Where Is the Semiconductor Industry Going?
- A multiple case study of six semiconductor companies

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December 2007
Master Thesis
Faculty of Engineering
Lund University, Sweden
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Abstract

Title: Where Is the Semiconductor Industry Going? – A multiple case study of six semiconductor companies.

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Purpose: The purpose of the thesis is to investigate how the semiconductor industry will develop during the period 2007-2012.

Issues: The main issues presented are:

- How will the competitive landscape change from 2007 to 2012?
- How will companies succeed in the industry in 2012?
- What position will the Integrated Device Manufacturers take in the value chain in 2012?

Method: In order to achieve the purpose of the thesis the multiple case study is complemented with a study of the market and technology trends. The necessary material and information is gathered mainly through qualitative research such as interviews, mainly with people within Ericsson Mobile Platforms. Further the information is gathered from industry newspapers available on-line.

Conclusions: Competitive Landscape: The study has shown that the semiconductor industry will be characterized by hyper competitiveness and cost reduction. A transformation is approaching due to the upcoming technology which requires completely new solutions and huge amounts of capital.
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**Position:** The findings suggest that without in-house manufacturing the Integrated Device Manufacturers will have a narrower area of business and will be compensating by moving forward in the value chain, trying to establish as Technology Enablers.

**How to succeed:** Furthermore the case companies have shown diverged strategies on how to succeed and a Key Success Factor Analysis identified Broadcom, Infineon and Texas Instrument as the companies most likely to succeed in the industry in 2012.

**Key words:** Semiconductors, Integrated Device Manufacturer, Value Chain, Key Success Factor, Broadcom, Freescale, Infineon, NXP, STMicroelectronics, Texas Instruments
Acknowledgements

The thesis work has been a fast and fascinating journey that began in early December 2006 with a text message from Cambodia to Sweden. With that text message we decided to do our master thesis together. When we were both on Swedish ground again it did not take long before we contacted Martin Zander at Ericsson Mobile Platforms to see if he could be interested in having two students in his group during the fall of 2007. The first meeting was held at Ericsson Mobile Platforms in mid April where the content of the thesis was presented. We found the subject and the study interesting and decided to take on the work starting in September 2007.

It became clear from the start that the biggest challenge would be the time limitation set by Ericsson Mobile Platforms as the thesis work was a part of a bigger project and had to adjust accordingly. The time limit has not only been negative though since it has given us plenty of extra motivation that would not have existed otherwise. Thanks to an interesting topic for the thesis as well as helpful co-workers at Ericsson Mobile Platforms the journey did not become too hectic and still offered time for needed reflection.

We would like to express our gratitude to our supervisors at Ericsson Mobile Platforms; Mattias Löfgren and Martin Zander, who has given us valuable inputs as well as the freedom to analyze on our own. Furthermore we would like to thank all the interviewees, both internal and external, for their time; especially Mathias Nawroth and Magnus Karlberg for several fruitful meetings. Without the interviewees’ commitment to the project and their inputs the study would have been less usable. Further, we owe a thanks to our supervisor at Lund University; Ola Alexanderson, for his professional and academic guidance throughout the project. Last but not least we would like to thank Elisabeth Geijron for many useful and inspiring conversations over a cup of tea and a fruit.

Lund, December 2007

Joakim Nideborn                         Kristina Strähle
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# Abbreviations

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<th>Description</th>
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<tr>
<td>ASIC</td>
<td>Application-Specific Integrated Circuit</td>
</tr>
<tr>
<td>CDMA</td>
<td>Code Division Multiple Access</td>
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<tr>
<td>CM</td>
<td>Contract Manufacturer</td>
</tr>
<tr>
<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>EDGE</td>
<td>Enhanced Data rates for GSM Evolution</td>
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<tr>
<td>EMS</td>
<td>Electronics Manufacturing Services</td>
</tr>
<tr>
<td>Fab</td>
<td>Manufacturing Facility</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field-programmable gate array</td>
</tr>
<tr>
<td>GPRS</td>
<td>General Packet Radio Services</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>GSM</td>
<td>Global System for Mobile communications</td>
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<tr>
<td>HHI</td>
<td>Herfindahl-Hirschman Index</td>
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<tr>
<td>HSDPA</td>
<td>High-Speed Downlink Packet Access</td>
</tr>
<tr>
<td>HSPA</td>
<td>High-Speed Packet Access</td>
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<tr>
<td>HSUPA</td>
<td>High-Speed Uplink Packet Access</td>
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<tr>
<td>HW</td>
<td>Hardware</td>
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<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>IDM</td>
<td>Integrated Device Manufacturer</td>
</tr>
<tr>
<td>IPR</td>
<td>Intellectual Property Rights</td>
</tr>
<tr>
<td>Kbps</td>
<td>Kilobit per second</td>
</tr>
<tr>
<td>KSF</td>
<td>Key Success Factor</td>
</tr>
<tr>
<td>M&amp;A</td>
<td>Mergers &amp; Acquisitions</td>
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<tr>
<td>M&amp;W</td>
<td>Mobile &amp; Wireless</td>
</tr>
<tr>
<td>ODM</td>
<td>Original Design Manufacturer</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>PESTEL</td>
<td>Political, Economic, Social, Technological, Environmental, Legal</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research &amp; Development</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
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<tr>
<td>SCPA</td>
<td>Semiconductor Chip Protection Act</td>
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<td>SMIC</td>
<td>Semiconductor Manufacturing International Corporation</td>
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<tr>
<td>SMS</td>
<td>Short Message Service</td>
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<tr>
<td>SoC</td>
<td>System on Chip</td>
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<td>ST</td>
<td>STMicroelectronics</td>
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<td>TDMA</td>
<td>Time Division Multiple Access</td>
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<td>TE</td>
<td>Technology Enabler</td>
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<td>TI</td>
<td>Texas Instruments</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>TSMC</td>
<td>Taiwan Semiconductor Manufacturing Company</td>
</tr>
<tr>
<td>UMC</td>
<td>United Microelectronics Corporation</td>
</tr>
<tr>
<td>UMTS</td>
<td>Universal Mobile Telecommunications System</td>
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<tr>
<td>WCDMA</td>
<td>Wideband Code Division Multiple Access</td>
</tr>
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1 Introduction

This chapter will give the reader a short background of the problem studied, followed by a discussion that will conclude the purpose, focus and delimitations of the thesis. Finally the disposition of the thesis is presented.

“Alea iacta est”

– Julius Caesar

1.1 Background

The semiconductor industry became a viable business around 1960. Until then all electrical components had been discrete; they could only perform one function and many of the components had to be wired together to create a functional circuit. With new technology, Integrated Circuits (ICs) were developed with multiple components put together on the same chip.¹

There are a few materials that are classified as semiconductors. The most well known is silicon, but there are also other elements and chemical compounds that are semiconductors, for example germanium or aluminum gallium arsenide. Semiconductors have the ability to conduct electrical current and they can be regulated in the amount of conductivity.²

The semiconductor industry has developed enormously since 1960 and today it is one of the world’s key industries. The rapid development in the industry results in massive Research and Development (R&D) costs with 15-30% of the net sales spent on R&D.³ To minimize the costs and risks of R&D many companies create alliances and collaboration networks.⁴

Today it is possible to produce chips with 65-nm process node technology; and the development will keep shrinking the size of the chips. There is already research on 45-nm and 32-nm process node technology going on, within five years the 22-nm technology will most likely be possible to

¹ www.micron.com 2007-09-06
² Interview Karl Nideborn, former semiconductor scientist
³ Interview Mathias Nawroth, Business Intelligence EMP
⁴ www.infineon.com 2007-09-06
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implement. With the great amount of capital required to sustain continued miniaturization, the semiconductor industry is faced with a standpoint, should they and is it profitable to continue with the development? The usage of the latest technology has decreased dramatically during the last twenty years. Today the cutting-edge technology is used in less than every other case.5

The Integrated Device Manufacturers (IDMs) are now considering cutting down on in-house manufacturing by outsourcing the production. Simultaneously they are trying to move forward in the value chain which is a result of the selling of manufacturing facilities for semiconductors (fabs).

Ericsson Mobile Platforms (EMP) is a part of Ericsson. EMP is a leading platform supplier. EMP was one of the first companies in the world to license open-standard technology platforms to manufactures of mobile phones and other mobile communication devices with several different standards. EMP’s position as one of the world’s most important producers of mobile platforms makes them an important player in the telecom market. With important costumers like Sony Ericsson and LG that are among the world’s leading producers of mobile phones.6

1.2 Problem discussion

Analysts are saying that there are too many players on an all too small market at present time. The large investments that are necessary to bring the technology to the next level opens for Mergers and Acquisitions (M&As) among the companies that exist on the market today.7

Due to the fierce competition in the semiconductor industry more companies seem to be acquiring new competencies and broadening their business area; including everything from forward integration to offering complete mobile platforms. This has turned into an unpleasant situation for EMP as they have ended up in a position where their suppliers have become their competitor. To be in their situation is quite unfavorable, since the suppliers are likely to prioritize their own production in a situation of crisis or lack of raw material.

5 www.infineon.com 2007-09-06
6 www.ericsson.com 2007-09-10
7 Interview Mathias Nawroth 2007-09-12
The close collaborations that are going on throughout the value chain might be contributing to the suppliers acquiring knowledge about the mobile platform manufacturing. One of the things that will be investigated in the thesis is whether or not the IDMs already have, or if it is reasonable to believe that they can or will acquire the competences that are crucial to succeed with this form of forward integration. Since the semiconductor industry is developing very fast, the performance of semiconductors will improve significantly before 2012. How this development will continue is of course of great importance for the Technology Enabler (TE), since it enables new solutions, better performance and possibilities to even smaller units.

Due to the high development cost of new production technology it is not certain that the same companies exist in the market five years from now. Many companies work together with shared development, a possible development of these collaborations could be some kind of mergers or maybe even acquisitions. A suitable way to understand which companies are strong respectively weak is to identify Key Success Factors (KSF) that are vital to succeed in the industry.

### 1.3 Areas of inquiry

To be able to create a good understanding of what is going to happen in the future, it is crucial to have a good understanding of the present.

1. Our first area of inquiry is to understand the value chain, where the semiconductor suppliers create their value, their position in the value chain and how it will change over the five following years.

2. The second area of inquiry is to understand the market and technology trends that are essential in the industry during the period of 2007-2012. What Key Success Factors (KFS) are crucial to have in order to be successful in the industry today and what has to be improved in order to be competitive in 2012?

3. The authors’ final area of inquiry concerns the competitive landscape in the industry 2012; with alliances, emerging markets and M&As as important components.
1.4 **Purpose**

The purpose of the thesis is to investigate how the semiconductor industry will develop during the period 2007-2012.

1.5 **Focus**

The study will focus on the first half of the value chain; since it is not realistic that semiconductor companies will extend their business any further than that. The main purpose is to map out the industry in 2012. To be able to do so, the present must be understood before looking into the future, and therefore the industry in 2007 will be studied and this will lead to the development for the forthcoming years. The focus will be on the Mobile and Wireless (M&W) part of the semiconductor industry since it is in this part the chosen case companies are of most interest to the authors and EMP. Besides M&W, there are several other segments in the semiconductor industry:

- Automotive industry
- Broadband
- Computer industry
- Consumer electronics
- Industrial

1.6 **Delimitations**

To be able to determine how the semiconductor industry will look in 2012 it is vital to study some of the main companies in detail, to see how they will develop. To make this an achievable assignment given the timeframe, there had to be some priorities made. Within the given timeframe it is not possible to study all the companies in the semiconductor industry. Consequently the authors, together with EMP, have limited the semiconductor companies to six of the most important ones in the M&W segment:

- Broadcom
- Freescale
- Infineon
- NXP
- STMicroelectronics (ST)
- Texas Instruments (TI)
1.7 Target group

The main target group for our thesis work is EMP, who to a large extent has formulated the assignment. However, the information that is essential to EMP will be presented in a separate report that is confidential.

The target group for this document is first and foremost Lund University and the final year students at the faculty of engineering and others with a special interest. To gain the most out of the thesis it helps if the reader has some basic knowledge about semiconductors and the mobile platform industry. If not the authors recommend the reader to examine Chapter 4 very carefully as it provides a background to those with none or little knowledge of the subject.

People involved in the semiconductor or telecommunication industry could find it interesting to read the thesis work.

1.8 Disposition

Chapter 1, Introduction: The background to the thesis is presented, followed by the problem discussion. Moreover the authors are presenting the purpose and the necessary delimitations to make the thesis achievable within the given timeframe.

Chapter 2, Methodology: The different methodological approaches and methods are described. Choice of methodology is presented. The affect the
methods had on the outcome of the study will be discussed in Chapter 7, Conclusions.

**Chapter 3, Theoretical Framework:** Here the applicable theories will be described and the theoretical framework is set. This framework will be used together with the Empirical Framework in order to conduct the analysis and draw the Conclusions. The chapter is divided into four subchapters regarding General Forecasting, Strategic Approach, Status Quo Theory and ends with Requirements and Final Decision.

**Chapter 4, Setting the context of the case:** This chapter aims to give a deeper background of the technology, industry structure and the case companies. Different technology standards within the industry are presented and explained. The chapter is intended for those readers with little, or no, knowledge on the subject.

**Chapter 5, Empirical Framework:** The authors’ findings are presented in four subchapters concerning factors affecting the industry, the competitive landscape 2007, the value chain in 2007 and the Key Success Factors and Threshold Factors.

**Chapter 6, Analysis:** The authors present their analysis of the empirics by using the methodological and theoretical approach described in Chapters 2 and 3. The chapter consists of four subchapters; Key Success Factors, competitive landscape 2012, upcoming trends and value chain 2012.

**Chapter 7, Conclusions:** The conclusions are drawn by the authors on basis of the results and the most important findings. The choice of method and theory is discussed together with further areas of study.
2 Methodology

This chapter describes different methodological approaches and methods. Moreover, choice of methodology is presented and how these are predicted to affect the outcome of the study. Primary and secondary data are discussed.

“Using case studies for research purposes remains one of the most challenging of all social science endeavors.”

– Robert K. Yin

2.1 Methodological Approach

The limited timeframe and the extensive assignment will affect the authors’ knowledge generation during the thesis work. The choice of the number of case companies also matter. This situation does not favor the possibility to have a positivistic approach during the work with the thesis. Instead, the authors will have a hermeneutic approach where their prior knowledge will affect their way to collect and understand information which is not the case in a positivistic approach.\(^8\)

The hermeneutic approach includes not only the problem but the environment surrounding it. This approach is suitable when conducting a qualitative study, discussed further in Chapter 2.1.4.

2.1.1 The Subject and the Case Study

The subject of the thesis was proposed to the authors by EMP in April 2007. The subject was of interest to EMP and the authors as well as it suited the authors’ education. Although the subject was familiar it still proposed many challenges to the authors as microelectronics and process node technology.

The choice of subject was approved by the supervisor, Ola Alexanderson at the Department of Industrial Management and Logistics at the faculty of engineering at Lund University, in early June 2007.

\(^8\) Björklund & Paulsson, p 65
The need of a case study arose with the desire to understand a complex real life situation and case study research permits researchers to keep a holistic characteristic of the real life situation. A case study is one of several ways of conducting research while as other ways include experiments and analysis of archival information, among others. Other methods often demands that the researcher has access to large samples of data and follows a rigid protocol in order to examine a limited number of variables. Case studies, on the other hand, involve an in-depth examination of an instance or event that is a case. When using such an approach the method can generate and test hypotheses if used as a research strategy.9

The case study will include the semiconductor industry and its forecast in 2012. The industry will be surveyed by using six different case companies.

The choice of case companies was made by EMP since they regard these companies to be the most interesting ones on the M&W segment of the semiconductor market, from an EMP perspective. The companies are all active when it comes to innovation and R&D investments.10 The number of case companies gives validation to the study to an extent that fewer case companies would not.11

2.1.2 Explorative, Descriptive, Explanative and Normative Approach

The existing knowledge on the subject of the study decides whether your study can be explorative, descriptive, explanatory or normative. If the amount of knowledge is insignificant you use a more explorative approach and the purpose of the study is to find fundamental knowledge. One other option is to have the descriptive approach when the knowledge is already basic and there is already an understanding of the area. The objectives when using a descriptive approach is to describe but not explain the existing relationships. Explanative studies can be used when searching for deeper knowledge when the researcher wants to both portray and explain the situation. Finally the normative approach can be used when some knowledge and understanding already is obtained. The objectives in normative studies are to give guidance and suggest measures.12

9 Yin, pp 2 – 4
10 Interview Mathias Nawroth 2007-09-12
11 Björklund & Paulsson, p 59
12 Björklund & Paulsson, p 58
Due to the authors’ lack of knowledge within the semiconductor industry, the study will have an explorative approach in this area. This study will be conducted with a combination of an explanatory and normative approach since this study will want to search for deeper knowledge about the future market situation as well as give guidance and suggestions by means of the scenario we have constructed. This combination of approaches is closely linked with the purpose of this thesis which is to investigate and understand as well as create new solutions. The normative approach will be used in the study but primarily to suggest measurements to EMP.

### 2.1.3 Inductive, Deductive and Abductive Method

Some studies are conducted with an observation in real life, ask one or several questions about this observation and then find a theory that can explain and answer the question/questions. An amount of empirical data is gathered, analyzed and combined in order to find the connection between the reality and the suitable theory. This is the inductive method.\(^\text{13}\)

When using the deductive method the researcher uses the existing theoretical framework as a starting point of the research and tries to match it with a piece of reality.\(^\text{14}\) The different methods are illustrated in figure 2.1.

![Figure 2.1 Illustration of inductive and deductive approach](image)

In empirical papers, and thus partly in this thesis, the starting point is in the reality and the work is being made with an inductive method. In an inductive study the researcher has the desire to work up a collection of data with the assistance of theory, models and concepts and this will be one part of the work procedure of the study. When the researcher alters between the

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\(^{13}\) Rienecker & Stray Jørgensen, p 160  
\(^{14}\) Rienecker & Stray Jørgensen, p 160  
\(^{15}\) Lundahl & Skäravad, p 41, figure 4.1 translation by the authors
two different abstraction levels the abductive method is being used. The method can be seen as a combination of the two previous ones and creates the possibility to differ between the theoretical and empirical framework. This method will bee the chosen procedure since the thesis will have its platform in reality but several theoretical approaches will be applied on the case study.\textsuperscript{16}

\textbf{2.1.4 Qualitative and Quantitative Approach}

Quantitative methods are often used when the researcher wants to display structure in a wide range of data and with efficiency supply the information that is most important. The purpose of a quantitative approach is to measure a large amount of data in order to answer or explain one or several hypotheses. The information in the study is often presented in numerical terms in order to generalize the quantitative approach. The method is appropriate to use when the study does not go too deep into one research unit but instead has a broad set of research units.\textsuperscript{17}

The qualitative method is used when a deeper understanding of a research unit is preferred. There are fewer possibilities to generalize when using this method since the study subject is specific.\textsuperscript{18} There are often unsystematic and non structured observations, for example profound interviews that may lack feasible possible answers, in qualitative studies.\textsuperscript{19}

It is foremost the purpose of the study that sets the approach to qualitative or quantitative. Studies that are based on interviews and observations should be performed with a qualitative approach.\textsuperscript{20} The authors intend to implement such a study thus the qualitative approach will be used but some qualitative aspects will be included.

\textbf{2.2 Data collection}

Different types of data are needed at different stages of the research work. The types of data are closely linked with the approach of the study and determine the way of collecting the information needed.

\textsuperscript{16} Björklund & Paulsson, p 62
\textsuperscript{17} Holme & Solvang, pp 76-78
\textsuperscript{18} Björklund & Paulsson, p 63
\textsuperscript{19} Holme & Solvang, pp 76-78
\textsuperscript{20} Björklund & Paulsson, p 63
2.2.1 Primary and Secondary Data

Primary data is information that is specifically created for the study. A case study relies on primary data from for example interviews or direct observations.\(^{21}\) The interviews are being held by the authors with key persons at EMP as well as external interviews. Data from interviews are sorted, categorized and evaluated. The interviews can be formed in different ways, like a group discussion, mail conversation or a dialogue.\(^{22}\)

Secondary data is all already existing material like literature and web based sources. This information is not generated specifically for the study and is therefore rarely covering the exact area of interest. When using this information it is very important to be critical to the contents and consider whether it is really vital for the subject.\(^{23}\)

During the pre-study phase, secondary data constitutes the main part of the data collection. When reaching the late knowledge phase, the understanding gets deeper and primary data gets more interesting. Relevant secondary data becomes more difficult to find and it is easier to realize which primary data that needs to be gathered.

2.2.2 Pre-study

In the pre-study phase it is suitable to use various literature sources in order to get an overview of the subject and understand the background. As a complement to this, it is possible to do interviews with people who can contribute with ideas and give guidance.\(^{24}\)

To get an introduction to the semiconductor industry the authors have read recent publications to get an updated view of what the industry look like at present date.

2.2.3 Main Study

The first stage in the main phase of a scientific study is to gather information in order to get an even deeper understanding of the subject, which is called the knowledge phase. To find information at this stage is often more difficult simply because there are fewer people with deep

\(^{21}\) Yin, pp 89-96  
^{22}\) Björklund & Paulsson, p 68  
^{23}\) Björklund & Paulsson, p 67  
^{24}\) Björklund & Paulsson, p 75
knowledge of the subject. In order to compile the collected information and draw conclusions of the data it is recommended to generate new information.

Suitable ways of data collection in the knowledge phase are interviews with experts and questionnaires. Since the purpose is to generate new knowledge, it is difficult to do literature studies at this stage. The experts within different areas at EMP are anticipated to be of great help when collecting information. In the early stage of the knowledge phase interviews will be performed in a free way to get a basic understanding and advice of how to proceed. At the end of the knowledge phase it is possible to perform more specific interviews with more direct questions and discussions between the authors and the experts.

After the knowledge phase it is needed to confirm and explain the obtained knowledge. This can be done through focused interviews, concentrated to specific questions. Here the close expertise at EMP is an asset.  

2.2.4 Sources of Criticism

In order to determine further use of the thesis it is important to see what range of objectivity, reliability and validity that lie in the thesis and in the work that has been conducted in order to achieve the purpose.

2.2.4.1 Objectivity, Reliability and Validity

With a hermeneutic approach it is implied that the study itself will not be completely objective as the authors’ previous knowledge and values are comprised in the study. As the study does not include EMP as a case company the objectivity is easier to uphold by the authors.

Reliability gives the degree of accuracy in the measurements, which is to what extent the same result appears when conducting the same study several times. When using a hermeneutic approach in combination with the sort of case study the authors have had in mind, interviews are a common way to collect data. To increase the reliability in the study the authors can add control questions during the interviews to establish the reliability of the study and the questionnaire. Use of triangulation can increase the reliability, see figure 2.2.  

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25 Björklund & Paulsson, p 75
26 Björklund & Paulsson, p 65
27 Björklund & Paulsson, pp 59-60
By using two different methods in order to study the same object increases the reliability if the outcomes of both studies are similar. The questions in any questionnaires should be clear and none biased. To increase the objectivity in a hermeneutic study the authors should consider the objectivity to be honesty, ethics and moral as conventional objectivity is hard to reach when the researcher uses a hermeneutic approach. The validity concept concerns to what extent the researcher has studied what was intended to be studied. In order to assure the validity of the study the researcher should see the reality from as many aspects as possible.

2.2.5 The Delphi Method

The Delphi Method is a systematic and interactive forecasting method that obtains forecasting from a panel of independent experts within the subject of the study. The method is iterative as the experts are asked to answer the same questions over and over again in the iteration process. After a round of questions each expert is asked to revise their replies after acquainting themselves with a summary of the other experts’ opinions. The experts are encouraged to revise their earlier respond and after a few iterations it is believed that the range of answers will decrease and they will converge towards the “correct” answer. The iterations do not go on forever but are stopped after a pre set criterion, such as a maximum number of rounds have been reached or the stability of the result has reached the goal.

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28 Björklund & Paulsson, p 76, figure 4.6 translation by the authors
29 Wallén, pp 66-67
30 Armstrong, pp 287-295
The Delphi Method can be divided into three different categories:\footnote{www.njit.edu}

1. **Industrial Grouping or Professional Association Sponsorship** – this category includes studies that are sponsored by an industry association or a professional association. The studies are usually of broad nature and aim to forecast the future of an industry. As an association sponsors, the study is often outsourced to an external consultant or research company.

2. **Individual Corporate Sponsorship** – the category is similar to the first one but the study is sponsored by a single company. The study is still outsourced to an external organization or company but the studies can be of both generic and specific interest. Some of the results are public but they do not have to be.

3. **Corporate In-House Delphi Research** – the final category includes Delphi studies within a company or corporation. Members of the corporation staff conduct the study. These studies and the result of them are usually not published or distributed.

This method is very broad but far too time consuming for this study. The number of iterations and the number of experts demands a timeframe that does not exist in this particular case study. But the authors intend to use parts of the method by using expert opinions in the research as their answers can give a path to follow for further investigations. The Delphi Method gives a clear way of collecting data that can be used during the entire study.
3 Theoretical Framework

This chapter describes the different theories considered during the thesis work and which to use in the study. General Forecasting Theory is studied followed by different Strategic Approaches. Status Quo Theory with a Twist and Final Decision complete the chapter.

“Only a fool would make predictions – especially about the future.”

– Samuel Goldwyn

3.1 General Forecasting – Preparing for the Future

General forecasting theory is often based upon different types of strategic methods since a strategy is the direction and scope of an organization over a long time. In order to give a direction it is evident that the desired or most likely goal has to be created.32

There are different requirements to the theories that will be applied in this study. The theories can not be too extensive concerning time consumption as the authors have a strict time schedule. It is important that the theories used will be able to comprise the different aspects that are interesting to look into during the study as well as the entire area of investigation. If such a theory can not be found it is up to the authors to combine different theories in order to find one that does. The theories should be easily applicable onto the existent situation. Since the thesis will be conducted with the help of an abductive reasoning the existent situation should be compatible with the scenario created from the theoretical framework. The theory should primarily facilitate achieving the purpose of the study. Theories and the guidance they give in different situations are shown in figure 3.1.

32 Johnson, Sholes & Whittington, p 31
Where Is the Semiconductor Industry Going?

3.1.1 Building Scenarios

In a high-tech industry such as the semiconductor industry the business environment has a high level of uncertainty arising from rapid change. During these sorts of circumstances it may be too hard or even impossible to develop a single view of the future and how the environmental factors will impact the organization’s strategy. To be able to understand the future environment that a company operates in a different approach must be considered by building scenarios. Scenarios are plausible future settings of how the area researched will develop. The scenarios are based on a variation of influences, drivers of change being the most important.\(^{34}\)

In order to get reliable scenarios the development must be based on present knowledge of current trends and signals to future developments, and this is what scenario analysis does. Although not entirely a forecasting technique the method aims to predict the future by a process of thinking and communication. In a multiple scenario approach several scenarios are constructed – classically three or four – that show different views of how the

\(^{33}\) Johnson, Sholes & Whittington, p 358  
\(^{34}\) Johnson, Sholes & Whittington, p 76
Where Is the Semiconductor Industry Going?

future may look like 5 to 25 years ahead, and shorter time spans if the industry is fast-moving as in this case. Scenario analysis can be either qualitative, quantitative or a combination of both. 35

This approach suits the study especially well since it assists reaching the purpose of the study. In order to be consistent the authors will choose to use a qualitative scenario analysis that conventionally takes the form of narratives.

3.2 Strategic Approach

In order to conduct a strategic thesis work or study it is important for the authors to detect and clarify their definition of strategy and how they see the world. The strategic approach can shift as the situation that is studied alters and it is therefore beneficial to shed light on which strategic tool/tools that will be used in the study.

3.2.1 Strategic Lenses, which one to use?

There are different ways to look at strategy and how it should be understood, developed and implemented. The authors will study and describe the three ways described by Johnson, Scholes and Whittington (2005).

3.2.1.1 Strategy as Design

This is the most common view of strategy where strategy development can be a logical process in which the forces and constrains on the organization are weighed to establish clear strategic direction. 36 This lens might be too constrained for this study as it takes too much regard to the company’s situation instead of the overall reality. It is focused on the direction instead of the goal which makes it unsuitable as the only theory to use since the purpose of the thesis is to achieve a goal as well as a direction. With this said, the authors will not eliminate this lens from their spectra as it gives a structured way of thinking about strategy and the pathway to follow. It might be the most useful lens as the authors themselves will create forces and constraints to the study by building a theoretical framework throughout this chapter. Further more it is not recommended to use a single lens angle to

35 Grant, p 319
36 Johnson, Scholes & Whittington, p 32

17
look at a problem, as this may result in failure to see all the complex issues raised.

### 3.2.1.2 Strategy as Experience

This approach is based on adapting precious strategies that have been influenced by the experience of managers and others in the organization. The process is strongly driven by the taken-for-granted assumptions infested in the organization’s doctrine. Insofar as different opinions and strategies exist to choose from the decision process will not only take into consideration a rational and analytical process but bargaining and negotiation as well.\(^{37}\) The approach will partly be useful when looking at previous shifts in the competitive landscape as well as technological development until present time. This may give a foretaste of what is to come, as stated in Chapter 1.3, but the analysis can not entirely depend on this theory but rather be a foundation. Several more theories must be taken into consideration to build a nuanced view.

### 3.2.1.3 Strategy as Ideas

The strategy as ideas emphasizes the importance of the environment around organizations, companies, business units etc. since this environment could be the explanation to why innovation, and with that change, takes place. Strategy is not seen as something planned from the top but as something emerging from within and around the organization. Top management must be aware of these types of trends, behaviors and foremost the patterns in which they develop since they will shape the future strategies of the organization. The new ideas often have to battle with the already existing strategy created by the “Strategy as Experience” lens above since the former one is not yet accepted, or confirmed to be working.\(^{38}\) Since this theory is most suitable for management the authors choose not to use this particular lens in the study.

### 3.3 Status Quo Theory with a Twist

Many theoretical frameworks have been described as simply status quo theory that does not say anything about the past or the future but only the present, static situation.\(^{39}\) The authors will try to investigate a couple of

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\(^{37}\) Johnson, Scholes & Whittington, p 32  
\(^{38}\) Johnson, Scholes & Whittington, p 32  
\(^{39}\) Grant, p 106
those theories and with a twist try to see if they can work in the dynamic context that the study takes place.

### 3.3.1 Porter’s Value Chain

Porter’s value chain has its focus on the microeconomics of one specific company or organization. The primary activities are directly concerned with the creation or delivery of a product or service. These are the activities that add value according to the customers and thus the activities that the customers are willing to pay for. The supporting activities help to improve the primary activities but are not directly concerned with the creation of the product or service as shown in figure 3.2.

![Figure 3.2 Porter’s Value Chain](image)

By activity mapping the value chain, greater awareness can arise regarding costs and differentiation as well as possibilities to lower cost. Porter argues that competitive advantage is created when a company performs critical functions better or/and at a lower cost than its competitors.\(^4^1\)

This extension of the value chain analysis could help the authors achieve the purpose of the study but might be too time consuming as six companies are to be investigated.

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\(^{40}\) Johnson, Scholes & Whittington, p 137, figure 3.6

\(^{41}\) Thompson, p 342
Where Is the Semiconductor Industry Going?

3.3.2 The Value Network

A value network is the context within which a firm exists, establishes an operation process and works with suppliers and partners in order to create value and so forth gain net sales of a prospect customer. Each company’s strategy defines its ability to handle the threats and opportunities that come from disruptive versus sustaining innovation. The value network gives the macro economic view of an industry.

A simplified model of a Value Network is shown in figure 3.3.

![Figure 3.3 The Value Network](image)

This method is used as it is rare for a single company to undertake all of the value creating activities of a product. That is why a company is part of the wider value network that creates the value from product design to the end customer. It is important for managers to understand what type of value network the company exists within as this creates a foundation for outsourcing decisions. By mapping the value network, the best partners and suppliers can be chosen and the type of level the relationship should be. Could the supplier be a strong and important allied or should it stay as just a supplier?

The theory gives a broad and varied picture of the situation and environment in which a company exists. This favors the theory in this study as such a picture is desired to achieve. The model is easy to modify according to the existing situation. Although these aspects are excellent it is an even more time consuming theory than the value chain since it describes a further complex situation.

3.3.3 PESTEL Analysis

To distinguish the influences in the micro-environment it is possible to investigate the macro-environment with the help of a PESTEL (Political, Economic, Social, Technological, Environmental and Legal) analysis. In

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42 Christensen & Raynor, p 44
43 Grant, p 103
44 Johnson, Scholes & Whittington, p 140, Exhibit 3.7
45 Johnson, Sholes & Whittington, p 141
order to separate the important factors from the vital ones it is crucial to understand the connection between a PESTEL analysis and the value network described in Chapter 3.3.2. A reason for this is that the core of the company’s business environment comes from, and is formed by its relationship with its customers, suppliers and competitors.\(^\text{46}\)

There are some factors in the PESTEL model that might be more important than others. The macro-environment is the most general layer in the description of a business environment. However, by using the PESTEL analysis the study can be more focused and specific, especially when choosing what factors in the PESTEL model to take under consideration.\(^\text{47}\)

To include all the factors in the analysis is not considered necessary by the authors as previous knowledge shows that some factors are not relevant as their affect is insignificant. There are however three factors that have a great impact on the case companies’ situation and these factors are:

- Economic factors; the industry is based on research and development with 15-30\% of net sales invested in R&D. This high technology development requires consistent monetary input. Thus the economic environment within the company as well as the external economic environment will be a vital factor to take into consideration when studying the industry.

- Technological factors; the industry is technology based and there are many technology related alliances and collaborations between companies in different positions in the value chain. Consequently the technological factor should be included in the industry analysis in order to get the best possible overall picture.

- Legal factors; the legal factors have an impact on the industry since there exists an extensive trade with intellectual property (IP) due to the high level of technological development in the industry.

Those with lesser impact are Political, Environmental and Socio-cultural factors.

\(^{46}\) Grant, p 68  
\(^{47}\) Johnson, Scholes & Whittington, p 65
3.3.4 Competitor Analysis

The purpose of a Competitor Analysis is to:  

- Forecast competitors’ future strategies
- Predict competitors’ likely reactions to a company’s initiatives
- Determine how competitors’ behavior can be influenced in the aim of making it more favorable.

To be able to understand and generate these three purposes it is vital to be informed about the competitor. The information often comes from internal business intelligence departments or external companies with focus on business intelligence reports on a consultant basis. The boundaries between public and private information is not always clear and it may be difficult to distinguish between legitimate information and illegal industrial espionage. Therefore this theory might not be optimal as the thesis shall be based on public data. Even after considering this fact the theory is still one of the most suitable when fulfilling the purpose of the study and as that it will be used as a framework.

3.3.5 Mergers and Acquisitions

When a company merge with another company or acquires one, the changes can be dramatic. Mergers and acquisitions (M&As) are decisions made on a corporate strategy level of a company. Acquisition is one way to develop a company or grow and is often called non-organic growth. If the acquisition is hostile the word takeover is preferred. A merge is when two companies both agree to come together.

This area is particularly difficult to research because of problems with data availability. If the objective is to study the change in a company’s performance before and after an acquisition, then several years of data is needed to ensure that longer-term effects are studied once any early implementation problems are overcome. However two companies, A and B, can be studied after the merge or acquisition as the new company AB. The performance of company AB can be compared to the previous performances.

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48 Grant, p 113
49 Grant, p 113
50 Thompson & Martin, p 20
Where Is the Semiconductor Industry Going?

of company A and B as independent companies. If the AB company a year later acquires C and then D it is difficult to distinguish what effects the particular B acquisition had but company A’s overall ability to incorporate new companies into its main activities which often can be seen in the company’s financial statements such as their annual reports.51

The authors will use the theory regarding M&As in order to identify trends in the semiconductor industry and how they are developing. In order to distinguish performance of the case companies before and after acquisitions the overall financial statement will be studied.

3.3.6 Forward Integration

The term vertical integration is commonly used in economy. It aims to describe a company’s change in the supply chain and can be further divided in forward integration and backward integration. Let us assume that a company is in manufacturing, a backward integration would then suggest that the company takes over its supplier’s activities and forward integration that it for example takes over their distributor’s activities, see figure 3.4.

![Figure 3.4 Vertical Integration](image-url)

When a company wants to advance in the supply chain they forward integrate. This can be done in some different ways. The most aggressive way is through a merger or an acquisition of another company that has the competences that needs to be obtained in order to move forward. Another option is through a joint venture, something that also might seem to be a radical action. Forward integration can also be created organically, which normally in the semiconductor industry is more risky, since the company has to develop new competences from scratch which often requires a large amount of capital.52

51 Thompson & Martin, pp 561-565
52 Thompson & Martin, p 504
3.3.7 Alliances

An alliance is where two or more organizations share resources and activities to pursue a strategy. Alliances have become increasingly popular since companies cannot always cope with increasingly complex situations from internal resources alone. The company might lack materials, skills, innovation, finances or access to markets and this can be obtained by entering or forming an alliance. Despite the good intentions about half of the alliances world wide will fail.53

The authors will look closer at alliances in the semiconductor industry in order to understand the complex relations that exist and how they will develop.

3.3.8 Herfindahl-Hirschman Index

The Herfindahl-Hirschman Index (HHI) describes the concentration of companies in an industry and is used for measuring competition. The index is defined as the sum of the square of companies’ market shares and results in a number between 0 and 1. A high index is equivalent with a market where one company has a monopolistic position (the square give the large companies more impact on the index) and a low index reflects on an industry with several small companies. A HHI index less then 0.10 represents a market that is not concentrated, that is the competitive situation is good. An index between 0.10-0.18 represents a moderately concentrated market and a HHI index above 0.18 stands for a relatively concentrated market which often indicates that one company is superior to the rest. A merge that increases the HHI by more than 0.1 often raises antitrust concerns. The HHI formula follows.54

\[ H = \sum_{i=1}^{n} s_i^2 \]

Where \( H \) is the Herfindahl-Hirschman Index, \( s \) is the market share of firm \( i \) and \( n \) is the number of firms.

When it is not possible to calculate every company in the industry the formula allows that the largest companies share are taken under consideration and that the share left is divided between an estimated number of companies with identical market share.

53 Johnson, Scholes & Whittington, pp 353-356
54 www.quickmba.com 2007-10-11
A few examples to help understand how the index works:

In an industry following the formula \( H = \frac{1}{n} \) that is all companies have equal market share, an industry with four companies will obviously have a higher HHI index than an industry with ten companies.

\[
4 \cdot 0.25^2 = 0.25 \\
10 \cdot 0.1^2 = 0.1
\]

If the formula \( H = \frac{1}{n} \) does not apply, (which is the most common situation) a study of the market shares for each company has to be made, for example an industry with one company having 91% of the market and nine companies with 1% each will give an extremely high index, implying that there is one company with an almost monopolistic situation.

\[
0.91^2 + 9 \cdot 0.01^2 = 0.829
\]

The index will give the authors an opportunity to distinguish the competitive climate in the industry.

### 3.3.9 Key Success Factors and Threshold Factors

In order to clear out how the industry’s profit is shared between the competitors the researcher can identify Key Success Factors (KSFs) and Threshold Factors (TFs). TFs are those factors that are essential for a company to be able to compete successfully in a given industry. Without these resources, the company can not meet customers’ requirements and will not have a future in the industry. The difference between KSFs and TFs is that a company can not exist without TFs, but how successful they are, is dependent on which KSF they possess. Per definition all of the case companies have the TFs, although some of them might be at risk of loosing one or more.\(^{55}\)

The KSFs are the answers to the following question:\(^{56}\)

*For our organization/company to be successful, we must be good at the following activities:*

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\(^{55}\) Johnson, Sholes Johnson, Scholes & Whittington, p 119

\(^{56}\) Grant, p 92
Where Is the Semiconductor Industry Going?

The purpose of a KSF study is to look explicitly at the sources of competitive advantage that a company can obtain in an industry and so forth be able to identify KSFs. The identification can be set up by using the model shown in figure 3.5.  

![Figure 3.5 Identifying Key Success Factors](image)

This analysis on its own gives a static version of how to compete successfully at that exact moment it is performed and consequently during an industry’s life cycle these factors continually change. Therefore it is of value to explain the static nature of the theory so that the results will not be misleading but if combined with a forecast mindset a dynamic picture can be seen.

This theory gives a good framework to distinguishing KSFs and thus distinguishing certain aspects of the competitive landscape, both in 2007 and in 2012.

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57 Grant, p 93  
58 Grant, p 93, figure 3.5  
59 Grant, p 310
3.4 Requirements and Final Decision

After addressing quite a few theories the decision of which ones to use and what they can add more specifically to the study will be defined. In order to map the competitive landscape of the semiconductor industry in 2012 there are a few things that are needed. The first being what the industry looks like today and the case companies’ different positions within. In order to study this area the authors find that a mix between the value chain and the value network is suitable. The value network, including every dimension, is too complex and time consuming, and while giving a wide view it might not be able to provide a clear picture as the complexity becomes too high. Therefore the authors have chosen to scale down the dimensions and only view from the perspective of the vertical dimension. The authors choose to name this model the value chain, but not referring to Porter’s Value Chain. In figure 3.6 the model is shown. To see the figure in a larger scale see Appendix 1.

![Figure 3.6 The Value Chain](image)

This model will be used in the study of 2007 as well as in the study of 2012. In order to forecast the value chain in 2012 there are a number of factors that have to be investigated. The first step will be to map out the present industry and the case companies’ positions. The next step concerns what factors that will be important to possess in order to survive, and be successful, in the industry in 2012. When put into this context the KSF analysis and the TF analysis become useful for the authors. It is vital to understand what factors that decide a company’s future in order to forecast it. The KSFs will be identified by using the Delphi method with a panel of experts that will be asked to define KSFs as well as TFs for the industry. The potential KSFs will be identified during brainstorming with the authors and people from the panel of experts. The brainstorming sessions will take place when the authors have collected enough data, through PESTEL analysis, competitor analysis and customer analysis, in order to suggest
possible KSFs. After compiling the information the same experts will be asked to rank the possessing rate of the factors on each of the case companies. By combining the KSF with the market trends, which take in the customers and the competitors, it will be possible to foresee if the KSFs will change to a great extent or remain the same.

It is not only the companies themselves and their features that decide the future positions. The environmental factors play a part as well. That is why the PESTEL analysis will be used as well as looking closer at alliances and M&As, so that an additional angle will be studied, the “outside-in-perspective”. A closer look on the authors’ view of the connections between the different theories and how they will be used in relation to each other is shown in figure 3.7.

![Figure 3.7 The theories used in relation to each other](image)

The purpose of the thesis is to investigate how the M&W segment of the semiconductor industry will develop during the period 2007-2012. The connections between the theories and between the macro and micro-environment are shown. The KSFs comes from a combination of the economical, technological and legal factors as well as from customers and competitors way of acting. Hence the KSFs will affect the possible positions in the value chain and how the case companies can and may position themselves.

By using this combination of theories and the methodological approach discussed in Chapter 2 the authors believe that the purpose of the thesis will be achieved and a multi-faceted view will be produced.
4 Setting the Context of the Case

The chapter gives a wider background of the settings of the case than presented in the introduction chapter. Technology development and industry structure are presented as well as the six case companies.

Past experience, if not forgotten, is a guide to the future.

– Chinese proverb

4.1 Industry Structure

The different parts of the value chain are explained more in detail for the reader to get an overview of a somewhat complex industry. The same model used in this chapter is later used to show the different companies’ positions in the value chain.

4.1.1 Foundries

Companies that supply the IDMs with semiconductors are called foundries and they focus on the manufacturing process of the semiconductors. This manufacturing process requires more than four hundred discrete steps.\textsuperscript{60} Foundries are located at the lowest stage in the value chain of a mobile phone or other electrical devise. Due to the extremely expensive development costs, it is common that IDMs collaborate with foundries in the development of new technology. To be able to maintain the margins it is vital to have economy of scale. The cost to set up a state-of-the-art fab today is about $2-3 billion which for most companies is a very big investment. By 2010 it is expected that a fab will cost about $5 billion.\textsuperscript{61}

\textsuperscript{60} Christensen, Anthony, Roth, p 158
\textsuperscript{61} www.techweb.com 2007-09-27
The largest company in this segment is Taiwan Semiconductor Manufacturing Company (TSMC). They have close collaboration with a number of IDMs. TSMC operates several fabs, located in Taiwan, Singapore, China and the US. The company is listed on the Taiwan Stock Exchange and on the New York Stock Exchange under the trading symbol of TSMC.62

United Microelectronics Corporation (UMC) is another large foundry. UMC is Taiwan-based as well and has additional offices in Japan, Singapore, Europe, and the US.63 Other important foundry companies are Shanghai-based Semiconductor Manufacturing International Corporation (SMIC), Singapore-based Chartered and USA-based IBM Microelectronics. The foundries’ market shares are shown in figure 4.1.

![Market share foundries 2006](image)

Figure 4.1 Market share foundries 200664

4.1.2 IDMs

An IDM is a company that designs and manufactures ICs. IDMs are designing the Mask Work and IP core (or IP block) for the semiconductor

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63 www.umc.com 2007-09-24
64 LaPedus M. (2007-05-16) Foundries face obstacle course in 45nm race, EETimes
components. The Mask Works are a series of related images representing the three-dimensional pattern of the semiconductor material and which parts that should be removed to form a chip. A semiconductor chip is not possible to patent, however if the Mask Work is registered, it is protected by the Semiconductor Chip Protection Act (SCPA) with the symbol. The IP core is a unit of logic or chip layout design for making an Application Specific Integrated Circuit (ASIC). The IP core is owned by the developer but can be licensed to other companies.

Many of the IDMs are no longer willing to take the risks related to the extremely high development cost of the latest manufacturing technology and are therefore outsourcing the manufacturing to foundries. Some of the IDMs have their own fabs while others are fabless, that is they do not have any in-house manufacturing. In between these alternatives there is the so called fab lite strategy which is when an IDM has outsourced a part of their manufacturing to one or several foundries but still has some in-house manufacturing. The design and testing of the semiconductors are still made by the IDMs, regardless of fab strategy. The table below is for the reader to get an understanding of the companies’ size in the semiconductor industry.

<table>
<thead>
<tr>
<th>Q1-07 Rank</th>
<th>Q2-07 Rank</th>
<th>Company Name</th>
<th>Q1-07</th>
<th>Q2-07</th>
<th>% Change</th>
<th>% of Total</th>
<th>Cumulative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Intel</td>
<td>7,668</td>
<td>7,728</td>
<td>-0.78%</td>
<td>12.25%</td>
<td>12.25%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Samsung Electronics</td>
<td>4,835</td>
<td>4,716</td>
<td>-2.46%</td>
<td>7.48%</td>
<td>19.73%</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Texas Instruments</td>
<td>2,900</td>
<td>3,030</td>
<td>4.48%</td>
<td>4.80%</td>
<td>24.53%</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>Toshiba</td>
<td>3,109</td>
<td>2,510</td>
<td>-19.27%</td>
<td>3.98%</td>
<td>28.51%</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>STMicroelectronics</td>
<td>2,276</td>
<td>2,418</td>
<td>6.24%</td>
<td>3.83%</td>
<td>32.35%</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>Renesas Technology</td>
<td>1,948</td>
<td>1,985</td>
<td>1.90%</td>
<td>3.15%</td>
<td>35.49%</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>NXP</td>
<td>2,539</td>
<td>1,963</td>
<td>-22.69%</td>
<td>3.11%</td>
<td>38.63%</td>
</tr>
<tr>
<td>8</td>
<td>9</td>
<td>Qualcomm</td>
<td>1,259</td>
<td>1,367</td>
<td>8.58%</td>
<td>2.17%</td>
<td>43.11%</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>Infineon Technologies</td>
<td>1,202</td>
<td>1,363</td>
<td>6.32%</td>
<td>2.16%</td>
<td>45.27%</td>
</tr>
</tbody>
</table>

All Others 35,975 34,519 -4.05% 54.73% 100.00%

Total Market 65,418 63,071 -3.59% 100.00%

Figure 4.2 Top 10 Semiconductor companies Q2 2007

As seen in figure 4.2 TI and ST are the largest companies after Q2 2007 with about 5% respectively 4% market share. Freescale and Broadcom is not among the ten largest companies and are therefore not on the list.

65 www.patentstation.com 2007-10-17
66 www.isuppli.com 2007-09-03
however, in the end of 2006 Freescale had 2.3% of the market and Broadcom 1.4%.  

4.1.3 Technology Enablers

The TE is the link between the IDM and the Brand Owner or the Original Design Manufacturer (ODM) in the value chain. In many cases the TE does not produce any hardware of their own, but instead they let IDMs produce chips after their reference design. The TE also provides platform software and applications. Since this does not involve any physical commodity, TE deals to a large extent with licenses and Intellectual Property Right (IPR).

Important TEs are Nokia and Motorola, working under their own brand, as well as EMP and Qualcomm.

4.1.4 ODMs & EMS

The Original Design Manufacturer (ODM) is a company that manufactures a product that will be sold under another company’s brand (in this model the Brand Owner). Brand Owners uses ODMs for multiple reasons, it allows them to focus on their core competencies, and it reduces risk and increases flexibility. The ODMs are often used in international trade to make use of low labor cost, proximity to market and in some cases due to legal aspects.

Some different terms can come up when discussing this kind of outsourcing; Contract Manufacturer (CM), Electronics Manufacturing Services (EMS) and ODM. The idea is basically the same, the difference between contract manufacturer and ODM is that the ODM usually owns the intellectual property for the product, which the CM does not. An EMS is a CM that not

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67 iSuppli Corp  
68 www.ericsson.com 2007-09-27  
69 www.pcmag.com 2007-09-27
only manufactures products but offers design and supply chain assistance as well.\textsuperscript{70}

\subsection*{4.1.5 Brand Owners}

![Diagram of the semiconductor industry supply chain]

The Brand Owner is, to many consumers, seen as the mobile phone manufacturer; this is not completely true. In reality the Brand Owner is often involved directly in just a small part of the production of the phone. Normally the consumer does not have any idea of all the middlemen. Many of the brands can be seen as Original Equipment Manufacturers (OEM), which means that they sell products that are manufactured by other companies under their own brand. This terminology might seem strange; since they are not really the original manufacturers.\textsuperscript{71}

The Brand Owners most important task is to get the consumer to buy their products. A pleasant design of the phone and high-quality applications is important to succeed in the competitive business.

The big five Brand Owners are Nokia, Motorola, Samsung, Sony Ericsson and LG representing more than 80\% of the market.

\subsection*{4.2 Global Mobile Phone Market}

With total sales of 270 million units, the global mobile phone market grew by 17\% in Q2 2007. As seen in figure 4.3, Motorola has lost over 7\% of their market shares and is the only one of the big five Brand Owners that has lowered their market share. An old product portfolio with lack of new phones is a contributing factor for the defeat. Nokia has increased their position as the superior market leader and there do not seem to be any signs that this should change in the foreseeable future. With new products Nokia has managed to increase their sales in the high-end segment and as a result ended up with a higher average selling price. Samsung and Sony Ericsson have been able to capitalize on Motorola’s weak quarter. Samsung’s new products, with focus on multimedia applications, are to a large extent

\textsuperscript{70} www.techweb.com 2007-09-27

\textsuperscript{71} www.techweb.com 2007-09-27
Where Is the Semiconductor Industry Going?

responsible for their growth. Sony Ericsson, with a strong high-end portfolio and increasing sales of mid-tier products in the emerging market, South America, are looking strong for the future if they can maintain their margins and average selling price. LG has presented some popular 3G-models, with an appealing price, that have been successful in Western Europe and Asia/Pacific. However, LG is likely to face a tough period with lower average selling price and thinner margins.²²

<table>
<thead>
<tr>
<th>Company</th>
<th>Q2 07 Sales</th>
<th>Q2 07 Market Share (%)</th>
<th>Q2 06 Sales</th>
<th>Q2 06 Market Share (%)</th>
<th>Market Share Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>99 958</td>
<td>36.9</td>
<td>77 748</td>
<td>33.7</td>
<td>3.2</td>
</tr>
<tr>
<td>Motorola</td>
<td>39 486</td>
<td>14.6</td>
<td>50 532</td>
<td>21.9</td>
<td>-7.3</td>
</tr>
<tr>
<td>Samsung</td>
<td>36 191</td>
<td>13.4</td>
<td>25 757</td>
<td>11.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Sony Ericsson</td>
<td>24 317</td>
<td>9</td>
<td>15 308</td>
<td>6.6</td>
<td>2.4</td>
</tr>
<tr>
<td>LG</td>
<td>18 433</td>
<td>6.8</td>
<td>14 639</td>
<td>6.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Others</td>
<td>52 484</td>
<td>19.3</td>
<td>46 764</td>
<td>20.1</td>
<td>-0.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>270 871</td>
<td>100.0</td>
<td>230 750</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.3 Worldwide Mobile Terminal Sales in 2Q07 (Thousands of Units)²³

The fastest growing market today is Asia/Pacific where mobile handset sales rose to almost 100 million units, which represents an increase of 40% in one years time. Worth mentioning is that the India handset market at the moment decreases, probably temporarily, while the Chinese market continues its rapid growth. The emerging markets in Eastern Europe, the Middle East, Africa and South America had a moderate development; the sales have increased by approximately 5%. The majority of the growth is a result of low- and mid-tier devices. In Japan the sales of Q2 reached 12 million units, which were one tenth more than 2006, but an apparent decline since Q1 2007. Two of the largest markets North America and Western Europe have both had a steady growth. For more detailed information, see figure 4.4.²⁴

4.3 Mobile Telecommunication Standards

The most important standards for mobile communication, divided in 2G and 3G standards, will be explained more in detail.

4.3.1 2G

The second generation (2G) of wireless telecommunication is, contrary to the first generation, using digital radio signals. There are basically two different technologies for 2G, Time Division Multiple Access (TDMA), used in Global System for Mobile communications (GSM) and Code Division Multiple Access (CDMA), used in cdmaOne.\(^\text{76}\)

4.3.1.1 GSM

GSM is a second generation wireless mobile system which was introduced in 1991 and is today the world’s leading mobile system and is used in over 100 countries. The difference from the first generation wireless systems is that GSM uses digital technology and the time division multiple access transmission method. Originally, GSM was developed only for voice telephony but now supports data transfers speeds up to 9.6 kilobit per second (kbps) and makes it possible to send and receive Short Message Service (SMS) and other basic data services.\(^\text{77}\)

The GSM networks operate on the 900MHz and 1800MHz wavebands in Europe, Asia and Australia, and on the 1900MHz waveband in North America, parts of South America and parts of Africa.\(^\text{78}\)

\(^{75}\) www.gartner.com (August 2007) 2007-10-25
\(^{76}\) www.cdg.org 2007-10-03
\(^{77}\) www.gsmworld.com 2007-10-01
\(^{78}\) www.ericsson.com 2007-10-01
4.3.1.2 GPRS
General Packet Radio Service (GPRS) is a connectivity solution based on Internet Protocols that supports a wide range of applications. Enabling speeds up to 40 kbps (theoretically data rates up to 170 kbps are possible, however this speed is almost never offered by the operators), equal to the speed of a dial-up modem, being more than four times faster then GSM systems. GPRS enables usage of data services like Internet and e-mail. Mobile systems of the second generation that are combined with GPRS are often referred to as 2.5G, which means that they are faster than 2G and somewhere in between the second and third generation.

4.3.1.3 EDGE
Enhanced Data rates for Global Evolution (EDGE) is an enhancement of the GSM radio access technology, providing faster bit rates for data applications. There is a relatively small incremental cost of including EDGE capability in GSM networks (for many networks it is just a software upgrade). As a result of this, all new GSM infrastructure deployments are EDGE capable and nearly all new mid- to high-level GSM devices also include EDGE radio technology. EDGE supports data rates up to 384 kbps which is comparable with the data rate for early Wideband Code Division Multiple Access (WCDMA) and brings the 2G standard even closer to 3G. Therefore EDGE is seen as 2.75G.

4.3.1.4 CDMA
CDMA is a digital mobile telephony system, developed by Qualcomm. The CDMA technology is basically a spread spectrum that allows many users occupy the same frequency at the same time (read more about the technology under WCDMA). CDMA only relates to the air interface, whereas GSM is a specification of a complete network infrastructure, CDMA gives the operator more freedom to choose a suitable network. The CDMA air interface is used in both 2G and 3G, in 2G under the standard cdmaOne and in 3G under CDMA-2000 and WCDMA.

When GSM has been dominating Europe, CDMA has been the most important standard in North America and parts of Asia.

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79 www.etsi.org 2007-10-02
80 www.gsmworld.com 2007-10-01
81 www.gsmworld.com 2007-10-02
82 www.etsi.org 2007-10-02
83 www.cdg.org 2007-10-04
4.3.2 3G

The third generation standard for wireless communications is based on the International Telecommunication Union (ITU) program, Interventional Mobile Telecommunications-2000 (IMT-2000). By linking global networks it provides a framework for worldwide wireless access.\(^{84}\)

The major difference between 2G and 3G is the data rates, where 3G is the significantly faster of the two. This allows the user to use two or more applications at the same time.

4.3.2.1 WCDMA / UMTS

WCDMA is the technology behind the Universal Mobile Telecommunications System (UMTS) standard, which is closely connected to the 2G GSM standard. The technology provides increased network capacity and reduces cost for voice and data services. As the name reveals (Wideband Code Division Multiple Access), WCDMA uses codes to identify the user signals which mean that all users transmit on the same frequency at the same time. With GPRS or EDGE every user allots a channel within a frequency band (the same principle as a regular radio). The WCDMA technology is therefore more secure and less sensitive for noise.\(^{85}\)

The standard supports data rates up to 2 Mbps when combining several code channels (the data rate is 384 kbps per channel) and enables video streaming and makes it possible to do things simultaneously, for example having a conversation and check e-mail at the same time.\(^{86}\)

4.3.2.2 HSPA (HSDPA / HSUPA)

HSPA (High Speed Packet Access) is usually divided in to HSDPA (High Speed Downlink Packet Access) and HSUPA (High Speed Uplink Packet Access). The difference is simply that HSDPA regards downloading and HSUPA the uploading of data from the mobile unit. HSDPA is a software-based enhancement that improves the capacity range of WCDMA networks by two and increases the downlink data speeds of a factor 5-10.\(^{87}\)
Where Is the Semiconductor Industry Going?

In Sweden the mobile operator, 3, offers data rates up to 7.2 Mbps (2007-10-02). This speed decreases with the distance to the sources; therefore the really high speed is only possible to reach in the big cities. 88

4.3.3 Market Share by Technology

The industry is at the moment in an interesting phase, changing from the second to the third generation of mobile phone technology. In industrialized countries the 3G technology is getting more and more spread. The different standards that have been reviewed in the earlier subchapters represent the market shares shown in figure 4.5. As seen in figure 4.5, GSM is the dominant technology standard with 38% of the shipments in 2006. Following, with about half the share, are GPRS with 19% and CDMA with 15%.

![Shipment by Technology in 2006](image)

Figure 4.5 Shipment by technology in 2006 89

The average market growth within the M&W sector is predicted to be about 7% yearly up to 2012. 90

4.4 Case IDMs

For the reader with lack of knowledge of the semiconductor industry, this part will give an introduction to the six case companies. The diagrams in figure 4.6 and 4.7 shows key figures that are important in order to understand the economy of the industry and how the companies are performing.

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88 www.tre.se 2007-10-02
90 www.st.com 2007-09-30
Where Is the Semiconductor Industry Going?

Figure 4.6 Revenue, R&D Investments and Net Income (Data from 2006, Freescale 2005)

Common for all the IDMs are that a substantial part of their net sales is spent on R&D, about 15-30% (see figure 4.6 and 4.7) which is extremely high compared to other industries.

Figure 4.7 Key figures (The data is from 2006 except for Freescale that is from 2005)

The companies only have about one third of their net sales in the M&W segment, more details on the different companies’ performance will be disclosed in the following chapters.
4.4.1 Broadcom

4.4.1.1 Company Information
Broadcom Corporation is one of the leaders in semiconductors for wired and wireless communications. With one of the industry’s broadest portfolios, Broadcom provides System-on-a-Chip (SoC) and software solutions to manufacturers of computing and networking equipment, digital entertainment, broadband access products and mobile devices.

With net sales of $3.36 billion, 2800 patents and 6000 pending, makes Broadcom one of the largest companies in the industry, particularly strong in wireless communication.  

Broadcom is listed on the New York Stock Exchange (BRCM). The headquarters is situated in Irvine, California.

Figure 4.8 Broadcom’s distribution of sales

4.4.1.2 Technology and Products
So far, Broadcom has reached their first design win in 3G and is expected to win several designs in the near future. Today, the company can offer mobile phone solutions to the WCDMA/EDGE/GPRS/GSM standards. Broadcom has a very flexible manufacturing which gives an advantage over its competitors when it comes to bringing 65-nm and 45-nm SoC products to market.

91 www.finance.yahoo.com 2007-11-12
92 www.broadcom.com 2007-09-13
93 Interview Mathias Nawroth 2007-09-12
Under 2007 Broadcom presented the industry's first single-chip Wi-Fi, Bluetooth, and FM solution for mobile devices and the first 65-nm single-chip EDGE system solution.\(^\text{94}\)

### 4.4.1.3 Partners and Alliances

Since Broadcom is a fabless company they are not part of any alliances in process node or fab development. Recently they have started to deliver chips to Nokia for Nokia’s EDGE phones.\(^\text{95}\) Broadcom also works with Samsung regarding 3G.

### 4.4.2 Freescale

![Freescale logo]

#### 4.4.2.1 Company Information

Freescale Semiconductor is a global leader in design and manufacturing of embedded semiconductors for the automotive, industrial, networking and M&W markets. Before 2004 Freescale was a part of Motorola Corporation, but in December 2006 Freescale was acquired by a private equity consortium lead by the Blackstone Group. Freescale has design, R&D, manufacturing or sales operations in more than 30 countries and its headquarters is situated in Austin, Texas. Freescale is one of the world's largest semiconductor companies with 2006 net sales of $6.4 billion, of which 30% is in the M&W industry.\(^\text{96}\)

![Freescale's distribution of sales](image)

**Figure 4.9 Freescale's distribution of sales**

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\(^\text{94}\) www.broadcom.com 2007-09-13  
\(^\text{95}\) Walko J. (2007-08-13) Nokia ends IC development for mobiles, EETimes  
\(^\text{96}\) www.freescale.com 2007-09-13
4.4.2.2 Technology and Products
Thanks to its broad market which is covered by three business units, Freescale gains benefits from economy of scale. Freescale has several design wins in both 2G and 3G and the company possesses technology for EDGE/WCDMA/HSDPA. 97

4.4.2.3 Partners and Alliances
Freescale still has a close collaboration with Motorola, which by far is their largest costumer. The company supplies more than half of Motorola’s 2G and 3G portfolio. 98

4.4.3 Infineon

4.4.3.1 Company Information
Infineon Technologies is a leading semiconductor company with focus on automotive and industrial and M&W markets, where they offer complete system solutions. The headquarters is located in Neubiberg, Germany. Infineon is listed on the Frankfurt stock-market (IFX). The net sales for 2006 were €4.1 billion of which 30% in M&W. 99

Figure 4.10 Infineon’s distribution of sales

97 Interview Mathias Nawroth 2007-09-12
98 www.freescale.com 2007-09-13
99 www.infineon.com 2007-09-14
4.4.3.2 Technology and Products

Infineon supplies semiconductor components such as baseband processors, Radio Frequency (RF) transceivers (where they are market leading) and power management chips. Apart from this, the company has platforms for mobile phones, including software solutions. The RF-transceivers are primarily for the GSM, GPRS, EDGE and WCDMA standards.  

4.4.3.3 Partners and Alliances

In May 2006 Infineon’s memory product division was carved out into a separate company, Qimonda. Infineon still owns 86% of the stocks in Qimonda.

Infineon has a rather wide costumer base with customers such as Nokia (GSM), LG (EDGE), Apple (EDGE) and Panasonic (WCDMA).

4.4.4 NXP

4.4.4.1 Company Information

NXP was formerly a division of Philips but is now an independent semiconductor and software company, supplying a wide range of markets. NXP is 80% owned by a private equity group (Philips owns 20%) and has the headquarters located in Eindhoven, The Netherlands. The net sales for 2006 totaled €5 billion, of which 33% was in the M&W industry.

![NXP's distribution of sales](www.nxp.com 2007-09-24)

Figure 4.11 NXP’s distribution of sales

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100 www.infineon.com 2007-09-14
101 Interview Mathias Nawroth 2007-09-12
102 www.nxp.com 2007-09-24
4.4.4.2 Technology and Products
NXP’s Nexperia mobile multimedia solutions enable mobile TV, connectivity, gaming, MP3 audio, MPEG-4 video, digital imaging and GPS. NXP’s strength is in FM Radio ICs for portable applications, Power Management ICs and RF-solutions.\(^{103}\)

4.4.4.3 Partners and Alliances
NXP Software is an independent company that provides software solutions that improve sound, voice, and video quality in mobile handsets.\(^{104}\) Earlier NXP has been a part of the Crolle2 Alliance together with Freescale and ST. After leaving the alliance they started collaboration with TSMC.\(^{105}\) The most important customer to NXP is Samsung; other customers are various Chinese ODMs.

4.4.5 STMicroelectronics

4.4.5.1 Company Information
ST is one of the world’s largest semiconductor companies with net sales of $9.85 billion in 2006. Their largest business area is the M&W segment with approximately 35% of their net sales. The company’s sales are well balanced between the semiconductor industry’s five major high-growth sectors, shown in figure 4.12. The headquarters is located in Geneva, Switzerland and the stock (STM) is available for trading at the New York Stock Exchange and on Euronext Paris.\(^{106}\)

\(^{103}\) www.nxp.com 2007-09-24
\(^{104}\) www.nxp.com 2007-09-24
\(^{105}\) Walko J. (2007-09-04) NXP halts fab lite slide, EETimes Europe
\(^{106}\) www.st.com 2007-09-14
4.4.5.2 Technology and Products
ST has a broad product portfolio and is the leading producer of application-specific analog chips and power conversion devices. They have a leading position in ICs for mobile phones. In addition to the mobile and wireless industry they have a strong position as a supplier to the automotive industry, where they are ranked third after Freescale and Infineon.\textsuperscript{107}

4.4.5.3 Partners and Alliances
ST has developed a worldwide network of strategic alliances, including product development with key customers and technology development with other semiconductor manufacturers. ST recently (August 2007) entered a partnership with Nokia, in which ST will develop and produce 3G-chipsets and modem technologies for the next generation of Nokia’s 3G mobile phones.\textsuperscript{108} ST also does business with EMP, as they provide them with digital base band.\textsuperscript{109}

4.4.6 Texas Instruments

4.4.6.1 Company Information
TI is the largest of the case companies in the M&W industry; it serves innovative electronics companies by providing semiconductor technologies and helping them develop new ideas. TI is headquartered in Dallas, Texas,\textsuperscript{107} \textsuperscript{108} \textsuperscript{109}

\textsuperscript{107} www.st.com 2007-09-14
\textsuperscript{108} www.redeye.se 2007-09-14
\textsuperscript{109} www.st.com 2007-09-04
and has manufacturing, design and sales operations in more than 25 countries. The stock (TXN) is traded on the New York Stock Exchange. The net sales for 2006 totaled $14.3 billion, of which 35% was in the M&W industry.$^{110}$

![TI's distribution of sales](image)

**Figure 4.13 TI’s distribution of sales**

### 4.4.6.2 Technology and Products

TI is leading in Digital Signal Processing (DSP) and analog semiconductors as well as chips for mobile handsets. As a result TI has managed to gain a cost leadership in 2G mobile platforms chipsets.

During 2006 TI spent $2.2 billion on R&D, which contradictorily is among the highest in the segment per employee but lowest relative net sales.$^{111}$

### 4.4.6.3 Partners and Alliances

TI has a very broad customer base with customers such as EMP, Nokia, LG and Motorola. Earlier they have had close development collaboration with Nokia. The intention is to increase their partnership with their foundry partners within the near future. TI remains a key distributor to the 3G chipset market through its strong position at Nokia and EMP.

### 4.4.7 The Qualcomm factor

Qualcomm is an IDM that has not been a part of the study; however, the authors think it is important to point out that Qualcomm represents a big part of the industry.

Qualcomm has focused on developing CDMA, licensing wireless technologies and selling ASICs that implement them. Qualcomm is the

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$^{110}$ [www.ti.com](http://www.ti.com) 2007-09-14

$^{111}$ [www.ti.com](http://www.ti.com) 2007-09-14
inventor of CDMA standards. Besides this, the company owns a significant number of key patents in the 3G standard WCDMA. The income from the licensing of these patents and related products are a major component of Qualcomm's business. Qualcomm has a strong position in the industry and are making money on their licenses. Many companies do not like Qualcomm’s way of doing business and mean that they have unproven patents. Broadcom and TI have had several patent litigations regarding these questions and now Nokia is getting involved. So far Qualcomm is winning, but the litigations continue.

112 www.qualcomm.com
113 Reuters (2007-11-22) Qualcomm wins a round in patent battles with Nokia, EETimes
5 Empirical Framework

The empirical findings are presented; first the technological, legal and economic factors are described followed by the competitive landscape of 2007. Finally, the value chain of each case company in 2007 is presented as well as the KSFs and TFs.

Everyone has some tricks they can do, but each has his own way of doing them.

– Chinese proverb

5.1 Technological, Legal & Economical Factors

The technological, legal and economical factors are the ones that remain after evaluating the relevancy of the PESTEL analysis in Chapter 3. These three factors and their affect on the semiconductor industry, and the companies within it, will be presented closer in the following subchapters.

5.1.1 Technological Factors

The two main technological factors are process node development and wafer fab development. The wafer fab development is focusing on maximization unlike the process node development that is focusing on miniaturization.

5.1.1.1 Process node development

In 1965 Gordon Moore, co-founder of Intel formulated what later became Moore’s law. What he said was that the numbers of transistors on a chip will double every eighteen to twenty-four months. So far Moore has been right. However, the law has had different interpretations within several different areas through the years. In the semiconductor industry Moore’s law works as guidance for the semiconductor manufacturers’ process node development, where the process node is halved every eighteen to twenty-four months.¹¹⁴

¹¹⁴ www.intel.com 2007-09-25
Today the 65-nm process node is reality and the process node development seems to continue following Moore’s law for another couple of years. The next process node, where development already has come far and is expected to be industrialized in early 2008, is the 45-nm process node. 45-nm offers designers the possibility to choose between a 40% reduction in die size (the die size refers to the components physical surface on the wafer) or a 40% increase in gate counts, compared with the 65-nm node. One negative aspect at 45-nm is the high power consumptions of the ICs, the standby leakage will stand for more then half of the total power consumption. The manufacturing process will not differ that much from 65-nm. The market leading foundry, TSMC, recently announced (2007-10-19) that they already have finished developing 45-nm and will have 22-nm developed during 2011.

The problems seems to be rising at 22-nm (which is equivalent with 220 Angstrom) and beyond when both the costs and the technology is starting to limit further development. At 22-nm there is about 40 atomic layers to work with since the diameter of an atom is about five Angstrom. To go further than 22-nm some inventions have to be made, but the research at these levels has not yet started. Many companies do not use the latest technology in most of their products today, in many cases in less than half of the production volume.

5.1.1.2 450-mm wafer fabs
The production of ICs is a very advanced and time consuming process; the complete process takes up to two months and is divided into several steps. The circuits are created on a wafer of extremely pure semiconducting material (normally Silicon). Today the 300-mm wafer is the most common size but the debate is whether or not it will be replaced by the 450-mm wafer as the leading size in the future. The argument for changing to 450-mm fabs is that it would be possible to produce 50% additionally while the equipment cost is about the same. Early calculations show that the semiconductor industry could make a 30% reduction in cost per wafer by implementing 450-mm wafer fabs. The transition is discussed among the largest companies (Intel, Samsung, TSMC and Toshiba) and could be reality.

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115 Sabtarini M. (2007-09-13) A look at the 45-nm IC design challenges, EDN
118 LaPedus M. (2007-10-31) Fab tool vendors on 450mm move: 'Flawed and misguided', EETimes
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in 2012. A 450-mm fab is estimated to have a final price tag of about $10 billion, about twice the price compared to a 300-mm fab.

On the other side stands a few of the smaller manufacturers (AMD, Freescale, IBM, Qimonda, Renesas and Spansion) which instead are thinking about developing and improving the 300-mm fabs to be more competitive. What it comes down to in the end is that this most likely is a question of cost. Which companies will be able to afford the 450-mm fabs? The assumption is that the manufacturing process will work just as good as with 300-mm wafers but so far few studies have been done in the area.\textsuperscript{119}

5.1.2 Legal Factors

One of the most important and most complicated factors to explore and understand in the semiconductor industry is the one concerning the legal aspects. Business worth billions of dollars, without any physical components or units, is made in the industry every year. EMP is an example of a company that does not sell any physical components themselves, they are instead focusing on businesses with IPR, such as patents and licensing. The importance of IPR is common for the whole business; in every stage of value chain there is decisions to be made concerning IPR. The IP core is owned by the developer but can be licensed to other companies.\textsuperscript{120}

To say that TEs are selling mobile platforms is in certain cases a modification of the truth. Take EMP as an example, as stated before they do not sell any physical components, instead they sell licenses of mobile platforms.\textsuperscript{121}

With this large amount of business in patents and licensing it might seem as no surprise that the companies involved have different opinions of how far it is acceptable to go without making infringements at a patent or license. Actually, the patent litigations in the semiconductor industry have increased during the last decade. Of the case companies, Broadcom and TI are ranked high in number of litigations, followed by ST. During 2007 Freescale has been the most active company. Most common is that the litigation is between rivals, since it is extremely important for the companies to protect their patents.\textsuperscript{122}

\begin{thebibliography}{122}
\bibitem{119} www.semiconductor.net 2007-10-11
\bibitem{120} www.patentstation.com 2007-10-17
\bibitem{121} www.ericsson.com 2007-10-17
\bibitem{122} Miller T. (2007-09-14) Semi industry sees rise in patent lawsuits, \textit{EETimes}
\end{thebibliography}
5.1.3 Economic Factors

The technological factors all have large effect on the economy, which is explained in chapter 5.1.1 as well as competition and supply activities.

5.1.3.1 Competition

The semiconductor industry is extremely competitive, with a HHI as low as 0.034 among the IDMs (see figure 4.2 and Appendix 2 for calculations). The extremely low index indicates a very competitive industry with several companies fighting over market shares. In contrast to this the HHI among foundries is surprisingly high, 0.29 (see figure 4.1 and Appendix 2 for calculations) which to a large extent is a result of TSMC’s dominating position, with almost half of the market. One of the differences between the two segments is the threshold resources that are needed to enter the industry. As a foundry a huge amount of capital is needed in order to be able to produce the quantities that are necessary to cover the massive fixed costs. To be able to enter the IDM segment the capital is not that important, clearly the fixed costs are not as high and the competence that is missing is possible to acquire through licenses.

With a number of companies offering similar solutions it is vital to have a well organized company to be able to cut the costs. Since the components in the IDM segment often have short lifecycles it is preferable for the company to have a short pay back time. This is not always easy since many components come with high development costs and uncertainty.

To keep the costs down it is vital to run simulations and verifications at an early stage before launching new ASICs to ensure that they work correctly. There is no space for extra costs and delays, since being late to the market will have a very negative impact on the sales figures (see figure 5.1), roughly losing 20-25% of the potential sales every quarter.\footnote{Clarke E. FPGAs and Structured ASICs: Low-Risk SoC for the Masses, www.design-reuse.com}
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<table>
<thead>
<tr>
<th>Time-To-Market</th>
<th>Potential Sales Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-To-Market</td>
<td>100%</td>
</tr>
<tr>
<td>3 Months Late</td>
<td>73%</td>
</tr>
<tr>
<td>6 Months Late</td>
<td>53%</td>
</tr>
<tr>
<td>9 Months Late</td>
<td>32%</td>
</tr>
<tr>
<td>12 Months Late</td>
<td>9%</td>
</tr>
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</table>

Figure 5.1 Consequence of being late to market with new ASICs

There are fewer Brand Owners today compared to a couple of years ago because of the consolidation climate that have existed within the entire handset industry. For example Ericsson and Sony consolidated into a joint venture, Sony Ericsson, in 2001 and BenQ acquired Siemens in 2005.

5.1.3.2 Development cost

As mentioned several times before, the development costs in the semiconductor industry are very high. The cost of setting up a new 300-mm wafer fab today, totals at least $2.5 billion. In 2010 the amount for building a similar fab is expected to be doubled. Companies who are willing to build 450-mm fabs will probably face a cost close to $10 billion when it becomes reality. The trend in wafer fabs is that the cost for setting up a fab is increasing exponentially (see figure 5.2). At the same time the capital cost per manufactured unit is decreasing exponentially, making the fabs more economical. Due to the consolidation in the industry a 300-mm fab today represents a substantial part of the overall industry net sales, about 1.3%, which is ten times more than a single fab did in 1960. This is a result of the increasing cost of the fabs; many IDMs will no longer have the economy that is necessary to have own fabs and will in the future be forced to use foundries.

References:

124 Clarke E. FPGAs and Structured ASICs: Low-Risk SoC for the Masses, www.design-reuse.com
125 www.sonyericsson.com
126 www.benq.com
127 www.intel.com 2007-10-11
128 www.zdnet.com 2007-10-11
129 www.icknowledge.com 2007-10-15
Designing a standard ASIC cell is both an expensive and risky project and it is not getting any cheaper since more high technological solutions are demanded. On the contrary, it is getting more expensive as the process node development costs are increasing exponentially, see figure 5.3.
5.1.3.3 Supply Chain

The structure of the value chain in the semiconductor industry changes periodically, depending on the level of vertical integration that maximizes the profit at a certain time. The value in semiconductor devices is shifting from manufacturing to design, which shows when the process and material development is moving further back in the chain. This movement in the value chain has lead to increased outsourcing and closer collaborations among the companies.\textsuperscript{132}

The large companies, thanks to their economy of scale, are successful in lowering the cost, in both production and distribution, which gives them the possibility to keep the sales price low and put pressure on the smaller competitors. With the changing business model many semiconductor companies are moving forward in the value chain, leaving the responsibility for their supply chain on distributors. When semiconductor companies must focus on their strengths and expand their competences to succeed with the forward integration it is suitable to extend the distributors role to manage technical support functions.\textsuperscript{133}

5.2 Competitive Landscape 2007

The authors have focused on three areas of the competitive landscape 2007; M&As, Alliances and Emerging Markets.

5.2.1 Mergers & Acquisitions

M&As have been common within the semiconductor industry as there are many different companies that have been specializing in different areas. For natural reasons it has been common to acquire specialized niche companies in order to incorporate the knowledge into one’s own company. Such miner niche companies are acquired so that they can help expand the product offerings and boost productivity. There are numerous advantages to be obtained by a small acquisition, as an alternative to a large one, including lower risks concerning integration and the possibility to immediately integrate the teams of highly skilled people from the new company. One of the case companies which have this type of small acquisition strategy is TI as stated by Rich Templeton, CEO of TI, in September 2007.\textsuperscript{134}

\textsuperscript{132} Rieppo P. (2005-05-13) How to Respond to Changes in the Semiconductor Value Chain, \textit{Gartner}

\textsuperscript{133} Kurup D. (2007-04-01) Riding the value chain, \textit{ECN Asia}

\textsuperscript{134} Ojo B. (2007-09-10) TI only has eyes for smaller analog players, \textit{EETimes}
Even if TI has acquired several small companies it is Broadcom that has had the most aggressive acquisition strategy of the six case companies. Since 1999 the company has carried out more than 30 strategic acquisitions. The rate has been to acquire about one or two companies per quarter and the pace will not reduce according to Scott McGregor, Broadcom’s president and CEO (2007-09-17).\textsuperscript{135}

As stated there are several of the case companies that acquire other companies on a regular basis. But there are not only acquisitions made by the case companies but also of the case companies. When Electronic News ranked the top 50 M&As of the electronics market during 2006 two of the case companies were on that list, namely Freescale on a second place and NXP (before the acquisition known as Philips Semiconductors) ranked fifth. Both companies were acquired by private equity consortiums. Of the top 50 eight were companies in the semiconductor industry. Four of these had been acquired by private equity consortium and the remaining four by other semiconductor companies. The deals within the semiconductor industry hit a real boost in 2006 with nearly $37 billions in announced deals during the three first quarters compared to merely $7.5 billions during all of 2005.\textsuperscript{136}

Companies with a low stock price risk being acquired by companies that are looking to extend their product portfolio or eliminate competition by taking over a company. For the time being, Infineon seems to be a company that is in the risk zone of being acquired. In order to strengthen its position, and prevent the possibility of being acquired, Infineon has acquired a company that has knowledge within software consequently Infineon not only strengthened its position but also extended its competence into the software area.\textsuperscript{137}

Joe Osha, and analyst at Merrill Lynch means that companies such as Broadcom and Infineon needs to consolidate or exit the cellular baseband chip market seeing that TI and Qualcomm dominate the business. The theory of further M&As is supported by David Carney, a technology M&A principal at Deloitte Consulting. He contends that the technology convergence has just started and he sees a growth cycle of 10 to 15 years during which the M&A situation will accelerate.\textsuperscript{138}

\textsuperscript{135} Schneider T. P. (January 2006) Broadcom Inside, \textit{Electronic Business}
\textsuperscript{136} www.edn.com (2007-10-09)
\textsuperscript{137} Hammerschmidt C. (2007-09-12) Infineon's Ziebart in an acquisition spree, \textit{EETimes}
\textsuperscript{138} www.edn.com (2007-10-09)
5.2.2 Alliances

Alliances have been prioritized in order to create faster research and development process which leads to shorter time-to-market for the companies involved and their customers. As the technological development becomes more costly and demands more diversity when it comes to software many companies have learned that in order to develop disruptive technology they have to be in intimate technological collaborations. There are basically two different types of alliance in the industry; the fundamental technology alliances that lay the ground for increased performance in products and efficiency and alliances considering for example standards and software. In other words, collaborations do not only exist between the IDMs themselves but also between IDMs and foundries, TEs or Brand Owners. However, the alliances that are by far most cost intensive are the technological alliances concerning development in process node technology and wafer fabs, where the Crolles2 and Common Platform Alliance (a.k.a. IBM Alliance) are the most interesting ones.\(^{139}\)

Long-term collaborations can be established between suppliers and customers in the semiconductor business, in fact, this is a very common event but the alliances can change and shift rapidly depending on the agreements between an IDM and its customer. For example recent collaboration between Nokia and ST has been established in the 3G market where Nokia supports ST with 200 engineers in order to develop HSPA technology.\(^{140}\)

The alliances presented below are a few examples of the many collaboration and alliances that exists in the semiconductor industry. The first two, Crolles2 Technology Alliance and the Common Platform Alliance are both based on technology development unlike the third, the MIPI Alliance that is a softer alliance concerning standardizations within the M&W industry.

5.2.2.1 Crolles2 Technology Alliance

The Crolles2 Alliance was created in April 2002 by ST, NXP (at that time Philips Semiconductors), Freescale (at that time Motorola) and TSMC. The alliance opened a joint R&D center in Crolles, France, dedicated to nanoelectronics and semiconductor manufacturing on 300-mm silicon wafers. The joint R&D center was created in order to pioneer in Complementary...

\(^{139}\) www.freescale.com (2007-10-10)

Metal Oxide Semiconductor (CMOS) technology and started with 90-nm processes to continue towards 32nm during its lifetime. The purpose of the alliance was to allow the companies involved to share the costs of developing advanced technologies and speed up time to market. The alliance facilitates a 300-mm wafer manufacturing pilot line and the three major partners (not including TSMC) invested approximately $1.4 billion in the facility up to 2005.\textsuperscript{141}

The alliance contract will conclude at the end of 2007 but there has already been one defection from the collaboration as NXP left the alliance in early 2007 in order to work with TSMC solely.\textsuperscript{142} For a brief moment there were discussions about IBM’s possibility to replace NXP in the alliance but IBM has denied any such interest.\textsuperscript{143}

5.2.2.2 Common Platform Alliance

IBM has established relations with the foundry Chartered and Samsung. Infineon, Freescale and ST are joint development partners in this chip fabrication technology development for mobile platforms and the agreement is signed on through 2010. The companies will work together in the next-generation 32-nm process node technology. The alliance aims to have joint development of process design kits and will research how their technology will fit into the existing fabs.\textsuperscript{144} The main purpose is to restrain the spiraling cost of building chips with 32-nm process node technology that has exploded to about $4 billion. The collaboration builds on previous alliances on 90-, 65- and 45-nm process node development. The research is to be conducted at IBM’s 300mm wafer fab in East Fishkill, USA.\textsuperscript{145}

5.2.2.3 MIPI Alliance

The Mobile Industry Processor Interface (MIPI) Alliance is an open organization that works towards accelerating the adoption of application-rich mobile devices. MIPI sets standards for hardware and software interfaces between the processors that can be found in mobile terminals. By setting these standards and encouraging the adoption of them throughout the industry, the alliance intends to reduce the fragmentation existing in microprocessors and software interfaces. The alliance has nearly 100

\textsuperscript{141} www.emsnow.com (2007-10-10)
\textsuperscript{142} www.silicon.fr (2007-10-10)
\textsuperscript{143} LaPedus M. (2007-01-23) IBM: no interest in joining Crolles2, \textit{EETimes Europe}
\textsuperscript{144} Stokes J. (2007-05-24) IBM alliance will take the fight with Intel down to 32-nm, \textit{ARS Technica}
\textsuperscript{145} Goodin D. (2007-05-23) IBM builds alliance to tackle 32nm design, \textit{The Register}
companies as member and the core purpose is to, with the help of the standards; help the mobile industry to introduce more sophisticated devices with shorter time to market. The board member companies are for example ST, NXP and TI.  

### 5.2.3 Emerging Markets

In the semiconductor industry there is continuous change in every aspect. New markets emerge and old ones disappear. In view of the semiconductor industry there are a few markets that can be considered emerging ones and those are:

- India
- China
- Africa
- Russia
- South America

Among these markets some are more developed than others, for example China can almost be stated as an established market when compared to India, see figure 5.4. Russia has been emerging but the market growth is now stagnating due to the fact that the market seems to be moving towards a more mature state. Africa and South America are not shown in the figure but South America has a subscription similar to the one of China when including Brazil. If Brazil is excluded the level of South America is more similar to the one of India. This shows the extraordinary position that Brazil represent.

![Growth in Emerging Markets](image-url)

**Figure 5.4 Growth of subscriptions in emerging markets**

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146 www.mipi.org (2007-10-10)

147 www.ti.com 2007-10-18
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There are three aspects that can be of interest when studying an emerging market; are there new suppliers, competitors or customers. Are the customers end customers or are they business to business customers?

When it comes to new suppliers the primarily emerging markets in this segment are India, Greater China (including Taiwan and Hong Kong) and Russia. During 2007 there has been an explosion of chip design work in India as offshore design centers emerge, set up by for example TI, Broadcom and ST among others. The plan to support development of fab industry in the country was initiated in 2005 based on a proposal from SemIndia, a consortium led by Vinod Agrwal. In early 2007 there were three fabs in the country and several multinational companies were interested according to the Union Minister for Communications and IT, Davanithi Maran. 148

Greater China has about 85% of the foundry world market already and can not be seen as an emerging market in this aspect but rather as an existing one that is still growing. 149 One major driving force behind Greater China’s totally dominant position, the trends towards going fab lite and outsource to foundries are the distinctive difference in labor costs when comparing Western Europe and USA with Greater China. For example NXP shuts down their fabs in France in order to work with TSMC instead and ST shuts down fabs in USA. 150 151

The Russian semiconductor market is driven by the very fast growth of its telecommunication sector that had a 25 to 30% growth in 2006 compared to the world’s overall growth of 6%. 152 The largest semiconductor manufacturer in Russia, Mikron JSC, launched its Fab project in 2006 in a technology partnership with a European semiconductor manufacturer. The project is located in the Russian equivalent to the American Silicon Valley near Moscow and the first production line is scheduled to start at the end of 2007. 153

New emerging customer markets are one interesting segment to look closer at although the percentage of sales that is sold to emerging markets is smaller in comparison to the established markets. ST for example has 5% of

148 www.xbitlabs.com 2007-10-18
149 www.pwc.com 2007-10-18
150 www.nxp.com 2007-10-18
151 www.st.com 2007-10-18
152 www.send2press.com 2007-10-18
153 www.thomasnet.com 2007-10-18
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their sales in India, Russia, Africa, South America and Middle East and those are the markets that they consider to be emerging. The African market is very small and often the political situation is unstable, even so, ST has two back-end design centers in Morocco. Freescale has no activity in Africa while Infineon only has distribution and representatives in South Africa. Africa and India are seen as the primarily markets for ultra-low-cost, entry-level phones and this gives an opportunity for those IDMs that have the possibility to manufacture for this segment with great cost management.

In figure 5.5 the five largest suppliers of hand sets in the emerging markets are shown as well as their supplier relationship with the six case companies.

![Figure 5.5 Relationship mapping and markets share in emerging markets 2006](image)

As seen in figure 5.5 Nokia and Motorola are very dominant on the emerging markets with over 80% of the shipments when put together. Of

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154 www.st.com 2007-10-19
155 www.freescale.com 2007-10-19
156 www.infineon.com 2007-10-19
our six case companies there are only two who are suppliers to Motorola and that is Freescale and TI. Nokia has four out of the six case companies as suppliers excluding NXP and Freescale.

To see new estimated subscribers in South America, China, India and Africa during the time period 2006-2012, see figure 5.6.

![Emerging Market Development 2006-2012](image)

**Figure 5.6 New Subscribers in Emerging Markets 2012 Compared to 2006**

The prognosis is that even in 2012 less than 50% of the population in the emerging markets will have a handset subscription. Worst is Africa and India with an estimated penetration rate of about 20% although India does a major leap from 2005 where the penetration rate was only 5%. China and South America are said to have a penetration rate of about 40% in 2012. Still, the next billion customers are said to come from the emerging markets.

### 5.3 The Value Chain 2007

The Value Chain model was created by the authors to illustrate the manufacturing process from raw material to a complete mobile phone and to show the case companies’ position in the chain. Since this study focuses on the value chain between Foundry and TE, these are the areas that will be

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157 www.ti.com 2007-10-19
158 www.ti.com 2007-10-19
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described more closely. The process is divided into five fields, each one representing important functions in the manufacturing process. This does not mean that there have to be five different companies involved; it can be fewer or more. The first field, Foundry, contains the ASIC manufacturing and ASIC back-end design. Back-end design refers to supporting functions for the production including production planning, testing and logistics. Some companies have back-end design without having any ASIC manufacturing, why this is somewhat on the border between Foundry and IDM. In the IDM segment, ASIC front-end design and hardware drivers are two important factors. ASIC front-end concerns the construction of the circuit containing drawings, layout and simulations. In the TE segment there are three important functions; Platform reference design, Software and Applications. Platform reference design links all parts together to a complete phone, software including stack and applications for example phonebook and calendar.

More and more IDMs are now moving towards the fab lite model, which means that less manufacturing is done in-house and more is outsourced to foundries. This is simply a result of the risks and costs connected to owning fabs and the development of new process node technology. The volumes that have to be obtained to finance the development are only possible to achieve for the largest companies. Instead most of the IDMs are moving forward in the value chain, towards the TE field. The TE is the border between hardware and software; this is one reason why forward integration is very interesting. Since the IDMs already have the hardware competence but normally lack software competence the movement towards TE is challenging for the IDMs, to succeed they have to acquire software competence. This is one of the affecting factors behind the merges and acquisitions in the industry today. The companies that do not have the software competence must in some way acquire it in order to move forward.

\[159\] LaPedus M. Clarke P. (2007-03-15) IDM firms move towards ‘fab lite’ model, EETimes
The arrows that are placed above the value chain in chapter 5.3.1-5.3.6 show the companies’ positions in the value chain in 2007 and their core business. The dotted line illustrates that the company is doing it partly or doing it with a partner.

5.3.1 Broadcom

Broadcom stands out from the crowd as they are the only IDM in the study that is totally fabless. Their process techniques are standard ones which make it possible for them to subcontract the manufacturing process to independent silicon foundries. Broadcom instead focuses on designs that, according to them, give a competitive advantage. Moreover, the strategy eliminates the high cost of owning wafer fabs. Broadcom has also outsourced their testing and assembling activities to subcontractors. Their key silicon foundries are TSMC, Chartered, SMIC and UMC. Broadcom continuously investigate and evaluate the possibility and benefits of moving towards smaller geometry process technology. Presently (2007) Broadcom designs most new products in 65-nm process node technology.160

There are other specifics that Broadcom possess, for example their frequent acquisitions of companies that have capabilities that Broadcom is interested to add to their value creation. Since 2002 Broadcom has acquired 14 different companies of which two during 2007; Global Locate Inc., which is a leading provider of GPS products and software, and Octalica Inc., a developer of network technologies based on MoCA™ (Multimedia over Coax Alliance).161 The Coax Alliance has, apart from Broadcom, members such as TI, Infineon, NXP, Freescale and ST.162

162 http://www.mocalliance.org 2007-09-19
Broadcom’s strategy for the coming years is to get design wins in 2007, launch new products in 2008 and roughly double their market shares by the end of 2009. They will focus on 3G solutions through WCDMA, HSPA and EDGE since Broadcom recently made a deal with Nokia regarding EDGE chips. The deal is a significant one for Broadcom, since they manage to get volumes on their new, so called Venus single-chip EDGE multimedia processor. Recently Broadcom expanded their partnership with Samsung to include advanced 3G cellular solutions for a new series of Samsung mobile phones.

5.3.2 Freescale

Freescale has two areas of manufacturing, die manufacturing as well as packaging and test. The company emphasizes on lowering cost, reducing cycle time and limiting time to market of new product introductions. Freescale has today seven fabs that they own themselves as well as one joint pilot line and two final manufacturing fabs. However, Freescale is looking to sell two of its fabs, one active and one non active, so the number of fabs will be reduced in the near future (2007-09-05).

When Freescale was acquired in late 2006 for $17.6 billion it was the largest privatization in history in the semiconductor business. The company earlier suffered from slow decision making and conservative leading. This was supposed to change with the reorganization that followed. However, so far not much has happened from an outside perspective.

Freescale is still very dependent on their old owner, Motorola, who is their only volume customer in M&W and their supplier of the protocol stack.

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163 Walko J. (2007-10-04) Nokia to discontinue in-house mobile chip devt, EETimes
165 Clarke P. (2007-09-05) Freescale appoints group to sell off its two fabs, EETimes Europe
166 iSuppli (2007-11-20)
They also have an exclusivity contract with Motorola that expires in 2009. Freescale is the number one semiconductor supplier to the automotive industry but their business with M&W products is still significant. Unfortunately, their profitability in the M&W segment is not as good as for the overall company. Within the automotive industry they are closely followed by Infineon. In late 2006 Freescale was one of the early platform vendors to develop a multi-call HSDPA solution as well as it had come far in the power management area.  

5.3.3 Infineon

Infineon has been a typical IDM for several years but is now transforming itself to a fab lite manufacturer. Today Infineon uses its own fabs for RF, mixed-signal and high-tech projects while it is outsourcing the remaining manufacturing to foundry partners. Since Infineon will not continue with in-house manufacturing beyond a certain node the company is about to reduce today’s R&D spending, that represent about 20% of the net sales, by at least 50%. Infineon board member, Hermann Eul, means that as a company that provides complete system solutions it is important to understand all aspects of a system’s functionality and integrate it onto a chip. He thinks this is one of Infineon’s core competences and that the R&D money should be spent to enable complete system solutions offers.

Infineon has strength in its broad customer base, with key customers as Nokia, LG, Panasonic, Samsung, and Apple. They have recently signed an agreement with Motorola to develop a single chip 3G RF transceiver (2007-09-25). Another factor that makes Infineon strong is its software competencies through their subsidiary, Comneon. Last year Infineon lost their prime mobile chip customer, their former owner, Siemens. Siemens

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167 LaPedus M. (2007-08-02) Freescale drove auto IC market 2006, EETimes
168 Hammerschmidt C. (2007-09-03) Infineon keeps faith in tech development, EETimes
mobile phone unit was acquired by the Taiwanese company BenQ who decided to go with another supplier.\textsuperscript{170}

Recently Infineon’s CEO, Wolfgang Ziebart announced that the company is looking for new acquisitions. The reason for this is to strengthen their position in the industry, especially after rumors that Infineon’s low share price might attract investors to take over the company. Infineon has already announced its purchase of LSI’s mobility product line.\textsuperscript{171} To finance this Ziebart is planning to sell about 13\% of Infineon’s share of Qimonda (which would reduce their ownership to 73\% and use the capital to acquire rivals in the high-end chip business.\textsuperscript{172}

### 5.3.4 NXP

Since NXP was acquired from Philips by a private equity group a year ago it has moved against the trend in outsourcing. A year ago the company was 18\% outsourced and today that number is between 10-15\%. However, the strategic goal is still the same, to be 30-40\% outsourced to TSMC in 2010 and fab lite. NXP’s CEO, Frans van Houten, said in an interview with EETimes that the fabs in Nijmegen, Netherlands and Hamburg, Germany are still very important to the company after closing down the plant in Boeblingen, Germany. He is convinced that it will be profitable to be vertically integrated and means that the company will never be a complete fabless operation, as the flexibility is such an important factor. In January 2007 NXP made a remarkable move by leaving the Crolles2 Alliance with members such as ST and Freescale to create collaboration with TSMC instead. According to van Houten the decision to leave Crolles2 was necessary as it did not create enough value for NXP; the company’s over all economy of scale was three to four times too small in order to return the investments.\textsuperscript{173}

\textsuperscript{170} Rusu A. (2006-07-24) Infineon’s Chips in LG Mobile Phones, Softpedia
\textsuperscript{171} Hammerschmidt C. (2007-09-12) Infineon's Ziebart in an acquisition spree, EETimes
\textsuperscript{172} Wiesmann G. (2007-09-12) Infineon to chip away at stake in Qimonda, Financial Times
\textsuperscript{173} Walko J. (2007-09-10) NXP takes fab lite route, EETimes
Today NXP is active in about 50 segments but wishes to reduce this number and specialize in the segments where it sees potential. NXP will no longer work with W-LAN modules for mobile phones, power amplifiers or simple front-end modules. Instead it will commit to chip sets for 2.5G and 3G cellular platforms. The last year NXP has made two acquisitions, the mobile unit of Silicon Laboratories and the BlueStreak microcontroller lineup of Sharp Microelectronics. If the right opportunity comes NXP has around $800 million for acquisitions to help strengthen their position in the chosen segments.174

In a short perspective NXP will not change its current position in the value chain, but it will have doubled its outsourcing in 2010 and will move towards being a fab lite manufacturer.

5.3.5 STMicroelectronics

Europe’s largest semiconductor company, ST, has shown clear signs that it is moving towards the fab lite model. Recently the company decided to close two U.S. wafer fabs and an IC assembly site. Within three years it will close another three fabs, of which two are located in the U.S. After that ST will no longer have any manufacturing in North America. According to Carlo Bozotti, president and CEO of ST, the closure of the fabs is simply an action to cut costs. They are already about 15% outsourced and that number will increase during the coming years. After they have closed the fabs in North America, they will have decreased their number of fabs from 17 in 2005 to a total of 9 fabs.175

The Crolle2 Alliance, where ST represents a major part, will during 2007 complete the 45-nm CMOS process technology. After 2007 it is unclear

174 Walko J. (2007-09-04) NXP halts fab lite slide. EETimes Europe
175 STMicroelectronics Q3 2007 Results Presentation
how the alliance will continue since it only expands until the end of the
year.\textsuperscript{176}

ST is now discussing possible manufacturing alliances or foundry
relationships with several Chinese and Taiwanese companies. Grace
Semiconductor and SMIC are two of the foundries that are possible for
collaboration. ST needs to find partners to transfer their technology to, when
it wants to decrease its number of fabs.\textsuperscript{177}

Nokia’s decision to focus on its core competencies and outsource a larger
part of its activities has affected the industry; especially ST. Nokia has
provided ST with a design win for an HSPA chip set. This will most likely
strengthen ST’s position in the market.\textsuperscript{178}

\textbf{5.3.6 Texas Instruments}

![Value Chain 2007 Texas Instruments](image)

Figure 5.12 Value Chain 2007 Texas Instruments

TI is the largest of the case companies with about 50\% of the 3G chipset
market. In early 2007 TI decided to rely solely on foundries for its
manufacturing of components beyond 45-nm, that is 32-nm, 22-nm and so
forth. The extent of this strategy leaves TI without any fabs in the digital
area if the strategy is taken to its end. In present time TI has in-house
manufacturing as seen in figure 5.12. When the 45-nm process node
technology is reached TI will work together with its foundries to co-develop
digital process technology. TI has used different foundries (TSMC, SMIC
and UMC) as buffer suppliers and their own output can vary with time and
economic situation.\textsuperscript{179}

\textsuperscript{176} LaPedus M. (2007-07-10) ST to close three plants; move impacts 4000 jobs, \textit{EETimes}
\textsuperscript{177} Clarke P. (2007-08-29) ST in partnership talks with China firms, \textit{EETimes Europe}
\textsuperscript{178} Walko J. (2007-08-13) Nokia ends IC development for mobiles, \textit{EETimes}
\textsuperscript{179} Clarke P. (2007-01-24) Texas Instruments exits process development race, \textit{EETimes Europe}
TI uses a somewhat different strategy of outsourcing, a hybrid fab strategy. About half of the logic chip production is today outsourced and that number is to increase in the future. However, it is unlikely that TI is going completely fabless since there is a huge demand for single chip mobile phone products which leaves the company with a need for both internal and external production.

TI’s foundry strategy is divided by product category. At the 65-nm process node it has three foundry partners; Chartered, TSMC and UMC. At the 45-nm node the company will collaborate with TSMC and UMC. At 32-nm TI will work together with partners on process technology development. Instead of developing inside, the process will be developed at the foundry and then transferred back to TI. In this way they will create a higher integration with the suppliers, which seems like a smart move when the relations to foundry partners are getting even more important in the future.\(^{180}\)

TI has been extremely successful during the last few years, with increased profit every year. Analysts now see a future for TI with a more moderate growth rate. This is to some extent is a result of higher competition within Nokia.\(^{181}\)

### 5.4 Key Success Factors and Threshold Factors

In order to identify possible KSFs and TFs in the semiconductor industry for 2012 the authors conducted brainstorming together with people from the panel of experts, with diverse competencies. The panel consisted of people with the following titles:

- Global Account Manager
- Hardware Sourcing Manager
- International Product Marketing Manager
- M&W Systems Group Manager
- Product Manager
- Senior Expert
- Senior Sourcing Officer
- Senior Staff Engineer

\(^{180}\) LaPedus M. (2007-05-22) TI bares details of new ”hybrid” fab strategy, *EETimes*

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- Strategic Business Intelligence Manager
- Technical Product Integration Manager

The brainstorming was conducted continually throughout the gathering of empirical data, evolving as the authors’ knowledge base grew. After several iterations with people from the panel of experts 23 factors were identified as possible KSFs or TFs. A questionnaire was formed around these factors (see Appendix 3) and sent out to the panel of experts in order for them to rank the factors from 1-5 by importance as KSF or TF in 2012. The respondents were allowed to add factors if necessary and rank them as well. Only one of the experts added a factor and therefore this factor was not included in the forthcoming study.

After receiving the answers from the panel of experts the authors compiled the information and six KSF and five TFs were identified, seen in figure 5.13 and 5.14.

<table>
<thead>
<tr>
<th>Key Success Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to reduce costs</td>
<td>4.75</td>
</tr>
<tr>
<td>Time to customer</td>
<td>4.57</td>
</tr>
<tr>
<td>Good relations with customers</td>
<td>4.50</td>
</tr>
<tr>
<td>Economy of scale</td>
<td>4.29</td>
</tr>
<tr>
<td>Risk management</td>
<td>4.13</td>
</tr>
<tr>
<td>Good relations with suppliers</td>
<td>4.11</td>
</tr>
</tbody>
</table>

Figure 5.13 Key Success Factors in the semiconductor industry

<table>
<thead>
<tr>
<th>Threshold Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>High volume delivery capability</td>
<td>5.00</td>
</tr>
<tr>
<td>Competent R&amp;D</td>
<td>4.80</td>
</tr>
<tr>
<td>Product quality</td>
<td>4.50</td>
</tr>
<tr>
<td>Supply capabilities</td>
<td>4.50</td>
</tr>
<tr>
<td>Delivery reliability</td>
<td>4.20</td>
</tr>
</tbody>
</table>

Figure 5.14 Threshold Factors in the semiconductor industry

In order to see which ones of the case companies that had the KSFs a KSF mapping was conducted by the authors and people from the panel of experts which is displayed in Chapter 6.1. The definition of TFs states that all the companies must have these factors; otherwise the companies would not exist in the industry, therefore a TF mapping has not been done.
6 Analysis

In this chapter the authors will analyze the findings from the study. The identified KSFs will be an important factor for setting up the 2012 value chain. The competitive landscape and upcoming trends will also be analyzed.

“You have to allow a certain amount of time in which you are doing nothing in order to have things occur to you, to let your mind think.”

– Mortimer Adler

6.1 Key Success Factor and Threshold Factor Analysis

In order to determine the KSFs and the TFs the authors used the questionnaire in Appendix 3 and sent it to nine internal and three external persons with good knowledge of the semiconductor industry. Out of the respondents, eight internal and all of the external respondents answered the questionnaire. When determining the KSFs and the TFs the authors ranked the answers as in the questionnaire in Appendix 3. The factors were ranked from 1-5 with 5 being the most important factor. The TF answer was ranked with seven points for each X in the TF box because a company can not even exist in the industry if it does not have the TF and therefore this carries greater weight. This ranking system helped the authors to separate the KSFs from the TFs. Out of the original 23 factors, six were identified as KSFs and five as TFs with the requirement of having a score above 4.0. The KSFs are shown in figure 6.1.

<table>
<thead>
<tr>
<th>Key Success Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to reduce costs</td>
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<tr>
<td>Economy of scale</td>
<td>4.29</td>
</tr>
<tr>
<td>Risk management</td>
<td>4.13</td>
</tr>
<tr>
<td>Good relations with suppliers</td>
<td>4.11</td>
</tr>
</tbody>
</table>

Figure 6.1 Key Success Factors in the semiconductor industry
One explanation to the fact that “Good relations with supplier” came as low as it did could be that many of the IDMs in the study does not have many suppliers on whom they are depending concerning the products since the IDMs have fabs of their own. This factor though will be more important with the parallel development towards the fab lite concept. One of the major forces within the industry that the authors have identified is the economic factor where the ability to reduce costs, at any level, is vital for a company’s success. This is clearly shown in the KSF analysis since this factor got the highest score of all the KSF that were determined. “Time to customer” and “Good relations with customers” are two factors that are closely linked with the alliances in the industry together with “Ability to reduce costs”. “Economy of scale” can be achieved with the help of one of the five big Brand Owners, preferably Nokia or Motorola which have the largest volumes in present and emerging markets. If an IDM is going to be able to handle risk the company should not be dependent on either one supplier or one customer within an industry. If this is the case that IDM has not a good “Risk management” and this might jeopardize their position within the industry, depending on the stability of their relationship with their single customer.

The TFs are as earlier explained something that a company must possess in order to even exist in the industry. This logic says that the IDMs already have these characteristics otherwise they would not have survived in the industry. Even so, these factors change with time as does the KSFs and therefore it is vital to identify them regularly in order to see what might drive a company out of an industry. The TFs are shown in figure 6.2 with a ranking from 1-5 with 5 being the most important factor.

<table>
<thead>
<tr>
<th>Threshold Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>High volume delivery capability</td>
<td>5.00</td>
</tr>
<tr>
<td>Competent R&amp;D</td>
<td>4.80</td>
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<tr>
<td>Product quality</td>
<td>4.50</td>
</tr>
<tr>
<td>Supply capabilities</td>
<td>4.50</td>
</tr>
<tr>
<td>Delivery reliability</td>
<td>4.20</td>
</tr>
</tbody>
</table>

Figure 6.2 Threshold Factors in the semiconductor industry

To get an understanding of which case companies that has the best stand point in order to succeed they were scored for every KSF and the KSF mapping is shown in figure 6.3. Please observe that for Freescale, Infineon and ST the KSF factor “Good relations with suppliers” is not applicable as they have their own fabs to a large extent.
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Table 6.3 KSF mapping of the case companies

<table>
<thead>
<tr>
<th>KSF Mapping</th>
<th>Broadcom</th>
<th>Freescale</th>
<th>Infineon</th>
<th>NXP</th>
<th>ST</th>
<th>TI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to reduce costs</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Time to customer</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Good relations with customers</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Economy of scale</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Risk management</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Good relations with suppliers</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>N/A</td>
<td>2</td>
</tr>
<tr>
<td>Sum</td>
<td>10</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Percentage of maximum</td>
<td>83%</td>
<td>60%</td>
<td>70%</td>
<td>33%</td>
<td>60%</td>
<td>100%</td>
</tr>
<tr>
<td>Ranking</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 6.3 KSF mapping of the case companies

0 = Does not have the factor today and will most likely not have it in 2012
1 = Have it partly today and/or might have it in 2012
2 = Have it today and will most certainly have it in 2012
N/A = Not Applicable

The mapping was conducted with the help of iteration with the Delphi board used during the KSF questionnaire phase. The board was asked to rank the companies on the basis of their knowledge assisted by the definition of each factor in order to avoid any obscurity. This mapping clearly sets TI as the “winner” with a full pot closely followed by Broadcom in second place. In third place came Infineon with 70% of the possible scoring. Behind them came Freescale and ST with average scoring although it is worth to mention that Freescale got zero points in “Risk Management”. The obvious underachiever is NXP with only 1/3 of the possible points and with as much as three zeros. The analysis of the KSFs will be further discussed in each company’s specific sub chapter.

6.2 Competitive Landscape 2012

The data collected in the empirical framework will here be analyzed with the help of the methods presented in Chapter 2 and the theoretical framework in Chapter 3.

6.2.1 Mergers & Acquisitions

There have been several rumors of M&As between companies in the semiconductor industry. The authors see some of them as relevant due to the existing climate in the industry where many players fight over an increasing, but yet too small, market. As stated earlier in the report the average market
growth in M&W is predicted to be about 7% yearly up to 2012. Although this will make some room for the existing players, there still exists a hyper competition that will not allow all of the players to coexist. A few of the case companies have taken precautions in order to avoid being acquired but the authors believe that maybe one or two companies still will be divided and sold as in the case of the companies owned by private equity consortium. The market consists of many small companies with Intel as the market share leader with 12% of the overall market while the case companies in this study has the following market shares displayed in figure 6.4.

<table>
<thead>
<tr>
<th>Company</th>
<th>Market Share Semiconductor industry%</th>
<th>Net Sales in M&amp;W ($M)</th>
<th>Market Share in M&amp;W%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcom</td>
<td>1</td>
<td>1295</td>
<td>6</td>
</tr>
<tr>
<td>Freescale</td>
<td>2</td>
<td>1740</td>
<td>8</td>
</tr>
<tr>
<td>Infineon</td>
<td>2</td>
<td>1710</td>
<td>8</td>
</tr>
<tr>
<td>NXP</td>
<td>2</td>
<td>2070</td>
<td>9</td>
</tr>
<tr>
<td>ST</td>
<td>4</td>
<td>3465</td>
<td>16</td>
</tr>
<tr>
<td>TI</td>
<td>5</td>
<td>5005</td>
<td>23</td>
</tr>
</tbody>
</table>

Figure 6.4 Market share in the semiconductor industry vs. net sales in M&A, 2006

As the case companies each have similar market shares as the rest the authors believe that no one of these companies will acquire each other since the costs would be unbearable but rather continue the “growth-by-acquisition”-strategy by acquiring smaller feature specific companies in order to broaden their product portfolio and make it more complete. A merger or acquisition can also boost the efficiency by implementation of routines and roadmaps from the bought company. Another advantage in this strategy is that by acquiring, the company can expand their customer base while eliminating competition. The authors sooner see mergers between these players than acquisitions. These mergers must occur between companies that are rather similar in order to achieve a synergy effect and to avoid that the consolidation work takes up too much energy.

6.2.2 Alliances

Alliances in technology development have in the past been of great importance to the semiconductor industry. It has allowed companies to share development costs and to keep up with Moore’s law. There are of course alliances of different characters going on in the industry, with collaborations concerning process node development by the authors seen as one of the
Where Is the Semiconductor Industry Going?

most important, simply because the enormous amounts and risks associated with this development. A distinguishing character for this kind of alliances has been that several companies have been involved, sharing the costs. In 2012 it is expected that fewer of the IDMs are interested in in-house manufacturing leaving question marks regarding the future alliances in process node development.

The Crolles2 Alliance is ending in 2007. NXP has already made deals with TSMC, Freescale, Infineon and ST has part in the Common Platform Alliance, which will continue with process node development down to 32-nm and end in 2012. TI has declared that 45-nm is the last node for them to manufacture in-house.

By 2012 it is likely that TSMC by far is the largest foundry and supplier of semiconductors to the M&W industry. It is difficult to say who will collaborate with whom, but it will most definitely still be alliances in process node development. The IDMs that still have in-house manufacturing will probably seek their way to TSMC or another foundry for collaboration. The world’s largest semiconductor producer, Intel has gone their own way so far and seems to continue in that direction for the coming nodes, where they already have come far. In general the computer industry is one node further in the process node development than the M&W industry and this is expected to proceed. Other big semiconductor manufacturers like Samsung and foundries like UMC, Chartered and SMIC are possible partners that must collaborate to have a chance to compete with TSMC. IBM, Chartered and Samsung are today a part of the Common Platform Alliance.

A common trend in alliances is that they take place in the early part of the value chain. There are two main reasons and the first one regards the major technology investments that are made early in the value chain. Without partners the amount of capital can be too large for one company to handle. The second reason is that companies further to the right in the value chain often are careful not to reveal and share their core competence.

6.2.3 Emerging Markets

There are two primary factors that will affect the semiconductor industry concerning the emerging markets. First there will be an increased demand for low-end cellular handsets due to the emerging economies in first and foremost Asia and India but also in Africa and South America. If these markets follow with the earlier development there should be real opportunities in these markets for those IDMs that have a low-end focus and
can hold the costs down to an absolute minimum level. The authors see such potential in Infineon and TI. Infineon are delivering GSM chip sets to Nokia and it is 2G technology that is of current interest. TI has the advantage of already delivering high volume sales as well as having excellent relationships with the major foundries in order to get lower prices which could boost their product sales within the low-end segment.

The second factor concerns the clear trend towards shutting down fabs in Europe and USA meanwhile no new ones are opened. Instead the manufacturing goes to foundries in Greater China and those will continue to take an even bigger market share that today is almost theirs alone. This will provide some IDMs with cheaper foundry services than if they did it themselves but the risks will increase as the control of the manufacturing decreases. The power between foundries and IDM will depend on the prioritization that the IDM has according to the foundry. A highly prioritized IDM will be able to get the same amount of flexibility as if the company had its own in-house manufacturing while a lower ranking might lead to problems for the IDM.

Due to long lead times in the semiconductor industry there does not seem to be any threats of competitors coming from the emerging markets, at least not in a five year period of time.

The supplier-customer relationships between the IDMs and the Brand Owners might very well state whether the IDM can take advantage of the emerging markets. Nokia has the largest market share (see figure 5.5) in emerging markets with 54% of the shipments in 2006. These numbers are an indication of which companies that will succeed more than the others in the emerging markets with the addition of the companies’ strategy when it comes to low-end or high-end handsets.

### 6.3 Upcoming Trends

The trends the authors see today will most likely have major impact on the industry in 2012. Even though the development is proceeding rapidly the investments in technology are huge and this does not allow many unplanned strategy changes. The company position that wants to be obtained in five years is probably already planned for today. The question is if anything, who will be able to follow their strategy and achieve their goals?
6.3.1 Technology trends

As seen in 2007, more and more of the IDMs are moving towards the fab lite strategy. This is something that already has started happening and is likely to continue during the forthcoming years, since many of the companies are realizing the risks associated with owning fabs. These risks are many; the development of new process node technology needs a lot of capital and is getting more expensive and uncertain for every node, in addition to this there is always a risk of not succeeding in the development work. To get economy in a fab it is vital to have volumes to cover the development costs and be able to keep a persistent production flow. Since there does not exist many IDMs that can fulfill these demands it is likely to see an overall decrease in fab owning by the IDMs during the five years to come.

Today many of the IDMs own their fabs. Since the cutting edge technology only is used in about half of the circuits, some of the IDMs will keep some of the fabs they have to continue in-house manufacturing of 90-nm or 65-nm parts in order to have a more flexible manufacturing process that is not completely dependent on the service from foundries. For the IDMs active in the M&W segment, not many will continue with in-house manufacturing in the cutting edge technology for more than possibly one more node, 45-nm. The exception is ST. In 2012 the 22-nm will probably be the latest technology, which most likely only will be produced by the foundries and possibly Intel.

By 2012 it is likely that some of the smaller companies have gone completely fabless and instead rely solely on the foundries. The problem that arises with this strategy is that since they are small companies the volumes they buy from the foundries are not that significant and it is likely for the small IDM to be placed further down on the priority list. In times of high demand the foundries are likely to prioritize other companies, with larger volumes, before them. This is a factor that will affect the industry in such a way that it is likely to see an increased consolidation level and faster acquiring speed in the industry.

Not all IDMs are planning to go fabless; TI and NXP have announced that they do not want to be fabless ever because they feel like they have to be able to control their production capacity to keep their flexibility level high.182,183

182 Walko J. (2007-09-10) NXP takes fab lite route, EETimes
The process node development today is often done in alliances to reduce the risks and share the costs, something that will continue in the future because of the increasing costs and the more uncertain technological aspects beyond 22-nm.

As discussed earlier in the thesis, the trend for IDMs is forward integration in the value chain. The value is getting higher in software development and this is something that more and more companies are realizing and want to capitalize on. Not all of the case companies seem to have the same strategy towards forward integration; some of them have a very active acquisition strategy in moving forward and others focusing more on their core competences as an IDM. This will be further discussed in Chapter 6.4.

6.3.2 Economic and Legal Trends

Since the trend in manufacturing is moving from owning of fabs towards relying on foundries, cost reduction is getting even more vital since the area for making money is getting narrower. This has shown in the Key Success Factor analysis where “Ability to reduce costs” was seen as the most important factor. A well functioning supply chain and efficiency is getting even more important, as there is no room for additional costs.

With the fixed cost increasing exponentially, volume is getting more and more important. This will make it difficult for the smaller companies to uphold their business and they are likely to be targets for acquisitions, if they do not choose to merge with another company. This is something that has been going on in the industry for several years and the pace is likely to speed up. In the foundry segment of the value chain TSMC has a very dominant position with almost half the market and they are likely to increase their share with the benefit of economy of scale and being in the cutting edge of technology development. TSMC certainly looks very strong and in five years the other foundries will have problems to compete.

IDMs releasing their foundry part allowing them to focus on moving forward towards the TE field of the value chain. What most IDMs are missing today, or at least have lack of competence in, is software. This is certainly something that they will have to improve if they aim to get established as a complete TE. The most common way to acquire competence within software seems to be through acquiring companies that

183 LaPedus M. (2007-05-22) TI bares details of new “hybrid” fab strategy, EEtimes
has the competence, since this can be a faster and more efficient way compared to organic growth. It seems like most of the case companies will try to position themselves as TEIs as well as IDMs in 2012, which of course will lead to an even higher level of competition in this area.

### 6.4 The Value Chain 2012

As seen in earlier chapters there are a few clear trends in the industry that will affect the case companies. Some of the trends are driven by the IDMs themselves and some of the customers and Brand Owners from the front of the value chain. However, these trends, and the changing climate in the industry, are affecting the IDMs and they are handling the changing circumstances in different ways.

The KSF analysis has been considered together with the trends and the competitive landscape analysis. The gathered information and analysis has been used in order to identify the case companies’ future positions. Once more, the value chain model will illustrate the company position but please note that this time it illustrates the case companies’ position, and core activities, in 2012. See figure 6.5.

![Figure 6.5 The Value Chain Model](image)

**6.4.1 Broadcom**

![Figure 6.6 Value Chain 2012 Broadcom](image)
Broadcom is the company with the second best KSF scoring in the industry with 10/12 points. The KSF “Economy of scale” is a weakness area for Broadcom; they are the company with the lowest sales in the industry and are missing value since they can not spread their fixed costs over large volumes and are close to the critical sales volume of $3 billion.

Broadcom has shown a somewhat different approach on how to do business than its competitors. They invest a lot of money to grow by acquiring companies and have the highest R&D costs of the case companies, yet they are making money. However, Broadcom recently presented its results for Q3, even if the net sales was higher than expected, the quarterly profits fell with 75% compared to the same period last year. Broadcom explained the weak numbers by two factors; unexpected R&D costs and increased patent litigations with Qualcomm. These two factors are threatening Broadcom’s future, the increasing costs of patent litigations which are tough as they are up against Qualcomm who is a much larger company with superior resources. The higher R&D costs are eating into their profit.

Except for these factors, Broadcom seems to have a promising future in M&W after getting the Nokia contract for EDGE chips and collaboration with Samsung in 3G, regarding chipsets and software. Since Broadcom does not have any own manufacturing, they have an advantage over their competitors in not having to reorganize with the selling of fabs when their competitors are going fab lite. Broadcom is in the front of the development and maybe the most high tech companies of the six. They have an expertise in wireless and gain from synergy effects since all of their business areas in closely linked with wireless communication.

Overall Broadcom is in a good position, even if they are the smallest company of the six, they have plenty of capital. There are a few threats, in patent litigation that is time consuming and expensive, and increasing development costs, that can jeopardize their future if they do not manage the costs. Given that Broadcom now has volumes at two of the big five Brand Owners, and one foot in Motorola as well, they will most likely be an important company in the M&W segment and will most likely have taken market shares by 2012.
6.4.2 Freescale

With a KSF scoring 6/10 Freescale is average in the industry. The lack of KSF “Risk management” is a clear threat, since they are very dependent on Motorola. Freescale is facing a tough future within the M&W segment. The company as whole is profitable with a profit margin of 10% (2005), however the M&W unit has only a profit margin of 4% and the margins are not likely to get better. During Q3 the company dropped in net sales, in relation to the other companies in the industry, from 9th place in 2006 to 16th place, in the overall semiconductor industry, which shows that they are having problems keeping up with the growth of their competitors.\(^{184}\) Freescale is very dependent on Motorola, not only because Motorola is their only volume customer in M&W, but also because they provide Freescale with their protocol stack. With fierce competition from one of the giants in the industry, TI, Freescale will have problems to remain competitive beyond 2009, when their contract of exclusivity with Motorola expires. Freescale existence in M&W is completely dependent of Motorola, their future lies in Motorola’s hands.

Unlike the NXP case, the private equity consortium (The Blackstone Group, The Carlyle Group, Permira Funds and Texas Pacific Group) that acquired Freescale a year ago has been surprisingly passive; no major changes or acquisitions have been made so far. The most common strategies in leveraged buyouts is to buy stable companies with good economy, that are underperforming, make some complementing acquisitions to strengthen the company and then either go public or sell off parts of the company. Exactly what plans they have for Freescale is difficult to know, but they seem to focus on cash flow now and will probably do this for a few years and then sell of the parts that do not make enough money, today this is the M&W segment.

\(^{184}\) LaPedus M. (2007-10-31) Top-10 chip rankings for Q3 shows big shakeup, *EETimes*
Since Freescale today is the number one supplier of semiconductors to the automotive industry it is reasonable to believe that they will focus on that segment more actively since they have a good position, profitability and economy of scale in that segment. The M&W segment is, compared to the rest of the company, somewhat underperforming. This will need some action, eventually a sell-off is the most likely solution. Another possibility for Freescale is to find a partner in the M&W segment to broaden their customer base and acquire software competencies and an own stack. It is not likely that Freescale’s M&W unit will look the same in five years as it does today.

6.4.3 Infineon

Infineon’s KSF scoring, 7/10 points give them the third position in the industry. They are average in most areas, but have realized the importance of reducing costs and having economy of scale, where they have a very
Where Is the Semiconductor Industry Going?

good scoring. Infineon has experienced a tough year 2006, with a loss of about 7% of their net sales. The M&W unit has taken a big beat after losing their most important customer, Siemens. This can to a certain extent explain the loss during last year. Together with the rumors that ST might want to acquire Infineon has not made them look very strong. However, Infineon has made clear that they do not have any intentions of being acquired and are now working on building a broader customer base and does not seem that dependent of one single customer anymore. With Nokia outsourcing their GSM chipsets, LG in EDGE and new customers like Motorola and the newcomer, Apple, Infineon seems to be in a rather good position for the future, if they can get the volumes up at their customers. In 2006 Infineon had about 30% of their overall sales in M&W; this is a number that most likely will increase when the new customers starts to show in the accounts. In their quarterly report Q4 2007, Infineon foresee a significant increase in net sales in the M&W segment and expect to be able to break even, something they have not been able to do in a long time. At the same time they will have a decrease in net sales in their Automotive and Industrial segment due to season variations and a weak U.S. Dollar. Just as Freescale, Infineon has a large percentage of their sales in the automotive industry and are the second largest company in that segment.  

Infineon is one of the companies that can benefit from the development in emerging markets, since they are starting to get volumes at Nokia in GSM and has LG as a customer which is focused on low-end mobile handsets.

By 2012 Infineon will most likely have quit their in-house manufacturing and rely solely on foundries. With their broad customer base they will have a good chance of rising from the tough situation they experienced last year and establish themselves as one of the most important companies in the M&W segment by 2012. Until 2012 the company has plenty of time to develop competitive 3G software (through Comneon) and they have shown that they are willing to invest if they find interesting acquisitions, for example LSI earlier this year. With these facts taken under consideration it is to be expected that Infineon will be competitive as a TE by 2012.

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6.4.4 NXP

NXP is the company with the lowest KSF scoring, with only 4/12 points. They are lack of three KSFs; “Time to customer”, “Good relations with customers”, and “Risk management”. In addition they have problems with the TF “Delivery reliability”.

NXP was acquired by a private equity consortium (Apax, AlpInvest Partners, Bain Capital, Kohlberg Kravis Roberts & Co. and Silver Lake Partners) a year ago. Since then a lot has happened within the company. They have acquired two companies, narrowed their business areas and quit the Crolles2 alliance. Today NXP is only outsourcing a small part of their production and are still running their own fabs with old technology. Even if they intend to increase their outsourcing more in the future they have declared that they will never be completely fabless. Since they are not a member of any process node development alliance, they will not be able to manufacture in-house with the latest technology in the future. NXP has had problems keeping up in the rapid development, a problem they to a certain extent seem to have realized now and are trying to solve. The acquisition of Silicon Labs mobile unit earlier this year definitely was of strategic importance as it allowed them to catch up on the CMOS technology.

NXP has to work hard to maintain their position in the M&W industry since they have a quite unfavorable position with only Samsung as volume customer. To get back on their feet they need a more focused strategy, even if they already have narrowed their business areas they still have over 40, which is too many. Their CEO has announced that they want to be number one in what they do, which is almost impossible in this competitive industry when they have as many focusing areas. They have capital for making further acquisitions and strengthen their position in the areas where they wish to be successful. There are two scenarios to consider when looking at the private equity’s strategy for NXP in the upcoming years:
- Strengthen NXP to be a profitable company by further investments
- Divide the company into parts and sell them, with the intention to make more money from the sum of every unit than what they paid for the company

So far the private equity seems to follow the first strategy, by working to strengthen the company in order to be more competitive. This is a strategy that is not often seen in these situations. The authors do not see NXP as a competitive company in 2012, as there is too much that has to be changed and a strategy that is difficult to succeed in implementing. The more likely scenario is that the M&W unit is sold of, with the low KSF scoring and lack of three KSFs, NXP can not be competitive in the industry.

### 6.4.5 STMicroelectronics

![Figure 6.11 Value Chain 2012 STMicroelectronics](image)

ST received an average KSF scoring with 6/10 points. They are average at most of the KSFs which makes it difficult to see an apparent future. Most of the areas where ST has got a one scoring are closer to two that it is to zero. Overall they have a rather good position for the future and certainly have a favorable situation after being one of the big winners in Nokia’s reorganization. The 3G quantities from Nokia will without a doubt boost their sales and they have a great opportunity to acquiring new competencies with 200 of Nokia’s engineers working very close with ST’s 3G chip development.

So far ST has kept a low profile when it comes to moving forward in the value chain. When the rest of the IDMs are spending much money in acquiring competencies in technology enabling, ST is keeping their core business as a traditional IDM and leave the TE parts to their customers. As long as ST has the collaboration with Nokia there is no need to take any
risks in moving forward, since they already are making good money with the volumes that Nokia supply.

ST is the only one of the case companies that is likely to continue with in-house manufacturing in the latest process node technology for another couple of nodes. Exactly how far they will go is unclear but since they have not explicitly said that they will quit in-house manufacturing and are developing 32-nm technology together with IBM, among others, it is reasonable to believe that they will continue at least as far. ST seems to have found a position that is a good fit for them in the value chain and are making good money where they are. The intimate collaboration with Nokia is likely to persist for several years since both partners are putting great effort into making it work. The question the authors are asking themselves is to which extent ST will be able to benefit from the Nokia collaboration in the future? After working with Nokia for a few years they will definitely have some competencies that they did not have before, subsequent of the collaboration, but to what extent they will be allowed to use them is uncertain. The most likely scenario is that ST will keep working close with Nokia and that the volumes Nokia supplies are enough for ST. Besides Nokia, ST has LG and EMP as customers, which diversifies their risk.

In a five year perspective ST most likely will keep their position in the value chain and focus on what they do best.

### 6.4.6 Texas Instruments

![Figure 6.12 Value Chain 2007 Texas Instruments](image)

TI showed their strength when they received 12/12 points in the KSF scoring. Obviously they do not have any major weaknesses and seem to be doing most things right. TI is the largest of the case companies with four of the big five Brand Owners as customers. Over the last years TI has shown a remarkable increase in profitability, from 12% profit margin in 2003 they have stepwise increased their profitability every year to 30% in 2006. With these numbers TI is by far the most profitable company in the industry.
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Analysts now foresee a drop in TI’s earnings growth in 2009 and their margins in M&W; this can to a certain extent be explained by loosing volumes at Nokia to Infineon, ST and Broadcom. TI will still be the prime supplier but the tougher competition indicates that a more moderate future is to come. Nevertheless, TI is the strongest company of the six and their future looks really pleasing, with one half of the 3G chipset market and the ability to deliver large quantities, they have an advantage over their competitors by their economy of scale combined with their ability to keep the costs down. Their position in the value chain is not looking to change too much. They are making good money on what they do and are focusing on their core competencies. Moving forward in the value chain for TI would be to stepping on their customers’ toes, something they certainly do not want to do since they are doing business with almost all the important companies in the industry. It is more likely for them to collaborate closely with one or two of the big Brand Owners and deliver tailor made solutions in large quantities. One should be aware that TI has most of the competences for competing successfully on a TE level and it is possible that they decide to deliver low-end 3G platforms. This is not likely to happen soon but in five years time it is possible.

7 Conclusion

The final conclusions are drawn by the authors from the analysis and the most important findings are presented. This chapter consists of industry trends, the case companies, and reflection of the authors work and finally further areas of study are proposed.

“Careful. We don’t want to learn from this!”

– Calvin & Hobbes by Bill Watterson

7.1 Industry Trends

Today, a clear trend towards consolidation between companies in the industry can be seen. The costs for the fundamental development are increasing exponentially as the companies are trying to keep up with Moore’s law. Economy of scale is getting crucial to be competitive and this is the most significant driving factor for the mergers and acquisitions that are taking place in the industry. The fast rising costs are leading to a re-positioning of the Integrated Device Manufacturers; many of them are realizing that they do not have the quantities necessary for driving fabs and manufacture in-house. This has resulted in that many Integrated Device Manufacturers are selling fabs and outsourcing large parts of their manufacturing to foundries. Without the foundry part, Integrated Device Manufacturers have a more narrow area of business and are compensating this by moving forward in the value chain, trying to establish as technology enablers.

The value in hardware is no longer dominating; there are massive amounts of money in intellectual property rights and software, something that the Integrated Device Manufacturers have realized and are trying to capitalize on. The importance of protecting intellectual property has shown in increasing patent litigations between the companies in the industry.

7.2 Case companies

After identified Key Success Factors, by questioning of experts in the industry, and evaluating the case companies and to what extent they possess
them, the authors have been able to determine how the future may look for the different companies. This theory is not the only one who has assisted the authors as stated in Chapter 3. The identified factors are shown in figure 7.1.

<table>
<thead>
<tr>
<th>Key Success Factors</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to reduce costs</td>
<td>4.75</td>
</tr>
<tr>
<td>Time to customer</td>
<td>4.57</td>
</tr>
<tr>
<td>Good relations with customers</td>
<td>4.50</td>
</tr>
<tr>
<td>Economy of scale</td>
<td>4.29</td>
</tr>
<tr>
<td>Risk management</td>
<td>4.13</td>
</tr>
<tr>
<td>Good relations with suppliers</td>
<td>4.11</td>
</tr>
</tbody>
</table>

Figure 7.1 Key Success Factors in the semiconductor industry

The conclusions drawn from the Key Success Factor Mapping (see figure 7.2) was that Texas Instruments and Broadcom are the companies with highest potential for success in the future. Broadcom got 10 points out of 12 and Texas Instruments 12 out of 12 points. Both Broadcom and Texas Instruments will maintain strong in the mobile and wireless industry. Infineon came third with 7 out of 10 points and the authors see potential in them if they can get volumes with one of the big five Brand owners. Freescale and STMicroelectronics shared the fourth place with the same scoring. STMicroelectronics seems to have a stable future and are not expected to make any radical changes during a five year perspective while Freescale’s mobile and wireless unit is expected to be sold. The mapping analysis showed that NXP is in the worst situation out of the six case companies. They only got 4 out of 12 possible points with zero points on three factors and the authors expect their mobile and wireless unit to be sold off.

<table>
<thead>
<tr>
<th>KSF Mapping</th>
<th>Broadcom</th>
<th>Freescale</th>
<th>Infineon</th>
<th>NXP</th>
<th>ST</th>
<th>TI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to reduce costs</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Time to customer</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Good relations with customers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Economy of scale</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Risk management</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Good relations with suppliers</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>N/A</td>
<td>2</td>
</tr>
<tr>
<td>Sum</td>
<td>10</td>
<td>6</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Percentage of maximum</td>
<td>83%</td>
<td>60%</td>
<td>70%</td>
<td>33%</td>
<td>60%</td>
<td>100%</td>
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<tr>
<td>Ranking</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 7.2 KSF mapping of the case companies
7.3 Reflection of Work Method and Theoretical Framework

During the thesis the authors have used several methods in order to conduct the work. Initially a lot of time was spent on information search to get an overview of the industry structure and the case companies. Many articles were read and home pages were studied. The authors have always studied the sources critically and even though the reference list is long, many sources did not measure up. The sources used in the study have been objectively reviewed; especially the internet based ones such as EETimes that is a well renowned electronically based newspaper. In order to raise the validity of the study the authors searched for confirmative sources if the primary source could be questioned.

The interviews have been conducted with experts in the mobile and wireless segment of the semiconductor industry. As many of them work at Ericsson Mobile Platforms their opinions might not be completely objective, and the authors have taken this under consideration when evaluating the answers from the interviews.

Initially the authors believed that they would use the Scenario Method differently. Several scenarios are typically identified and then compared with each other in order to conclude which one that will be the most likely output. This was the original approach which the authors intended to follow but it became clear after some time that this would not be realistic or even benefit the study. Additionally Ericsson Mobile Platforms was not interested in a Scenario Analysis and preferred only one scenario. If the authors would have set up for example three different future scenarios there would have been only one that had a chance of ever happening. The scenarios could have been very similar which on the other hand would have made it unrealistic to choose between them. With this realization the authors set up only one scenario per company instead of one realistic and two completely unrealistic ones. The core of the Scenario Method has still been used since one of the main issues in the study has been to identify the driving forces within the industry and base the single scenario upon these.

The Delphi Method has been very useful when collecting information about the Key Success Factors and Threshold Factors. The basic foundation of the Delphi Method has been used, the brainstorming, and the use of a panel of experts to answer the questions raised by the brainstorming. However the authors lacked time to carry out iterations, which characterizes the study,
with the questionnaire when identifying the Key Success Factors and Threshold Factors. Iterations were used when conducting the Key Success Factor Mapping, even so the conventional use of the Delphi Method could be questioned.

The strategic approach used has mainly been a combination of “Strategy as Design” and “Strategy as Experience”. The “Strategy as Design” approach has been useful when conducting the analysis which represents the strategy in the thesis. The authors’ initial criticism of this approach showed to be exaggerated since the approach can be expanded and conclude an entire industry instead of focusing on one company alone. The “Strategy as Experience” approach was used throughout the thesis work and helped with the drawings of the conclusions at the end together with the design approach. This approach has been used when looking at upcoming trends by mapping present and former situations and trends in the industry. The authors have not only used their own experience but have focused on finding people with desired expertise in order to conduct much of the study work, for example the Delphi study.

When reflecting on the theoretical framework the authors see some adjustments that have been made. The competitor analysis has been conducted even though the authors predicted that it would be difficult due to the demand of public data throughout the thesis. The data collection was somewhat easier than the authors foresaw which made the theory very useful. Instead of finding too little information the data available was extensive and the authors instead had to screen the information in order to find the most useful and reliable source. Porter’s Value Chain was seen as too static, centralized around one specific company and too detailed for this study. After conducting the study this outlook was confirmed since the main purpose was to study an entire industry with the help of six case companies, not one specific.

The PESTEL analysis gave a diversified image of which factors that is most important in the semiconductor industry. The technological and economic factors showed to be driving forces in the industry. The legal factor is not one of the main driving forces but important just as well, especially the litigations concerning IP. On the whole the theoretical framework has been the foundation of the study together with the methodological framework since these frameworks have given the study validity as the area studied has been approach from many different angles.
7.4 Further studies

The authors believe that it would be of interest to both EMP and the industry in general to do the same study in three to five years, foremost because of the rapid development in the industry and the question marks regarding Freescale’s and NXP’s future in the industry.

An in-depth study of the process node development would be of interest in one or two years when the sub 22-nm process node technology is approaching since the technology has to change radically in order to handle further miniaturization. This area is very complex and is definitely large enough for a whole Master Thesis.

Reflection is always something to recommend, particularly the Emerging Markets prognosis that has been made should be reviewed in about five year’s time in order to see if the next billion of customers in fact came from these markets. The level of impact from the Emerging Markets on the IDM industry is also something to focus on in a further study.
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“*The secret to creativity is knowing how to hide your sources.*”

– Albert Einstein

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Appendix 1; The Value Chain Model
Appendix 2; HHI calculations

Foundry HHI

\[ 0.45^2 + 0.14^2 + 2 \cdot 0.07^2 + 0.05^2 + 22 \cdot 0.01^2 = 0.287 \]

IDM HHI

\[ 0.121^2 + 0.14^2 + 0.076^2 + 0.048^2 + 0.039^2 + 0.038^2 + 2 \cdot 0.03^2 + 0.029^2 + 0.028^2 + 2 \cdot 0.023^2 + 0.022^2 + 0.021^2 + 2 \cdot 0.02^2 + 0.019^2 + 0.017^2 + 0.015^2 + 2 \cdot 0.014^2 + 0.013^2 + 37 \cdot 0.01^2 = 0.0355 \]

Brand Owners HHI

\[ 0.369^2 + 0.146^2 + 0.134^2 + 0.09^2 + 0.068^2 + 19 \cdot 0.01^2 = 0.190 \]
Appendix 3; Questionnaire

Questionnaire concerning KSFs in the Semiconductor Industry

We are two Master Thesis students from Lund Institute of Technology that are writing our master thesis concerning where the semiconductor industry is going on a five year horizon. The thesis work is made in collaboration with Ericsson Mobile Platforms. One part of our study aims to investigate what Key Success Factors (KSF) that will be crucial in order to succeed in the industry in 2012. To limit the field we have chosen to study six companies that are active in the mobile and wireless segment in the industry.

These questions aim to give an input to which factors that are considered KSFs in the semiconductor industry. KSFs can be the answers to the following question:

*For an organization/company to be successful, they must be good at the following activities:*

The KSFs both distinguish what the company’s customers want as well as how the company can compete successfully with its competitors.

In order to distinguish the factors that are vital, not just important, we ask you to answer the following questions concerning the semiconductor industry and it alone.

Please do not confuse KSFs with Threshold Factors that are the factors a company must possess to even exist in the industry. For clarification see figure below. Some of the stated factors will have a short explanation, to make things as clear as possible.
1. Please rate these following factors from 1 to 5 where 1 is “*Not important as a KSF*” and 5 is “*Very important as a KSF*”. If you consider the factor to be a threshold factor, please only mark the field “Threshold factor”. Mark your answer with an X.

<table>
<thead>
<tr>
<th>Factor</th>
<th>1 Not Important</th>
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<td>Good delivery times</td>
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<td>Product quality</td>
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<td>The product fulfills the expected quality</td>
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<td>High volume delivery capability</td>
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<td>Possibilities to fulfill the demanded quantity</td>
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<td>Competent R&amp;D</td>
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<td>Competence to do the right things at the right time</td>
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<td>Alliances in process node development sub 45-nm</td>
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### Where Is the Semiconductor Industry Going?

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<td>For mobile and wireless devices, not for memories</td>
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<td>Economy of scale</td>
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<td>Long term partnership with an Brand Owner</td>
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<td>Good relations with suppliers</td>
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<td>Ability to reduce costs</td>
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<td>Differentiated in industries other than mobile &amp; wireless</td>
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<td>Complete solution</td>
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<td>Competence to offer a complete system solution, from foundry to a</td>
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<td>Design wins in LTE</td>
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<td>Reduce risk by having several suppliers/customers</td>
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<td>Supply capabilities</td>
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<td>A well functioning and effective supply chain</td>
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2. **Are there any factors that you would like to add? In that case, please rate these factors in the same way as the factors above.**

If you have any questions please do not hesitate to contact us by phone or e-mail.

Best regards,

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joakim.nideborn@ericsson.com kristina.strahle@ericsson.com