5 DOMINANT DESIGN INDUSTRY

Once the main problems of a new technology are solved, many companies experiment with different solutions until a dominant design emerges. Consolidation sets in and few global players survive.

In many industries we have a basic standard for whole product families on the market: We know what a car or a cell phone looks like. The similarities between devices from different companies – like Smartphones - are not limited to their exterior design. The technical details are all remarkably similar as well. For many devices there is a technical paradigm, which is a dominant design that is valid for decades, can only be changed by a Kuhnian revolution and which usually only changes due to pressure from the market. Vested interests and invested capital are too big to be changed every few years. Different designs compete against each other, standard technologies and established technologies fight for their survival and only radically improve their efficiency once they come under pressure from new products. This extends the life of the old technology and pushes new technologies into niches at the beginning. Revolutions take longer than the newcomers expect.

![Figure 6: Dominant design leads to crowding out of firms](source: Based on data in George Nichols Engler, "The Typewriter Industry: The Impact of a Significant Technological Innovation" (Los Angeles: University of California at Los Angeles, 1970).

The dominant design is not determined by technology alone. The more open and complex a product is and the more socially and politically questionable, the more its dominant design is influenced by society. A typical example for this interplay between technology, society and
politics are nuclear power plants. Once a design is accepted by the authorities and the public, nobody wants to change it, even if the new design would be safer.

Figure 7: The Dominant Design is not determined from a technical standpoint but by society.

Weight sensors are usually only influenced by technology and technicians because the sensors are hidden from the customers. Most users do not even know what technology they are using. The choice of which weight sensor to use is based on technical characteristics like precision and resolution. The pot-technology has a high precision and a high resolution and is therefore used in laboratories; String and stretch have a lower precision, are cheaper and have found their dominant design in industries and households.

Figure 8: 3 Dominant Designs: Weight sensors for balances

The same is true for textile machinery. The width and complexity of the fabric define the dominant design of the machines. The gripper weaving machine by Dornier has emerged as the dominant design for complex and narrow pieces of fabric. It is very well suited for high precision, but is expensive and slow. For wider fabrics the projectile weaving machine by
Sulzer won recognition. Air jet weaving machines are considered as the most productive and are applicable for narrow and simple fabrics.

![Diagram of market-segmentation weaving machines](image)

**Figure 9: Market-segmentation weaving machines: Width and complexity define the dominant designs**

In contrast, SMS on mobile phones became a dominant design very quickly with no market segmentation at all. No technician would have believed it, society made the choice.

5.1.1 ABERNATHY – UTTERBACK MODEL

Abernathy and Utterback have developed a simple model to explain what happens when a new technology the new standard. The process consists of 3 phases:
5.1.1.1 FLUID PHASE

Whenever a company develops a new technology, the market spreads the rumour that this could be the next big business. Many companies try their luck. In the first phase, firms experiment and compete with different designs that improve the functionality and drive down costs. The market is tested with many different approaches based on the users’ needs and different technical concepts. Product innovation is the name of the game. The production process is flexible in order to easily accommodate major changes and lot sizes are rather small. The plant is located near the user or source of technology. Uncertainty looms large and competition is mostly between SMEs. Big money is useless, risks are too big and opportunities are still too small. Thus small suppliers prevail. This is the typical environment of a biotechnology start-up at the beginning of the 21st century.

5.1.1.2 TRANSITION PHASE

Later, designs converge or disappear if the fluid phase turns out to be a bursting bubble. The market determines most of the product alternatives, standards set in and volume increases fast. Due to the rising volume, process innovations are predominant. Internal technical capability is expanded and opens many opportunities. The production process becomes more rigid. Towards the end of this phase a dominant design emerges in many cases. Prizes fall and some

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1 Abernathy, W.J. and Utterback, J.M. – Patterns of Innovation in Technology, Technology Review 1978
companies already flee due to heavy competition. At the peak there are at least some dozen companies on average per sector in the US alone. Around 1910, when Ford entered the car industry, there were more than 500 car making companies in the US. It may be that no dominant design emerges or that there are only regional dominant designs. In 2010, there is still no dominant design for houses. Architects and owners prefer prototypes. But there are dominant designs for house-heating, like gas, oil or heat pumps combined with electricity.

5.1.1.3 DISTINCT PHASE

The transition phase leads to the emergence of the dominant design. This allows the “elephants”, the big companies to move in. The pressure to reduce costs and improve quality increases. It is easier for big companies than for small companies to cut costs. They invest heavily in process innovation, branding and aesthetical design. The production process gets rigid, capital-intensive and efficient; the cost of change is high. The big players decrease costs. More and more companies are squeezed out of the market. At the end there are 3 – 5 global players. Typical examples of products in the distinct phase are cars, mobile phones and as of recently, cement producers. Sometimes the situation changes rather fast. In 2007 there were approximately 120 car producers in China. This regional market is protected. Thus, when a new car economy emerges it will go through all the phases of the Abernathy-Utterback model within the next few years: Most probably only few Chinese car producers will survive the competition.
There is a lot of economic logic behind this model and it explains many of the developments we see today in the car industry, the textile machine industry and the mobile phone industry. Small companies can manage small risks and pave the way to the market with innovative products. Big companies then adopt these ideas and invest their engineering and purchasing power and their large amount of available capital into the new field.

The Abernathy Utterback-model\(^2\) can be extended: At the end of the early fluid phase, which is affected by uncertainty and various product variants, convergent customer needs reduce the

number of alternatives of a product. This leads to companies producing the product the customers demand in large quantities. Once one type of innovative product has become predominant, the transition phase begins. With the increasing product volume quality problems may arise and new technologies make process innovation possible. After the dominant design is clear and big companies control the market, a new way of competing against each other is with design innovations. These sequences can be seen with a patent analysis in food production, for example condensed milk. The highest number of requested patents changes from the product, to processes, to design and finally to patents for specific applications.

![Relative share of condensed milk patents in relation to total patents – from product to process to design innovation](image)

**Figure 13:** Relative share of condensed milk patents in relation to total patents – from product to process to design innovation

### 5.1.2 Examples of Dominant Designs

#### 5.1.2.1 Video Recorder

The video recorder was invented around 1950. Ampex brought the first machine to the market in 1956, the Ampex VRX-1000. It was the size of a juke box. Then Japanese companies started to miniaturize.

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3 From M. Koch, S. Regenscheit, NDS diploma thesis, ETH 2005
The Japanese companies changed from a vertical to diagonal trace and could reduce the tape width from 2 inches to 0.75 inches. The hand held video recorder became a technical possibility. In 1980, Japan exported more than $15 bn worth of consumer electronics and 75% of its export profit was due to video recorders. Sony thrived and today nobody remembers Ampex for their video recorders, even though Ampex made $53 million with its visual storage systems in 2005. Japan set the standards and thus determined the dominant design for video recorders.

After 1980 everybody knew what a video recorder looked like, what the required quality was and how it could be embedded in an industry producing optics, tapes and cinema equipment. A dominant design was born that later integrated CCDs and memory chips. Modules changed but product architecture remained the same. Over the last few years this design has come under more and more pressure from digital cameras and cameras in mobile phones.

5.1.2.2 Post-it

A similar dominant design emerged over 20 years ago with Post-it from 3M. After 15 years of tinkering around and of encountering big problems in manufacturing, 3M was able to sell more than $2 million of Post-it products in 1981. The technical challenges were enormous: How does one make glue that sticks to two surfaces but at the end only adheres to the original side?
3M still keeps its manufacturing processes secret. Since 1980 the number of sold post-it products has been steadily increasing.

5.1.2.3 TypeWriter

The principles of the typewriter were known at the beginning of the 18\textsuperscript{th} century. The first patents can be traced back to 1868, which were applied for by Christopher Sholes. The Sholes patent was sold to Densmore and Yost, who made an agreement with E. Remington and Sons, both famous sewing machine manufacturers, to commercialize the machine as the Sholes Type-Writer. This was the origin of the term typewriter.

Remington began producing its first typewriter in 1873, in Ilion, New York. It had a QWERTY keyboard layout. In 1885 there were already 5 companies in the US selling
typewriters. Technical improvements created a wide-spread acceptance on the market. More and more companies entered the new business. Around 1910 the number of suppliers peaked at around 40.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td>1714</td>
<td>Writing machine invented</td>
</tr>
<tr>
<td>1868</td>
<td>Patent Sholes</td>
</tr>
<tr>
<td>1873</td>
<td>Remington produces writing machines for the first time</td>
</tr>
<tr>
<td>1885</td>
<td>5 suppliers</td>
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<tr>
<td>1887</td>
<td>Tech. improvements create acceptance on US market</td>
</tr>
<tr>
<td>1890</td>
<td>10 suppliers; Remington dominates</td>
</tr>
<tr>
<td>1890</td>
<td>Underwood becomes market leader through technical improvements</td>
</tr>
<tr>
<td>1904</td>
<td>Royal: last successful entrant</td>
</tr>
<tr>
<td>1909</td>
<td>4 dominant firms: Underwood, Remington, Royal, Smith &amp; Brothers</td>
</tr>
</tbody>
</table>

Figure 17: US Writing Machines 1714-1909: Mechanics first

Afterwards most suppliers were squeezed out by a merciless business war. In the 1930s four companies survived in the US: Underwood, Remington, Royal and Smith & Brothers. The modern typewriter emerged with moving paper, fixed keys and today’s keypad. The dominant design remained stable for decades to come.

None of the 4 leading typewriter companies were able to make the change in due time and adapt the new electrical technology. An outsider, IBM, became the market leader with a market share of more than 60%. The new technology had a slow start: The first electrical model came onto the market in 1906. In 1950 market share was still below 10%, but in 1967 it went up to 70%. Some of the old leaders disappeared; the survivors had market shares below 10%.

A slow start is typical for substitution products. It takes 40-50 years to get a reasonable market share. This is mostly due to the fact that the old technology is improving all the time and that there are vested interests in keeping the new technology all over the market: Factories and production are not yet written off, customers do not want to retrain and regulators are reluctant to accept new safety standards.
The third wave, the word processors, developed a little faster: At the beginning of the 1970s, word processors appeared on the market as stand-alone office machines. They combined the keyboard text-entry and printing functions of an electric typewriter with a dedicated processor for editing the text. You were able to save documents on memory cards or diskettes. In 1975 more than 200,000 machines were sold. In a very short time, there were more than 55 suppliers on the market, such as Wang, IBM, AT&T. Together they sold 4 million machines in 1986. The time for imitation has decreased significantly in modern times!

However, due to the emergence of the personal computer (PC), most business-machine companies stopped manufacturing the word processor as a stand-alone office machine. The PC is today’s dominant design for writing, even though portable PCs, such as Laptops and Tablets have started to squeeze them out of the market. Again during these changes, some old leaders have lost and many newcomers who tried their luck were crowded out within a few years. Today the PC is fighting for its survival: More and more dedicated machines are grabbing more and more market share. The keyboard remains a dominant design for input.
Speech recognition has been around for many years, but has big acceptance problems because of quality issues.

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<tbody>
<tr>
<td>30 firms sell PCs; Apple, Commodore, ...</td>
<td>500'000 PC sold; IBM 30% market share</td>
<td>125 new models; 18 new firms; IBM sells &gt;500'000 PC</td>
<td>Market shares: IBM 49%; Apple 13%</td>
</tr>
</tbody>
</table>

Figure 20: Personal Computer: Crowding out due to progress

Dominant designs are not always optimal. A typical example is the keyboard. It is 10 – 15% slower than the optimal keyboard would be which would combine the fastest fingers with the most frequent letters. Because the mechanical components of the typewriter towards the end of the 19th century were not able to keep up with the speed of the users’ fingers, Remington had to slow down his users’ typing speed and move some frequently used letters further apart.

1870 arrangement of the letters: frequent letters to fast fingers

- mechanics blocks
- slow down fingers (!)
- our keyboard (15% slower than ideal one)

Figure 21: Dominant designs are not always optimal: QWERTY

But once a technology gets established, it sets the standard, it is the dominant design and nobody wants to change it anymore. Thus the barrier to change gets higher and higher.
Retraining millions of users does not make sense in the advent of speech recognition programs which may lead to the keyboard becoming redundant.

![Figure 22: Lock-in-effects create sub-optimal dominant designs, even in more or less free markets.](image)

In this sense, technology has a memory. We have lock-in effects. Each additional Microsoft Windows user increases the value for already existing users in terms of problem-solving, additional equipment or service. The costs for switching get too high. Good enough is good enough. Thus, sometimes, free markets may lead to sub-optimal technologies. This is especially relevant for Internet technologies that create an “increasing marginal utility” with every new user: The more users apply a specific technology, the higher the value for every single user.

5.2 **Definitions**

**Dominant design**
A design that becomes an industrial standard for a specific product. As soon as it emerges, industry gets security and is able to invest heavily and on a long-term basis.

**Lock-in**
Sometimes a technology becomes standard not because it is better, but just because it is available, proven and has the biggest market share. Attempts to substitute it fail, switching costs are too high.

**Bottleneck**
A technical module that limits the overall capacity of a system. E.g. limit use of electrical cars.
5.3 Questions, Discussions

- Do you see a dominant design in today’s laptops? Has it changed over the last 5 years?
- Is there a dominant design in one-family houses?
- What are the economical advantages of a dominant design?
- Do you see a connection between dominant designs and paradigms?