Noise and Silence in the Hearing Instrument Industry

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Foreword

This working paper was initiated on the basis of our joint interest in the hearing instruments industry. We represent two different departments at the Copenhagen Business School and have, therefore, in many ways very different research traditions. Furthermore, Kristina Lee is involved in the industry on a daily basis through her Industrial Research program. This connection has produced insights which also spurred many a discussion.

The research has spanned about 13 months of effort, although at various levels of intensities, and it has been highly explorative. Our curiosity has produced a vast number of observations and the present report is, thus, certainly more comprehensive, but also perhaps with more perspectives than planned.

We expect it to be used for three different purposes. Firstly, as an in-depth analysis of the industry, particularly providing some explanation for the observed stability of market structure over time in the face of technological innovations. Secondly, the report may serve as teaching material supplementing theoretical treatments in industry analysis and technology strategy. Finally, the research report may serve as a springboard for future research.

The outline of the report is as follows: Section 1 provides an introduction to the empirical and theoretical problem to be investigated; section 2 outlines the industry's structure; section 3 is a review and discussion of three theoretical perspectives on the relation between technology and industry structure; section 4 is an in-depth industry analysis of all levels and interfaces of the value chain; in sections 5 and 6 we consider the future perspectives and line up some theoretical implications of the analysis.

We would like to use this opportunity to thank three persons who have seen earlier drafts of this work. They have all in their own way been very helpful in framing our work. We acknowledge the constructive inputs from Ivo Zander, Stockholm School of Economics; Jens Frøslev Christensen, Copenhagen Business School; and an industry representative whose identity we cannot reveal. Furthermore, we appreciate the sparring provided by Torben Poulsen, Technical University of Denmark.

Whether the reader is an industry representative, a student, or a researcher, we hope you will enjoy reading our analysis. Comments can be directed to either of us at the Copenhagen Business School and will be most welcomed.

Kristina Lee & Peter Lotz
March, 1998

Summary

This report examines the stability in the hearing instrument industry. Over the past 25 years, the industry has changed only very little in terms of industry structure. It seems odd that a technologically very active industry should be stable in terms of structure. Current theoretical and practical concerns of hyper-competition and high pace technology development argue that technological innovations should have severe impact on industry structure. In a broad-scope analysis of the industry, we seek to correlate the type of technological development carried out in the industry to its structural development.

The empirical analysis consists of an examination of possible factors influencing the stable industry structure covering the entire value chain including the interfaces within it. We conclude that there are a number of stabilizing factors in the hearing instruments industry structure and technology which account for the relative stability of the industry (measured by changes in market shares, mergers & acquisitions, entry and exit).

The factors most important to stability is, in our view, the *systemic character of hearing instrument technology* and *the "sticky" distribution channel* (dispensers). The former implies that possibilities for breakthrough technology in the hearing instrument itself and its sub-components are restricted, providing a high degree of inertia. The structure and competence of the dispenser level implies that the commercialization of new types of hearing instruments takes place at a slow rate. Both factors limit first-mover advantages and thus competitive upheaval.

But also customers and suppliers contribute to stability: At the end-user level, factors contributing to stability are stigma, getting-used-to-effects, and the issue of essentially trying to make a product which compensates for a defect organ. Furthermore, our analysis of the price-elasticity of hearing instruments show that price reductions will not be profitable to the industry and will not increase market penetration substantially. Combined, these factors essentially establish a demand limit which is not expected to be moved or overcome unless significant improvements in price/performance of hearing instruments come about. At the supplier level, the stabilizing factors come from oligopolistic competition and the systemic character of hearing instrument technology. In the component market for one important type of strategically important parts (transducers), competition has historically been limited with only one or two suppliers, a factor which limits variation significantly.

The analysis of actions and moves by hearing instrument manufacturers lead us to term the type of competition among them as one of a *"friendly oligopoly"*. This expression is meant to signify the friendly coexistence of a number of important, competing hearing instrument manufacturers. We conjecture it to stem from a defensive attitude, as reasons for overtly

competitive behavior are few (price reductions and increased advertising seem to have little effect on market shares). The friendly oligopoly has enabled a number of joint efforts among competitors (patent pool, joint R&D-projects and alliances, development of shared fitting software, production agreements, and joint marketing). This obviously gives competition a different face than is usually portrayed.

We question the possibility of future stability in light of digital signal processing technology. This new technology may change the competence distribution between suppliers and hearing instrument manufacturers. The recent success of Widex' fully digital hearing instrument, Senso, may signify a new era in the hearing instrument industry. However, these potential changes remain to gain full effect.

In terms of theoretical considerations, we question the predictive usefulness of the innovation typologies which have been proposed recently, although their explanatory power may prevail. In our analysis of the hearing instrument industry over the past 25 years, we could not identify innovations with disruptive effects on industry structure. Analytically, that may have two reasons: One, there was no innovations with this potential; and two, the innovations were there, but their effects may have been restrained. Our analysis shows the inadequacies of existing theories in distinguishing between these two possibilities. This industry does not lack innovations, but neither does it lack stabilizing factors which provide a "bulwark" against disruptions in structure. While we cannot measure these two effects against each other, our analysis suggests that we in the hearing instrument industry are dealing with a combination of innovations with limited potential for disruptive effects and a strong "fence" of stabilizing factors dampening variations.

Since stability is the hallmark of mature industries (which often are perceived as boring), understanding *why* such industries are stable is crucially important for developing our models and ideas about industrial organization and strategic management in especially in such industries.

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1 Introduction

It is commonly accepted that competition and technology nowadays change at an ever increasing speed. Observations of breakthroughs in technology (microprocessors, biotechnology, software) and the ensuing emergence of new strong companies (Texas Instruments, Genentech, Microsoft) or the elimination of old flagships (Facit, WordPerfect) have led business people and researchers to speak of a new era in competition in which nothing is stable, technology is unpredictable, consumers are disloyal, and competitors come and go (D'Aveni, 1995, is an example).

An influential strand of theories elaborating on the product-life-cycle (Utterback & Abernathy, 1975; Abernathy & Utterback, 1978) has demonstrated that new technologies may disturb the "law-and-order" in established industries (Klein, 1977; Tushman & Anderson, 1986; Henderson & Clark, 1990; Suarez & Utterback, 1995). This research tradition considers what happens in an industry when a new technology appears, and conjectures a causal relation running from technology to industry structure. It provides one possible reason why industries may be turbulent.

Accepting that technology may cause turmoil in an industry, it may come as a surprise that some industries with high technological activity are relatively stable anyway. The hearing instruments (hearing aids) industry is typically described as a technologically vigorous area. Important features of annual reports from hearing instruments companies (see e.g. recent annual reports from Oticon or Phonak) are always the applause of new technological breakthroughs, and general technical magazines (and newspapers) frequently report on technological progress in hearing instruments (e.g. Adam, 1996). And yet, since the last major entry in the early 1970s, the structure of the hearing instrument industry has remained surprisingly stable (stability measured by e.g. entry and exit, market shares, and merger activity).

The purpose of this article is to investigate the stability of the hearing instruments industry over this period. In our attempt to answer this question, we follow two main paths. The first is a discussion of what it takes for a technology to cause turmoil. That is, not all technological innovations have the potential of allowing newcomers into an industry. This discussion builds on the work of Anderson & Tushman (1986) and Henderson & Clark (1990). Our approach includes a study of the specific character of the hearing instrument technology, emphasizing the consequences of the systemic features of the technology on the possibilities for turbulence. The second path tries to identify counteracting forces, that is, factors that prevents possible major technological breakthroughs from disrupting the industry. We call these forces stabilizing factors and identify a wide range of them on all levels and interfaces of the value chain.

To a large extent, our study is an investigation of an industry which is in a "mature" stage, answering the question of why the industry continues to exhibit the same old patterns of behavior and structure instead of e.g revitalizing or engaging in cut-throat competition. Or, in other words, what creates inertia in this industry? Framed this way, the study is a broad-scope analysis of a specific industry, trying to cover a wide range of features relevant for the question of stability. The study does, however, focus on two aspects, which we consider of particular interest: The character of technological development in the industry and the nature of competition. In order to comprehend the full dynamics of the industry and place these two aspects in their right setting, we have gone a long way to try to examine the entire value chain, from end-users to distributors to manufacturers and to component suppliers.

This analysis is reported in section 2, with the discussions of technology and competition in the core section 4.3. Section 1 presents the basics about the industry, including evidence on stability, plus a discussion on the interaction between technology and industry structure. After having identified what has kept the industry in its existing shape over the past 25 years, we ask the question in section 3 of whether there are signs of refurbishing in the industry, any changes that may potentially cause the industry to restructure. And finally, in section 4, we outline a number of potential implications for theory of our study.

As should be obvious (if only by its sheer size), the nature of the study is not that of an article. Rather, what we present here is a “research report”, communicating to others our observations from a particular industry. True, we have tried to make sense of our observations and to place them in a theoretical framework (that goes of course especially for the influence of technology on structure), but the emphasis has been more on painting a comprehensive picture of the industry than on testing a specific hypothesis. But with the basics documented in this report, we can move on to more specific analyses.

2 Industry structure and history

The hearing instrument industry as we term it today has existed for about 100 years. The industry is concerned with alleviating hearing impairment (specifically, so-called sensorineural hearing impairment[2]) with external hearing instruments. Defined this way, the boundary of the industry is relatively clear-cut. It does, for example, not include implants[3] or other medical/surgical solutions to hearing problems.

The hearing instrument industry is not a large industry. Total revenues was in 1994 app. $1 billion (wholesale prices) on a worldwide basis, and the number of instruments produced is some 5 million a year (Frost & Sullivan, 1994). It is estimated that for the second half of 1990s the growth in units will be 2 pct. yearly, while growth in value will reach 5 pct. accounting for both inflation and more expensive instruments (Frost & Sullivan, 1994). The US market was in 1993 the largest market, accounting for almost 40 pct. of the total world market revenues, while Europe accounts for app. 35 pct. Measured in units, the relative size of the European market is larger and the US-market smaller, due to the higher unit-prices in the US.

Most geographic markets grow at a very stable rate, but the US-market is somewhat more volatile and has been influenced by more or less random events. Thus, after 15 years of relatively steady growth, unit sales dropped in 1993 and 1994, probably influenced by FDA (Food and Drug Administration) and US-Senate discussions about tougher hearing aid regulation (Strom, 1997).[4]

Present industry structure

The structure of the industry seem to be relatively fragmented. No one company dominates the world industry, and worldwide almost 200 companies claim to produce hearing instruments.[5] However, many of these companies are small, locally oriented and technologically unsophisticated.

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2 At first, the industry was only able to alleviate so-called conductive hearing impairment, but later also sensorineural hearing impairment could be accommodated. Now, conductive hearing impairment can be medically remedied, and hearing instruments are primarily targeted towards sensorineural impairment, that is, defects in the inner ear.

3 Cochlear implants are not substitutes for hearing instruments.

4 Examining US data 1965-1996, we found growth in unit sales to be totally un-correlated with growth in GDP (real or nominal).

5 The American trade association (Hearing Industry Association, HIA) has 38 manufacturing members.

Table 1

Hearing instrument companies with programmable instruments, 1997				
Founding year	**Start of hearing instr. production**	**Company name**	**Headquarter**	**Ownership**
1979	1979	Argosy	MN, USA	Private
1994	1989	Audio 'D'	PA, USA	Private
1940	1940	Beltone	IL, USA	Private
1925/1936	1947/1936	Bernafon-Maico	Switzerland / MN, USA	Oticon (1996)
1948	1948	Dahlberg (Miracle Ear)	MN, USA	Conglomerate
1943	1943	GN Danavox	Denmark	Conglomerate
1976	1979	Hearing Services Internat.	MN, USA	Argosy (1988)
1986	1986	Micro-Tech	MN, USA	Private
1981	1981	Omni Hearing Systems	TX, USA	Starkey (1988)
1904	1946	Oticon	Denmark	Public
1891	1948	Philips Hearing Instrum.	The Netherlands	Conglomerate
1947	1947	Phonak	Switzerland	Public
1954	1954	Qualitone	MN, USA	Starkey (1996)
1984	1984	ReSound	CA, USA	Public
1956	1956	Rexton	Germany	Siemens (1986)
1847	1910	Siemens Hearing Instrum.	Germany	Conglomerate
1996	1990	Sonar (3M)	MN, USA	ReSound (1996)
1963	1971	Starkey	MN, USA	Private
1964	1964	Unitron	Canada	Private
1956	1956	Widex	Denmark	Private

Notes: In cases when founding year is after start of hearing instrument production, the present company is continuing activities from other companies.
The years in parenthesis under ownership are the years of take-over.
The years for Bernafon-Maico represent Bernafon and Maico respectively, since both companies were active hearing instrument manufacturers before they were merged in 1986.

Sources: The list of companies appeared in Hearing Journal, May 1997.
Information about years is from Skafte (1996), Hearing Journal, Nov. 1997, company web sites or direct inquires.
Information about headquarters is from Hearing Journal, Dec. 1997.
Information about ownership is from Hearing Journal, Nov. 1997, web-sites or direct inquires.

Table 1 provides a list of all companies having launched "programmable hearing instruments" at the US market. Programmable hearing instruments were, until recently, the most advanced instruments in terms of signal processing. This is not necessarily a list of the world's largest companies, but the companies on the list have all shown a certain technological commitment to the industry, and for the non-American companies an indication of internationally orientation. There are 20 companies on the list, six of which, however, are subsidiaries of other hearing instrument companies. On this basis it seems fair to say that a roster of about 15 companies (with subsidiaries) would be sufficient to cover all important players in the industry.

It appears that the companies are concentrated in relatively few geographical areas: In North America, Minnesota (Minneapolis) hosts most of the companies, and in Europe, Denmark has a disproportionate number of companies. No Japanese companies appear on the list. Only one Japanese company, RION, seem to operate internationally. We shall return to the other parts of the table below.

Looking at overall *market shares,*[6] Siemens was in 1996 the largest company, followed by Starkey and Oticon[7], all of them with market shares roughly between 15 and 20 percent according to industry participants.[8] Probably 80% of the market is covered by the 9-10 largest companies.[9]

There are two main types of hearing instruments in terms of design: 1) Behind-the-ear (BTE) instruments, which have a case behind the ear connected via a small plastic tube to an ear piece, and 2) instruments with all parts in one case placed *in* the ear. The latter type may be subdivided in a) the traditional in-the-ear (ITE) instruments with the case fitted into the outer ear, and b) in-the-canal (ITC) instruments and c) completely-in-the-canal (CIC) instruments which are very small and almost invisible since they are placed deeper in the ear canal. Overall, BTE is the most popular type of instrument, covering app. 55 pct. of the world market, but its share is slowly decreasing. In the US, ITE instruments have long been the most frequently dispensed instrument, now rapidly being substituted by ITC/CIC instruments (Frost & Sullivan, 1994).

A breakdown of the world market into the three product types (see table 2) reveals a structure with a clear leader in each segment, especially in the ITE and ITC products. (These latter product-markets are dominated by North American companies, probably because of the preference for that type of products in that geographical area.)

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6 See the end of this section for a note on data.

7 The market share of Oticon has increased considerably since 1993 (table 2), due mainly to the acquisition of Ascom Audiosys (Bernafon)(see below).

8 In 1997 Starkey Laboratories had annual sales of USD 300 mill. and 2,350 employees (Ward's Business Directory 1998), while Oticon (the group) in 1996 had a net turnover of app. USD 165 mill. and employed some 1,700 persons (company web site). Figures on Siemens' hearing instrument activities are not available due to the group structure.

9 Oticon's presentation materials; Merrill Lynch (1997).

Table 2

Hearing instruments **World market shares (revenues) in three product areas (percentages), 1993**			
	Behind-the-ear	In-the-ear	In-the-canal
Siemens	24	14	12
Oticon	10	<5	<5
Danavox	9	<5	<5
Philips	7	<5	<5
Phonak	7	<5	<5
Widex	6	<5	<5
Starkey	<5	29	31
Miracle Ear (Dahlberg)	<5	14	15
Beltone	<5	10	12
Argosy	<5	8	8
Note: *<5* means a market share of less than 5 pct. in that product area. Source: Frost & Sullivan (1994)			

The structure of each of the three product segments is roughly the same: A leader accounting for 24-31 pct. of the market followed by a handful of important players with 6-15 pct. market share. The degree of concentration varies, however, slightly. The "old" product (BTE) has a less concentrated structure (a Hirschman-Herfindahl index, HHI,[10] of app. 1000), while the "newer" ITE (with a HHI of app. 1400) and especially the "newest" ITC product (HHI of app. 1600) are slightly more concentrated.[11]

A closer look at the seemingly fragmented structure in the hearing instrument industry therefore reveals a concentration that qualifies the industry as an genuine oligopoly.

Industry history

In 1953 the transistor (invented in 1949) made it into hearing instruments, allowing new and smaller designs, not only because of the transistors themselves but also because of lower power demands and therefore smaller batteries (Bergenstoff, 1993; Hearing Journal, Nov. 1997). Many different designs competed, and only late in the 1960s the eventual winning design, the BTE instrument, gained more than a 50% market share in the US. The companies

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10 In an industry with *n* companies, the HHI index is calculated as $\sum s_i^2$, where s_i is company *i*'s (*i* = 1, 2, 3, ... *n*) market share measured in percent. The value of HHI thus ranges from 0 (indefinitely many small companies in the industry) to 10000 (one company, a monopolist, with a market share of 100).

11 Industries with a HHI of more than 1800 are likely to trigger anti-trust investigations by the US Department of Justice.

engaged in this turbulent battle were on the one hand the old, "pre-transistor" companies, and on the other hand the range of new, truly "electronic" companies, established in the 1950s. Few new companies entered in the 1960s, perhaps due to the slow growth in sales.[12]

Barely established as an industry standard, the BTE instrument was challenged by the ITE instrument. Actually, as early as in the mid 1950's both Danavox and Miracle Ear had presented hearing instruments which had all parts in one shell in the ear. In 1968, this type of products had captured only 9% of the US market, increasing to 31% in 1977. (Hearing Journal, Nov. 1997). In 1983 ITE instruments had captured more than 50% of the US market (Cranmer, 1985), and from that time ITE (with its sub-types of ITC and CIC) has dominated the American market. Today, only 16% of the instruments sold in the US are BTE.[13]

The development of ITE instruments was spurred by the miniaturization of components (e.g. batteries and microphones) and the development of integrated circuits. With these advances, it technologically seemed to be a bigger problem to make high quality, reliable ITE instruments than to make them small (Oticon web site). The major problem for the penetration of ITE instruments was therefore not technological, but logistic: While BTE instruments are standard products, ITE instruments are custom-made since the whole ITE instrument must fit the ear perfectly (Bergenstoff, 1993). It was the American company Starkey that first solved that problem, entering the industry from the distribution-side: The company was founded in 1961 as a dispenser, expanded with a molding laboratory in 1968, and introduced ITE instruments in 1971. (We shall return to this innovation in section 3 below.) Although Starkey earned a clear first-mover advantage, other companies followed, and by the mid 1970's ITE instruments were well established, at least in the US.

From this time, we thus have the two main hearing instrument designs established.[14] The industry had found its "shapes", its "dominant designs", thereby moving from "adolescence" to "maturity". Of course technological development did not come to a halt with that, but most uncertainty about the overall design of a hearing instrument was eliminated. We therefore divide the newer industry history in two distinct period: One ranging from the introduction of transistors in 1953 to the establishment of the dominant design in the mid-1970's, and one covering the following two decades. For the remaining part of this report, our focus will be on the latter period in an attempt to understand the stability of the industry in this period.

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12 In the mid 1950 US-sales increased rapidly, but during the decade from 1958 to 1967, unit sales increased only 25% to about 400,000 (Hearing Journal, Nov. 1997). From 1967 sales increased until 1972, only to fall back to the 1967-level in 1977 (due to a Federal Trade Commission intervention). From then on, however, sales increased rapidly.

13 As indicated earlier, BTE is still the preferred type in the rest of the world.

14 To some degree they are competing, but the also have different applications: The BTE's are especially good for children and for persons with severe hearing losses.

Beyond the technology, however, there is another reason for choosing the mid-1970's as a turning point: In the first period, US distribution started with dealers marketing normally only products from one manufacturer. For example, Beltone, established in 1940, set up a national network of dispensers exclusively dealing with Beltone instruments already in 1941(Hearing Journal, Nov. 1997). During the 1950's and 1960's this system was gradually abandoned and by the mid-1970's it only included a minority of distributors. The single-line marketers were substituted by more independent multi-line dispensers, carrying instruments from several manufacturers. The reason for this change was the emergence of the "clinical referral system". In this, a medically trained "audiologist" examines the patient and prescribes a specific brand and model of instrument, which is then provided by a dealer (Skafte, 1996). To be able to benefit from this system, dealers had to carry many different models. Also pushing this development was that the Federal Trade Commission – for antitrust reasons – intervened and required one manufacturer to stop requiring distributors to sell only that manufacturer's products in 1953 (Skafte, 1996).

Furthermore, the referring audiologists were unhappy with the situation, too: Some felt that they should not only chose the hearing instrument for the end-user but also provide it. This was, however, considered "unethical" by many, especially the association of audiologist. Nonetheless, some audiologists started dispensing around 1970, and in 1978 it was legally enforced that audiologists could also sell hearing instruments (Hearing Journal, Nov. 1997).

While still considered two different types of dispensers, the former franchising single-line dealers and the audiologists both converged towards the now well-known American hearing instrument dispenser. Not only legally independent from manufacturers, dispensers also became more and more independent in choosing which instruments to fit a particular patient: The 1950's and the 1960's saw the growth of numerous "hearing health care clinics" throughout the world. As a result of their research hearing instruments were improved (Bergenstoff, 1993). But also the general knowledge about hearing was enhanced, and many new measuring instruments were developed. Equipped with more knowledge and with new measuring instruments, the dispensers came out of the first period as a truly independent and indispensable part of the American hearing health industry.

Industry structure development

As shown in table 1, all existing European companies and many of the American companies have been active since the 1950s. The 1960s was a particularly quiet decade in terms of *entry*, and except for the important entry of Starkey, only in the late 1970s we saw some entry activity again, maybe spurred by the growth in US sales from 1977. The 1980s witnessed a handful of entries, typically based on some proprietary technology. These companies have yet to prove that they will be long-term survivors.

While table 1 registers survivors, it would be more ideal to have information on also non-surviving companies, that is all entries (and exits). Such data are hard to establish, but a historic review of the industry (Skafte, 1996) does confirm that entry has indeed been limited.

Also, there has been relatively little *merger and acquisition activity* within the industry. Starkey did buy a couple of small companies in the 1980s, and in 1993 Dahlberg was acquired by Bausch & Lomb (US), which, however, had only minor activities in hearing instruments. More important in terms of industry structure was the 1995 Oticon acquisition of the Swiss company Ascom Audiosys (Bernafon-Maico), since its size was about a third of Oticon (after Ascom's acquisition of Bosch's (G) activities in hearing instruments). Also ReSound has been active: It acquired Viennatone (AUT), and in 1996 it bought 3M Hearing Health (renamed SONAR) whose patents were an important asset (see also section 4.3).

Data on long-term *market shares* would be the "correct" measure of structural development, but unfortunately it is not available (see section 1.3). There is, however, indications of great stability: Over the past two decades, it has been the industry's opinion that Siemens, Starkey and Oticon have been the leading companies worldwide. Furthermore, over the past three decades the three Danish companies (Oticon, Danavox, and Widex) together have been said to cover one quarter of world demand.[15] These two statements are confirmed by the different (and incommensurable) figures on market shares that we have had access to (non reported). But accurate long-term data on shares are not available (see sub-section below)

To some degree, therefore, we rely on secondary data sources in drawing a picture of industry development. One such source is experienced industry observers and participants. Whenever we have asked persons with relations to the industry their opinion on industry structure, we have had answers like "It has stayed very much the same over the last 20-30 years".[16] Such statements may be biased in many ways, but we are nonetheless convinced that they contain a reasonably correct perception of the development.

Incomplete as our data may be, it is our conviction that the overall trend in hearing instrument industry structure since the mid-1970s, therefore, is one of stability, when assessed by measures as entry and exit, mergers and acquisitions and market shares. We must admit, though, that precaution is necessary, and the next section deals in more detail with the data problem.

A methodological remark on the availability of data

As we stated above, data on our subject is not readily available. But also industry stability is very difficult to measure. In principle, our hypothesis is very "data demanding": It requires

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15 That was probably slightly overestimated in the 1980s, when they struggled to adjust to the customized ITE production.

16 This particular quote is from a telephone interview with Mrs. Marjorie Skafte, Editorial Director of Hearing Review, in October 1997. Mrs. Skafte has been a hearing instrument trade magazine reporter for more than 30 years.

data on individual, long-term, international market shares. This poses a series of problems. First, what is a market share, or rather, what is the market? In this case, we would like the market to be the total world market for hearing instruments. This definition, however, rules out most usual data sources: Only very few nations generate general data on market shares in industries, and no coordination across nations is possible. Also, in general statistical sources, industries are rarely dis-aggregated to the level of so narrowly defined industries as hearing instruments.[17] Second, census data and the like in this area do not exist for long periods. And third, even if market share data exist, census data cannot identify companies over time. Companies may change legal status, ownership or headquarter address and every time the question arises as to whether the company is the same before and after the change. All in all, census data may be used for studies of entry and exit or of changes in concentrations ratios, but for the study of the relative position of identified companies over time, census data are still not applicable (if available at all).

Some of these problems are alleviated using less rigorous data sources. Since market shares is a fundamental variable in strategic planning, most companies try to estimate at least their own share of the relevant market. However, such data are typically considered confidential and not publicly available. This problem is exacerbated in the hearing instrument industry because very few companies are listed on stock markets. Of the major companies only Oticon, Phonak and ReSound are quoted. The implication is that neither data on the individual non-quoted companies are available nor their (official) interpretation of the market situation in annual reports and the like.

Our solution to this problem of lack of market share data has been to try to obtain market share figures from a variety of sources. Generally, we have not been very successful.[18] Reliable data on market shares are not publicly available except for occasional (and incommensurable) market analyses like Frost & Sullivan (1994). The North American market is the best described market (and that certainly biases our analysis towards America) but even for that market, reliable longitudinal data on market shares are not available. Furthermore, to our knowledge academic treatments of the industry are non-existent.

We would like to emphasize that all information about industry structure and behavior used in this study is publicly available, or at least is well known to people in the industry.

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17 And only at this level, meaningful analysis of company behavior can take place. This is a recurring problem for economists analyzing publicly available data. For example, even when Davies & Geroski (1997) supplemented UK census data with a range of other data sources, they could not overcome the problem of dis-aggregating industries from a “3-digit” to the more relevant “4-digit” level.

18 Of the institutions approached should be mentioned the Hearing Industries Association (HIA) (USA), the Swedish agency for procurement of hearing instruments (SUB), and the PIMS Database (USA).

3 Stability, maturity and innovation

It is the stability described in section 2 that we take as a challenge to explain. But why would we at all be surprised to find a stable industry? After all, many industries remain stable over a long period. For one thing, is it a widespread opinion, ranging from recent business economists (D'Aveni, 1995) to more vintage economics studies (Gort, 1963; Caves & Porter, 1978) that industries with strong emphasis on R&D and technological development are more prone to be turbulent. And indeed, the hearing instrument industry is an R&D intensive industry, with companies spending up to 12% of sales on R&D.[19] One reason for spending so much probably is the rich opportunities for technological development which has challenged the industry in the form of e.g. smaller and better integrated circuits for signal processing, smaller and better transducers and batteries, more powerful software plus an expanded fundamental understanding of sound and hearing.

So the hearing industry might stand out as an exception to a normal pattern (as far as we can identify a "normal pattern" below). We might, therefore, study the hearing instruments industry because of an interest in studying the unexpected, the anomaly, in order to test the validity of generally accepted relationships. To do so, we need to probe deep into the mechanisms accounting for the evolution of industry structure. In fact, the literature still has very little to say about the mechanisms providing for stability versus turbulence. The few studies in this area have provided statistical correlations, but we still have no comprehensive theory of why some industries are stable and others turbulent. In this sense, observed stability needs explanation as well as turbulence does. This is our primary intention in this analysis.

Many forces interact to produce an industry structure. Some of these forces are "destructive" (to borrow from Schumpeter), potentially breaking down existing structures and giving way to new. Others are "conservative", creating inertia and supporting *status quo*. The final outcome for an industry depends on the relative strengths of destructive and conservative forces.

In this section, we are looking for predictions on when to expect stability or turbulence in an industry, paying special attention to the relation between industry structure and technology. Thereby we try to identify conditions under which technology should be expected to create turbulence. We draw upon three different bodies of research: First, we extract results on the relationship from industrial organization. These suggest possible explanations for turbulence on the industry-level. But they do not identify the mechanisms by which these factors impact industry structure. We therefore, secondly, present the product life cycle as one, more detailed conceptualization of the relationship. And thirdly, we deal with the direct relation between an

19 12% of net sales was what ReSound, according to its 10K filing, spent on R&D in 1996. Oticon spent 9% the same year. These two companies being among the most "aggressive" technologically, we suspect that 12% is a good estimate of the upper bound of R&D intensities in the industry, at least among the bigger companies. The lower limit is much harder to determine.

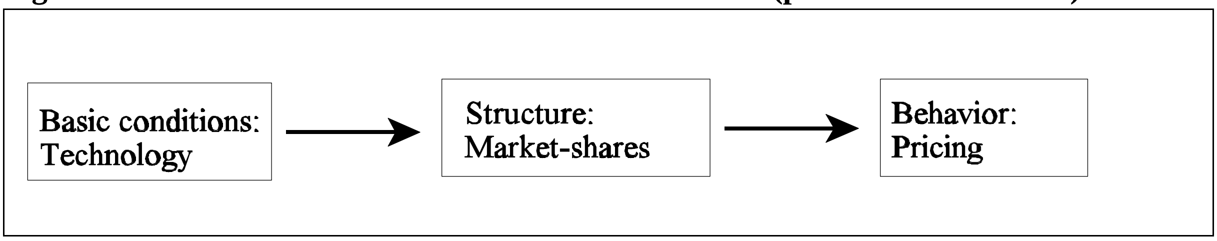
innovation of a specific kind and the industry structure. As these perspectives apply different units of analysis, we take them as complementary rather than competing perspectives.

Industrial organization

No academic field is dedicated exclusively to the study of "the dynamics of industry structure". The economic discipline of "industrial organization" (IO) has industries as its unit of analysis, but – as we will discuss below – IO is not rich in conjectures on the development of market structure over time.

The treatment of technology in economic theory is usually to take the development of technology as given (unexplained), and to study the impact of technical change on phenomena such as employment and income distribution. In the studies of technology and industries, the main conceptual framework of industrial organization, is that of the so-called Structure-Conduct-Performance (S-C-P) paradigm (Scherer & Ross, 1990). According to this frame-work, technology is part of the "basic conditions" that determines the industry structure, which in turn determines the behavior of the companies in the industry. An example of the logic is the results of economies of scale: If an industry is applying a technology that displays large economies of scale, it is unlikely that many companies can coexist in that industry. The structure will be one of a few companies, if not just one. The behavior of these companies will in turn be oligopolistic, if not monopolistic. Figure 1 illustrates this line of causation, emphasiz-ing the traditional focus of industrial economics on pricing behavior.

Figure 1: Main causal relations in the S-C-P framework (performance omitted)



This is a very naive model, and an elaborated version of the S-C-P framework would stress the feedback mechanisms, that is, ways in which behavior influences structure and technology. The literature of industrial organization discusses numerous examples of behavior affecting structure, most of them concerning entry: Pricing may deter entry, building excess capacity may preempt profitable production possibilities, and setting high quality standards may raise rivals' costs. Also, attempts have been made to explain the rate and direction of technological development by structure, cf. the so-called Schumpeterian hypothesis.[20]

Focusing on for explanations for the evolution of industry structure, the logic of the S-C-P

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20 See Cohen (1995) for a discussion of the so-called Schumpeterian hypothesis on the influence of market structure (concentration) on innovative activity (not to be confused with Schumpeter's .

framework points at the basic conditions as the place to look. And, indeed, technological developments may often change economies of scale – and specifically the minimum efficient scale (MES) of production – explaining some changes in structure. For example, a natural monopoly may disappear and allow entry if new technologies allow efficient production in smaller scale or if a market expansion allows more companies to produce at MES. And generally, the concept of "entry barriers" has an important bearing on industry structure: If entry barriers are low and there is a profit to be made, entry will occur, and the industry structure will become more fragmented. If barriers to entry are high (as in the case of a natural monopoly), no entry will take place, and the industry will not get more fragmented.

A large number of empirical IO studies have focused on entry, that is, analyzing how many new firms are entering specific industries. A good reason for this focus on new firms is the availability of census data on entry. Another strand of IO studies is analyses of concentration, that is, how much production is carried out by the biggest firms. Cross-section studies of concentration are relatively frequent, and provide insight into the determinants of market concentration (MES being an important example).

With entry and concentration we have two important ingredients of stability and turbulence. But since stability and turbulence inherently are dynamic concepts, we need longitudinal studies, and unfortunately these, especially those of concentration, are rare, hindered as they are by data problems.

And even longitudinal concentration-studies would not capture the full flavor of stability versus turbulence. An industry with no entry and exit and the same concentration ratio over time might in fact be a very turbulent industry: The same group of companies could change relative size over time in such a way that it would not be registered in the concentration ratio.[21] Only very few studies have gone beyond the mere registration of changes in concentration ratios over time.

And yet, the concept of stability should encompass all these elements: It should include entry and exit, and it should include also an enhanced version of concentration studies, taking into consideration changes in market share positions among incumbents.[22] Turbulence (as the flip-

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21 A CR2 (the combined market share of the two leading companies) of, say, 90% may be the result both of the two companies having each a market share of 45% and of one having 80% and the other 10%. An (reverse) example of this may be the Internet browser market with Microsoft quickly gaining share from Netscape. That particular market would not qualify as a stable market, despite a stable CR2 and no entry.

22 As Caves & Porter (1977) put it: "The theory of entry barriers has been limited unnecessarily by confining itself to the movement of firms form zero output to positive outputs. It becomes much richer – yet remains determinate – when set forth as a general theory of the mobility of firms among segments of an industry, thus encompassing exit and intergroup shifts as well as entry." (p. 241.) This perspective further lead Caves & Porter to define the concept of "strategic groups", that is,

side of stability) was introduced as the appropriate term by Beedsley & Hamilton (1984) to be applied, though, only to entries and exits in that study, but Acs & Audretsch (1990) included also expansion and contractions of incumbents under this label.

While the term “turbulence” therefore is of recent date, the interest in the subject matter goes back more than 30 years. The stream of results is so “thin”, however, that hardly no general results can be extracted. Comparing results from e.g. Gort (1963), Caves & Porter (1978), Acs & Audretsch (1990) and Davies & Geroski (1997) is difficult because of differences in populations studied (time and location) and because of differences in measures of turbulence as well as models and statistical techniques. Actually, none of the independent variables have the same sign of coefficient in all four studies.

Nonetheless, Davies & Geroski (1997) succeeds in drawing at least two interesting, though still preliminary, conclusions that are not totally at odds with the other studies: First, that “while concentration is typically fairly stable, this stability conceals considerable turbulence in market shares among leading firms” (p. 389), and second, that advertising, and (to a lesser degree) R&D and innovation plays a major role “in affecting both concentration levels and industry turbulence” (p. 389). That is, the more advertising and R&D, the more concentrated and at the same time more turbulent industries.

This result is partially at odds with Caves & Porter (1978). In terms of levels of instability. They found that high product R&D intensive industries are more turbulent than low product R&D intensive industries, while there are no difference in turbulence in low and high advertising intensive industries (p. 303).[23] Moreover, it seems as if product R&D is more effective in creating turbulence in highly concentrated industries. So while we may be skeptical about the role of advertising as a driving force in market share variation, the effect of product innovations seems to be corroborated in these statistical analyses.

Unfortunately, none of the studies were designed to identify the mechanisms through which advertising and R&D actually influences turbulence (in particular, it is an interesting observation from the Davies & Geroski study that advertising and R&D at the same time prevents entry from newcomers and allows for turbulence among incumbents, an observation that we

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companies following similar strategies. Under the influence of Porter (1980), the companion term “mobility barriers” came to describe barriers to mobility *between* strategic groups. While mobility between strategic groups does contribute to overall industry turbulence, it remains only part of the concept of turbulence.

23 It seem reasonable to expect R&D to be a more powerful disrupting force than advertising. With e.g. Sutton (1991, p. 314) it might be argued that the image of a company created by advertising may be carried over from one product generation to the next, providing the company with a competitive advantage largely independent of products. Changes in competitive positions based on changes in advertising therefore probably are relatively smooth. Contrary, a product innovation may immediately override the competitive position established on technology outdated by the new innovation.

return to below).[24]

The product life cycle

So while it seems safe to conclude that technological development increases the volatility in market shares, the IO[25] studies do not spell out the mechanisms behind this relationship. And probably a comprehensive model for the interaction between the evolution of industry structure and industry behavior, especially regarding advertising and R&D is not available (and will not be in the foreseeable future). We are therefore left with more or less well documented conceptualizations about these relationships. The “product life cycle” is one such. Stemming from a marketing management perspective (see Levitt, 1965), William Abernathy and James Utterback in the late 1970's (Utterback & Abernathy, 1975; Abernathy & Utterback, 1978) enhanced the marketing concept of a product life cycle into a broader “model” of industry evolution. Specifically, they added two important dimensions to the product life cycle: First, they argued that the transition into a mature stage was accompanied by the emergence of a “dominant product design”, and second, they hypothesized a specific pattern of product and process innovative activity over the cycle.

The generality of the product life cycle is hotly disputed, but, again, in the absence of better alternatives, the idea has survived and has been applied to a number of industries. For example, Abernathy & Clark (1985) examines the automobile industry, and while Utterback & Suárez (1993) and Suárez & Utterback (1995) compare seven industries in depth, Gort and Klepper (1982) examined 46 products through the lenses of the product life cycle. It is widely acknowledged that only products with opportunities for both product and process innovations may follow the product life cycle (Klepper, 1996, p. 565). This excludes on the one hand e.g. standard petrochemical products that do not undergo product innovations over time, and on the other hand those customized products, as specialty machinery, for which process innovations are almost irrelevant.

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24 Generally, the referred statistical studies are not very explicit about such mechanisms. They rarely build on any elaborate idea of how the variables inter-correlate. However, to the degree that the empirical studies manage to establish “stylized facts”, these mechanisms may be construed afterwards. Dosi et al. (1995) and Klepper (1996) are examples of such efforts.

25 These studies do not strictly follow the traditional IO framework of causal relations (Scherer & Ross, 1990). “It is not certain where share variation fits into the traditional industrial organization trichotomy of industry structure, behavior, and performance” (Ogur, 1976, p. 1). Originally intended as a measure of industry performance in the line of anti-trust oriented research, market share variation may be seen as proxy for the strength of competitive forces, that is, “diminished variation may suggest the presence of conspiracy” (Ogur, 1976, p. 3). But share variation may also be interpreted as part of industry behavior. Incumbents may well try to behave in ways that both aims at precluding entry and to reduce volatility in the distribution of market shares. An example of the latter may be a cartel that “freezes” industry structure. And finally, share variation may be argued to belong to “structure”, if it is a direct consequence of buyer and seller characteristics (which it is in Stigler’s theory of oligopoly (Stigler, 1968)). Accordingly, in our attempt to understand stability in the hearing instrument industry, we will entertain a whole range of explanations, not limiting ourselves to one of these perspectives.

Based on this criteria, hearing instruments seem to be an obvious candidate for a product life cycle study. Furthermore, the industry lives up to the predictions of the "model" of the emergence of a dominant design (or rather two, BTE and ITE), and a stable industry structure. In a product life cycle of the four stages[26] of "introduction / development", "growth", "maturity" and "decline" (Levitt, 1965; Porter, 1980), the hearing instrument industry in the period studied here fits the mature stage best.

The predictions (summed up in Porter, 1980) on structure and behavior in the mature stage, however, only partly fit the industry: The market has not become a mass-market, emphasis on production costs does not seem to be an essential feature of the industry, competition is not focused on price, margins do not seem to be decreasing, and shakeout is not happening. And most importantly, product innovation is probably the most essential competitive dimension of the industry (elaborated in section 4).

So what we have is an industry that apparently does not follow the standard predictions, but sticks to its own logic: Its structure remains stable despite heavy competition on product innovations.

Product innovation as an engine of change in structure

But does technological change – and especially product innovations – necessarily need to be destructive (in the Schumpeterian sense) and create turbulence by allowing new companies into the industry, and perhaps even trigger a new product life cycle and coin a new industry? Or to use the expression from Abernathy & Clark (1985, p. 18): What can cause the "de-maturity" of an industry?

If an innovation causes turbulence in an industry, and especially if it induces entry, it seems logical to infer that this particular innovation (or its imitation/adoption) poses non-trivial challenges to incumbents. On the other hand, if an innovation does not lead to turbulence and entry, the innovation probably has been easier to handle for incumbents. That amounts to saying that some innovations builds on the competencies that established firms must have already in order to be active in the industry, while other innovations require additional competencies and even may render incumbents' competencies obsolete. The "destructive" power of an innovation therefore depends on how "different" the competencies related to the new technology is from the competencies of the old technology.[27]

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26 Abernathy & Utterback (1978) use three stages, Gort & Klepper (1982) use five.

27 Note that the "height" of innovation, that is, the degree of improvement in performance of the new technology over the old, does not directly influence an innovation's effect on turbulence. Indirectly, though, it is conceivable that innovations with strong effects on performance will also influence industry stability because minor under-performance in one area (e.g. product performance) may be compensated by an increased effort in another area (e.g. marketing). Also, since barriers to imitation/adoption seldom are unsurmountable (even strong patents often can be "invented around"), but rather a matter of time and patience, companies often will have a chance to catch up if they are

In a number of papers, Tushman and Anderson[28] have pursued this idea by proposing the dichotomy of competence-enhancing and competence-destroying technological discontinuities (innovations). Only if innovations tend to destroy existing competencies in the industry, are we to expect entering firms to be able to out-compete incumbents. Although it is clear that what ultimately determines a company's chances of survival is its competencies (in this relation, competencies to create, imitate or adopt architectural innovations), it is also clear that the identification of such competencies is not an easy task. Technology is a truly multifaceted entity, and company competencies are probably even more so. To approach the question of the degree of difference between competencies directly, without a well-defined categorization or typology of competencies, therefore seems difficult and subject to great subjectivity. Even if a one-by-one assessment of each innovation turns out to split a sample of innovations in two relatively distinct types (as it apparently does in the samples of Tushman & Anderson), such a method is very difficult to replicate by other researchers on other samples (or even the same).

Another attempt attacks the question from the technical side, trying to identify features of an innovation that may cause disturbance. This is the approach of Henderson & Clark (1990), who distinguish between two types of potentially disruptive innovations: Radical innovations and architectural innovation. While the radical innovation is defined as one which changes both the "core concepts" (e.g. components or basic technologies) and the linkages between these concepts (that is, the architecture of the product), then the architectural innovation "only" changes the linkages between core concepts, "recycling" the elements. (These two types of innovations are compared to two other types, modular innovations and incremental innovations, which are not expected to have disruptive effects.)

Henderson & Clark (ibid.) argue that both radical and architectural innovations often create difficulties for established firms and that they may even redefine the industry, but somewhat contrary to expectations, they also argue that architectural innovations are potentially more disruptive than radical innovations. While a radical innovation "creates unmistakable challenges" (ibid., p. 13) and therefore calls for immediate action, architectural innovations are more subtle in the sense that "(m)uch of what the firm knows is useful and needs to be applied in the new product, but some of what it knows is not only not useful but may actually handicap the firm" (ibid., p. 13). This may be a confusing situation and even if the problem is correctly comprehended it may be difficult to handle, as major parts of the company's competencies and organization may be structured around a specific architecture of the product. The company needs to re-build its architectural knowledge, that is, the knowledge that allows the company to understand and improve the linkages between the elements of a product. But "(b)ecause

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allowed time and capital. But the bigger the advantage of the new technology, the more difficult it will be to regain lost positions the industry. Therefore, it should be expected that while the degree of "difference" in competencies required for its imitation/adoption is the major determinant of an innovation's disruptive effect, the height of the innovation will amplify this impact.

28 See e.g. Tushman & Anderson (1986) and Anderson & Tushman (1990).

(established firms') architectural knowledge is embedded in channels, filters, and strategies, the discovery process and the process of creating new information (and rooting out the old) usually takes time" (ibid., p. 18). So while the competencies for improving core elements of a product may be readily identified (and if not easily then often at least possibly replaced), then the competencies needed for architectural innovation are both more difficult to identify and to replace.

Whether Henderson & Clark are right in conjecturing that architectural innovations are more disruptive than radical innovations should be left for an empirical test (if testable at all, see below), but the idea that the changes in architecture (or basic design) may create more turbulence among competitors than changes in the elements of the product is one step towards an understanding of the influence of technology on industry structure. And it corresponds well with the idea of a dominant design whose emergence often seems to lead to considerabe exits from an industry.

Summing up upon the two approaches, Anderson & Tushman focus on the competencies needed for a specific innovation, that is, characteristics *not* of the innovation directly, but of some requirements to produce it. Henderson & Clark attempt to identify features of the innovation itself that may cause changes in industry structure. The two approaches clearly are not mutually exclusive: The Henderson & Clark acknowledges that in the end, it is the endowment of competencies that determines a company's commercial success, but instead of attempting a direct identification of the relevant competencies, Henderson & Clark claim that some technological changes are of a kind that inevitably must challenges incumbents as much (or even more) as they challenge entrants. While such an approach clearly is a roundabout "detour" compared to the approach of Tushman & Anderson (and possibly only a first step towards a full understanding of the relationship between technology and industry structure), it does make sense if we have better chances of analyzing technologies than competencies. That is the case, in our opinion, not the least because researchers seldom have access to internal studies of all (or most) companies in an industry. In a study of the impact of technological change on industry structure, the advantage of the Henderson & Clark approach is that a researcher can study technology in its instrumental sense in order to operationalize the explanatory variable, while in the Tushman & Anderson approach the study must deal directly with (that is, somehow measure) competencies in incumbent firms and in entrants for old and new technology, respectively. The disadvantage of the Henderson & Clark approach is that it reduces explanations to only one dimension of technological change (architectural or not), and is as such inherently is reductionistic.

In section 4.3 of this report, we try to characterize technological change in the hearing instrument industry, arguing that its particular characteristics did not allow for neither much entry nor much variation in market shares. But before we present our analysis of this and other aspects of the hearing industry during the last 25 years, we will briefly sketch one of the events that marked the passage from the old "regime" to the one prevailing now:

Starkey's entry into the industry coincided with the introduction of an important innovation, the in-the-ear (ITE) instrument, which – as we have described – turned out to become a dominant design alongside with the BTE instrument. The innovation was made possible by the ever decreasing size of components, and technically, an ITE instrument is little more that standard components packaged in another type of case. Already in the 1950s many companies developed ITE instruments, but they never succeeded in the marketplace. So Starkey was not the first company to produce an ITE instrument, but Starkey as a small, up-coming company entering the field did succeed.

Therefore (as seems to be the rule in this industry) it took only a couple of years before competitors were able to produce similar products, if they did not carry ITE products already. But still only Starkey succeeded in commercializing ITE instruments. If the basic lay-out of an ITE instrument did not diverge much from a BTE instrument, *organizationally* it required a shift from to-the-shelf production to customized production, since every ITE case has to be moulded to the individual customer, and components have to be arranged in order to fit the specific case. Starkey, new as manufacturer but well established already as dispenser of hearing instruments, was able to set up an organization that could handle this problem. That turned out to be more difficult to handle for the existing companies. They had little technical problems in developing another ITE instrument, but many problems in changing their internal organization. So while this innovation was only modestly new in technical terms, it required an all new logistics system which was not "compatible" with incumbents' logistics systems.

Here we probably have a pretty clean example of an innovation that was not at all "radical". It did not challenge the use of existing "core concepts", especially in the field of components. Neither did it challenge the fundamental linkages between these components (although it turned out that "feed-back" problems increased with the shorter distance between microphone and speaker in an ITE instrument). The challenge was a truly organizational question: How to set up a logistic system that could efficiently handle customized production? With most technological competencies acquired in the production of BTE instruments still highly relevant, it may have seemed to be a "piece-of-cake" for the incumbents to cope with the challenge from Starkey initially. But as Henderson & Clark suggest, the fact that most of the more visible competencies are still relevant may actually distract attention from the fact that an underlying condition for competition has changed, leading incumbents to downplay the importance of the innovation, and thereby allowing the innovator considerable lead-time.

We would not pretend, either, that we could have predicted the disruptive power of the ITE innovation by classifying it as an architectural innovation. Only after it happened, with hindsight, we – and the actors – understand the difficulties in organizational restructuring.[29] It

29 It is all too tempting to use our knowledge of the impact of the innovation on competition and market structure in classifying innovations, but obviously that leads us into a tautology: We cannot classify one variable that is supposed to affect a second variable on the basis of its impact on this same,

certainly is possible *ex ante* to think of conspicuously disruptive innovations in the hearing instrument industry: One such would be the ability to regenerate hair-cells in the ear. If the hair-cells can be reestablished, the person may regain the ability of hearing. Not only would such an innovation be competence-destroying, it would probably be industry-destroying altogether. But the continuum between the “innocent” innovation and such a “destructive” innovation must be described also. The problem of operationalizing innovation as a variable, that is distinguishing architectural from non-architectural innovations, therefore, prevents rigorous testing of the Henderson & Clark hypothesis, and leave this field of research without much predictive power. But hopefully that situation will change with more research in this area.

The example of Starkey also illustrates how important it is to take a broad perspective on the relation between technology and the evolution of industry structure. A narrow definition of technology may preclude us from understanding fundamental aspects of change. This is basically the reason why we in section 4 make an effort in covering a wide range of aspects of the industry, not exclusively dealing with technology narrowly defined.

A precautionary remark should be made before turning to the case. With only a rudimentary theory on the evolution of industry structure and dealing with only one case, the nature of our study still is very explorative. We do not in any sense pretend to *prove* causal relationships in this report. But, for one thing, we can advance possible, novel explanations and, for another, our study may prove as inspiration for hypotheses testing.

To sum up and lay out the plan for the remaining parts of the report, the purpose of this study is to identify those factors that account for the prevailing stability in the hearing instrument industry, an industry with only minor changes in structure over a period of approximately 25 years. We conduct a broad-ranging analysis of technology, not only on manufacturing level of the value chain, but also in adjacent stages, and of competitive behavior of the companies in the industry. After the analysis of the past 25 years in section 4, we shall in section 5 discuss possible challenges to stability.

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second variable. We, thus, need a more precise operationalization (independent of industry structure) of the different classes of innovations before we can conduct more rigorous studies of the relations between technology and the evolution of market structure.

4 Stabilizing factors

In this section we examine the factors which can account for stability. The section is organized along the lines of the value-chain of the hearing instrument industry, starting from the down-stream end with end-users, moving up-stream through dispensers and hearing instruments manufacturers to component suppliers. At each of these four levels we identify factors that influence stability in our central analytical object, namely the hearing instrument industry. The supply chain of the industry can be depicted as follows:

Table 3

Value chain of the hearing instrument industry				
Level	Component supplier	Hearing instrument manufacturers	Dispensers	End-users
Role	Components delivered: * Transducers (microphones and receivers) * Electro-mechanical components (switches, volume controls, trimmers) * Amplifiers * Hybrids * Batteries	* Assembly components into hearing instruments - some (ITE and ITC) are made-to-order, some (BTE) can be kept in stock. * The primary concern of this level is signal processing technology and insight into audiology.	* Measure hearing impairment, make audiograms, take imprints of end-user's ear, order the hearing instrument from manufacturer and when received fit it to the particular hearing impairment. Service the instruments and sell batteries. The system varies among countries; e.g. public in DK related to hospitals, private in D and the US through retailers.	* Those who wear hearing instruments go to a dispenser to be measured, advised, and fitted in relation to the purchase of a hearing aid. End users are typically elderly people and those impaired from work-related noise.

4.1 End-users

Is has been said about hearing instruments, that at least 5% of the world population need them, but nobody wants them. While this is not all true (still 5 mill. units are sold every year world-wide), there is something to it, and the industry has for long struggled to figured out why.

Market analysts repeatedly claim that only a fraction of potential users actually do wear a hearing instrument. Kochkin (1997) sums up a series of market analyses and finds that the incidence of hearing loss in the American population is roughly 10%.[30] Of this population only

30 The author does remark, however, that this figure probably is a minor underestimation since the market analyses did not include nursing homes etc. More importantly, though, is that the degree of hearing loss among these 10% varies a lot. According to the National Center for Health Statistics, out of an estimated 20,3 million people with hearing trouble in 1991, only 4,8 million cannot hear

between a fifth and a quarter are actually users of a hearing instrument. The penetration figures even seem to have been relatively stable over the course of the last decade (Reuters, 1996). The situation apparently is the same in other countries, such as Denmark and Japan (Morgen-avisen Jyllandsposten, 1997; Aktuel Elektronik, 1996). Such stability is typically explained by a market being saturated. However, is the market for hearing instruments saturated, and is there any means of increasing penetration? In this section we shall try to shed light on these questions, focusing on product quality, problems of getting used to the instruments, stigma, and price.

Product quality and stigma

First, no hearing instrument can correct a hearing loss completely. That is, a hearing instrument cannot repair the defects of the ear, but it can compensate for some of the lost hearing. The quality of the instruments is therefore important to market penetration. The better hearing instruments, the more hard-of-hearing persons will be willing to use them. But as of today, hearing instruments still are only (a distant) second-best to normal hearing. This is, of course, a major challenge for manufacturers.

Second, it takes time to get accustomed to the device. Typically the period of getting-used-to-it will last approximately 6 months. Specifically, those who have not heard anything prior to getting a hearing instrument may have severe difficulty getting used to suddenly hearing the refrigerator "humming", the birds singing, and so on. Some hard-of-hearing people do not have the patience for this or are not informed of this fact when buying it, thus concluding that the hearing instrument is of no use or perhaps even stressful. This is particularly so in cases where the hearing instrument is inappropriately fitted to the particular hearing impairment. Many a hearing instrument has ended up in the drawer - often much to the regret of family members and close friends.[31]

Third, stigma is a very important barrier for persons with a hearing loss to buy a hearing instrument.[32] This is underscored by the observation that hearing instrument sales increased when Ronald Reagan first had a hearing instrument fitted in 1983, when he switched to an in-the-canal hearing instrument in 1986, and when Miss America of 1994 bolstered the image of those using hearing instruments as she herself wore one (Skafte, 1996).[33] The typical associa-

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and understand normal speech (Sándor, 1994).

31 Machan (1996) tells the, presumably not uncommon, story of why her $3,600 pair of ITC hearing instruments are now sitting in their case.

32 26% of potential users did not buy a hearing instrument in 1991 for that reason; another 17% of potential users did not buy a hearing instrument due to lack of awareness of own hearing loss (Skafte, 1996).

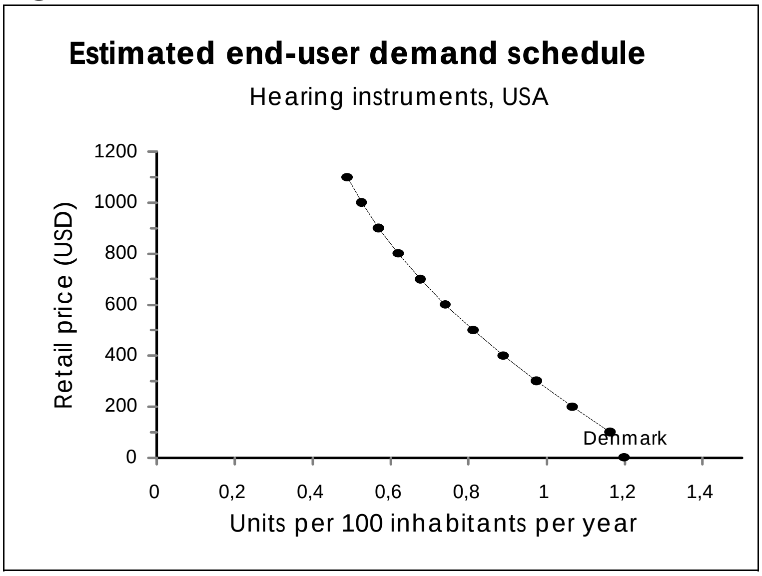
33 As of writing, President Clinton is announced to have a hearing loss, and is being fitted a pair of instruments. Newspapers claim that it has immediately increased sales (Hendren, 1997).

tions with hearing instruments are that they are for old people, for not-so-smart people, or for people who are out of touch with their environment (work, family etc.).

Price elasticity

Fourth, apart from stigma and problems of use, there might be a pricing-based explanation: Would lower prices expand this market (and would higher prices contract it)? And as important: Does it pay to change prices? Figure 2 is based on the meticulous market research carried out by Sergei Kochkin. Observations from his MarkeTrak III analysis (Kochkin, 1992) are used to construct a demand schedule.[34] The schedule is anchored in the empirical observation of 0.6 units sold per 100 inhabitants at the average price of $800. In the US annual sales were about 1.6 million units in 1995. With a population of 260 million, the number of dispensed units was roughly 0.6 per 100 inhabitants.

Figure 2



The price elasticity (the relative change (percent) in volume as a result of a relative change (percent) in price) is rather low. It ranges from –0.1 in the lowest price bracket to –0.8 in the highest price bracket.[35] Price reductions therefore do not open very large new markets. Halving the price from $800 to $400 would increase the market by 48%, and almost free hearing instruments (priced at only $100) would barely double the number of units sold. On the other hand, higher prices will not eliminate much demand. Increased prices have a relatively large impact on volume, but still a $300 increase on top of a price of $800 (a 37.5% increase) will only scare away less than 20 percent of the customers (Kochkin, 1992).[36]

The ensuing effects on turnover and profitability of price changes are relatively straightforward: Growth in unit volume cannot compensate for lower prices, and it therefore does not

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34 Kochkin's analysis covers ITE instruments in the US. We have added the Danish observation.

35 Price elasticities from -1 to 0 are generally considered low.

36 Volume changes are always relative. Here we discuss the relation between price and volume, and – compared to other industries – a change in price in the hearing instrument industry does not produce a big change in volume. That is not to say that the industry would not consider a doubling of volume very attractive, especially if prices did not have to be lowered to obtain this, but this is apparently not viable under the present demand structure.

pay for the industry as a whole to lower prices. On the contrary, somewhat higher prices probably will increase profits (Kochkin (1992) seems to agree on this). It should be noted that prices are retail-prices and that we therefore analyze the dispenser-level. Since the ultimate end-user demand schedule is the same for manufacturers also, and dispenser-prices generally are marked-up manufacturer-prices, probably the same results would apply to the manufacture-level. Whether it holds for component suppliers is not so obvious. Due to economies of scale and an even more inelastic demand for their products, suppliers of some components may actually prefer manufacturers to pursue a low-price-high-volume strategy to a high-price-low-volume strategy.[37]

Figure 2 includes a data-point for Denmark also. In this country, hearing instruments are free (price is zero for end-users). In 1995 60,000 units was dispensed to a total population of some 5 million (Aktuel Elektronik, 1996). That yields 1.2 units per 100 inhabitants. It is interesting that the observation fits so well with the estimated demand curve for the American market. Even the position – which is a bit too much to the left in the diagram to fit the US demand schedule – may be explained by the fact that the Danish quantity probably is underestimated compared to a situation of free hearing instruments, since in a third-party-payer situation, hearing instruments are typically subject to a rationing (queuing) arrangement which obviously limits the dispensed number of units.

The identification of an absolute, upper limit to sales of hearing instruments makes sense in that a hearing instrument, unlike many other products, is of a kind that you only buy one (or two) of at a time. What this analysis tells us is simply that it is difficult to imagine more than a doubling in volume (assuming present-state technology and unsolved stigma problems), measured in units, even if hearing instruments become totally free for the end-users. Given the present quality of the instruments, the stigma attached to wearing them, and problems of fitting etc. the market is a limited one.

That there is a natural limit to the number of units sold, does not imply, however, that revenues in the hearing instrument industry cannot be increased. As the inelasticity of demand indicates, there is a market for more expensive instruments, and if these instruments also improve quality, solve some stigma-related problems and/or are easier to fit, then the demand curve may well shift to the right, increasing demand. One might in fact interpret the manufacturers' strategies of spending heavily on developing digital instruments (seeking improved quality) and smaller instruments (relaxing stigma problems) as ways of exploiting this possibility. These are probably much wiser strategies than trying to lower prices. Only in case of major economies of

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37 This may explain the emphasis on pricing strategies in Kochkin's (1992) article: Sergei Kochkin is employed at Knowles, which is one of the largest suppliers to the industry (see section 4.4). Maybe Knowles would like the producers to scale up production by reducing price in order to demand more components from suppliers. But when demand is inelastic the hearing aids producers can earn more by raising prices and accepting reduced output.

scale in the production of hearing instruments, the increased number of units would be able to prevent profits per unit to fall. And such economies seem unlikely.[38]

A conclusion on this discussion of price elasticity and the possibilities of increasing penetration is that high prices do keep some but not many customers away, and that, given the existing demand schedule, a boost in sales can only be profitable if third-party payment becomes widespread.[39] And even in that case there are limits to the impact on volume: First, even with truly free hearing instruments, the increase in volume would not be dramatic, and second, the necessary third-party payer will probably always establish some rationing, threshold and/or co-payment system, limiting even further the increase.

Thus, we see four main reasons for the limited penetration of the market: Quality of the instruments, problems in fitting and getting-used-to the instrument, and stigma. The price of the hearing instrument seems to play only a minor role for penetration.

If part of these problems stem from lack of information on the merits of hearing instruments (which is certainly not an unreasonable expectation), one obvious way of alleviating these factors limiting the market (shifting the demand function to the right) is advertising. In most countries, however, advertisements for hearing instruments are limited. It seems as if pull-effects is not much used in the industry (that is, manufacturers' marketing *vis-à-vis* end-users to have them "pull" the product through the dispensers). Generally, it seems as if the market is relatively insensitive to marketing efforts (Starkey, 1997). We will discuss this question further in section 4.3.

A way of overcoming buyer stigma and problems in getting used to using hearing instruments is counseling of end-users. It is generally accepted that counseling is an important factor in hearing instrument purchase, use and acceptance (Crandell, McDermott & Pugh, 1996). Specifically,

> "..even limited amounts of counseling significantly decreased the three problems most often cited by the elderly as reasons for not using amplification [that is, a hearing instrument]. These problems included perceptual difficulties in background noise [e.g. speaking with one person in a cocktail party], dexterity concerns [making it difficult to use the volume control and switch of app. 3.5 mm in diameter] and the belief that their hearing loss was not significant enough to warrant a hearing instrument" (ibid, p. 26)

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38 Assuming (somewhat arbitrarily) that it now costs $400 to produce a hearing instrument, a simple calculation based on the data from figure 2 says that if absolute profits should remain the same after a $200 decrease in price and the ensuing increase in quantity from 0.6 to 0.75, costs would have to be reduced to $280: A 30% cost reduction caused by a 25% increase in quantity!

39 Apparently, hearing care is increasingly included in American employee benefit plans and HMO plans (Employee Benefit Plan Review, 1997)

For counseling to be credible in a situation with strong information asymmetries, the counselor probably needs to be independent of parties with economic interests in the sale of the hearing instruments. Most hard-of hearing persons will therefore want to consult a physician (or even an audiologist) before buying a hearing instrument.[40] But a non-dispensing physician or audiologist rarely can recommend a specific brand of instrument, as most hearing losses differ, and the range of available models is large and ever-changing. The choice of brand and model thus is very much in the hands of the dispensers. Their dealing with the credibility problem may vary, but one standard solution is to carry more than one brand, signaling independence from a specific manufacturer. This explains the structure of the dispensing industry, an issue that we return to in section 4.2.

This whole situation limits the chances for new market opportunities. It is hard to imagine entirely new types of customer-segments. With end-user preferences stable and well known by manufacturers, it is all the more likely that no one company (incumbent or entrant) will be so lucky as to find a niche that can seriously alter the balance of power in the industry. This certainly seems to be the situation, as Kochkin (1996) remarks: "over the last 10 years it is apparent that little has changed in terms of new markets or new customer segments".

4.2 Dispensers

The dispenser is here used as a common denominator for different types of mediators between hearing instrument manufacturers and the end-user. Dispensers are the distribution level in hearing instruments. Mostly, dispensers order instruments directly with manufacturers (or their local subsidiary). Wholesale is not common in hearing instruments.

Therefore, dispensers are retailers who sell and fit hearing instruments very much like opticians and optometrists sell glasses. Worldwide, there are a number of different types of dispensers. In the US they are either audiologists (who have an academic training) or hearing aids specialists (who have approx. 6 months training), in Germany dispensers are audiologists, in the UK free hearing aids are distributed by the hospitals (while some specialist stores offer full priced hearing instruments), and in Scandinavia the public hearing clinics dispense the government-paid instruments.[41]

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40 In fact, even in the US, a federal regulation prohibits the sale of a hearing instrument unless the buyer has first received a medical evaluation from a licensed physician. That requirement, however, is frequently waived.

41 There are some US mail-order companies selling very cheap hearing instruments (down to $30). However, they seem to represent only a marginal part of the market for hearing instruments, and do not compete directly with standard instruments. They may, however, because of poor quality and lack of customized fitting contribute to the general impression of hearing instruments as not being able to alleviate hearing losses.

The function of all dispensers is to measure and model in audiograms the particular hearing impairment; take imprints of the patient's ear; advice on type of hearing instrument (e.g. in terms of type, brand, size, signal processing); order that hearing instrument at the particular manufacturer; receive it and fit it to the particular hearing impairment (depending on the type of hearing instrument either manually using a screw-driver to position the trimmers, or digitally by connecting the instrument to a PC or fitting-box). After-sales-services and service-agreements are individually up to the particular dispenser. Dispensers thus provide essential value-adding in the supply chain (measuring, ordering, fitting, service).

Dispensers as stabilizers

Of 13.3 million potential users in the USA, more than 70% were influenced *not* to purchase a hearing instrument either by the professional they consulted or by their lack of trust in that professional. Similarly, a positive recommendation of a hearing instrument by a hearing professional is the most important determinant of purchase intent (Kochkin, 1993).

Further, despite the importance of counseling for the sales of hearing instruments (cf. quote in section 4.1), approximately 80% of "instruction time in hearing instrument classes is devoted to technological issues in hearing instruments" (Crandell, McDermott & Pugh, 1996) rather than counseling instruction. This was underscored by Schweitzer (1996) who found that 84% of surveyed end-users agreed or strongly agreed to the point that "the service and the personality of the dispenser is as important as the hearing device(s)" (1996, p.14).[42]

The problem of insufficient knowledge on the side of dispensers is reinforced because the task environment for dispensers has increased to a highly complex level. That is, the number of product types has increased, the technology is changing (from analog, over programmable to digital), there is a wide variety of offerings (multiple programs in one hearing aid, directionality, other new features), and software programs are becoming integral parts of a hearing aid and the fitting. These factors interact and make the selection among different types of hearing instruments a complex decision. Furthermore, trends of programmability and digital hearing instruments imply that the use of fitting software (often integrated with office and client management programs) is required for dispensing hearing instruments. Also, hearing instruments manufacturers' sales representatives are increasingly required to perform training sessions as additional education for dispensers to have them consider some of the newer types of hearing instruments and related technology (software programs). In order to oversee and deal with this complexity, dispensers stick to the aspects of their work that they know and slowly take in new tasks as they can.[43]

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42 Crandell, McDermott & Pugh (1996, p. 29) further observe that "it appears that few graduate programs have additional space within their established curricula for further counseling instruction, suggesting that the status-quo in counseling instruction will likely prevail".

43 The increasing demands on dispensers presumably also is the reason why there has been a significant shift in balance between dispensing audiologists and hearing aids specialists in the US, the former

Thus, according to the cover story of the Hearing Journal in January 1997 (Kirkwood, 1997): "Essential as technological advances are to increasing consumer acceptance of and satisfaction with hearing instruments, these advances are of little value unless fitted by hearing professionals with the skills and knowledge to tap their full potential" (ibid., p. 29). Furthermore, Sergei Kochkin, is quoted for pointing out that the instruments scoring highest in consumer satisfaction "tend to be the advanced programmable hearing instruments". Kochkin adds, "If more dispensers were to embrace this advanced technology, there would be much more positive word of mouth. We have to upgrade the dispensing outlet" (ibid., p. 29-30). The distribution barrier, thus, may be particularly frustrating for companies introducing newer types of hearing instruments.

The sales barrier at the dispenser level can be related to the lack of tradition for promoting new hearing instruments through advertising (cf. section 4.3) on the part of hearing instrument manufacturers. This leaves the sale and choice among products entirely up to the dispenser: Each hearing loss is unique, and the broad range of instruments have such a high technological content that the average end-user will not have a clue as to the difference between the various models. Therefore, hearing instruments cannot be sold without professional counseling, providing the rationale for a dispenser level.

Links between dispensers and manufacturers

One way of solving the problem of inertia at the dispenser level would obviously be for manufacturers to take control over dispensers by establishing their own chain of dispensers. Transaction cost theory would argue for vertical integration on the basis of transaction frequency, asset specificity, and uncertainty (Williamson, 1985). Assuming that transactions are frequent and occur under uncertainty, we shall focus on asset specificity and the problem of “getting incentives right” so that dispensers will undertake the necessary investments in equipment and training in order to promote hearing instruments from a specific manufacturer better.

Vertical integration is not unknown in the industry, but the vast majority of dispensers are *legally independent* from the hearing instrument manufacturers. This does not mean that the dispensers carry instruments from every manufacturer. In fact, 58% of US-dispensers carry 3-6 brands (Skafte, 1997). Most dispensers have ties to a couple of manufacturers, from some of which they may also receive training and education of dispenser staff. However, vertical integration (or elements of it) is clearly a feature of the *manufacturer-owned or manufacturer-controlled* dispensers. The share of more or less vertically integrated dispensers seems to be around one fifth: Only 18% of US-dispensers carry only 1 brand (Skafte, 1997). An example of

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taking over market shares from the latter. (The tendency is reported in the annual reports on market developments in trade magazines such as the Hearing Dealer, Hearing Instruments and the Hearing Review.) There are now app. 6,000 hearing aid specialists and app. 5,000 dispensing audiologists in the US.

this is the franchise chain of Miracle Ear (franchised by Dahlberg, now Bausch & Lomb) which was relatively successful in the USA until an FDA-warning in April 1993 (Food and Drug Administration, 1993) on the use of incorrect information in advertisements caused sales to plummet.[44]

There are benefits and drawbacks to both of the types of relations: Independence makes it difficult for manufacturers to support dispensers, e.g. in advertising and training, because the manufacturer cannot be sure that his contribution will benefit his own products. This problem is solved in the franchising model, which allows the manufacturer to advertise own brands and training the dispenser, knowing that the benefits of these efforts will accrue to his franchisees and himself only.

However, as we discussed in section 4.1, the dispenser has a serious problem of credibility and trust-worthiness: In order to signal independence from manufacturers the dispenser may want to carry products from more than one manufacturer.[45] To solve (part of) the credibility problem, the dispenser may want to be independent.[46] But again, if the dispenser carries products from more than one manufacturer, each manufacturer will be reluctant to invest in the dispenser, as he cannot know whether that investment will benefit himself or his competitors. And without such investments, no specific assets will be accumulated with the dispenser, and the transaction cost argument for vertical integration will not apply to this case. So as long as credibility is important, franchising is unlikely.

On top of this argument against specific investments, the hearing instrument market is highly differentiated with very heterogeneous demand. Compare e.g. with glasses for which lenses differ basically along a one-dimensional axis running from lenses for long-sightedness to lenses for short-sightedness. Hearing losses are much more complex and no single instrument or series of instruments can cover all types of hearing losses.[47] More specifically, although hearing instrument manufacturers typically can deliver all types of hearing instruments in terms of size, they cannot cover all types of signal processing technology and algorithms used. Again, this requires dispensers to carry many brands and therefore precludes investments in brand-specific

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44 The warning was issued to six companies (Dahlberg / Miracle Ear, Electone, Siemens, Omni, Starkey, and Beltone), but industry sources suggest that it hurt Miracle Ear disproportionally.

45 The analogy to this situation may be the computer network consultancy company that sells a package of systems design and hardware. Such a company might want to carry hardware components from different hardware manufacturers in order to signal independence from these.

46 The more well-educated and demanding the customers, the more serious is this concern. Today, with general access to the Internet with company web-sites presenting (and praising) numerous products, and with independent consumer information, dispensers may be challenged more than ever.

47 The situation resembles that of advanced Hi-Fi audio equipment for which every fan has his own idiosyncratic requirements and preferences, not to talk about books or music records. Within such markets no single manufacturer can cover all types of demand.

assets and an ensuing vertical integration.

In the case that a manufacturer eventually would market a product portfolio that covers all customer needs, vertical integration might be more frequent. (We return to this possibility in section 5.) Still, of course, the credibility problem remains unsolved in that case.

The conclusion on vertical relations thus is, that is seems unlikely that manufacturers will be able to take control over dispensers via franchising or similar arrangements. This leaves the manufacturers without much influence on the relations to the ultimate end-user, and therefore with a reduced array of market influencing instruments, a situation that makes it particularly difficult to promote new products.

Chain-stores

While the manufacturers may find it frustrating to be decoupled from the daily contact to end-users, the dispensers might see the relationship to manufacturers in another perspective: As mentioned in section 2, there is a limited number (max. 20) of manufacturers on a global scale. The dispenser structure is much more fragmented: In a free-market situation as the American, there is one dispenser for every 20-22,000 inhabitants, since there are app. 11,000 dispensers in the US. That gives the average dispenser an annual sale of only about 150 instruments. So there are many, small dispensers confronting a limited number of manufacturers.[48] This is potentially a bad situation for the dispensers. It definitely is difficult to negotiate lower instrument prices for one, small dispenser.

The obvious solution to this problem of weak bargaining power is the creation of chain-stores. Chain stores (or cooperative purchasing) would provide the volume that could be used in bargaining with manufacturers and would moreover enable the establishment of manufacturer-independent training. Admittedly, chains and cooperatives are emerging (most frequently in Europe), but still the concept has not succeeded to the same degrees as in many other retail sectors, such as glasses and contact lenses.[49]

There probably is no simple answer to the question of why hearing instrument retailing is so fragmented. One reason may be the limited supply of persons with the right skills for managing a chain of new dispenser stores. As long as fitting hearing instruments is a highly customized process, fitting personnel must be well educated and trained. If there is no threat of new entry, existing dispensers might not feel the need for getting together in some kind of cooperation. Also, a new store might have a hard time gaining sufficient volume in a local market that is

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48 In section 4.2, we will come back to this “power balance” to see how manufacturers deal with the relation to dispensers.

49 It is possible, though, to find American examples also. One chain is Hear for Life. It cooperates closely with Danavox.

already occupied.[50] In a slow-growing market this could be a major problem, contrary to e.g. the fast food market, where the personnel problem also is solved. And finally, dispensers may not feel like getting together. The culture of this trade may well be hostile to any arrangement that reduces the degrees of freedom for each dispenser.

Interestingly enough, a chain-store development might not necessarily be opposed by the manufacturers. Even though a chain may be a tougher counter-part in negotiations, it may well be that it is easier to introduce new products and services through a chain than through a large number of free-standing dispensers, and chain-stores certainly will economize on contacting and contracting costs because of fewer relations. The eventual outcome definitely is difficult to predict, both in terms of distribution of benefits between the two levels in the value chain and in terms of possible structural changes on the manufacturing side. It may well be that the emergence of a few, strong chains would eliminate some of the weaker manufacturers.

A perspective on such a situation might be obtained by comparing the American system to a government-procurement system such as the Danish: In the latter case (which is rather similar to e.g. the British, Swedish and Australian cases), hearing instruments are distributed free to patients through government agencies, the so-called “hearing clinics”. The Danish clinics jointly procure instruments (some 60,000 a year) by annual tenders, with each of the large clinics (Bispebjerg, Århus, and Ålborg) each dispensing app. 7,000 instruments annually (Sundhedsministeriet, 1997). Such customers are very interesting for the manufacturers, both because of the volume and because of the low sales costs (one bid suffices). The customer, however, is also very demanding due to its technical and medical experience, and the industry frequently laments over the clinics’ reluctance to accept the latest (and most expensive) instruments. With limited budgets, centralized expertise and a commitment to provide (technically) adequate solutions to as many patients as possible, it has been difficult for manufacturers to penetrate socialized hearing care systems with high-performance instruments, simply because the clinics do not accept the steep price for new, (maybe yet unproven) technical features.[51] Turning again to America, dispenser chains in free-market systems do not necessarily share these features, and may therefore be better vehicles for the introduction of new, high-performance (and expensive) hearing instruments, overcoming some of the existing inertia on the dispenser-level.[52]

Summing up, we see that the dispenser level is both a necessary mediator (contacting and counseling end-users) and an actual barrier (not loyal to the manufacturer, lacking technologi-

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50 This may be seen as a Hotelling type horizontal product-differentiation (Schmalensee, 1978).

51 In England (perhaps an extreme case), very few instruments distributed through the NHS system are ITE or programmable instruments.

52 However, in case managed care systems include hearing instruments, the result on competition will probably be more or less the same as in the socialized systems.

cal insight) in the relation between hard-of-hearing people and hearing instrument manufacturers. It furthermore appears to be a structural condition that will change only very unlikely.

4.3 Hearing instrument manufacturers

In addition to the stabilizing factors at the end-user and dispenser levels, of course the industry itself has certain characteristics that may influence stability. To this end, we will examine a range of possible explanations for this observed pattern including: Characteristics of demand; the complex character of technology; high exit costs; shared patents (patent pool); research collaboration; shared development of fitting software; production agreements; and information activities.

As mentioned earlier, the industry is fairly small, only app. 20 companies worldwide are really important, and the industry produces only approximately 5 mill. hearing instruments annually. In general, "everybody" knows each other both in the market place and personally. At industry fairs most staff from component suppliers and hearing instrument manufacturers meet and know each other by first name, and there is a tendency for people to stay in the industry once they have entered it. People thus have long tenure. But, of course, the companies compete. They bid on the same tenders put out by governments, and they appeal to the same dispensers in the free markets.

This section will try to assess the nature of competition in this industry. Without pretending to present an exhaustive list of competitive aspects, and with some observations only slightly more than anecdotally substantiated, the picture that emerges seems to be one of rather limited competitive interaction or more precisely, an industry with “cooperative islands” in the world of competition. On this basis we will hypothetically describe the industry as a “friendly oligopoly”.

The list of aspects starts with industry behavior conditioned directly by factors external to the companies in the industry, and then we turn to observations on more “proactive” or strategic behavior.

Characteristics of demand: Pricing and advertising
As we have discussed in section 4.1, even if the potential market has not been realized, nothing indicates that lower prices would be an effective (profitable) tool for increasing unit sales. Aggressive pricing by the industry as a whole does not seem to be a very rewarding behavior, in the sense that lower prices apparently cannot attract enough new customers to compensate for lost profit per unit. However, what is more interesting for the individual manufacturer than the market demand schedule is, of course, their individual demand curves, that is, the price sensitivity of their individual sales. Again, it seems as if price sensitivity is rather low. No one manufacturer seems to be able to capture large markets by lowering prices.

Essentially, this pattern may be attributed to the fact that the product is very differentiated, at least for non-technicians. This is not to say that hearing instruments *technically* are very different. In fact – within the same product type – they are more or less identical. However, what matters is that to dispensers and laypersons (including newspaper journalists) hearing instruments *appear* to be different. That goes for design and technology, the service they are accompanied by, the image created around them, and the way they are distributed. Non-technicians cannot compare them, and the cross-price elasticity between them therefore remains low. It therefore has little effect for one manufacturer to lower its prices.[53]

Price reductions may also not be attractive in a situation where very quick reactions from competitors are to be expected. In that case, even though extra customers may be reached, they will quickly disappear again, as competitors also lower their prices. The outcome in such a case will be lower prices for all, and only as many extra customers as the industry demand function allows. This argument seems also to apply, to some degree at least, in the hearing instrument industry. Especially the fact that dispensers frequently buy only one instrument at a time makes it possible to match discounts very quickly.[54]

On the dispenser-level, manufacturers' incentive schemes are adding considerably to low volatility. When dispensers have a big say in which instrument the customer chooses, and the customer is not very price sensitive (or has no alternative suppliers), the dispenser will not be encouraged to recommend a cheap instruments. He will be tempted to offer the one with the highest margin for himself. Still, that should not mute price-competition among manufacturers. However, if many manufacturers have loyalty programmes, rewarding dispensers that buy many instruments from the manufacturer, price-competition will be greatly reduced (Nalebuff & Brandenburger, 1996). And indeed, such incentive schemes are very frequent in the hearing instrument industry. They work much the same way as in the airline industry (Borenstein, 1992), exploiting the fact that customers have little bargaining power, and segmenting customers into groups with a high degree of loyalty to a particular manufacturer by creating switching costs in terms of lost loyalty bonuses.

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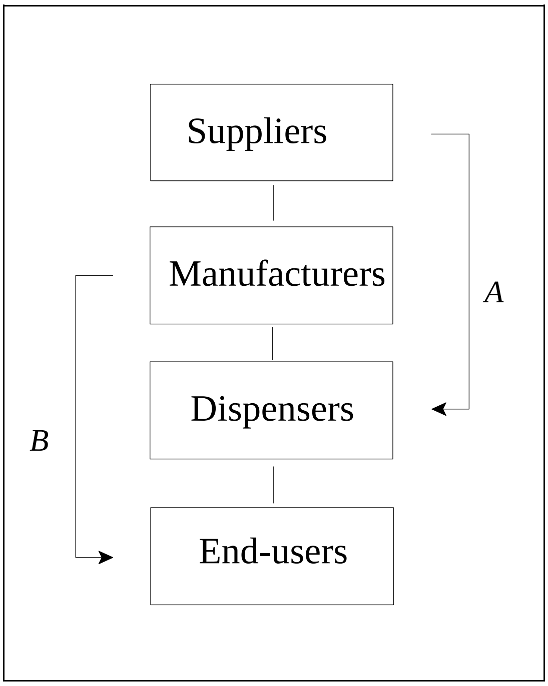
53 If buyers are technically well educated (as procurement agencies in countries with socialized hearing health systems, or perhaps chain-stores or cooperatives) competition tends to be much tougher because such buyers look primarily upon technical performance in relation to costs. Thorough and reliable consumer reports on hearing instrument performance may move the competition in the same direction.

54 It should be noted, of course, that this argument only applies if customers are willing to change dispenser if prices change, a situation that, cf. our discussion above, perhaps is not frequent in this industry.

If competition on price is not attractive, advertising might work. It may be useful to distinguish between brand-oriented advertising and general information about the benefits of hearing instruments. Brand-campaigns, in turn, may be directed both towards dispensers and end-users, while general information about hearing instruments should be targeted to the general public (potential users plus their relatives, colleagues etc.) and to some degree also family doctors.

Figure 3: Pull marketing in hearing instruments



Brand-oriented advertising is used, but not in very large scale. One major problem in creating a pull-effect (arrow B in figure 3) is that a marketing message to the end-users will have to be "filtered" through the dispenser. The end-user relies heavily on the dispenser to choose for him/her[55] and will probably trust the dispenser more than a marketing campaign. Even if potential users have formed preferences for a specific brand, it is not certain that the dispenser will agree that that particular brand is actually the best choice, and – even worse – the dispenser might not even carry that brand.[56] Here, the difficulty for a manufacturer with a novel product is that of a distribution level that is slow-reacting (sticky) due to the factors discussed above (professional self-esteem, incentive schemes etc.).

Another problem is that most people seldom buy more than a couple of different instruments in their lifetime (hearing problems are strongly age-related), and therefore do not pay much attention to the type of instrument before having to buy one. When advertising hardly creates brand-loyalty but rather awareness of hearing instruments in general, much of the benefit of an

55 Even if the dispenser directly encourages customers to look for alternatives, very few customers actually do visit several dispensers (at least according to our knowledge). One explanation is the limited number of dispensers in each neighborhood, another that customers trust the friends or doctors that typically have recommended a specific dispenser, still another that it is in the first place a major threshold to pass to admit to one person (dispenser) that help is needed, and many probably are willing to risk paying for not repeating that (somehow humiliating) situation (cf. our discussion of stigma).

56 An extreme version of this situation occurred when Oticon and Widex introduced their fully digital instruments in late 1995. The wide exposure also to a Danish audience induced a number of hard-of-hearing persons to call their local hearing clinic and ask if they could be fitted a digital instrument. Besides the fact that at least one of the manufacturers were not ready to deliver the instruments, the procurement process in the Danish, fully publicly financed system is not able to include new products that quickly. New types of instruments are only included in the assortment after thorough considerations over both costs and quality, and – like for private dispensers – only a limited number of brands are carried at a given point in time.

advertising campaign will accrue to competitors (spill-over effects), making advertising unprofitable for the individual company. The problem generally increases with industry fragmentation, that is, the smaller the companies are relatively, the smaller is the payoff that accrue to them compared to total industry payoffs. So even one of the three largest companies can only expect to reap one fifth (their market share) of the benefits of a general public marketing campaign (see also our treatment of "information activities below).[57] In section 4.4, we will see how this condition affects also suppliers.

The limited marketing efforts towards end-users may contribute to industry stability by reducing both entrants' and incumbents' possibilities for informing the public about new products. A number of studies of the cigarette industry showed higher profit and fewer entries when TV advertising was banned (see e.g. Eckard, 1991). If mass-marketing is not possible – for the reasons discussed above – the information channel between manufacturers and end-customers is shot off. Information about new products or other changes in the offers to customers must in that case get channeled through dispensers, probably retarding the impact, and underscoring manufacturers' dependence on dispensers. We will discuss possible changes in advertising behavior in section 5.

Thus, most marketing efforts by manufacturers are directed at dispensers. Such efforts come in the range from technical education to free cruises (sometimes combined). A major element in manufacturers' dealing with dispensers is incentive schemes and loyalty-bonuses which ties-in dispensers to particular manufacturers, thereby increasing the stickiness of the dispensers. Much of the marketing effort towards dispensers is thus "defensive" with the aim of building switching costs, in order to reassure that one's dispensers do not change to other manufacturers. Advertising towards dispensers probably cannot widen the total market, and it may move market shares only very slowly. These attempts at cementing status quo presumably have a direct stabilizing influence on structure, while they probably have no effect on total end-user demand.

When marketing messages to end-users get filtered through the dispensers, modifying or even nullifying manufacturer's claims, it is reasonable that pull-marketing is not widely used, and when furthermore conservative dispensers are tied-in to specific manufacturers, the possibilities for both existing and new companies in the field to gain market shares are certainly reduced, thereby stabilizing the industry.

The character of technology

Hearing instruments, no matter size or type of signal processing, are made up of roughly the same elements: A microphone, an amplifier, and a receiver (loudspeaker) is the technical core, powered by a battery. Adjustments may be made by switches and trimmers (small plastic items)

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57 These arguments may explain why the so-called project Pygmalion (Starkey, 1997) found that advertising generally is not effective for hearing instruments.

or, in the so-called programmables, by a programmed chip. The digital instruments have digital amplifiers plus additionally an A/D and a D/A converter to change the analog sound received to digital signals processed in the amplifier and back to analog sound to be send to the ear.

Even though a hearing aid therefore, *superficially*, is a standard electronic device with well-known components and should be able to benefit from the now “generic” technologies of electronics, the improvement of hearing instruments has not been a trivial process. It turns out that it has in fact *not* been possible simply to transfer technologies from other electronics fields. The tough limits on space have created development problems unique to the hearing instrument industry.

Obviously, the space limits influence the choice of power source. Only very few electronic components are designed for 1.4 voltage. Currently that has required the development of not only specialty circuitry capable of running on low voltage, but also the necessary development tools (e.g. mathematical simulations).[58] Besides the electronics, the small size also posed mechanical and acoustical problems. Most notable is the (still partly unsolved) problem of feedback from the receiver to the microphone.[59] As we will discuss below, the severe space limits have decisive consequences for the nature of technological development because of strong interdependencies among components.

Beyond the pure technological problems, hearing instrument development is hampered by the uncertainty in development objectives[60] stemming from the fundamental problem that hearing is a complicated physiological phenomenon, which is not thoroughly understood.

One of the reasons for the problems of understanding hearing is that – in contrast to glasses, which can fully compensate for a reduced ability to see – hearing instruments send amplified sound into a *genuinely defect* organ. Eyes may be defect also, but usually the lenses are just not “focused”. A hearing instrument cannot repair a hearing impairment, but can to some extent alleviate dysfunctional hearing. However, the auditory system which a hearing instrument is targeted at is still not fully understood, and it requires a multiplicity of disciplines (e.g. physics, anatomy, psychology, chemistry, neurology) to advance knowledge in this field. This implies that in order to understand and alleviate hearing impairment, a number of professions need to become involved.

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58 This is the main reason why we only now witness the introduction of digital sound processing in hearing instruments, a technology that has been available in standard Hi-Fi equipment for decades.

59 Conversation with Torben Poulsen, Department of Acoustic Technology, Technical University of Denmark, November 1997.

60 We are here dealing with the difference between “functional” uncertainty and “technical” uncertainty in development processes (see Freeman, 1982; Lotz, 1991). While technical uncertainty relates to problems of reaching a well specified technical objective, functional uncertainty refers to the problems of choosing the optimal technical specification, that is, the best design of the product.

A first consequence of this situation is that it is still not clear which technical solution is actually best for the users. The situation in hearing instrument technology is one of relatively rich technological opportunities, but only vaguely identified development targets.[61] The basic understanding of hearing does not point at any clear ways of how to substantially improve the performance of a hearing instrument.

Since we still do not know all about what hearing is and therefore not all about what the different kinds of hearing losses are, the industry is left searching for the optimal hearing instrument. Much development in hearing instrument is therefore a trial-and-error process, since no formal model can prescribe the optimal construction of a hearing instrument.[62] Not only is trial-and-error important for finding the best technical solution to a given development task, but trial-and-error is necessary also to find out which development tasks to strive for, that is, which type of instrument (features, size etc.) actually meets the users' best.[63] This allows a certain degree of "design competition" which spells itself out in the discussions over whether e.g. digitalization or directional instruments is the best path to pursue.[64]

A second consequence of this ambiguity is a reluctance to risk too much on far-reaching R&D projects. As chances of coming up with *the* solution are very small, it does not make sense for individual companies to invest heavily in one out of many possible development projects. It makes more sense to make minor steps, watch what competitors are doing, correct ones own direction according to what seems to be successful, and then take another small step.[65] This seems to a large degree to be the case in the hearing instrument industry. Generally, only when there is a consensus about where to go (and tools are available), development moves fast.

But if there is no such shared understanding regarding the development tasks for hearing

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61 Conversation with Torben Poulsen, Department of Acoustic Technology, Technical University of Denmark, November 1997.

62 Rosenberg (1982) describes the development of aircrafts, which took place also without a formal model of the performance of airplanes. Instead, according to Rosenberg, the development process relied on learning-by-using (trial-and-error processes being inappropriate for airplanes!).

63 Compare here to e.g. wind turbines: The overwhelming interest of a wind turbine manufacturer is to produce a turbine with a high energy production per investment cost (for the buyer of the turbine). This is a much more well-defined development (one-dimensional) task than in hearing instruments, which are more alike automobile in this aspect. In fact, Lyregaard (1993, pp. 40-41) lists eight performance criteria for a hearing instrument. To develop a better hearing instrument, the manufacturer must strike a balance between all eight performance dimensions.

64 It is, thus, possible to identify slightly diverging strategies for the manufacturers: For instance, Phonak emphasizes the directional hearing instrument, and Widex and Oticon seek improved signal processing and amplification by going digital.

65 This strategy makes sense even more since patent protection generally is not efficient for hearing instruments. A complex system (a car or an electronic instrument) is seldom patentable, but parts (components) may very well be. This is the case for this industry also.

instruments in general,[66] it certainly is the case for a specific aspect of the well-known ITE and BTE designs: The size of the instruments. There is apparently unanimously support for the position that “the smaller the instrument, the better”.[67] This creates a focus on a specific part of the development task, namely the reduction of size, or in short *miniaturization*. While research in the overall question of what is a “good” hearing instrument is still best described as a trial- and error process, miniaturization follows a different logic. Guiding this research and development is a *technological trajectory* (Dosi, 1982), mental guidelines shared by all members in the industry that focus attention on a limited number of problems and solutions. Size reduction has been an overarching development pursuit, assuming that customers always prefer a smaller instrument to a bigger, also even if quality is not the best. And certainly, the industry has been remarkably successful in making small instruments.

Returning to the technological problems of hearing instrument development, it is important to underline another consequence of limited space. Even though the number of components in a hearing instrument is limited, the interaction between these components is highly complicated because of the limited space available. Each component needs to be adapted to each and everyone of the other components, not only to optimize the total system of a set of specific components in general, but also to optimize a system of these components in a spatially specific combination, that is, in a specific layout in a specific case.

The systemic[68] character, the very high degree of interdependency of elements, is therefore pervasive in hearing instrument technology. Integration of technologies (whether components, production techniques or audiological principles) is extremely important. No new technology is of much value *per se* – only after integration with other technologies may it be useful.

This feature makes rapid movements difficult. Even if one part of a hearing instrument may be dramatically improved, that part still needs to be integrated into the system, and that process

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66 Lyregaard (1993) is a nice illustration of the bewilderment among industry participants on which way to go.

67 This is in a funny way a self-fulfilling prophecy: So concerned about the stigma problem, the industry has interpreted the visibility of a hearing instrument as the major cause of stigma. If only other people could not tell who are wearing hearing instruments, there would be no stigma problems. Therefore, a major feature of most brochures for hearing instruments is an emphasis on the product’s “tinyness” or invisibility. Thus, even if the customers did not share this view before, as soon as they visit a dispenser they are lured into the understanding that hearing instruments should not be visible, thereby underscoring the stigma problem.

68 The concept of “systemic” technology has been gaining interest during the 1980s. Rosenberg (1982) emphasized the complementarity between the individual elements of systemic innovations, Winter (1987) mentions the dichotomy between independent and systemic in an attempt to identify dimensions of knowledge, and finally Teece (1988) introduces systemicness in technology as a factor conducive for vertical integration, a perspective further elaborated on also by Langlois & Robertson (1995). A systems approach on nations is the emerging research field of “national systems of innovation” (Lundvall, 1992; Nelson, 1993)

may take some time as both manufacturer and component suppliers need time and resources to adjust the other parts. All elements must move together, co-evolve, making technological development smoother. This is a stabilizing factor in the sense that "jumps" based on even radical technological improvements along a single dimension of the complex hearing instrument technology are unlikely.

The result of these characteristics of technology of the product, is a development that has had miniaturization as its main component, added numerous improvements on partial problems, such as the feedback problem, or – with the programmable and digital instruments – automatic adjustments to the sound picture. Notwithstanding the efforts and the introduction of new technologies, the overall performance of the hearing instrument has been largely unchanged over the past 25 years.[69] It is easy to be carried away by the very technical language applied in promotional material for new instruments, and mistake the appraisals of the new generations of products for major improvements. Indeed, hearing instruments have become smaller and technically refined, but – for the user – no major breakthroughs have seemingly taken place. Both the lack of sufficient formal knowledge about hearing (making it unclear in which direction to go) and the systemic character of the instrument (making quick moves difficult) are stabilizing factors, impeding individual hearing instrument firms in developing radically new products.

So the impact of technology on industry structure is to favor incumbents and even to make shifts in market shares difficult. The systemic nature of the technology requires a broad "architectural" knowledge-base (see section 3), and such knowledge is not available on any market. The only way to obtain it is to participate in the industry, learning from one's own trial-and-error developments and hopefully also becoming able to decipher competitors' experiences. While in other industries entrants with new product innovations may cause disruption, in this industry the ability to produce product innovations is so closely linked to the learning that takes place by being in the industry that entry on the basis of new products seems unlikely.

High exit costs

We have mentioned (see table 1) the fact that only very few hearing industry companies are public (Oticon, Phonak, ReSound). A handful of companies are owned by larger corporations (Siemens, Dahlberg/Miracle Ear, Danavox, Philips). The remainder companies are typically privately owned, many of them with the founding family still involved in management, and with no other activities than hearing instrument production.

It is useful to analyze the differences in performance requirements and exit costs for the

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69 We are perfectly aware, that this is a somewhat subjective assessment that others may not share. The clue is to agree on what to consider a major improvement. We tend to take the perspective of the user.

different ownership structure of companies. Roughly speaking, a publicly held company must meet certain performance criteria to avoid major restructuring or acquisitions. A subsidiary of a large company may run at low performance for a period, but eventually it is sold or just closed down. Family companies, though, do not entirely follow such logic. A family owned company may well run for a very long time with almost no profits, the reason being lack of alternatives for management-owners: Exit costs are high. Such companies may choose to price almost at marginal costs just to stay in business.

No financial data are available, but it might very well be the case that some family owned companies are actually not profitable. If this is the case, industry structure (market shares) may for a while remain unchanged, making the industry seem stable. This might, however, conceal a spread in profitability that cannot leave the industry unaffected for ever. We return to this possibility in section 5.

Patent pool

In recent years 3M has built a considerable portfolio of patents on signal processing technology related to programmable and digital hearing instruments.[70] The number of patents (170 individual patents belonging to 25-26 "patent families" (Rude & Eriksen, 1997)) and especially the very broad and generic character[71] of the patents has threatened to block the development of new programmable and digital hearing instruments for the rest of the industry. Apparently, many hearing instrument companies were close to or actually did violate these patents, and in 1993 3M eventually sued ReSound for patent infringements. (ReSound, 1996b; Rude & Eriksen, 1997).

As a solution to the patent litigation, ReSound in the Spring of 1996 announced that it was about to take over "certain assets" of 3M's hearing health activities, including research facilities and patents and patent applications. The acquisition was completed in July (ReSound, 1996a; b). In August 1996, ReSound transferred the ownership of the 3M patents to a "Patent Partnership", called HIMPP (Hearing Instrument Manufacturers Patent Partnership) (ReSound, 1996c). This patent pool was set up by ReSound plus five other leading hearing instrument manufacturers (Danavox, Oticon, Phonak, Starkey, and Widex), with Siemens added soon after, and is chaired by Widex (HIMPP, 1996; HIMPP, 1997).

The purpose of HIMPP is limited to "acquire a large patent portfolio[72] and make it available to all interested parties in the hearing aid industry through membership in the partnership or through licence" (HIMPP, 1997). No more patents than the 3M patents have apparently been

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70 These are not patents on entire instruments, but on certain principles for digital signal processing.

71 Industry sources claim that the 3M patent portfolio included claims on obvious and well-known principles (Rude & Eriksen, 1997).

72 This presumably refers to the 3M portfolio.

added, but the possibility of expanding the portfolio is not excluded by the pool. It seems to be the intention that this patent pool shall buy "generic" patents that otherwise would block the development of new hearing instruments. "Strategic" patents that protect a particular instrument will not be pooled, but remain proprietary to the company which took out the patent.

The economics of patent pool arrangements are relatively complicated (see Andewelt, 1984) and not well explored. From an anti-trust perspective, four factors may have caused the industry to set up the collaboration: Firstly, the more important probably being an attempt to economize on contracting costs. It certainly is very costly to set up licensing agreements. The HIMPP solution limits the contracting costs to the initial formation of HIMPP, indeed a very simple and cost-efficient arrangement, granting all members all rights to use all 3M patents without any further negotiations or monitoring. Secondly, the pooling agreement eliminates the incentives to develop competing patents, economizing on R&D expenditures. And, thirdly, the industry probably also has considered the increased bargaining power of joining forces *vis-à-vis* the owner of a patent with possible applications in the hearing instrument industry. The patent pool in this situation turns into a purchasing agreement, similar to agreements among retailers (supermarkets, opticians, bookstores etc.) or hospitals to set up purchasing agreements and thereby act as one agent (a monopsonist) towards suppliers. With all the major companies in the pool, negotiation power *vis-à-vis* independent innovators seems to be considerable.[73] Finally, the partnership may engage in research activities that can produce new, generic patents. The 3M patent portfolio was established largely through a 3M collaboration with Washington University, an arrangement that could be repeated (Rude & Eriksen, 1997).[74]

If there in general are benefits (for participants) from establishing an industry patent pool, it might be worthwhile to question why it is such a rare phenomenon. Following the text-book (e.g. Scherer & Ross, 1990) requirements for cartel behavior, it may be argued as if the establishment of a patent pool requires elements as cultural and cognitive proximity between members in order to work. The establishment of the HIMPP patent pool may be an indication of the existence of such conditions in the hearing instrument industry, and thereby HIMPP contributes to the understanding of the "competitive climate" in the hearing instrument industry: Eliminating a potential, competitive advantage (ReSound could have kept the 3M patents proprietary) probably requires a relatively sophisticated common understanding of who is to win and who is to loose on this arrangement, and therefore on some kind of a compensa-

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73 If the value of a patent for a hearing instrument manufacturer is proportional to the manufacturer's current volume, the pool will have to pay only marginally more than the biggest non-pool-member would offer, a figure that goes towards zero as the pool includes more and more manufacturers.

74 While this is not an antitrust analysis, it is clear that the two first effects are welfare-increasing, by diffusing existing knowledge as widely as possible and by eliminating unnecessary, duplicate research. The third effect may well be welfare-reducing as it may reduce incentives for innovative activities related to hearing instruments, while the fourth effect may increase welfare by allowing research that no one company would undertake alone. Of course, these consideration are conditioned on no other effects on competition by the pool.

tion schedule (be it very simple). The same goes for possible future research project to which the pool-members must contribute according to some scheme. The establishment of such a scheme probably in most other circumstances requires so detailed and confidential information that an agreement will never be met, but in the case of the hearing instrument industry the long-lasting relationship and mutual understanding apparently enabled it.

By setting up the pool and agreeing on a compensation schedule on the basis of today's benefits for the participants, the agreement reduces the "risk" that one of the participants will benefit alone either by buying the patents (e.g. ReSound) at a price lower than their eventual value (similar to winning in a lottery) or by developing a patent that replaces the existing patents and thereby destroys their economic value. The pooling arrangement therefore contributes to "locking" the companies into the existing structure of relative size.

Research collaboration

Improved quality has great competitive potentials, especially since better hearing instruments may increase the fraction of hard-of-hearing persons that actually uses hearing instruments. But the market is usually very skeptical and slow moving, a characteristic that probably has been strengthened after the FDA intervention in the mid-1990s *vis-à-vis* Miracle Ear. However, improved quality has been a major concern of the manufacturers, and besides individual efforts to develop better instruments, there has been a least one major collaborative research effort.

Starting in 1989, the three Danish companies (Oticon, Widex and Danavox) participated in the research project ODIN, located at and managed by the Danish Technical University. Each of the companies contributed with manpower and the Danish government supplied basic financial support. The nature of the research was truly "pre-competitive"[75] aiming at enhancing the understanding of speech comprehension with background noise, one of many still unexplored areas of basic research within audiology, but the results have later been applied to the development of programmable and especially the fully digital hearing instruments.[76]

It certainly is remarkable that competitors agree in setting up joint research projects, in itself a sign of some degree of mutual understanding and recognition. However, the results of a joint research effort are as interesting. Besides sharing research costs and thereby producing results that smaller scale, individual projects may not have been able to generate, a joint project also has the effect of building common understanding of what are relevant problems and ways to solve them. It tunes the participating companies into a specific way of interpreting the problems facing them and coordinates (to some degree) the means for solving them, reinforc-

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75 That is, concerning research topics of such a basic nature that it needs additional, applied research in order to be useful for industry. The term has been widely use in EU research programs.

76 Interview with the former project manager of ODIN, Torben Poulsen, Technical University of Denmark, Fall 1996.

ing the established technological trajectory. Joint projects – on the one hand – prevent that some companies simply do not realize certain technical problems and possible solutions, thereby getting lost. On the other hand they make it more difficult for single companies to move rapidly alone along some technological dimension, trying to reap first-mover-advantages (and risking to make the wrong bets). Thus, joint projects may contribute to industry members keeping in step instead of each pursuing their own idiosyncratic ideas, thereby limiting variation.

Shared development of fitting software

While participation in the ODIN project was limited to only the Danish companies, most hearing health companies are now members of the Hearing Instrument Manufacturers' Software Association (HIMSA). HIMSA was founded by and is still owned by the three Danish companies plus Swiss Phonak, but soon most other companies supported the effort. Incorporated in Denmark in 1993, the aim of this collaborative effort was to develop a standardized fitting software to dispensers in order to promote the diffusion of programmable instruments.

Realizing that the penetration of programmable instruments was slowed down by the inability of dispensers to deal with the growing range of different fitting tools provided by the manufacturers, HIMSA decided to develop a PC based fitting software (called NOAH) that could accommodate all types of programmable instruments. Instead of producing model-specific transformers (boxes), the PC based system requires only that the manufacturer supplies the dispenser with a piece of software (and that the dispenser has a PC).[77]

The HIMSA cooperation has set an industry standard that obviously has muted a competitive dimension, namely the hardware boxes. Destabilizing effects from that area have thereby been avoided.[78]

Production agreements

Frost & Sullivan (1994) mention that some companies only produce some instrument sizes and source the remaining sizes by other hearing instrument companies. It certainly seems to be an attractive strategy e.g. for an American company producing ITE and ITC products to source BTE products with one of the European companies, if its sales of BTE products on the American market is too limited to warrant production.

The attractiveness of such agreements of course depends heavily on the degree of economies

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77 Interestingly, this should reduce the amount of specific investments and decrease switching costs for dispensers, allowing them to change supplier more easily. However, still only 57% of American dispensers use computers for testing and fitting (Skafte, 1997).

78 See, however, section 3 for the latest developments in the fitting field.

of scale and scope in production. Even though companies differ in terms of product range, this should not lead to the conclusion that mobility between the product segments is particularly difficult. Every manufacturer seems to be able to produce both BTE, and ITE and ITC products, and from the companys' product portfolios it seems more to be the case that the product preferences of served markets govern the product portfolio more than the other way around. That is, technological competencies of companies determining their choice of products. So even though a company may be capable of producing the full range of products, it may choose to manufacture only its most frequently sold types.

The ability to produce every type of hearing instrument might be exploited both by *not* producing and by actually producing: If economies of scale are substantial, it may well be more economical to use the ability to produce internally only to negotiate reasonable prices with another hearing instrument manufacturer, sourcing particular products to complete one's product range.

The extent of such activities is basically unknown to us,[79] but it probably can take place only under circumstances characterized by mutual trust and respect. It may indeed work best if the relationship is reciprocal, that is, one company producing BTE instruments for another company that in turn produces ITE/ITC instruments for the first company. In that case, hearing instrument manufacturers exploit each other's production competencies, tie each other in, and gain important information on each other, all factors furthering stability.

Information activities

If stigma is a major obstacle for the penetration of the potential market, there seems to be scope for a massive campaign towards the general public, educating it about the benefits of wearing hearing instruments. As a result of such discussions the American hearing instrument manufacturers, dispensers, and suppliers in 1973 initiated the formation of the Better Hearing Institute (BHI) as a vehicle for the dissemination of information about hearing health and hearing instruments.

Usually such collaborations are difficult for industries to establish, but in this case it succeeded. Support for BHI has not, however, been stable, and recent marketing research (Starkey, 1997) indicates that even if stigma is a problem, marketing efforts can do very little to alleviate the problem. The dwindling support for BHI may therefore be taken not so much as a sign of negotiation problems, but more as a realization that such efforts may not be worthwhile; that the customers do have the relevant information already, that they make reasonably rational choices (that they actually would not benefit enough from a hearing instrument to warrant the expenditure), and that no more information can persuade them to buy more hearing instru-

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79 Siemens' ambitious expansion of production capacity in Singapore and Suzhou, China, (see Siemens' home-page) may be part of a plan for the extension of shared production. If capacity exceeds demand, however, excess capacity may trigger price wars (see section 3).

ments.

Conclusion
Summing up on the industry behavior it should be stressed that the industry is in a situation where tough competition on price and advertising makes only limited economical sense, not only from an industry perspective but also for the individual companies. Also to some degree muting competition is technology, as it does not allow for major jumps. Finally, and probably partly an effect of the former characteristics, the industry participants have succeeded in building a series of collaborative undertakings, all of them adding to the mutual trust and respect among industry participants, which again facilitates further collaboration. Competition of course is still vigorous, we are certainly not dealing with anything like a cartel, but at least in some areas, along certain competitive dimensions, competition is supplemented with cooperation.[80] It is on this basis that we have coined the term "friendly oligopoly" on the hearing instrument industry.

4.4 Suppliers

Component suppliers deliver components to the hearing instrument manufacturer which assembles them with own parts. The degree of backwards vertical integration is limited, however, so the only component types which some hearing instrument manufacturers produce partly themselves are some electro-mechanical components and amplifiers.

As we have stressed in section 4.3 discussing the systemic character of the technology, each component interacts with all other components in the small space available in the shell of a hearing instrument. A component supplier, thus, cannot change a parameter of its component without influencing the functioning of the entire hearing instrument, all else equal. Once a component has been designed into a specific hearing instrument model, it typically will not be substituted by another supplier's components, neither a cheaper one (since even the so-called "drop-in" copies are never exactly the same as the original components) nor a better one (since one better component can rarely improve the performance of a whole instrument), thus establishing switching costs.

The manufacturer is the assembler of diverse components, and is therefore the coordinator of disparate suppliers and their components. Each supplier provides no more than one, small part of a larger whole, characterized by strong technological interdependencies. Therefore, if a supplier develops a new component with a changed functionality, such a component may be difficult to commercialize, since acceptance from several parties of the customer base is required. Acceptance has to be built with designers at hearing instrument manufacturers, who

80 We return to this observation in section 4.

have to reach acceptance with their production colleagues, and so on.

The fundamental reason for slow acceptance is the huge switching costs for hearing instrument manufacturers, incurred from changing supplier. These costs stem from required changes in testing, documentation, design, production processing, and purchasing. The industry, thus, estimates that the time it takes to switch from one electro-mechanical component to another is about two years. The reason is primarily that changes in the design are needed, and tooling has to be reworked or adjusted. Switching costs for transducers are 4-5 months and are primarily related to readjustment of the electro-acoustical parameters and purchasing routines (specifically part numbers).

Thus, the development of a new and superior component will not immediately, but only very gradually, be able to generate extra profits. This is, however, only one of two possible ways of getting success as a component supplier. Instead of seeking acceptance from many manufacturers, a supplier might bet on only one manufacturer, supplying that particular one with a custom-designed component. As development budgets are limited (so customized development cannot be carried out for all manufacturers), economies of scale in production for some components considerable (making a customized component more expensive than a standard component), and as the success of a new hearing instrument depends on much more than just one component, such a strategy is definitely very risky. All of this implies that competitive positions change only incrementally among component suppliers.

Now, if it is cumbersome to introduce components with new functionalities because of the suppliers' reliance on acceptance from manufacturers, this strategy obviously is not very attractive for suppliers. Instead, supplier development activities have focused on maintaining the same functionality in a component, but trying to make it still smaller and smaller. In short, "make the same but smaller", complying with and buttressing the miniatuization trajectory of the industry. As long as a component's performance is well-known, acceptance of a smaller version is almost guaranteed. This logic has driven component suppliers to develop still smaller and smaller components.

The competitive relations between key suppliers is illustrated in table 4. Each hearing instrument manufacturer tries to keep several suppliers for the same type of components in order to decrease the suppliers' bargaining power. However, the number of alternatives is limited, as is shown in table 3.

Table 4

Suppliers' product-markets					
	Knowles	Microtronic	RTI	Gennum	In-house production[1]
Transducers[2]	√	√			none
Electro-mechanical components	(√)[3]	√	√		little
Amplifiers			√	√	some

Notes:
1 Hearing instrument manufacturers' in-house production.
2 There are two other transducer suppliers which are expected to take up 3-5% of the market for transducers for hearing instruments: Lectret (CH/SIN) delivers microphones only, whereas Tibbetts (USA) deliver both microphones and receivers. Due to their small size, these suppliers have been left out of the table.
3 The parentheses by Knowles' position in electro-mechanical components is due to Knowles' recent acquisition of Ruf (mid 1996), establishing Deltek as their electro-mechanical division. However, this supplier is relatively small with an estimated share of 3% and this position has not been considerably developed, yet.

Electro-mechanical components (trimmers, switches, volume controls) are not strategically important to hearing instrument manufacturers. Their functions do not significantly affect the performance of a hearing instrument. Microtronic (DK) and RTI (US) have been dominant suppliers on the market for electro-mechanical components for about 20 years. However, they pursue different strategies. While RTI has focused on automation of production processes, Microtronic has centered its development around customized products. As mentioned, some hearing instrument manufacturers produce minor amounts of electro-mechanical components for their own use.

In this particular market, no major changes in neither technology nor structure have taken place. Due to digitalization of hearing instruments (see section 5), electro-mechanical components will gradually become superfluous over the coming years, and production will fade out. We will therefore not deal further with the component market.

Amplifiers are increasingly becoming strategic components for hearing instruments manufacturers. Gennum (CAN) is the largest player in this product-market, but RTI's position is improving. More significantly, however, is that the hearing instrument manufacturers are themselves increasingly designing and producing (parts of) their own amplifiers.

The amplifiers are the "heart" of the hearing instrument as this is where the signal processing takes place, enabled by the specific algorithms designed into the amplifier. The algorithms are uniformly designed by the hearing instruments manufacturers.

In terms of hardware, an amplifier consists of one or more integrated circuits (ICs) which are mounted on a hybrid together with passive components. Some hearing instrument manufacturers design their own ICs, but they do not produce them. Gennum and RTI are the main designers of ICs for hearing instruments.[81] But the final production of IC is carried out by so-called foundries (except that Gennum manufactures some analog ICs).

A majority of the hearing instrument producers design and produce their own hybrids. However, Gennum and RTI are also suppliers of hybrids.

Speculations on the implications for this component market of the advent of digital signal processing will be presented in section 5.

Transducers (microphones, receivers) are regarded as highly strategic components in terms of hearing instrument functionality and performance. Established in 1946, the American, family-owned Knowles has ever since been the de-facto standard setting player in the transducer product-market. This situation is, however, slowly changing as other companies recently have been first with new products (Tibbett with a small microphone and Microtronic with a small receiver). Knowles is now seen to make equivalents of these products. Roughly, Knowles accounts for 80% of the market for transducers and Microtronic takes up about 15%. With this market share, volume production at Knowles has been possible, a crucial requirement for cost-effectiveness in the production of a generic product such as transducers. Customization has not been prevalent on the part of Knowles *vis-à-vis* manufacturers, and Knowles has moved far down the learning curve of transducer development and production.[82]

A further factor buttressing the position of Knowles is the strong appropriability regime prevailing within transducers (as opposed to the hearing instrument as such). Patents are used to a very high degree because the parameters of transducers can be explicitly specified. Knowles has an impressive and highly effective patent profile. This essentially emphasizes Knowles' (somewhat) monopolistic situation on the market for transducers. Its closest competitor, formerly Microtel now Microtronic, has historically positioned itself in the market for transducers by engineering "around" these patents to deliver so-called “drop-in” replacements of Knowles' products, as this was seen as the most sound way of getting a foot-hold in the market for transducers. Microtronic is now attempting to change this follower-strategy and has successfully launched its first, non-Knowles-alike product.

Finally, Knowles has been active in affecting dispensers, trying to establish a market-pull effect (arrow A in figure 3, section 4.3). A particular case in point is the so-called "Class-D", which is the integration of a particular type of amplifier within the case of a receiver, a concept patented by Knowles. When launching this component, Knowles actively marketed the

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81 In field, also HEI (US) and Etymotic Research (US) are players.

82 The Danish hearing instrument manufacturer, Danavox, produced transducers in-house at some point in time. It is well-known in the industry that Knowles bought the production equipment and destroyed it.

component to dispensers, arguing for improved sound quality and smaller size of the hearing instrument, to have them "pull" the component through the hearing instrument manufacturers. This proved highly successful, and the Class D-concept is now a *de-facto* standard.

In this regard, Knowles' strategy has been unique for a supplier in the hearing instrument industry. Neither before nor after the Class D has such a marketing strategy been seen. The hearing instrument manufacturers did not approve of it, but the Class D has successfully penetrated the hearing instruments, and the manufacturers reluctantly had to accept it.

Knowles is also in other ways involved in both end-user and dispenser-level areas of concern. As mentioned earlier, the most influential market researcher in the hearing instrument industry is employed by Knowles (Sergei Kochkin), and Knowles is engaged (with Gennum and Northwestern University) in investigating the effectiveness of various types of marketing mixes (Starkey, 1997). These practices can thus be seen to cement Knowles' transducer- position throughout the entire value chain of the industry.

A decisive factor for Knowles engaging in these kinds of activities is its dominating position on its own market. Unlike a hearing instrument manufacturer that cannot avoid that benefits from advertising or general public information get captured by competitors, Knowles has historically been alone in its specific field of transducers, and could enjoy almost all benefits in the transducer market of e.g. an increase in total hearing instrument sales.

Knowles is thus in a virtuous circle, continuously cementing its own position and making entry or development of alternative suppliers' position extremely difficult. Although it is virtuous for Knowles, it might be frustrating for hearing instrument manufacturers as they are not accommodated in their requests for special components and as Knowles' bargaining power is maintained at a high level.[83]

Some attempts have been tried to change this situation. Siemens Audiologische Technik purchased the Dutch transducer supplier Microtel in 1989. As mentioned, Microtel developed and produced "drop-in" replacements of Knowles' products in order to reduce switching costs for hearing instrument manufacturers. However, in transducer production economies of scale are pervasive, and high volumes are necessary for profitable operations. In-house demand from Siemens itself could not establish sufficient volume in Microtel, and Siemens' competitors were reluctant to purchase transducers from Microtel due to confidentiality and lock-in concerns *vis-à-vis* Siemens.

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83 Knowles' (and Gennum's) position in the hearing instrument industry may be compared to the position of Intel and Microsoft in the PC industry. In the PC-industry, the lion's share of profits end up with the two major suppliers, Microsoft and Intel, while the producers of PCs – to be compared with the hearing instrument producers – earn only a modest part of total profits. See Borrus & Zysman (1996) for an analysis of the PC industry with this perspective.

Therefore, in 1993 an exclusive sales agreement allowed Microtronic to sell its own electro-mechanical components and Microtel's transducers at the same time. And in 1995, Microtronic acquired Microtel. Since then, Microtronic has developed as a small alternative supplier to Knowles, and has increased its market share to approximately 15%.[84]

In general, the lack of vertical integration between transducer suppliers and manufacturers can be explained by the scale economies in development and production of the component. No single hearing instrument manufacturer can live up to volume requirements for minimum efficient scale (MES) of production. And as the competencies needed for transducer production are so different from hearing instrument production, economies of scope in R&D and production are virtually non-existing.

Therefore, the vertical integration of Siemens could not break Knowles' monopoly, and it remains to be seen whether the uprising of Microtronic will serve as a significant challenge for this. In this respect, the behavior of the hearing instruments manufacturers could be of significant importance. If manufacturers actually feel exploited by Knowles,[85] they in principle could just shift to Microtronic (if not immediately, then gradually) and establish a balance of power between the two suppliers. However, as long as Knowles still has a cost and product-breath advantage compared to Microtronic, such a move is initially costly for each manufacturer. So while concerted action would be to the benefit of all manufacturers, each of them would rather let the others pay the price and keep buying from Knowles.[86] And despite of the friendly oligopoly in the hearing instrument industry and manufacturers' successful cooperation in other fields, there seems to be no successful coordination of support for the alternative supplier.

In conclusion, we take the combination of the systemic character of the technology, switching costs, and the very concentrated oligopolistic structure among suppliers as contributing to stability in the market for hearing instruments.

The very limited number of component suppliers may well limit possibilities for turbulence among hearing instrument manufacturers simply because all manufacturers will have to use the same suppliers and basically the same, generic components. The manufacturers may not like this situation: In order to be able to distinguish themselves from the other manufacturers, each

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84 Knowles' acquisition of Ruf in 1996 may be interpreted as a retaliation: With that move, Knowles entered Microtronic's core business of electro-mechanical components.

85 Of course, if the manufacturers have any leverage at all, they should assess carefully the trade-off between being exploited by a monopolist with major cost advantages due to scale economies, and buying from two competing companies, each of them with no chance of matching a monopolist's scale economies. The choice hinges on the degree of scale economies and the degree of competition between two possible suppliers.

86 This is a classic example of a Prisoners' Dilemma.

manufacturer seeks to introduce new products with superior and distinctive features. But to make a really different new hearing instruments that cannot be imitated immediately, the manufacturer would need customized components. However, as long as component suppliers are not forced by tough competitors into this business of customizing, they probably will prefer to produce as standardized components as possible. By doing so, they not only obtain the best short run protection of their market power, they also avoid the risk that one hearing instrument manufacturer – by introducing a successful instrument based on a customized component – should gain so much market share that captive production of components would be economical. (Had Siemens had a 50% market share, in-house production of transducers might have been feasible.) So obviously, component suppliers have a strong interest in keeping their customer base – the hearing instrument industry – fragmented, and one way of doing this is by insisting on standard products.

As long as the hearing instrument manufacturers are not in a position to produce their own components (at least not all of them, and especially not the transducers, as we have seen), the manufacturers must rely on the components from suppliers. In a sense, this deadlocks important dimensions of technological development in the industry, because the manufacturers cannot internalize the entire technological system and optimize over all components.[87] And a component supplier cannot enter the manufacturing business (forward integration) alone, only if component suppliers covering all component types go together they may succeed. We return to this possibility in section 5.

4.5 Concluding on stabilizing factors

The hearing instrument industry is facing a demand with a potential, absolute maximum: The number of customers that can be attracted – the hard-of-hearing people – ranges at about one tenth of a population. The actual number of customers is between a fifth and a fourth of these persons. This penetration ratio seems to be roughly the same in all countries. We have attributed the low penetration ratio first of all to product quality, stigma and problems of getting used to wearing a hearing instrument. These factors are very hard to change and we do not expect major changes in this area. What is left to influence the total size of the market is price. We estimate that free hearing instruments may (theoretically) double the US market in terms of units, but without major new third-party payers (or totally new cost structures), price reductions will not be profitable for the industry.

An industry with a very stable demand probably is not very conducive to major changes in

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87 We here see an example of the limits of the argument (e.g. Figueiredo & Teece, 1996) for vertical integration because of systemic technology. If economies of scale are sufficiently strong in some elements of the product, and the industry using these components is sufficiently fragmented, vertical integration of these elements may be impossible.

industry structure. It certainly is possible to move market shares in a situation with stable demand, but not to the degree that could be expected if demand had been volatile. Fluctuating demand allows new companies to come in during peak demand periods, while forcing out companies during sluggish demand.

The dispenser-level has a direct, dampening effect on changes in industry structure. Having the contact to the end-user, dispensers filter or adjust any information the manufacturers may want to convey the end-users. This limits the use of mass-marketing, even if hearing instrument as an experience good[88] should be considered an area well suited for mass-marketing. And with a stock of 11,000 dispensers in a country like USA, it is a daunting task for the relatively small manufacturers to convince them about their products' superior features. Instead, manufacturers have resorted to "defensive" marketing, aiming at preventing once convinced dispensers not to shift to a competing manufacturer. The stickiness of the dispenser level seems to make it an almost impenetrable barrier for manufacturers, contributing heavily to stability.

Technology also has features that dampens turbulence. Its systemic character requires the development process to emphasize system integration, not permitting quick, new product introductions based on a single innovation. Add to this that economies of scale do not allow manufacturers to produce their own components, but that they are produced as fairly standardized goods by a very small number of suppliers.

These two latter features of the industry, the sticky dispensers and the systemic technology, are probably the major contributors to stability. They make it very difficult to move quickly in developing and marketing a new product, and they therefore allow followers (other incumbents) to catch up before an irreversible lead has been established. It is not that first-mover advantages are eliminated altogether, but the advantage of being first with a new product is certainly reduced.

To a large degree, one may take another element of industry behavior – the friendly oligopoly – as natural reaction to this situation: If it is not possible to shake competitors with rapid product introductions and capture end-users' attention, then the companies might as well try jointly to improve their situation by setting up a number of collaborative arrangements. These collaborative efforts have the benefit of both reducing competition and pooling resources for development. It also may reduce the risk of entry, if the members can more effectively build competence together than individually. But with our data, it is still not possible to draw firm conclusions on the question that always follows cooperative behavior among competitors: Is there a benefit of free-riding, and if so, how can that be avoided? A tentative answer is that over-all benefits of free-riding are perhaps not large, and more importantly, the price of free-riding may be high: Trust and mutual respect could in this sense contribute to stability by

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88 As opposed to a search good, an experience good cannot be evaluated by the customer effectively before purchase. The customer cannot – without owning it – assess the value of an experience good.

including in the price of defection also the lost option of participating in future collaboration.

5 The future: Will stability prevail?

While the report to this point has been historical, in this section we shall try to look ahead and speculate on what might happen to the friendly oligopoly in the future. We do not pretend to be able to predict what will happen. We only try to identify changes in technology that may threaten the stability

We start out by recapturing the latest developments in industry structure: Apparently merger activities have been increasing over the last couple of years. We have seen Oticon buying a relatively large competitor and establishing itself as a strong number three in the industry, closely following Siemens and Starkey. Also, (not mentioned earlier) we have witnessed a close bilateral cooperation between Danavox and ReSound,[89] explicitly not a full-blown merger, but with strong commitments to joint technology development, and we have seen ReSound engage in yet another alliance with Philips. Again, this may well be pure incidents; merger activity seems generally to follow unpredictable cycles, but these are signs of increased concentration, and perhaps of a certain uneasiness or nervousness among the players. What may be the reasons for a possible concentration? From two perspectives, digitalization and changes in supplier structure, we will try to look ahead, in order to assess the structural stability of the hearing instrument industry.

Further penetration of digital technology. This will essentially demand completely new competencies of the part of hearing instrument manufacturers and require extensive investment in R&D. Since Oticon respectively Widex launched their fully digital hearing instruments in 1995, only by the end of 1997 other instruments of that type has appeared. This indicates the size of the task, but may also suggest that digital technology will only slowly be adopted by the industry as such. At present, there is thus uncertainty whether digital signal processing provides improved sound quality and speech recognition. But *if* digital signal processing proves to be of major value, and *if* the development of digital instruments are more resource-demanding (which the collaboration between ReSound and Danavox plus the retarded introduction from other players seem to suggest), *then* simple arguments about economies of scale will apply and force mergers and shake-out. In that case, digital technology will in years from now stand out as a radical innovation that caused a major restructuring of the industry.

An example of how this process could evolve may be the battle over fitting tools. Hitherto, as mentioned in section 4.3, the industry has agreed on supporting the NOAH standards, relying on dispensers to use PCs as the general hardware component. However, introducing Senso, Widex made the strategic move of delivering the fully digital hearing instrument with an extremely simple fitting box. By developing an independent fitting box, Widex went beyond the NOAH-cooperation in the industry. Widex recognized the difficulty for dispensers in

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89 This cooperation includes a third company; Audiologic (US) which specializes in digital signal processing technology.

purchasing and using computers and accommodated the (still many) computer-illiterate dispensers by offering the fitting box. So even “traditional” dispensers are now given the opportunity to dispense advanced hearing instruments, something very appealing. The PC-based NOAH standard was established in order to expand the diffusion of programmable hearing instruments by reducing the number of tools necessary for a dispenser to fit instruments. Apparently, the presumption that dispensers would acquire PCs was to optimistic. At least, many did not, and they are now offered the Senso fitting box that is much simpler to use than the PC-based tools. In principle, it could be imagined that even drug stores and the like could have the fitting box and be able to fit the Widex instrument.

By circumventing an agreed industry standard, Widex may have caught many competitors “on the wrong foot”.[90] If they thought that they could rely on the NOAH equipment for fitting, they now realize that they also have to develop a fitting box, probably postponing their introduction of digital instruments further. If the digital instruments meet the expectations (which is not yet clear), the box might have helped Widex to gain a lasting first-mover advantage. However, most of the established hearing instrument companies may imitate the technology, so for the advantage to endure it has to build upon a brand-loyalty that is unusual for the industry.[91]

The Widex move may even have a larger impact on the industry: We have identified dispensers as a major contributor to overall stability, but *if* the new Widex fitting box is actually so easy to use as claimed, *then* it may revolutionize dispensing, eventually eliminating existing dispensers. (Their detailed knowledge of audiology and available solutions may be superfluous if one instrument can be very easily fitted to accommodate the most common hearing losses.) Without the dispensers as a mediating factor, much more direct marketing (as in other consumer products) may be applied. That would be to the benefit of the large companies, as mass-marketing is very costly. Alternatively (as we discussed in section 4.2 under vertical integration), if the Senso instruments can alleviate all types of hearing losses, Widex might be tempted to set up their own dispenser-chains (most likely on a franchise basis). Also contributing to a shake-out may be the limited ability of un-experienced dispensers and potential customers to cope with more than a hand-full of brands. And finally, it may lead to more competition on price, favoring cost-efficient companies.

Even without exact numbers available, the success of the Senso seems to be unprecedented, a

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90 Giving the new product a name that – at least for some – signals a dramatic shift in competitive climate was probably unintended (“senso” means “war” in Japanese).

91 Whether this is possible is not clear. That there is very little brand-awareness in the industry now, does not necessary mean that building brands is impossible. And if possible, the companies trying will at least not have to fight existing brands, since they simply do not exist. Despite the presence of a large number of other stabilizing factors, the potentially very strong stabilizing factor of heavy brand-loyalty cannot be said to influence this industry at present.

success that has taken the industry by surprise. After the very slow penetration of programmables, the expectations to the more advanced instruments probably were tuned down. After all, digital instruments are very expensive[92] and would probably only appeal to those that otherwise would have acquired a programmable, indicating a small market. Also, competitors should be expected to establish their own digital brands soon enough to share the success. (Oticon was already there from the start.) But apparently, the Senso has the power to break the rules.

Changes in the supplier structure may be another potential cause of turbulence in the manufacturer industry structure. With digital processing, integrated circuits (ICs) become more important, and the hearing instrument manufacturers do possess the competencies needed for the design of ICs, but not for the production of them. However, possibilities for sourcing production capabilities exist. This leads to a decline in manufacturers' dependence on suppliers.

But the reverse is also true: Historically, it has been the hearing instrument manufacturers' discretion to develop the amplifier and fitting algorithms. This is regarded as the "heart" or "core" of the hearing instrument. However, with the advent of integrated circuits and hybrids, suppliers of these components may become capable of entering amplifier production, which in its turn will enable them to develop full-fledged hearing instruments. Imagine, *if* hybrid or IC suppliers could buy fitting algorithms on the market and put them on their hybrids, *then* this would establish the "core" of the hearing instrument as a product to be purchased on the free market, inviting especially hybrid producers to integrate forward into the manufacture of hearing instruments. A potential great advantage from such a move would be the integration in one company of a large part of the systemicness of hearing instrument technology. If a single company come to command a much larger market share this way than the leading firms have now, the whole structure of the industry (including suppliers and dispensers) could change dramatically.

Thus, as the two types of designers and producers (hearing instrument manufacturers and hybrid suppliers) see their product areas increasingly overlapping, there may be a ground for potential confrontation and turbulence, challenging the stability. There are "brakes", though, on the development: First, the required system integration is highly complex – even some of the incumbent hearing instrument manufacturers are still struggling with it. This competence is not easily attainable, and is therefore an important barrier to forward integration for suppliers. Second, as long as there are alternative suppliers, hearing instrument manufacturers probably will react to forward integration of an amplifier producer much the same ways as it reacted to the move of Siemens when it integrated backwards into transducers: They will probably only very reluctantly buy components from a supplier that is also active in their own core market.

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92 Whether digital instruments will stay expensive or will drop in price as many other digitalized electronic products remains to be seen.

The move by an amplifier producer, therefore, might well be not only costly, but also extremely risky: It must consider the possibility that the customers of its traditional core product, the amplifier, may turn their back to it, and go its competitors[93] or start their own production. Faced with this choice, it might be a safer strategy to concentrate on the production of amplifiers.

Concluding on the future perspectives, we do see potentials for change. Also, the more behavioral parts of the friendly oligopoly, the relationships building on mutual trust and respect, might not last. While some relations may well survive, many may also break down if the industry enters a more competitive era. As it takes a lot to build real friendships, maybe only a few defections (or even *perceived* defections) may break long-lasting relations. Small events may very well trigger processes that threaten the friendly oligopoly. A break-out from the agreements on supporting the shared standards on fitting software, or a decision to expand production capacity in order to be able to meet increased demand by own means may be examples of non-cooperative behavior to which only tough answers apply.

Still, however, most of the forces of stability probably will be intact for a long time. These "checks and balances" probably will keep the system running more or less unchanged for some time. But the chances are, that only apparently small changes (such as one manufacturer reaching MES for a critical component) may change the logic of the system entirely and drive it into dramatic changes.

93 Figueiredo & Teece (1996) provides examples from telecommunication equipment of this possibility.

6 Discussion and conclusion

Analyzing an empirical phenomenon so complex as an industry and applying so diverse analytical tools as we do, must produce several findings and conclusions both regarding its empirical subject matter and the theoretical perspectives applied. In this section we therefore first conclude on the reasons for stability and then point at a number of theoretically interesting results of the analysis.

Why stability?

This article was initiated by a curiosity as to why the hearing instrument industry seemed so stable. Both current theorizing on industry development (based on product-life-cycles models) and current perception of practice (hyper-competitive environments) led us to expect much more turbulence in this particular industry.

Our "bricolage" of and triangulating data on market growth and size, concentration on product-markets, entry/exit, and merger and acquisition activity did not change our perception of the industry as one which is fairly stable, acknowledging some variation in market shares over time.

First, though, a note on a feature of the industry that we do *not* count as a stabilizing factor: Some would argue that the sheer small *size* of the industry may be taken as the explanation for the stable development. The size, coupled with its fragmented character, implies that it does not make economic sense to carry out broad scale technology development projects. Also, it does not grant much rationale for huge marketing campaigns, or even entry. However, we have no *a priori* reasons to believe that smaller industries should be more stable than larger ones. Absolute profits may not be very large, but absolute investments may not need to be so either. And at least, if an industry is small, then there must be larger industries with larger companies with financial and technological muscles that potentially could take over small industries. In other words, we do not accept that this industry may not be very “attractive” for an investor with the right competencies or ideas.

In table 5, we sum up the stabilizing factors in the industry. Following our research strategy, they range from suppliers to end-user.

Table 5

Stabilizing factors at and between levels of the hearing instrument industry						
Suppliers	➪	**Manufacturers**	➪	**Dispensers**	➪	**End-users**
Technology used by all manufactu-rers. Powerful transducer supplier.	Switching costs. Only little customiz-ation of compon-ents.	Systemic and complex technol-ogy. High exit costs. Patent pool. Joint research. Production agree-ments.	"Tying-in". Fitting soft-ware.	Fragmented structure. Highly com-plex decision environment. Insufficient capabilities in high-tech instruments.	Lack of marketing. Independe-nt counsel-ing.	Technology far from op-timal. Market not transparent. Users too old to search. Low price elasticity.

We discussed in section 3 in some detail the possibility of new technology as a destabilizing factor. We raised the question of whether stability in this particular industry is caused either by lack of technological opportunities or by the stabilizing effects of structure and behavior of the industry. Since we do not have the counterfactual information of “what would have happened if there were no stabilizing factors”, we can of course draw only tentative conclusions on this question. What we have *not* seen in the industry is a major innovation affecting the functionality of the hearing instrument (making it clearly better).[94] Such an innovation would be the clearest example of a potentially destabilizing technological innovation.[95] So what we might want to explain is why we have not seen such an innovations in the industry during the past 25 years. Our answer to this question is twofold: First, because of the sticky distribution system (dispensers), it would take time and resources for even a major improvement to affect market shares. This reduces the incentive to pursue strategies of major breakthroughs. Second, the organization of the industry is not conducive to major research projects. The peculiar structure of a fragmented hearing instrument manufacturing industry that possesses the knowledge of “systems integration” (coordinating the interaction of the different components) combined with a highly concentrated component supplier industry that do barely more than developing “the same but smaller” components, apparently is a deadlock. Again, we have no clues as to what would have happened under a different industry structure, but this structure certainly is not conducive to the kind of vertically integrated R&D projects that may take the technology a major step further.

94 Again, we admit to be somewhat ruthless in our assessment here. Of course hearing instruments get better, and frequently a new hearing instrument gets high scores in customer satisfaction surveys. Still, however, even the digital instruments are not unanimously accepted as major improvements.

95 At this point, we need not distinguish between competence-enhancing and competence-destroying innovations, since we have not observed any *major* discontinuities at the level of hearing instrument functionality. We return to the question of innovations in components etc. below.

What the structure of the industry *does* support, however, are developments along the trajectory of miniaturization. We have witnessed as long series of discontinuities (innovations) in the development of the different components of the hearing instrument; innovations sponsored both by hearing instrument manufacturers and component suppliers. Most of them have as their main advantage over preceding products their small size, but still roughly same performance. This has allowed the existing manufacturers to take advantage of them without requiring a major restructuring of their competence base. Therefore, the technical innovations that actually have been developed, have not been competence-destroying, and have not challenged the existence of incumbent manufacturers.

Even if the past app. 25 years' success of the stabilizing factors do not guarantee success in the future, our preliminary conclusion is that the stabilizing factors will prevail for still some time. As we spelled out in some detail in section 5, the whole "system" may not, however, be very stable. We cannot be sure that only small changes can have major destabilizing effects. And especially the success of the Senso is thought-provoking.

In the long run, at least, few industries remain intact, and we have already mentioned one technology with truly revolutionizing power: The *regeneration of hair cells* in the ear would essentially make a defect organ intact, entirely eliminating the need for a hearing instrument, and obviously making the entire industry's competencies obsolete. This threat, however, it is expected to be something to consider more seriously only some time well in the future.

Theoretical perspectives

As to the implications for theory and future research we find three lessons interesting:

First, no matter how appealing the theories of technology and industry development are (Utterback & Abernathy, Henderson & Clark, and Anderson & Tushman), they seem to lack the possibility of empirical testing and prediction. Despite our sympathies for the idea of "architectural" innovations, it seems to be impossible *ex ante* to classify innovations into e.g. one type with destabilizing effects on industry and another type without such potential. And studies that pretend to do this, run a heavy risk of being tautologic. This problem may stem form two sources: First, technology is multidimensional, so it is always difficult to "aggregate" all of these dimensions into just one dimension. For example, a new engine may be fuel-saving but at the same time be less flexible or reliable or easy to start or whatever. There is a real problem in assessing the "value" of the change along all dimensions. And second, the "value" of each change is not the same for all users. That is to say that each industry and each company in an industry may have different benefits from adopting a specific innovation. Each company has its own idiosyncratic set of competencies and the fit between a new technology and existing competencies is a complex question. Finally, as in the hearing instrument industry, the industries – which the technology is supposed to affect – may vary in terms of "resisting capacity". Some industries may be shaken easily, others – like the one we have studied – seem to have built in a "bulwark" of stabilizing factors that prevent major changes to take place.

Therefore, our lesson from this study is that classifications of innovations may have their own "beauty" but the chances of turning them into predictive theories seem to be small.

Second, what we call "stabilizing factors" is closely related to "entry barriers" in traditional business economics or industrial organization. But with our interest in the long-term, over-all stability of this particular industry, entry barrier is too narrow a concept. While entry is indeed a major contributor to changes in structure, only large-scale entry usually has major impact on industry behavior and performance. Entry in itself is therefore not the only phenomenon to keep track of. Movements among incumbents may very well generate more important effects than entry. In the industrial organization literature, it has implicitly been assumed that the barriers to winning the first percent of the market for a newcomer are much higher than gaining an additional percent on top of a market share of, say, 13% for an incumbent. There may, of course, be good reasons for that, but still the barriers to gaining extra market share may be worth more study than hitherto has been the case.

The present study therefore takes up the challenge expressed by Caves and Porter, and we have focused as much on the factors preventing incumbents from winning market shares from each other as on factors limiting new entry. Instead of talking of barriers-to-entry, we have dealt with "barriers-to-change-of-the-established-order" or, as we label them, "stabilizing factors".

Industrial organization has a long tradition for analysis of entry, but in light of our study it seems to be as interesting to broaden this perspective to include models for stability among incumbents, in order to study the dynamics of the interaction between incumbents, a highly relevant question that has received only little attention. Data certainly are difficult to establish, but it probably would be fruitful to pursue both an in-depth strategy of selecting a limited number of industries for which long term market share data may be made available, and combining this strategy with studies on census-like data, however limited they are. The purpose of such studies should first of all be to establish some general ideas of the degree of stability, and secondly to identify important stabilizing factors. This would give the concept of competition a more nuanced face.

To this end, we would include the two most important factors from the hearing aids industry, the systemic character of technology and the stickiness of dispensers. As they seem to play an important role in this industry, it may be worthwhile to examine their relevance in other industries. Of course they should also be added to the standard list of barriers to entry.

Finally, we have been amazed by the puzzling coexistence of competitive and cooperative behavior in the hearing instrument industry. Such patterns have received only limited interest, but may be relatively frequent. Roughly, standard industrial organization studies mainly non-cooperative situations, and is quick in condemning cooperation as welfare reducing and as such just something to avoid. Some exceptions do exist, however, such as the discussions on potential benefits from cooperation in R&D (see e.g. Jorde & Teece, 1992). A totally opposite perspective is applied in the so-called network analysis that basically assumes away competition and studies the nature and benefits of cooperation.

Another important exception is von Hippel (1987) who has provided an interesting study of "know-how trading" in the steel mini-mill industry.[96] In this industry, engineers willingly gave away proprietary knowledge, provided that they could expect to get knowledge of more or less same value back in a not so distant future. Our case seems to differ from the mini-mill case both in breadth and managerial level. Hearing instrument companies seem to cooperate (or at least mute competition) in more dimensions than R&D, and also the responsibility for cooperation seems to be on central management, not just more or less autonomous engineers (who also engage in know-how trading) .

Whether this is actually a relatively normal situation is hard to judge. No doubt anti-trust authorities have changed business behavior, but it is interesting to recall the analysis of William Fellner, almost 50 years ago. Fellner distinguished between two types of cooperation between oligopolists:

> "The difference between "true" agreement and quasi-agreement is that the former requires direct contact while the latter does not." (1949, p.16)

He acknowledged that competition is the fundamental condition since

> "Agreements or quasi-agreements do not usually handle *all* economic variables entering into the determination of aggregate gains." (1949, p. 34)

Competition is muted in some dimensions, but not in others:

> "Economic behavior under fewness is *imperfectly co-ordinated; it remains competitive in a limited sense*. The competitive element stays significant; it applies mainly to the dynamic aspects of the problem which are connected with ingenuity and inventiveness and on the discounting on which it is difficult to reach agreement." (1949, p. 35)

Specifically, Fellner realizes that even if cooperation was supposed to cover all aspects of business activities, "inventiveness" would always create asynchronous development between the parties in the agreement, and that the agreement therefore must leave some aspect open for competition:

> "While oligopolistic firms typically live in a state of quasi-agreement, quasi-agreements do not

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96 See also Kreiner & Schultz, 1992, for a study of the barter economy in biotech firms. In their university-industry cases, however, trading of knowledge took place between non-competing actors.

> typically cover the entire range of market variables. The main reason for this appears to be that the relative strength of the participating firms is apt to change, and, if quasi-agreement included no outlets, the pressure exerted by the firms whose relative strength has increased would, in most cases, soon destroy the existing arrangements. The most significant reason for changes in relative strength derives from inventiveness. Quasi-agreements frequently allow the participating firms to handle certain variables on an individual-competitive basis; and these variables are apt to be more nearly associated with inventiveness than are the variables regulated by the quasi-agreement." (p. 183)

One of the main reason for the lack of studies in cooperative behavior is, of course, anti-trust concerns. Companies are for good reasons very sensitive to the question of agreements, formal and informal, with competitors. But if the business world has not dramatically changed since 1949, maybe cooperation and competition still go hand in hand much more frequently than we normally assume. It certainly is a question that deserves more attention: How frequent is the phenomenon and which forms does it take? We would especially add the question of which conditions are conducive to collaboration? We conjecture that in the hearing instrument industry collaboration is a result of limited possibilities for gaining competitive advantages over rivals, a sort of "if tough competition does not move market shares but only reduces margins, why bother". But this perspective does not solve the usual "free rider problem" which is haunting every cartel agreement. We have pointed at the importance of long-lasting relations and the difficulty for free-riders of gaining advantage as factors contributing to "nice" behavior, but still there is much to learn. However, a deeper understanding of collaboration among competitors would help us also to assess its positive and negative aspects for society.

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