve an interlocking effect: First, certain detailed technological concepts were claimed across various patent families, preferably among those that were aimed at protecting similar functions. Second, Gillette filed various so-called continuation applications which claimed overlapping aspects within the same patent family, and third, it applied a hierarchical patent claim structure, i.e., it filed different independent claims per patent claiming various (hierarchically structured) technological components, such as for blades and a blade unit. I further develop a set of propositions on how coupled systems and modularity shape interlocking patents. In short, (i) the degree of technological coupling increases the potential to establish interlocking patents, (ii) hierarchical claim structures may help protecting IP across module boundaries, (iii) centrality of functions and modules increases the potential to create interlocking effects. In addition, I discuss how legal and technological coupling jointly increase complexity which reduces imitability of these systems.

This paper makes contributions to the literature on value appropriation by investigating patent fencing for complex product industries. It also offers some explanations to increase value appropriation of modular systems, mitigating negative effects of imitation as are e.g.

described by Baldwin and Clark (2000) or Ethiraj et al. (2008). The findings that link the role of technical functions within complex products to intellectual property rights also add to the product development literature.

2. Theory

2.1 Value appropriation and patents

To appropriate value from their innovative activities, firms are eager to reduce spillovers to competitors by various means, such as lead time advantages, complexity, secrecy, or patents (Cassiman and Veugelers, 2002). Surveys from Arundel et al. (1995), Cohen et al. (2000), and Levin et al. (1987) uncovered many motives for using patents, such as preventing copying, obtaining licensing revenues, enhancing ones' position cross-license negotiations, or blocking of competitors. Patent protection, however, cannot perfectly prevent spillovers to others, which dampen a firms profits and market valuation (De Carolis, 2003, Markman et al., 2004). Even though imitation costs increase through patent protection (depending on the industry to which extent), imitators often face shorter development times as the original innovators, finally marketing imitations (Mansfield et al., 1981). However, direct imitation of products or processes is rare (Pil and Cohen, 2006), especially when patents were filed. Substitution (a special case of imitation according to Barney (1997), as long as similar technical means are utilized), occurs more often, but also minor improvements of a patented technology which, not necessarily, violate prior patents. In general, these spillovers altogether attack a patent holder's position in the market.

Guides for practitioners (Granstrand, 1999; Knight, 2001; Rivette and Kline, 2000a) describe several strategic approaches to better appropriate value through patenting, namely filing patents in a way that they represent clusters. Such clusters may, to some degree, be based on interlocking patent rights.

There is little work to date that studied such clustering strategies. On the industry level, Cohen et al. (2000) present the results of the Carnegie Mellon Survey (CMS). They gathered data from about 1,500 U.S. R&D labs, also looking at so-called patent fences, defined as patents that were filed with both the intent to block others and to not license the technology to third parties. The highest share of such (substitutive) fencing patents was found in the chemical industry, and the lowest values were uncovered in complex product industries, that, generally, rely heavily on cross-licensing (Grindley and Teece, 1997). Reitzig (2004) studied the value of individual patents from various industries and asked patentees if each patent was part of a cluster. He could not find a significant positive effect of the size of the cluster on patent value in cases where the principal motive of the patentees was blocking their competitors. A number of studies looked at the pharmaceuticals as a discrete product industry. On a general level, both Howard (2007) and Sternitzke (2010) mention that drug patents are frequently accompanied by additional patent filings, which contribute to drug lifecycle management activities. Recently, Sternitzke (2012a) investigated patent fencing within the pharmaceutical industry in more detail and found that fences are not primarily based on substitutive patents, as previously proposed by e.g. Cohen et al. (2000) or Reitzig (2004), but also involve a significant degree of complementary patents, filed to both protect imitation and block competitors. The centerpiece for all complementary patents was a basic patent, protecting the drugs' active ingredient, while subsequently novel patent filings claimed this ingredient jointly with, e.g., applications thereof, potentially prolonging overall patent protection of the drug. Sternitzke (2012b) expanded this view and found that especially basic drug patents are protected by a multiple so-called continuation applications which constitute further filings within the same patent family.[1] Finally, complementarity of patents is also central in complex product industries (Von Graevenitz et al., 2010).

[1] There are three types of patent applications summarized under the term continuations, which all might be filed

2.2 Modularity

Complex product industries often build on modularity, where products are composed of a number of modules, which has also implications on value appropriation. The concept of modularity has received substantial attention in the literature so far (Salvador, 2007, Campagnolo and Camuffo, 2010 with reviews), covering computer science (Parnas, 1972, Stevens et al., 1974), engineering (Pahl et al., 2007, Ulrich and Eppinger, 2000), and management science (Baldwin and Clark, 2000; Schilling, 2000). The latter two research streams focus on, among others, product design and here, the functional structure, being concerned with modular vs. integral designs as well as coupling of components (Campagnolo and Camuffo, 2010).

There is a vast number of definitions on product modularity, but the majority assumes that a (more or less) complex system is broken down into sub-groups (modules) of components, whereas the components of these sub-groups are highly interdependent within the groups and a highly independent across the groups, and there are (different types of) clearly defined interfaces between the sub-groups (modules) that facilitate module combinability and exchangeability (Campagnolo and Camuffo, 2010; Salvador, 2007; Gershenson et al., 2003; Ulrich, 1995; Stevens et al., 1974).[2] Modules fulfill one or more technical functions (Dahmus et al., 2001; Ulrich, 1995). Pahl et al. (2007) more specifically differentiate modules according to the nature their functions, differentiating between basic, auxiliary, special, and adaptive modules and, hence, functions. The relationship between the

at any time at the USPTO based on a still pending patent application: (i) continuation applications, which may not involve any novel subject matter, (ii) continuation-in-part applications which may involve novel subject matter that usually would be obvious over the pending application which is complemented, and (iii) divisional applications which may allow separating a patent application into several documents, often occurring when it comprises more than a single invention. Subsequently, the terminology continuation will be used for all three of them.

[2] However, it is not easy to clearly define modules or platforms in practice. Dahmus et al. (2001) mentions that e.g. Ford and Volkswagen have a completely different understanding of platform strategies, and Gershenson et al. (2003) report about a study where they asked design engineers to rate products according to their level of modularity, where they found a very high level of disagreement.

function structure, how the function structure is realized through physical components, and how the interfaces between the components are defined, is called product architecture (Ulrich, 1995; Ulrich and Eppinger, 2000).

As given in the definition above, it is the degree of connections through well-defined interfaces which determines to what degree a product design is modular or integral. According to Stevens et al. (1974), the number of connections between components and their strength defines a systems complexity, which is commonly described as coupling. This implies that when systems are integral rather than modular, complexity is much higher as there are more, and sometimes stronger, connections between the components, which makes imitation more difficult (Pil and Cohen, 2006; Mikkola and Gassmann, 2003; Ethiraj et al., 2008). However, this complexity comes at the disadvantage that also its inventors struggle, making further development more difficult. In fact, combining intermediate levels of modules or components deliver the best innovation performance (Fleming and Sorenson, 2001; Ethiraj and Levinthal, 2004). This simultaneously means that modular systems are easier to imitate, which has been shown by simulation studies (Ethiraj et al., 2008).

As mentioned above, substitution of modules (which may be synonymous to imitation), is a cornerstone of modular architecture (Garud and Kumaraswamy, 1995). For instance, Baldwin and Clark (2000) showed that after introducing a modular design, IBM lost a substantial portion of its market capitalization, allowing hundreds of competitors to build up the computer industry as we know it today through selling modular, substitutive products.

2.3 Interlocking patents and modularity

While it seems that patents clearly support value appropriation and mitigate negative effects of imitation for modular systems (Baldwin and Clark, 2000, Ethiraj et al., 2008), the current literature is surprisingly scant with respect to the role of intellectual property in that domain (Pil and Cohen, 2006). Henkel and Baldwin (2010) recently discussed the benefits of an IP modular structure in a theoretical paper, where each module is protected by *separate* IPRs of the same type. Their approach is based on characteristics of the open source software industry, assuming that there is an eco-system with many actors that support value creation through IP usage and further downstream development of the underlying modules that also delivers value upstream. So their model is based on a particular (complex product) industry but with specific business models that not fully apply for, e.g., other complex product industries such as mechanical engineering.

As patents in complex product industries frequently cover systems, devices or components which fulfill certain functions, it can be assumed that the interplay of such functions and systems, i.e. components and their coupling, determine a patents' content and may play an important role for formulating interlocking patents. In this light, it seems worthwhile to study how far patents were formulated within and across module boundaries.

3. Methodology

The scarcity of theory and evidence on how interlocking patents are created and how technical systems and modules shape such activities, I chose to inductively approach these issues based on case study research, following the tradition of Eisenhardt (1989). As can frequently be found in the literature, I selected an extreme case, which facilitates the extraction of the underlying mechanisms that play a role for shaping theory (Eisenhardt, 1989; Pettigrew, 1990), namely the Gillette company known for its famous razor business model. In the literature on IP strategies, the case of the Gillette razors is also a frequently cited one due to Gillette's superior patenting strategy (see, e.g., Rivette and Kline, 2000b). While a razor comprises two modules, the razor handle plus (disposable) blades as part of an integral cartridge, both a modular and integral product architecture can be studied within a single product. The object of the study was the Gillette Fusion razor which was introduced in the market in 2006 and the patents filed for this product.

3.1 Data collection

I used three sources of data: (a) prior literature describing (patent) strategies of Gillette, (b) patents filed by Gillette for the Fusion razor, and (c) the Fusion razor as technical artifact. Altogether, these sources allowed data triangulation. Blaxill and Eckardt (2009) provide an overview about US patents filed around the Gillette Fusion technology. Independently from this dataset, I also searched for Gillette patents in the Espacenet database and compared the results as well as those patents presented by Blaxill and Eckardt (2009) to the actual Fusion system available on the market. I found that one design patent and three from the previous Mach3 generation did not belong to the Fusion as outlined in Blaxill and Eckardt (2009), while three further patent families (with in total five patent applications) plus a further design patent were, in fact, part of the Fusion patent families. Finally, my search yielded 19 utility patent families with 41 patent applications, and eight design patents that, altogether, aimed to protect the Gillette Fusion razor. Blaxill and Eckardt (2009) listed several blade design and blade coating patents which were filed after the introduction of the Mach3, but clearly before the main Fusion patents. As it cannot be excluded that they might have been incorporated into the Fusion, I only considered them for robustness checks when searching for overlaps, not taking them into account for further analyses of this paper.

3.2 Data analysis

To better assess the scope of protection of these patent documents, I studied both the claims and drawings (the latter particularly in the case of the design patents which lack actual patent claims). I assume that an overlap of technological concepts between two patent documents implies that they are interlocking. US patent applications were the basis of this study, as many patents were not yet granted (and in some cases, will never be granted), while patent applications better reflect the strategic intents patent applicants are seeking than granted patents whose claims might have been reformulated during the approval process. For the 41 utility patents from 19 different families which may, to some degree, overlap, a direct comparison would mean 820 or 171 pairwise comparisons, respectively. Therefore, I utilized two filters and heuristics, reducing the amount of documents pairs to be compared to 31. To arrive at this number, I chose two approaches to identify similarities between documents: citation analysis (a technique which has been frequently employed to study relatedness of patent documents (Clarkson and DeKorte, 2006; von Graevenitz et al., 2010), and co-word analysis (Rip and Courtial, 1984; Callon et al., 1991; Lee et al., 2009). These two techniques provide some complementary views on relationships between documents (Sternitzke and Bergmann, 2009). A short description on identifying similar documents is provided in the Appendix. In addition to citation data, I also extracted continuation data from the USPTO Public PAIR system (providing information to what degree continuation, continuation-in-part and divisional applications were filed).

The content analysis of the patents' claims differs between (i) components of a razor, such as the handle, a cartridge, or blades, (ii) concepts (high level description of what has been claimed in the patents, such as the blade package, in this case overlapping with the razors' components), (iii) constructs (i.e. intermediate level details being part of concepts, such as the blade distance), and detailed technological constructs (more fine-grained aspects of constructs, such as a blade distance between 0.7 and 1.2 mm). In order to visualize overlaps between domains, I used social network analysis software (in this case UCINET (Borgatti et al., 1999)), considering patent applications as nodes, and ties as overlapping joint detailed technological constructs.

Furthermore, in order to elicit relationships between functions and modules as well as patent claims, I conduct function analysis as outlined in Pahl et al. (2007), differentiating between basic functions (essential), special functions (essential, but additional), auxiliary functions (optional), and adaptive functions (optional connections to other functions). Such functions are often seen as prerequisites for modules.

I also studied how far the concepts claimed follow a hierarchical technical structure, i.e. how far some components are part of components on a higher hierarchical level, such as a handle being part of a razor.

4. Interlocking patent creation at Gillette

Blaxill and Eckardt (2009) describe the recent history of Gillette razors, from the sensor (introduced in 1990) over the Mach 3 (launched in 1998) towards the Fusion system, which is marketed since 2006. According to Esty and Ghemawat (1991), Gillette has held a dominant market position in the transatlantic market, after having introduced a number of successful series of innovative razor systems, yielding a market share above 60% in the 1970s and 1980s. By then, the company encountered frequent imitation by its main competitors, the Schick Safety Razor Company, and by BIC from France. Schick, for instance, had made blades for Gillette razors for a number of years. The Sensor, the Mach3, and also the Fusion were perceived as landmarks in wet shaving. It can be assumed that the intense competition between these companies outlined also in McKibben (1998) and the role of these innovations triggered the creation of a sophisticated patenting strategy to protect the razor blades/cartridges of the three product generations sold through the famous razor/blade business model.[3]

[3] In the razor/blade business model, the razor is sold to consumers in order to create a lock-in effect, and disposable razor blades (supplies) are continuously sold at high margins, making the major contribution to the companies' revenues and profits.

Gillette filed 22 patents for the Sensor (Esty and Ghemawat, 1991; Rivette and Kline, 2000a), covering the suspension system of its twin blades as main innovation, the cartridge, angle of blades, etc. As the company's vice president of corporate R&D, John Bush claimed "we created a patent wall with those 22 patents. And they were all *interlocking* so that no one could duplicate the product" (Rivette and Kline, 2000a, p. 110; emphasis added). For the Mach3, Gillette filed 35 patents to protect the design, including a novel technology to form blades, the combination of three blades within a shaver, blade positioning, and, among others, an indicator strip signaling the degree of abrasion of the blades (Rivette and Kline, 2000b). Again, when filing the Fusion patent families, Blaxill and Eckardt (2009) mentioned that Gillette used "a blanked of protection surrounding its shaving innovation" (p. 135), without going into detail how far interlocking patents were filed. The key inventive step over the previous shaver generation (the Mach3) was the space between the blades (which is small enough to guarantee successful and comfortable shaving, but large enough to be able to clean the blades after shaving) and the number of blades (five instead of three as the Mach3). Therefore, one should expect to find these features as the core of patent protection.

4.1 The Gillette Fusion razor – an overview

Figure 1 (a) illustrates the electric version of the Gillette Fusion razor. The difference to the conventional version is the handle (see also Figure 4), while the cartridges are identical. The cartridge itself comprises the blade unit, comprising the blade package with its five flexible blades, a trimming blade to cut difficult-to-reach hair, and the lubricating strip for moistening the skin, as well as the blade guard to help guide the shaver (see Figure 1 (b)). The pivot mechanism is attached to the blade unit, comprising also the connection to the handle, which altogether form the razor cartridge. A plunger within the handle touches the blade unit and exerts a force onto it, allowing a better adjustment to the skin via the pivot mechanism. In addition, the plunger from the electric version causes the blade unit to oscillate, massaging the skin (see Figure 1 (c)). A release button at the handle enables interchanging cartridges via the interface. There is a small power on/off button on the electric handle, as well as tiny display showing the power level of the battery, with its housing incorporated into the handle. The battery can be removed from the shaver via a cap at the bottom of the handle, assuring that the housing is waterproof.

{insert Figure 1 about here}

4.2 Content of the Gillette Fusion patents

First, I looked at the content of the Gillette Fusion patents, which is also illustrated in Table 1. In total, there are ten major technological concepts protected by Gillette, with certain sub-domains, as the first two columns of Table 1 indicate. Gillette claimed one patent family on the blade design, two families on blade coating, five covered the blade package, two the trimming blade, two the blade guard, one the pivot mechanism, three cover the handle and its connection to the cartridge. The remaining five patent families distributed over two concepts address the handle and its electrical function, i.e. two families cover the circuit and switch, and three families address the battery housing. The concepts partially overlap with the components of a razor, as do concepts and constructs. An example for the former is the blade package, while the blade design exemplifies the latter.

{insert Table 1 about here}

Table 1 further provides, apart from patent (application) numbers also internal coding data for the families (familyID) and documents (DocID), which are subsequently used to refer to specific documents. The various documents per patent family emerge from continuation filings, which are described in the last column of the table, consisting of continuations and divisional applications (i.e. applications that were split up).

4.3 Legal coupling within modules

4.3.1 Coupling and interlocking patents

Second, I searched for overlapping detailed technological constructs between documents, following the methodology outlined in section 3 and the appendix of the paper, which also lists the detailed results of this search. Of the 31 patent pairs under investigation, overlaps across detailed technological constructs were found in 16. Figure 2 shows that, in fact, 16 of the 19 patent families are somewhat connected. Each patent family, indicated by its ID, is illustrated by a node. Concepts claimed are represented by the shape of the nodes. It can be observed that, while there are three isolated nodes, two network components exist. The smaller one relates to the handle and its electric unit, which is isolated from the main component. The latter is dominated by blade package patent applications, with family #1 as the most highly connected node. Hence, interlocking patent rights are more frequently found within the same constructs (see, e.g., the strong linkages between patent families #8 and #9, or #2 and #4), but also across module boundaries.

{insert Figure 2 about here}

So Gillette claimed certain technical elements in more than one patent family, within and across technological sub-groups of components with different functionality. For instance, the blades within the cartridge on the one hand must be easy to clean, which requires a sufficiently *wide* blade distance. On the other hand, the blades must assure a smooth shaving experience, which is reached through a *narrow* blade distance and blade flexibility, while at the same time a spring-mounted plunger exerts a force onto the pivotally-mounted plane in which the blades are situated, pressing them gently against the skin. Thus, multiple components of the razor fulfill multiple, interconnecting functions which are technologically highly coupled and, thus, complex. This alone makes it difficult to imitate such a cartridge with its integral structure, following the argumentation of Pil and Cohen (2006) and Ethiraj et al. (2008). When multiple patents are filed to protect components of complex systems, then these components may be mentioned in multiple patents as could be seen in the Gillette case. Hence, a high degree of technological coupling should make it easier to file separate patent families protecting certain technical details jointly, which leads to the following proposition:

Proposition 1: The higher the degree of technical coupling of components, the higher the potential to integrate these components into multiple patent families (cross-patent family legal coupling of components).

My results with respect of detailed technological components claimed across various patent families revealed that there are no linkages between the handle with its electrical unit, which is optional as Gillette markets both a conventional and an electric version of the Fusion, and the purely mechanical part comprising the blades, the blade package, etc. meaning that there are no detailed technological constructs spanning the boundaries of (the handle and the cartridge) modules. The reason certainly lies in the definition of modules given above, where technical coupling across modules is minimized, and so, in the light of the previous discussion, is the potential for formulating patent claims with overlapping technical constructs. Hence, boundaries of modules represent also boundaries for legal coupling which is tight to technological coupling:

Proposition 2: Modularity of technical systems reduces the potential of a component being claimed in multiple patent families (i.e. for cross-patent family legal coupling) across module interfaces.

4.3.2 Function, modules, and interlocking patent rights

I furthermore conducted a function analysis of the razor as an artifact as well as the concepts and constructs claimed within the patent documents in order to elicit patterns of modularity and their relationships to interlocking patent claims. Doing so, I followed the definitions of Pahl et al. (2007) who distinguish between basic, auxiliary, special, and adaptive functions. Basic functions and are essential for the product. They are accompanied by auxiliary (i.e. additional and also essential) functions. Special functions relate to complementary or sub-functions, which are optional, while adaptive functions, either essential or optional, are required to adapt to other systems. Technically, some of these functions may be represented by modules, whereas these modules may be integrated to a higher extent than those modules a customer may exchange, such as the cartridge and the handle of the razor.[4] Some of the functions are also perceived as product features by the customer. Figure 3 illustrates the functional structure of the Gillette Fusion razor. Arrows indicate the direction of an effect by the functions.

{insert Figure 3 about here}

Within the cartridge module, various functions exist. The most central and also basic function is cutting hair, accomplished by the blades. There are various auxiliary functions, such as preventing corrosion by using an anode connected to the blades, adjustment of blades to the skin by means of flexible blades, the adjustment of the cartridge to the skin by means of a pivot mechanism, and moistening the skin through a lubricating strip. In addition, difficult-to-cut hair can be cut by means of a trimming blade, which, again, can be adjusted easier through markings on the cartridge. A sufficient wide blade distance in the case of the five shaving blades as well as a canal next to the trimming blade assure easier cleaning of the blades under water.

The razor handle serves to hold the razor, which is a basic function. This function is complemented by an auxiliary function, i.e. a handle structure that assures a firm grip in a wet environment. The handle is finally releasable connected to the cartridge. There are also

[4] See Footnote 2 for ambiguity in defining modules.

several special functions with respect to the power unit available for the Fusion Power razor imposing vibrations to the cartridge.

Being in a central position as a basic function not only means that the components fulfilling the basic functions are more highly coupled, it may also imply that it could be necessary (or advisable) to mention these technical relationships also when filing patents for the surrounding components. So, for complex products protected by multiple patent families the potential increases that the components fulfilling the basic functions can be named in a number of different patent families, facilitating overlapping patents. Therefore, I propose:

Proposition 3: Components which fulfill basic functions and which are highly coupled with auxiliary, special or adaptive functions have a higher potential to be integrated into multiple patent families (cross-patent family legal coupling of components).

4.3.3. Strategic importance of functions

Table 2 provides an additional overview about the technological constructs claimed jointly across sub-groups of the razor cartridge. Here, the trimming unit and the number of blades are the most frequently used items. This is an interesting finding with respect to the trimming blade as it was claimed on the formal level only within a single patent family, and a less surprising finding for the blade distance, which is a core innovation of the Fusion shaver.

{insert Table 2 about here}

Important technologies are often protected through patent clusters (Granstrand, 1999; Knight, 2001; Rivette and Kline, 2000a). On the component level, the trimming blade appears to be an example here. It fulfills rather an auxiliary than a basic function, but according to Table 2, it is involved in legal coupling relatively often. So one can conclude that the frequency by which the trimming blade is mentioned in different patent families is also affected by its strategic importance for the applicant. This means that strategically important technological constructs (such as components) are more frequently claimed than one would expect from the location of the component or the basicness of its function. Hence, I propose:

Proposition 4: The strategic importance of technological components positively moderates the relationship between the degree of technical coupling and the likelihood to be integrated into multiple patent families (cross-patent family legal coupling of components).

4.4 Continuations

As Table 1 illustrates, 14 of the 19 utility patent families comprise 9 divisional applications and 13 continuations.[5] To name a few examples for continuations, the first patent filed in family #1 relates to the blade distance, but, by filing a divisional application, covers the flexibility of blades as well. In total, six patent applications are involved here, certainly as the blade distance is the main innovation in comparison to the Mach3 razor generation. Family #5, with seven independent claims, is further split up into a mechanism for the blades' corrosion protection, and also a blade package holder. In fact, the contents claimed within the documents of one patent family often overlap.[6] So, using continuations, Gillette applied a second approach to create interlocking patents that are based on the same patent family, in contrast to the content claimed in various patents across patent families and discussed above.

Filing continuations broadens the technological space, meaning that single patent applications are reformulated over time and partially split up. The results are legally independent patent documents, which, however, are closely related through their content and partially also overlap. The existence of such reformulations was already shown for pharmaceutical patents where they are primarily used for highly important substance patents

[5] There was one continuation-in-part from an application which was not published (and obviously withdrawn), so this continuation-in-part was treated as a regular application.

[6] For a robustness check, I also studied the patents granted within the dataset. Here, an overlap could be observed in three out of five families with at least one granted continuation, including e.g. a method to manufacture a device which has been claimed in the regular application, or adding more detail to certain specific features.

protecting the active ingredients of drugs (Sternitzke, 2012b). They are, according to Graham and Mowrey, 2004), very common in the software industry, but in many other fields as well (Hegde et al., 2009). Thus, continuations are a frequently applied approach for creating interlocking patent rights, but also allow reformulating claims later on that eventually cover products introduced by competitors (Lemley and Moore, 2004). Gillette also used continuations to protect its patent filings relating to the blade distance, one of the core concepts of the Fusion razor, where this family finally involves six patent applications. Hence, the finding that important inventions are protected by multiple continuations can also be seen in a complex product industry.

4.5 Hierarchical claim structure for across-module interlocks

Furthermore, I studied the nature of the independent patent claims contained in the utility patents filed.[7] In general, multiple basic types of claims are possible, protecting devices, systems, processes, etc. Gillette used mainly three basic types of patent claims: first, it filed product claims for a razor, a handle, cartridge, etc. Second, the company filed "method of manufacture" claims covering a razor, a handle, or blade unit. McKibben (1998), for instance, stresses the importance of manufacturing for a new razor, a key aspect to yield high profit margins, which explains why Gillette put considerable emphasis on such process patents. Furthermore, "method to use" claims were formulated, protecting the use of a cartridge, a method to connect a cartridge to a razor (aiming to protect the modular use), and a method to shave. Table 3 gives an overview about these three basic claim structures as well as the components claimed therein (i.e. the razor, cartridge, handle, etc.). The components are presented in hierarchical order. They describe how the components relate to each other technically (e.g. a blade is part of a blade package). Table 3 furthermore shows in which

[7] Generally, there are dependent and independent claims. While the former always reference to the latter, adding technical features and uses to an independent claim, the latter stand for themselves.

patent families such claims were filed, and how frequently which component was claimed in total.

{insert Table 3 about here}

The most frequently utilized product claim directly relates to a razor (claimed in 14 out of the 19 patent families), being on the first hierarchical level as it (theoretically) covers both the cartridge and the handle of the razor as well. Next, there is the blade unit claimed within six patent families, which, in its blade package, comprises the novel arrangement of blades with its much shorter distances in comparison to the Mach3 razor. Claims relating to the handle and cartridge come next, claimed in four and three patent families, respectively, from which the handle is mainly mentioned in those families relating to the electric version of the razor. This also underlines the importance of innovations made in these areas.

So far the interlocking effects of utility patents were analyzed. As mentioned before, Gillette also filed eight design patents for the Fusion razor. The results are presented in Figure 4, which illustrates the relationships between the different design patents based on some of the patents' drawings. Three design patents cover the manual version of the Fusion, and two relate to the electric version with a different handle. There are three additional filings relating to the cartridge, the blade unit contained therein, and the cartridge dispenser. The drawings show that certain elements of a razor are protected by multiple design patents. Regarding the complete razors, different design patents relate also to the handle (which is already protected by the razor design itself), and in the case of the manual version, the gripping element of the razor/razor handle was claimed independently as well. So Gillette also filed interlocking design patents here (following also a hierarchical technical structure) that complement the utility patents which, partially, rely on the same drawings.

{insert Figure 4 about here}

The hierarchical decomposition of technical systems facilitates the description of such systems in patent documents. However, there is a second advantage, as at the same time such a structure allows protecting technological components across module boundaries, given that modules are reflected in the components claimed. Therefore, I propose:

Proposition 5: Different modules of a product can be protected by a hierarchical claim structure, mentioning several technical constructs in independent claims that follow a technical hierarchy.

5. Discussion

5.1 Value appropriation and modularity

The case of the Gillette Fusion razor has shown that interlocking patents can be filed based on three basic principles: (a) using detailed technological constructs claimed in various patent families that cover technical details within the same module, (b) using technical hierarchy of components to claim features across module boundaries within the same patents, and (c) utilizing continuations to file several related (and overlapping) patent applications. Such approaches may help firms appropriate value through intellectual property more effectively. Filing such interlocking patents also helps creating patent fences, which, in this case, do not rely on substitutive patents as described in Cohen et al. (2000) or Reitzig (2004), but they build on complementary patents as recently shown by Sternitzke (2012a) for the pharmaceutical industry.

With respect to modular and integral systems, this paper adds to the prior literature that (a) more densely coupled systems facilitate drafting interlocking patents based on multiple patent families, (b) more central functions such as basic finctions facilitate the creation of interlocking patent claims across multiple patent families. Therefore, this paper contributes to filling the gap between IP and modularity as menioned by Pil and Cohen (2006). Employing function structures as a basis for interlocking patent rights also provides guidance for new product development scholars which, to date, have neglected the relationship between such structures and patent filings tight to them. The findings also expand our understanding of complex systems: Complexity is an effective isolating mechanism to protect firms' resources (McEvily and Chakravarthy, 2002). Imitators who wish to copy a product such as the Gillette Fusion shaver not only have to manage the complexity of copying technological coupling of components within these modules (Pil and Cohen, 2006; Mikkola and Gassmann, 2003; Ethiraj et al., 2008), they also have to cope with legal claims protecting these technological components and their coupling within multiple patent rights, with the consequence that they have to circumvent such legal coupling. In order to yield innovative solutions, which may be a necessity even for firms that intent to "copy" a product like the Gillette Fusion without infringing any patents, it is necessary to copy also inter-module relationships (Ethiraj et al., 2008). Hence, in this context, legal boundaries that protect either interfaces, modules, or both simultaneously further trigger complexity. As complexity increases with the number of possible combinations of different elements, these legal issues added to technical ones imply that complexity may increase by several orders of magnitude through filing interlocking patent rights.

5.2 Boundaries of interlocking patents

The findings from the Gillette case are certainly not a suitable strategy for value appropriation for every company, especially concerning module-spanning patent rights. Henkel and Baldwin (2010), for instance, argue that keeping an IP regime within the boundaries of a module (an IP-modular vs. an IP integral structure) allows the innovator of a core module to benefit from further developments occurring for downstream complementary modules. Their theoretical paper relates to the open source software industry and its business model relying on an ecosystem where such downstream developments take place. So for open source business models the approach of filing hierarchical patent claims might deteriorate the business model when these patent rights should be enforced.

A razor/blade business model, however, depends heavily on the concept of creating a lock-in with a product (in the Gillette case, the razor handle), and selling high-margin supplies over the course of time. For instance, third-party firms selling razor cartridges that fit to this particular Gillette handle would endanger this business model. In fact, when Gillette was still making relatively simple razors, competitors sold blades that also fitted into Gillette products (Esty and Ghemawat, 1991), making it difficult to pursue such a razor/blade business model effectively. Apart from razor/blade manufacturers such as Gillette, a range of industries have adopted this business model, such as inkjet printer manufacturers, copier makers for home users (Chesbrough, 2005), instant photography companies such as Polaroid (Gavetti, 2005), but also parts of the biotechnology industry (Mitchell, 2001). For them, it is pivotal to control IP for both the "razor" and the "blade": When considering the Gillette Fusion cartridge with its five flexible blades, its trimming blade and lubricating strip, etc. one could imagine that a competitor could design a similar cartridge which would not violate the Gillette patents, even though, in this particular case, would be a challenging endeavor in the light of the interlocking patent rights. In theory, the competitor then could also sell these cartridges to Gillette customers, despite the fact that they might deliver a different shaving experience. Therefore, it becomes an asset to control also the interface between the modules via IP, as every copied product needs to be connected to e.g. the razor handle. Gillette designed such an interface which could be protected by IP, filed patents accordingly (families 11 and 13), and it used its hierarchical structure to do so.

5. Conclusion

In this paper, I showed that Gillette used three concepts to create interlocking patents. I argued that technically highly coupled components within a module facilitate filing multiple patent families covering the same technical components or technical constructs, particularly if these components fulfilled basic functions. These filing strategies were described as 'legal coupling'. At the same time, technical coupling implies that it becomes inherently difficult to claim the same highly coupled components across module boundaries (i.e. interfaces), as *per definitionem*, such coupling is only strong within modules. However, by applying the principle of hierarchy, module-spanning claims can be filed. Continuations not only allow creating partially overlapping patents, they also induce uncertainty to the technical content claimed by a firm, increasing costs at competitors as they have to eventually redesign products broadly to prevent infringing upon a possible continuation application. Especially the two former strategies are different from those that had been described in the literature so far to create interlocking patents, in particular the concept where a core patent is complemented by e.g. application patents (see Sternitzke, 2012a). The reason should primarily lie in the nature of complex product industries where multiple functions are necessary or desired for a product.

The business model which a firm pursues imposes boundaries on using interlocking patents across module boundaries. In the razor/blade business model, where multiple modules are sold by the same firm, especially a core module and various supplies, having IP on the interfaces is pivotal for success in order to keep competitors at distance. However, such an approach may also be useful in many other areas, for instance in mechanical engineering where the after sales business with supplies as a revenue source gains more and more importance. To conclude, this paper not only deepened our understanding of the processes behind the creation of interlocking patents, it also complemented the previous and sparse literature on IP and modularity, with relevancy for new product development.

This paper also has its limitations. First and foremost, I conducted a case study without insights from interviews, omitting the internal perspective of the company whose patent strategy I am studying, which naturally leads to some limitations. However, as I am observing how patents were designed as they were published, omitting the observation of specific intents in the process of creating such patents does not change their final structure as it exists, and which still allows drawing some important conclusions on how to effectively draft interlocking patents. Second, this paper relates to a single case. Therefore, the findings presented therein should be investigated for other firms e.g. operating according to the razor/blade business model, such as inkjet manufacturers, or certain biotechnology firms. There may be further business models that would benefit from these approaches, others may be not. Future research could replicate such research on the level of individual patent claims for other industries e.g. telecommunications and semiconductors. Technological coupling can also take place across the boundaries of IP from different owners, explaining the emergence of patent thickets. Finally, deductive theory testing could build upon this work.

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Figure 1: The Gillette Fusion razor – electric version. (a) view from top, (b) cartridge, (c) cross-section of cartridge and cartridge connection.

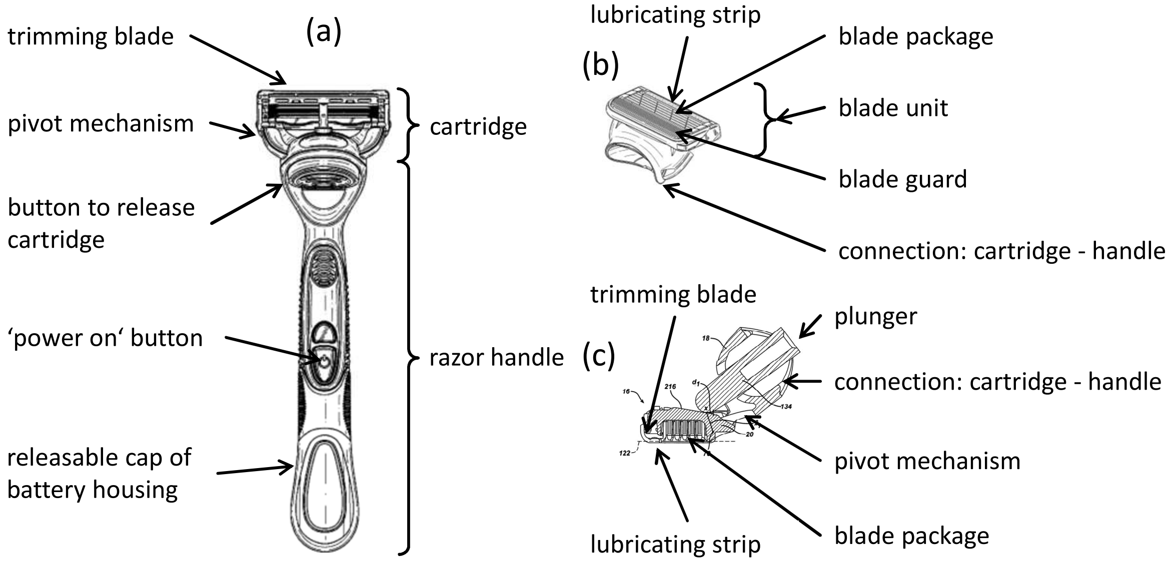

Figure 2: Network of overlaps between patent families. Tie strength is proportional to the number of joint detailed technological constructs. Family IDs plus concepts are indicated.

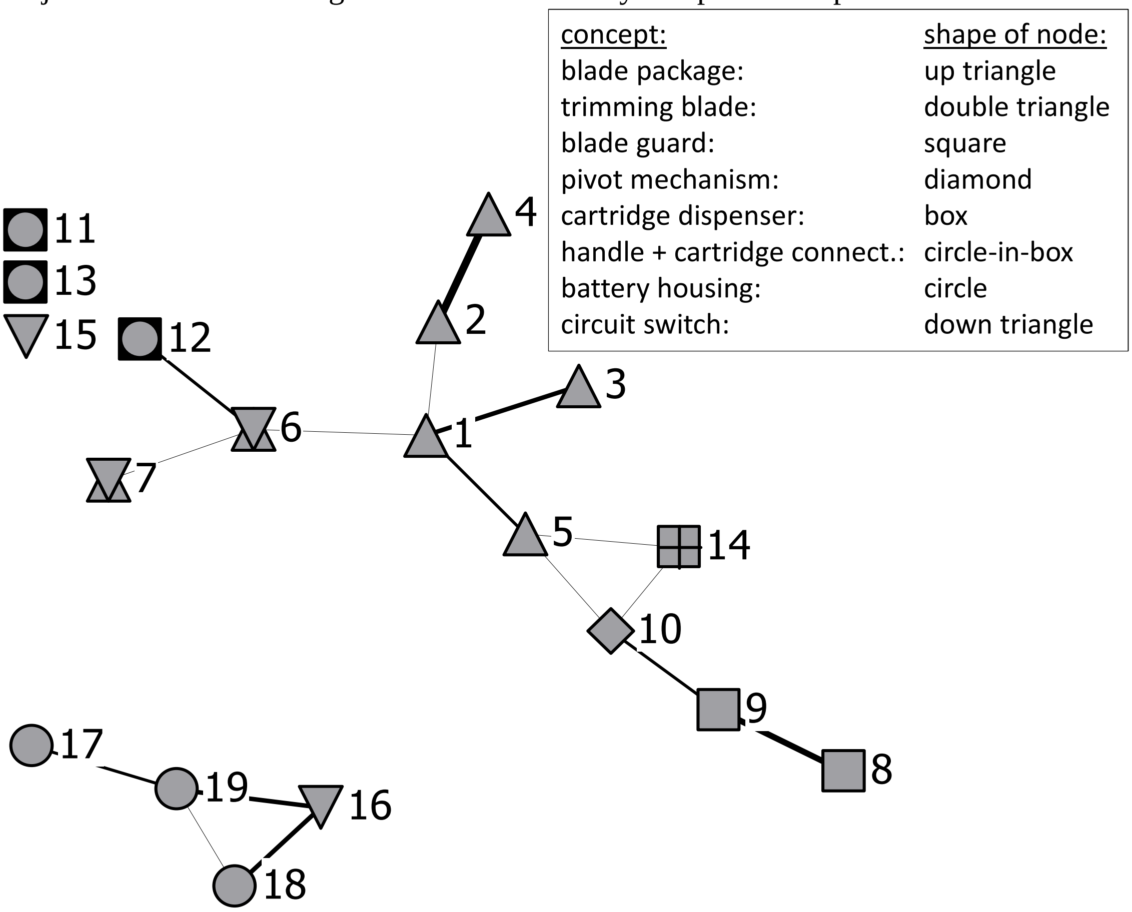

Figure 3: Function analysis of the Gillette Fusion razor, following Pahl et al. (2007).

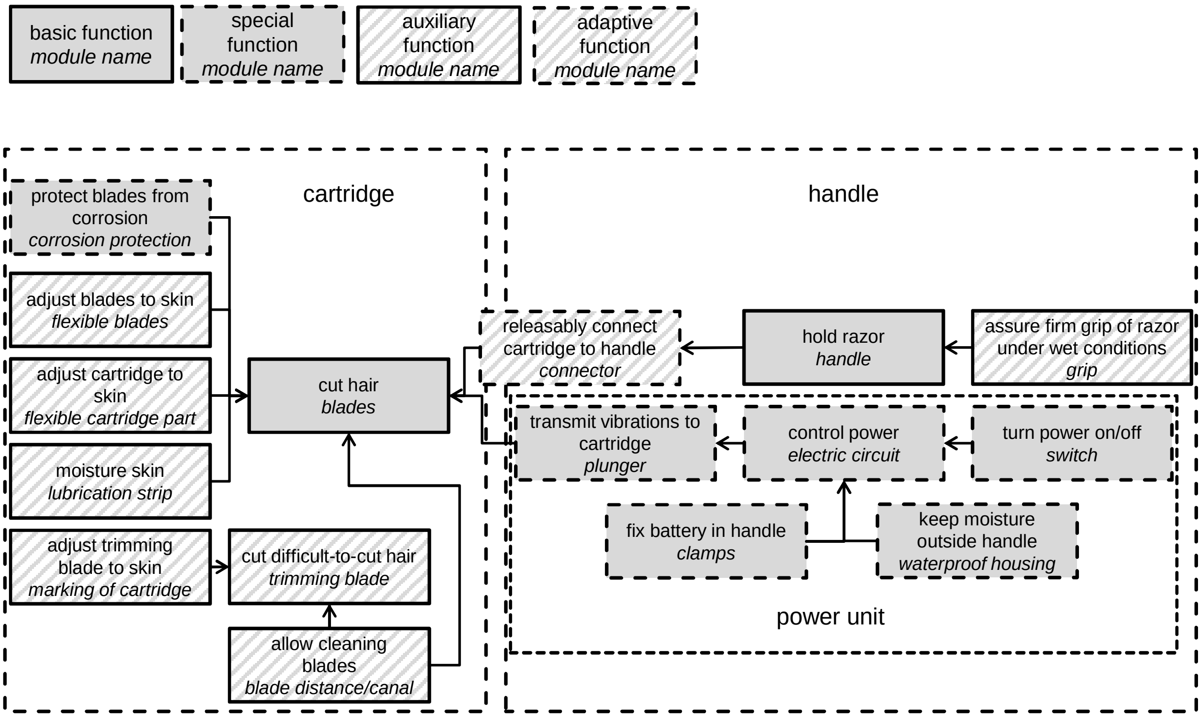

Figure 2: Design patents claimed for the Fusion design.

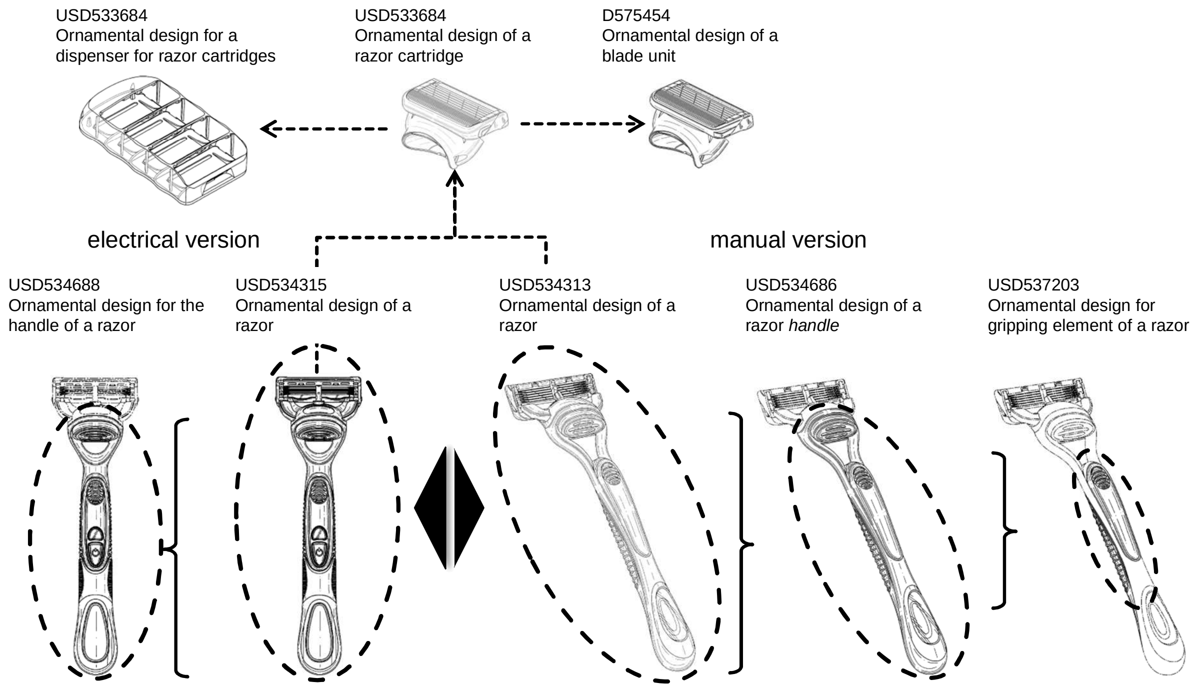

Table 1: Categories of patents, constructs, and patent family information

Concepts claimed	Constructs (details of concepts) (if not specified: first one, or see category)	Family ID	DocID	Patent application number	Continuations (CAP, DIV)
Blade package	Blade distance	1	1		-
			2		CAP
			3		CAP
			4		CAP
	Flexible blades		5		DIV
			6		DIV
	connector for supporting metal strip	2	7		-
			8		DIV
			9		CAP
	blade dimensions of supporting metal strip	3	10		-
			11		CAP
			12		CAP
	single blade holder	4	13		-
	trimming blade holder, corrosion protection	5	14		-
	corrosion protection		15		DIV
	holder		16		DIV
Trimming blade	Trimming blade + blade package	6	17		-
	Trimming blade: trimming comb guard		18		DIV
	Trimming blade alignment	7	19		-
			20		CAP
Blade guard	distance + force distribution of razor	8	21		-
			22		CAP
		9	23		-
Pivot mechanism		10	24		-
			25		CAP
Handle + cartridge. connect	release button	11	26		-
			27		CAP
	fingerpad	12	28		-
			29		CAP
	ejection mechanism	13	30		-
Cartridge dispenser		14	31		-
			32		DIV
Circuit + switch	Circuit/switch in wet powered razor	15	33		-
	Circuit in wet powered razor		34		CAP
	Circuit/switch in wet powered razor		35		DIV
	Switch housing of wet powered razor	16	36		-
Battery housing	closing system	17	37		-
	Battery housing in grip + actuator	18	38		-
	Battery housing in grip + actuator		39		DIV
	Battery housing in grip + actuator		40		CAP
	fixture in handle	19	41		-

CAP – continuation application; DIV – divisional application

Table 2: Legal coupling and claimed constructs

Joint concepts	Claimed constructs
blade package vs. cartridge dispenser	trimming unit
blade package vs. pivot mechanism	trimming unit
blade package vs. trimming blade	number of blades
pivot mechanism vs. cartridge dispenser	trimming unit
pivot mechanism vs. blade guard	trimming unit
	permanent or releasable of cartridge and handle
trimming blade vs. handle/connector to cartridge	number of blades
	stop position for shaving head when trimming blade is used

Table 3: Hierarchical structure of patent claims used, differentiating between product claims, manufacturing claims, and others (patent family level).

	Hierarchical structure (family ID)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	times claimed
Modules of product	Razor	X	X		X	X	X	X	X	X	X	X	X	X		X		X			14
	Handle											X					X		X	X	4
	Cartridge								X		X				X						3
	Blade unit*	X		X	X	X	X			X											6
	Blade package**		X	X																	2
	Trimming blade						X														1
	Lubricating strip						X														1
	Dispenser														X						1
Manufacturing	Method to make razor		X																X		2
	Method to make handle																		X		1
	Method to make blade unit				X	X															2
	Method to make dispenser														X						1
Others	Method of shaving								X												1
	Method to use cartridge														X						1
	Method to connect cartridge														X						1

*Partially described as subassembly. **Partially described as cutting member in the claims.

Appendix

Explanation of similarity analysis based on co-word and citation data

The legal scope of a patent is primarily determined by its claims. Therefore, I conducted a co-word analysis on these claims, following the approach outlined in Sternitzke and Bergmann (2009). In brief, the words from the claims were extracted per patent document. Then the most occurring words, and those that hardly let discriminate between documents, were deleted based on so-called stopword lists.[8] Next, the words were standardized by means of a porter stemmer (Porter, 1980), deleting plural endings, etc. As words with a medium occurrence allow best to discriminate documents (Blanchard, 2007), the long tail of single-occurring words was erased as well. Document similarity was calculated by an asymmetric matrix (list of words vs. documents in analysis), followed by a symmetric matrix using the inclusion index, which measures to what degree co-occurring words are represented in the document pairs. As Sternitzke and Bergmann (2009) could show, for comparisons as in this paper, the inclusion index is best suited.

In order to elicit citation links between the patent documents, I used citation information from the USPTO website. As the patent applications do not contain any examiner citations in contrast to granted patents (which were used where existent), I additionally extracted full text citations made by Gillette and its attorneys throughout the patent description.[9]

Based on both the matrix with the citation ties and similarity values, the cells (relating to single patent application documents) within the matrices were grouped according to patent

[8] For this procedure, three types of stopword lists were employed: First, a general one with words such as “the”, “is”, etc., a second with patent-specific language (such as “claim”, “comprise”, etc.), and third a list specific to the field of safety razors. Here, words such as “razor” do not have any discriminative power and are supposed to be deleted (Jarneving, 2005).

[9] Patent citations are subject to various limitations described in the literature.

family information from Espacenet. When either a citation link existed between two different patent families or the inclusion-index-based similarity value was higher than 0.5 for any document comparison between the family member documents, then the claims of the oldest documents from the patent families were manually compared.[10] This approach yielded the 31 document pairs for the comparison, one form of content analysis frequently employed in case study research.

For robustness checks, the patent filings on blade design and blade coating filed a couple of years earlier, but after the introduction of the Mach3, which were also mentioned by Blaxill and Eckardt (2009), were integrated as a robustness check. No overlaps for those patent applications among those families and with the primary dataset were found.

Results of the similarity analysis

Table A1: Linkage between document pairs and detailed technical concepts claimed jointly therein

document pair (DocID-DocID)	links connecting concepts/constructs*	Overlap based on detailed technological constructs
1-8	blade distance – blade package: connector for supporting metal strip	• number of blades
1-10	blade distance – blade package: dimensions of blades welded onto a supporting metal strip	• number of blades • angle of blades (direct (1) + supplementary (16)) • blade distance (direct (1) + distance of blade set (16))
1-14	blade distance – blade package: trimming blade holder, corrosion protection	• number of blades • design of blade guard
1-17	blade distance – trimming blade + blade package	• number of blades
1-23	blade distance – blade guard	-
1-26	blade distance – handle + connection to cartridge: release button	-
1-30	blade distance – handle + connection to cartridge: ejection mechanism	-
8-10	*blade package: connector for supporting metal strip – blade package: dimensions of blades welded onto a supporting metal strip*	-
8-13	*blade package: connector for supporting metal strip – blade package: single blade holder*	• longitudinal ends of blades/blade support • number of blades • cutting edges in a common plane • subassembly has snap-fitting structure for connection to razor housing • housing with a recess to incorporate subassembly
14-24	blade package: trimming blade holder, corrosion protection – pivot mechanism	• trimming unit

[10] When there was one document pair which had both a citation link and a similarity value > 0.5 simultaneously, then this document pair was chosen over the oldest from these patent families.

14-31	blade package: trimming blade holder, corrosion protection – cartridge dispenser	• trimming unit
17-19	*trimming blade + blade package – trimming blade alignment*	• embeddedness of trimming blade
18-28	trimming blade: trimming comb guard – handle + connection to cartridge: fingerpad	• number of blades • stop position for shaving head when trimming blade is used
21-23	*blade guard: distance + force distribution of razor – blade guard*	• elastomeric fins • fins longer than blades • A Shore hardness of fins between 28 and 60 • trimming unit
21-26	blade guard: distance + force distribution of razor – handle + connection to cartridge: release button	-
21-31	blade guard: distance + force distribution of razor – cartridge dispenser	-
23-25	blade guard – pivot mechanism	• trimming unit • permanent or releasable connection of cartridge and handle
23-26	blade guard – handle + connection to cartridge: release button	-
23-31	blade guard – cartridge dispenser	-
24-26	pivot mechanism – handle + connection to cartridge: release button	-
24-30	pivot mechanism – handle + connection to cartridge: ejection mechanism	-
25-31	pivot mechanism – cartridge dispenser	• trimming unit
26-30	*handle + connection to cartridge: release button – handle + connection to cartridge: ejection mechanism*	-
26-31	handle + connection to cartridge: release button – cartridge dispenser	-
26-38	handle + connection to cartridge: release button – battery housing in grip + actuator	-
30-31	handle + connection to cartridge: ejection mechanism – cartridge dispenser	-
36-38	switch housing of wet powered razor – battery housing in grip + actuator	• grip portion and battery cover form a water-tight unit • all components for battery-powered functionality within grip • subassembly within grip comprising carrier + switch or electronic on carrier
36-41	switch housing of wet powered razor – battery housing in grip: fixture in handle	• housing comprises grip portion + battery cover • grip portion + battery cover form water-tight unit • all components for battery-powered functionality within grip
37-38	*battery housing in grip: closing system - battery housing in grip + actuator*	-
37-41	*battery housing in grip: closing system - battery housing in grip: fixture + handle*	• pair of battery clamp fingers that exert force against battery • spring force of clamp fingers is 0.5N @ 9.5mm battery diameter, less when larger
39-41	*battery housing in grip+ actuator - battery housing in grip: fixture + handle*	• pair of battery clamp fingers that exert force against battery

*links between documents of the same concept/construct in italics
Number of blades only mentioned when in separate dependent claim (not as part of a complex main claim), except for family #1 where the number of blades plays a pivotal role.
If several documents within one family form a link then only those documents with the lowest ID are compared (i.e. the oldest).
When in one family both word-similarity > 0.5 and a citation link existed, then this pair ceteris paribus was chosen.