**AN OPPORTUNITY ASSESMENT FOR A NEW BUSINESS MODEL IN THE SEMICONDUCTOR INDUSTRY**

by

Sameer Khushal
M.Eng. Simon Fraser University, 2003
B.ASc. University of Toronto, 2000

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# Approval

**Name:** **Sameer Khushal**

**Degree:** **Master of Business Administration**

**Title of Project:** **AN OPPORTUNITY ASSESEMENT FOR A NEW BUSINESS MODEL IN THE SEMICONDUCTOR INDUSTRY**

**Supervisory Committee:**

______________________________________

**Dr. Pek-Hooi Soh**
Senior Supervisor
Assistant Professor, Segal Graduate School of Business

______________________________________

**Dr. Aidan R. Vining**
Second Reader
Professor, Segal Graduate School of Business

Date Approved: ______________________________________

# Abstract

The report presents an opportunity assessment for the business model of the Semiconductor Consulting Services Provider (SCSP) within the semiconductor industry. This assessment justifies the business needs for this model by examining the evolution of the semiconductor industry to date. The value proposition of this model is discussed based on its cost advantages relative to existing operating models within the industry. The two dominant operating models in the semiconductor industry, namely, Integrated Device Manufacturer (IDM) and Fabless Semiconductor Manufacturer (FSM), are presented. The relevance and appeal of the SCSP business model to IDM and FSM is discussed. Industry experts further provided their input in this study regarding the attractiveness of the SCSP model to fill the gap in the semiconductor industry.

This report concludes that SCSP is a viable business model and that the SCSP market will grow in revenue. As a new entrant, SCSP companies should begin by strategically focusing on FSM startups' manufacturing and operations outsourcing, followed by existing FSM companies and finally IDM companies.

**Keywords:** fab; fabless; integrated device manufacturer; outsourcing; outsourced assembly and test semiconductor

## Dedication

To my wife Shelly and my son Sohail who spent many nights and weekends without me: I will make it up to you more than you can imagine. Your endless support has allowed me to pursue my career and educational goals. This is a new beginning for us!

For my Mother and Father who sacrificed everything for my education and well-being: Thank you for motivating me to always achieve more. I would not have the options I have today without your guidance.

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# Table of Contents

# List of Figures

# List of Tables

# List of Abbreviations and Acronyms

| | |
|---|---|
| ASIC | Application Specific Integrated Circuit |
| BOM | Bill of Materials |
| CAD | Computer Aided Design |
| CPU | Central Processing Unit |
| IC | Integrated Circuit analogous to 'microchip' |
| IDM | Integrated Device Manufacturer |
| IP | Intellectual Property |
| IT | Information Technology |
| FAB | Wafer Foundry company specializing in wafer fabrication |
| FSA | Fabless Semiconductor Alliance |
| FSM | Fabless Semiconductor Manufacturer |
| FSM startup | A FSM company that has just begun business |
| GSA | Global Semiconductor Alliance |
| MEMS | Micro Electro-Mechanical System |
| Moore's Law | Describing the annual increase in microchip density |
| OSAT | Outsourced Semiconductor Assembly and Test |
| R&D | Research and Development |
| RoHS | Regulation of Hazardous Substances |
| Silicon Valley | Near Santa Clara, CA where many semiconductor companies are headquartered |
| SOC | System on Chip |
| TAM | Total Addressable Market (refers to $ value of market) |
| TSV | Through Silicon Via |
| VC | Venture Capital company |
| SCSP | Semiconductor Consulting Services Provider |

# 1: Introduction to the Opportunity Assessment

In this opportunity assessment a business analysis will be performed on a new business model within the semiconductor industry. Over the past decade, a new business model has emerged - that is Semiconductor Consulting Services Provider (SCSP)[1]. Businesses based on this model provide design, operations and manufacturing consulting services to companies within the semiconductor industry.

The opportunity for a new SCSP entrant is to fill an unmet need by targeting underserviced companies within the semiconductor industry. There are a wide variety of companies in the semiconductor industry that serve a variety of end markets. Current SCSP companies service high complexity products at the expense of high volume products. It will be shown that high volume end markets, such as smartphones, represent a large market opportunity for the SCSP.

This opportunity assessment makes clearly stated assumptions that are based on a general application of the SCSP business. Specific implementations of a SCSP may be limited by capital, resource, competition and other factors. A change in the environment of the SCSP would require a re-examination of the opportunity assessment to determine the viability of the business.

## 1.1 The SCSP

The SCSP works within the semiconductor supply chain to enable the smooth transition from product Research and Development (R&D) to manufacturing for Fabless Semiconductor

[1] In this semiconductor industry this model is more commonly referred to as a Value Chain Producer (VCP). To reduce confusion with other terms in this assessment SCSP was chosen.

Manufacturers (FSM)[2]. Key partners within the supply chain are semiconductor Fabricators (FAB) and Outsourced Assembly and Test (OSAT). The specialized expertise that the SCSP provides to FSM companies is difficult to obtain for the FSM. Substantial capital investment is required. Owing to the fact that the SCSP is supplying products and services to several FSMs, the overall price, risk and complexity to a single FSM is considerably reduced. Historically, the semiconductor industry was comprised of Integrated Device Manufacturers (IDMs) who are completely vertically integrated entities. It will be shown that the industry has evolved from few IDMs to many FSMs and then to the introduction of the SCSP.

## 1.2 Trends Supporting the SCSP Model

Increasing capital cost and technological complexity gave rise to the SCSP model in the year 2000 (eSilicon, 2010a) in partnership with Fabless Semiconductor Manufacturers (FSM). The adoption of this model has accelerated in recent years due to the switch of Integrated Device Manufacturers (IDM) to the FSM. The semiconductor industry is formed by a collection of IDM and FSM companies and their value chain partners (primarily FABs and OSATs). Until recently, all IDMs were vertically integrated and spent a large amount of capital on internal operations and manufacturing capability. Similarly, the revenue of the IDM is large as is their expenditure on the internal operations and manufacturing capabilities. The first large IDM to switch to the FSM model is AMD (Clarke, 2010). This switch alone will add greater than USD $2 Billion of additional business into the semiconductor supply chain, of which the SCSP is a member.

The design and process flow in the semiconductor industry has evolved in modular fashion, which allows the development of a supply chain consisting of specialized partners. Usage of a common manufacturing process allows for the fabrication of multiple products, of

[2] FSM, FSMs, and FSM companies are synonymous. The same applies for the terms FAB, FSM and OSAT.

varying complexity and type, at the same time. This favours the SCSP since the development of supporting resources for a manufacturing process can be leveraged against several customers.

Taking advantage of this tectonic shift in the balance between the IDMs and FSMs, the SCSP will create products and strategies to position itself for growth and the capture of these recently freed IDM supply chain dollars. The SCSP will primarily target the FSM, which has a strategic fit due to the specialized nature of products involved. It will be seen that the FSM can be better supported via the SCSP. The SCSP can provide the FSM value-added services such as design services, as well as close SCSP-FSM customer service and integration.

The general attraction of the semiconductor industry is evident due to high gross margins as well as Venture Capital (VC) funding of several FSM startups annually. These FSM startups are extremely unlikely to create internal operations or manufacturing capability. The continual entry of new supply chain revenues, through VC funding of these startups, also present a growth opportunity for the SCSP. Although not all of these FSM startups will be successful, a strategic analysis of the semiconductor product segments and end markets that are serviced will identify the FSM start-ups to partner with.

## 1.3 Assessment Framework

To understand how the need of SCSP materialized, a general history and overview of the semiconductor industry will be provided. This will be followed by a detailed description of the SCSP, a strategic analysis and a description of the addressable market. Financial and economic considerations will be touched on for further continuation in a formal business plan.

Based on industry expert interviews, the validity of the SCSP model is explored. Due to a successful track record of existing SCSP companies such as eSilicon and Open-Silicon, there is widespread acceptance of the SCSP model, especially amongst FSM companies and FSM startups. Hence, there are several factors that signal that the SCSP Total Addressable Market (TAM) is about to enter a phase of accelerated growth:

- Increasing technological complexity of semiconductor manufacturing
- Conversion of IDMs to FSMs
- General acceptance and credibility and acceptance of the SCSP model in the semiconductor industry
- Continuing funding of FSM startups by VCs

This opportunity assessment is a precursor to a formal business plan and relies on industry information, interviews, articles and the knowledge of the author. As such, although the analysis is believed to be complete for a preliminary investigation, further work has to be done to delve into the details of a formal business plan, such as more detailed models of the financial analysis, funding model, revenue model and strategic framework. Figure 1 shows how the opportunity analysis fits within the timeline for business implementation. The total time from the beginning of the opportunity assessment to business start is almost three years.

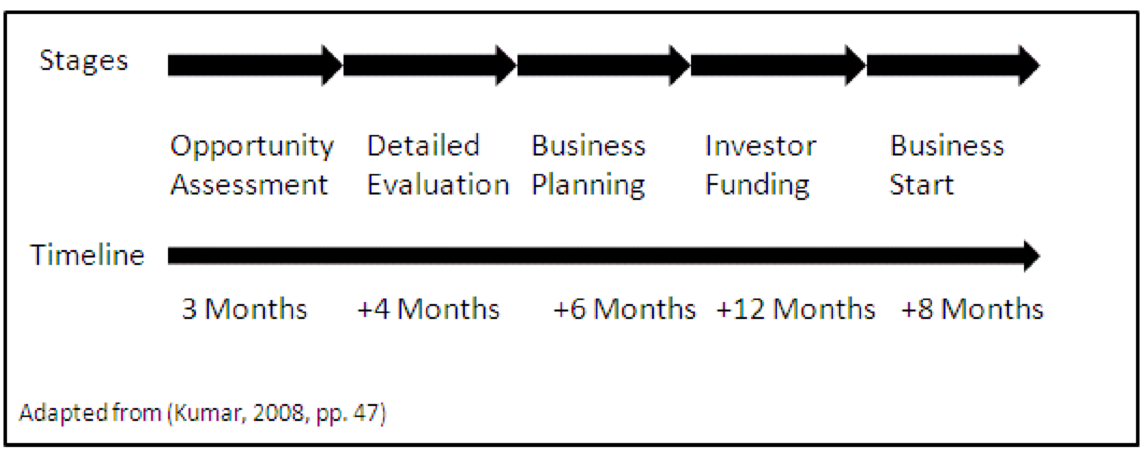


*Figure 1 General Opportunity Assessment Timeline*

# 2: Overview of The Semiconductor Industry

To understand how the Value Chain Provider (SCSP) business model has emerged from the business models that exist and have existed within the semiconductor industry, the history of the industry should be briefly understood with a focus on manufacturing operations and industry organization.

## 2.1 History

After several decades of research in the electronics industry, starting in 1901, the semiconductor industry was born with the invention of the transistor in 1948. The birth of the semiconductor industry was primarily accelerated by the additional funding of the US defence industry (Morris, 1998 pp. 26). The next major development was the invention of the Integrated Circuit (IC) in 1958, which is commonly referred to as a microchip (Morris, 1998, pp. 45). An IC is a collection of transistors designed to perform a particular function such as calculating a sum. Intel was a forerunner in creating ICs and initially had less than five thousand transistors on a chip. Intel founder Gordon Moore coined what is popularly known as “Moore’s Law” in 1965: The number of transistors on an IC doubles approximately every two years. This law has held true to this day, and has resulted in an exponential rise in the complexity of the IC. Today, over two billion transistors are on an Intel IC (Intel, 2008, pp. 5).

Over the following decades, the industry progressed to provide products primarily targeted to the defence and computing end markets. Since the early 1980s, there has been the emergence of Fabless Semiconductor Manufacturers (FSMs),  a form of semiconductor company that is structured to outsource almost all manufacturing and operations activity (Kumar 2008, pp.

18). In contrast, an Integrated Device Manufacturer (IDM) is a vertically integrated company which maintains its own operations and manufacturing infrastructure.

Characteristically a FSM, especially in the startup phase, is focused on only one product or a set of similar products. There are many applications built around an IC and hence a large number of product types that are each targeted by one or more FSM or IDM. The continual expansion of product functionality and scope has increased the application of the IC to almost all but the most rudimentary of products today (Kumar 2008, pp. 31).

In the past two decades, rapid progress was made in the semiconductor industry, both in enabling process and Computer Aided Design (CAD) technology as well as product application. However, this was interrupted by the Information Technology (IT) Bubble of 1995-2000 (Manyika & Nevens, 2002). The over-investment of capital into IT infrastructure projects resulted in excess capacity in IT infrastructures. Since all IT infrastructures use microchips, this resulted in a dramatic reduction in revenues when infrastructure spending dropped. Semiconductor companies were relying on exorbitant growth rates and had to scale back their internal structures to maintain their companies as viable entities. Despite this, many semiconductor companies have recuperated and enjoy higher revenues than ever before (McGrath, 2010).

The current application of products from the semiconductor industry is immense. Every modern piece of electronics has several semiconductor products inside, sourced from a large variety of semiconductor companies - both FSM and IDM. The continuation of Moore's law ensures that more functionality is placed in a smaller space and several ICs can be replaced by one. Thus, the continual miniaturization of electronics is based on the Moore's Law phenomenon as well as intense competition and renewal within the semiconductor industry (Crosbie, 2009).

The central geographic location of the semiconductor industry is in Santa Clara, California, the home of Intel since its founding in the 1960s. This area is commonly referred to as "Silicon Valley" (Gromov, 1996). There is still a considerable base of semiconductor companies there, and several FSM startups are formed annually there, with over one third of US Venture Capital (VC) investment centered in Silicon Valley (PricewaterhouseCoopers & National Venture Association, 2010, pp. 3). There are over 200 active FSM companies (Global Semiconductor Alliance, 2010), with most having a significant presence in Silicon Valley. The current geographic state of the industry is global with major players based in Europe, Japan and Korea (Morris, 1998, pp. 89), but none with a focused cluster of expertise such as in Silicon Valley.

## 2.2 Semiconductor Manufacturing Process Overview

A general understanding of the design and manufacturing process employed to create an IC is necessary to see how the SCSP model fits within the semiconductor design and manufacturing flow. The general IC design flow is shown in Figure 2. This flow is generally followed regardless of the type of semiconductor company, FSM or IDM. The modular nature of this flow allows for multiple company locations or outsource partners to perform specialized functions. In (a), the IC design is conceptualized and planned. During specific IC design in (b), CAD tools are used to plan in detail the overall implementation and specify features according to customer requirements. The stage in (c) presents the longest part of the flow, which may take up to two years for a complex IC. Here the design of IC is carried out. Interaction with internal manufacturing (IDM) or outsourced manufacturing (FSM) is initiated. In the case of the FSM, the FAB and OSAT partners provide technology information and support beginning with this stage and following through the rest of the flow. In (d) manufacturing is performed, either in prototype or mass-production. Regardless of product volume, the same equipment is used to create the IC parts.

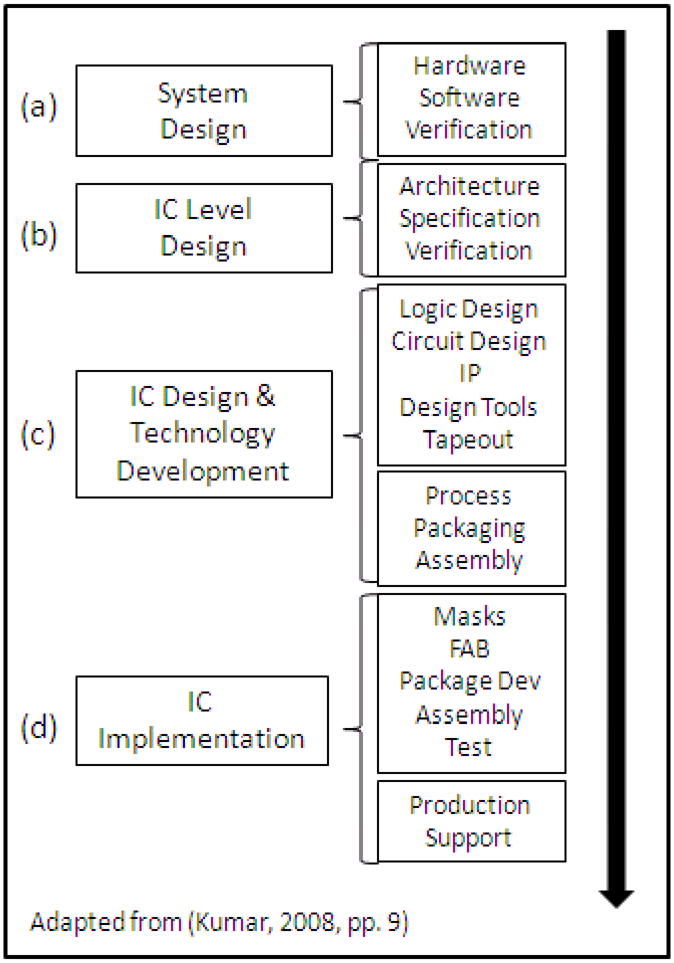


*Figure 2 IC Design Flow Overview*

To appreciate in more detail the ability of the SCSP to combine ICs from multiple customers, we refer to Figure 3, a more detailed view of stage (d) in Figure 2. There are 5 major steps in the manufacture of an IC.

In (a) The raw silicon material is sourced and purified for (b) where eventually a wafer is created. The wafer is a substrate where the transistors that cause a microchip to function are created, through metallurgical processes shown in (c). There will be many die on the wafer. The die is the functional component that performs a specified operation such as microprocessing. It is here that the SCSP can choose to put different die from different projects or customers. As shown in the diagram, there is a repeating pattern to the die on the wafer so that many (typically hundreds) of die are manufactured per wafer. These die are further individually tested and diced, and functioning die are referred to as ‘good’ die as shown in (d). Non-functioning ‘bad’ die are rejected. Next, the good die are protected from the environment by a package, which is commonly seen by the public as an IC or microchip. Lastly, in (e), the packaged microchip is tested again for full functionality, and any remaining reject parts are removed from the process. The good parts are then ready to be sold on the market.

Regardless of the business or operational model of a company in the semiconductor industry, this standardized manufacturing flow is generally followed by all companies, FSM or IDM, and has evolved into its current state over many decades (Kumar, 2008, pp. 175). The steps shown in Figure 3 are sequential and generally do not occur in parallel. This allows the process to be stopped and continued in different manufacturing plants, which may be geographically separated. For example, a typical division is to perform the wafer fabrication (c) and packaging (d) in separate locations, often in different countries.

Since the FSM company does not have its own manufacturing facilities, it will rely on outsourcing partners. Key outsourcing partners are Wafer Fabrication Facilities (FAB) and Outsourced Semiconductor Assembly and Test (OSAT) providers that provide services (c) and (d) respectively.

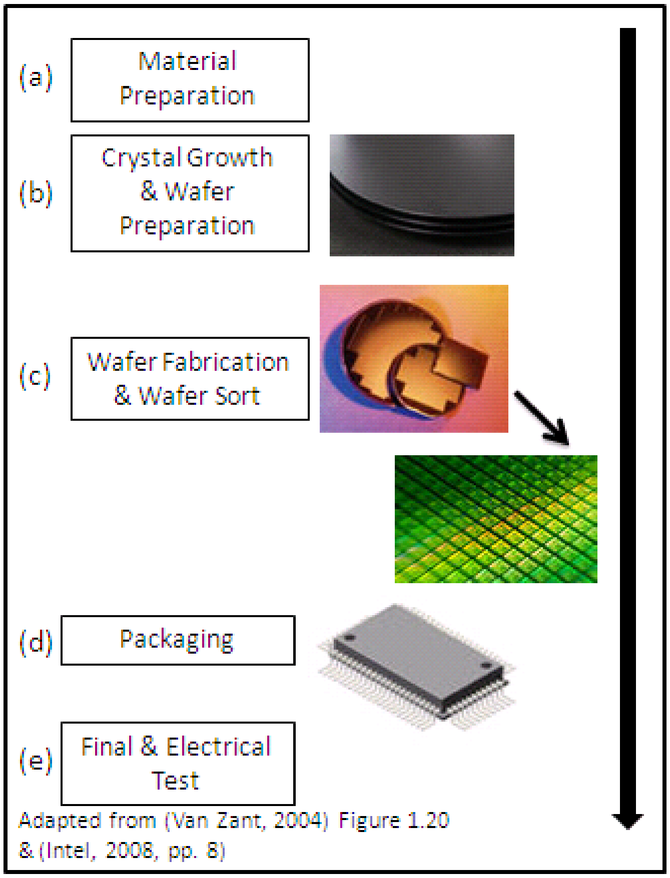


*Figure 3 IC Manufacturing Flow*

## 2.3 Semiconductor Technology Process Nodes

The single largest capital cost in semiconductor manufacturing is the R&D and construction of a FAB for a new technology process node[3]. Continual R&D in miniaturization of new process nodes leads to smaller die, which in turn results in increased capacity per wafer for customers, given the SCSP will place several different customer die on a wafer. The reduction in cost for each technology process node is shown in Figure 4. The R&D required to implement a new process node will be carried out internally for an IDM or at the FAB partner for the FSM.

[3] Process node refers to the smallest functional feature size in an IC. It is used as a universal industry reference to a particular process technology. Consensus has developed in the semiconductor industry on the nodes to pursue in order to maintain technology compatibility (ITRS, 2010).

There is a large cost for the implementation of a process node, typically at least two billion US dollars. As can be seen, for the same wafer size, the cost per transistor reduces over time, due to miniaturization. The greater the number of transistors that can be fit onto a die, the higher the functionality and feature set that is available for a particular IC. The SCSP must use the latest node when developing a product to obtain the lowest cost. The most modern process node is the 45nm process which enables greater product functionality on the same size die as a larger process node.

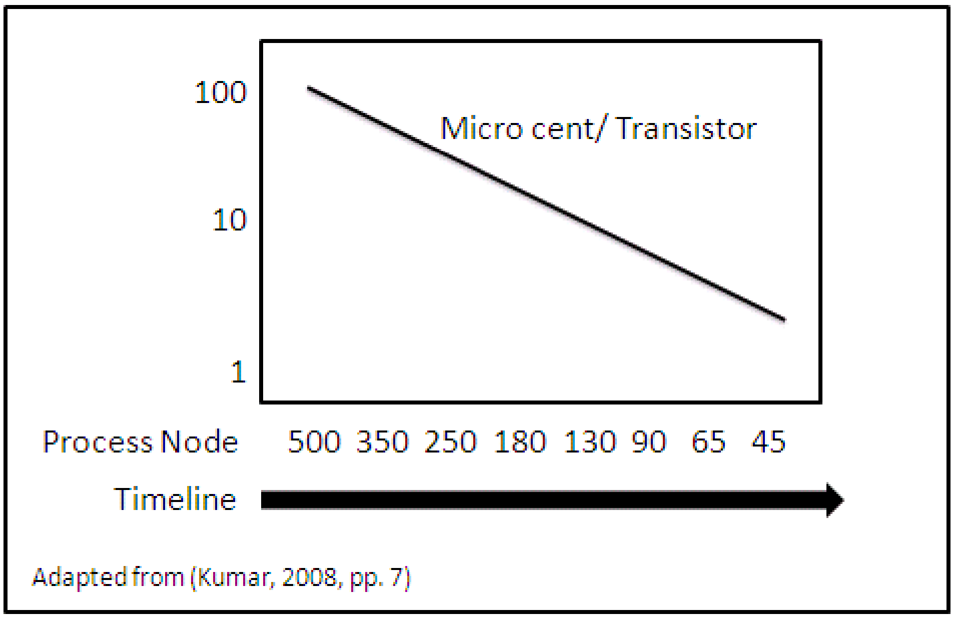


*Figure 4 Transistor cost vs. Process Node*

## 2.4 Product Evolution in the Semiconductor Industry

The mantra of the semiconductor industry is to create smaller, faster and cheaper ICs, with each progressive technology node creating smaller die with the same or greater functionality and cheaper manufacturing cost. Further miniaturization is important since it results in an increase in speed and performance combined with a lowering of power requirements. The key metric used to describe the density and scale of an IC are the number of transistors per device. Intense competition in the industry drives performance improvement such that the performance and density improvement between generations is greater than 50% (Kumar, 2008, pp. 99).

The higher density and resulting smaller size, to perform the same function, results in a proportionate 50% reduction in material cost. Therefore, customers of the semiconductor companies are constantly demanding the next generation of IC as soon as possible, to reap greater functionality, lower power and increased profit. This comes with the added benefit for a lower price and smaller physical size. As can be readily seen in any electronics store, consumers enjoy lower price and greater functionality year over year.

## 2.5 Semiconductor Product Segments

In general, the same design flow in Figure 3 can be followed for any microchip. The difference between different product functionalities lies in their complexity. Design and manufacturing time is proportional to complexity. A thorough understanding of the product lines in the semiconductor industry is not needed - it is only shown here to indicate which product lines are amenable to SCSP consideration. The linkage between SCSP and FSM companies will be touched on, which is based on established industry trends described for each product category (Industry expert #1, personal communication, May 3, 2010)[4].

The four main product categories which form the semiconductor industry (Investopedia, 2010) are described in the following sections:.

### 2.5.1 Memory

Memory chips are commodity products that are traded at daily spot prices. As such, margins are very small and FSMs do not participate in this area. IDMs are the sole manufacturers here. There has been much consolidation in recent years as combination of rivals business such as

[4] For details on the Industry Expert Interviews, refer to the Bibliography.

Intel and Micron combining their memory businesses (IM Flash Technologies, 2009). Large scale is needed to maintain commodity margins.

### 2.5.2 Microprocessors

Microprocessors are the central processing units (CPUs) that are present in any computer, phone or device that performs a computation. The largest semiconductor company, Intel, dominates this area followed by AMD (Reuters, 2010). Until recently both were IDMs, however, AMD has divested its FAB operations to partially transition to the FSM model (Clarke, 2010). There are some other niche manufacturers that focus on specific microprocessor markets such as mobile phones and small mobile computing appliances. The niche manufacturers are typically FSMs, such as Qualcomm, the largest FSM (Clarke, 2010). These niche manufacturers enjoy high volumes due to specific nature of their products. For example, they make microprocessors that have low power and functionality only for the smartphone market. These kinds of niche FSMs would be candidates to engage the SCSP model, since they are FSMs. Additionally, niche FSMs may find it very difficult to obtain the services of FABs and OSATs, due to very low volumes, which will force them to use the SCSP, at a possible price premium benefiting the SCSP.

### 2.5.3 Commodity Chip

These are standard chips such as power regulators that are simple in function and thus easy to replicate. There is a low barrier to entry to this market and margins are very small. The FSM and SCSP business models do not flourish here.

### 2.5.4 Complex & Custom ASIC

Custom microchips can be created for companies that need specific functionality that is not offered by off-the-shelf microchips. For example, a complex communications product by system-level manufacturer, Cisco will use Application Specific Integrated Circuits (ASICs) from a semiconductor company such as Marvell (Kumar, 2008, pp. 76). In this case, Cisco will contract Marvell to make the custom chips for exclusive use and not for sale to the general market. This subcontracting of custom chip manufacture is typically performed by a system-level company to a FSM. FSM companies developing products in this space have lower volumes. Thus, capital costs are substantial when amortized over individual products. To transfer some capital costs to the SCSP would create a healthier profit situation for the FSM. The SCSP can distribute the capital costs across its entire portfolio of customers.

## 2.6 Industry Evolution

Using the Abernathy-Utterback framework (Abernathy & Utterback, 1975) we see that the semiconductor industry has passed through the fluid and transitional phases and is now in the specific phase. The model examines product innovation, process innovation, the competitive environment and organizational structure.

The fluid phase in the semiconductor industry occurred prior to 1980. The framework correlates, since a major characteristic, highly-skilled labour and general-purpose equipment was prevalent at that time. As a result, outsourcing manufacturing outside of an IDM company was not possible, nor did FSM companies exist due to the captive nature of highly-skilled labour. The model follows that competition was not fierce and clear product segments had not emerged yet.

The transitional phase for the semiconductor industry occurred in conjunction with the emergence of the FSM company in the 1980s. Technology applications became specific and the range of product segments increased. Standardization occurred, for example, in the microprocessor market, Intel and AMD created products that were compatible with any personal computer system. Further standardization occurred in the memory segment, leading to interchangeable memory modules. Referring to the framework, the dominant design is the IC. The IC is the synthesized culmination of decades of development and introduced in previous product variations. Following the design flow with superior operational effectiveness to create an

IC and combining the synthesis of previous iterations leads to a dominant design within a product segment.

The first two phases can be characterized as exploratory and important for the forming of the industry. In the specific phase, incremental innovation and quality improvements drive product development. Clear product segments have emerged as described in section 2.5, and result in specific customers being served rather than general-purpose products. Manufacturing equipment is very specialized and highly skilled labour is no longer captive to the semiconductor company. This is correlated with the contemporary structure of the semiconductor industry where even IDM companies have chosen to divest their manufacturing base, such as AMD (Clarke, 2010) and employ the FSM model of outsourcing manufacturing. The ease with which outsourcing occurs allows the FSM to flourish. The dominant design of the IC, with standardized design and manufacturing flows, allows the targeting of product segments using the same base synthesized technology.

As follows with the specific phase in the model, competition is intense and there are some large FSM companies. Incumbent FSMs can secure their position with excellent supplier relations. The SCSP, out of necessity, which has to offer a competitive service to smaller FSMs, must also establish strong supplier relationships. An example is the current SCSP, eSilicon having an established contract with FAB TSMC (eSilicon, 2010a) since the year 2000. Based on eSilicon’s current revenues, the annual value of this contract is between USD $10 million and USD $20 million (Industry expert #1, personal communication, May 3, 2010)..The SCSP enables these firms, primarily FSM startups, to compete with incumbent FSM companies by rationalizing capital expenditures. Funding for the SCSP is provided by Venture Capital (VC) companies. The SCSP can better handle capital expenditures since they are distributed over all its customers.

By altering the business structure of new entrants into the market and to remove the main barrier to entry, which is very large capital investment, FSM startups can enter the market and focus on R&D efforts towards product design. The FSM startup may choose to maintain their operations infrastructure, but does not have the bargaining power of the incumbent FSM. The SCSP, with close relationships to suppliers and the ability to combine volume from various FSM customers enjoys greater bargaining power with suppliers than the single startup FSM.

FSM startup companies can only obtain Venture Capital (VC) funding if they use a model where they do not have to develop large capital manufacturing projects. Several FSM startup companies are funded every year (PricewaterhouseCoopers & National Venture Association, 2010, pp. 3) and no IDM companies are created. All FSM startup companies do not have an established manufacturing and operations team, and will likely not need one for several years. Using the SCSP as a consultant and partner in manufacturing gives both long-term cost and supply chain management benefits (eSilicon, 2010b).

## 2.7 The Semiconductor Value Chain

Inter-company relationships within the semiconductor industry, especially between a FSM and its outsourcing partners are vital to mutual profitability and form the business structure within the industry. Since the IDM generally does not have to maintain these relationships (save for base material suppliers) the discussion here will focus on FSM companies. This will help to frame the scope of the SCSP with relation to FSM companies (Investopedia, 2010).

When the semiconductor industry was firmly established in the 1970s, IDMs, such as Intel, controlled the entire process. This included all steps from specification through to design and manufacture. At that time, the cost of establishing a semiconductor wafer manufacturing facility (FAB) was much lower than it is today (Spectrum, 2003). The general trend is a doubling of cost for a FAB every four years, and in 2010 the cost is $4 Billion (Digitimes, 2010). Due to this large capital investment, alternative operational models have formed for companies within the semiconductor industry, particularly startup FSM companies.

FSMs are enabled by a variety of manufacturing partners as shown in Figure 5, with each arrow indicating a different value-added partner. Two main partners are FABs and OSATs who each specialize in particular manufacturing steps. Historically, FSMs managed all interactions represented by arrows. With the introduction of the SCSP, FSMs focus on product R&D, shown in the dashed shaded box. The remainder of the area in the dashed box is the core domain of the SCSP, and outside the dashed box remains the area of FSM responsibility.

The FAB and OSAT value-added manufacturing partners add the largest amount of cost to an IC (Industry expert #1, personal communication, May 3, 2010). The FAB and OSAT partners work on standardized technology and processes to enable multiple FSM companies to access their technology and services. FABs and OSATs will provide pricing to FSMs based on individual product volumes.

The SCSP can gain economies of scale and bargaining power against the FAB and OSAT partners by combining several FSM designs on a wafer. Operations and manufacturing functions are largely eliminated for FSMs. The combination of product volumes for all the FSM companies the SCSP is engaged in further increases bargaining power. Hence, the FSMs can enjoy better manufacturing costs over a direct relationship with suppliers.

In a typical scenario the lure of the SCSP can be illustrated with a FSM startup. FSMs in the startup phase can take several years to get to the point of manufacturing a product. Hence, they are reluctant to build and maintain an operations infrastructure to support sporadic manufacturing orders of prototypes (Industry expert #1, personal communication, May 3, 2010). It would be more efficient to use the capital for internal activities such as product R&D. Therefore, the large number of startup FSMs can now turn to the Value Chain Provider (SCSP) to manage these manufacturing requests, without specific operations or manufacturing expertise. Two successful SCSPs are eSilicon and Open-Silicon.

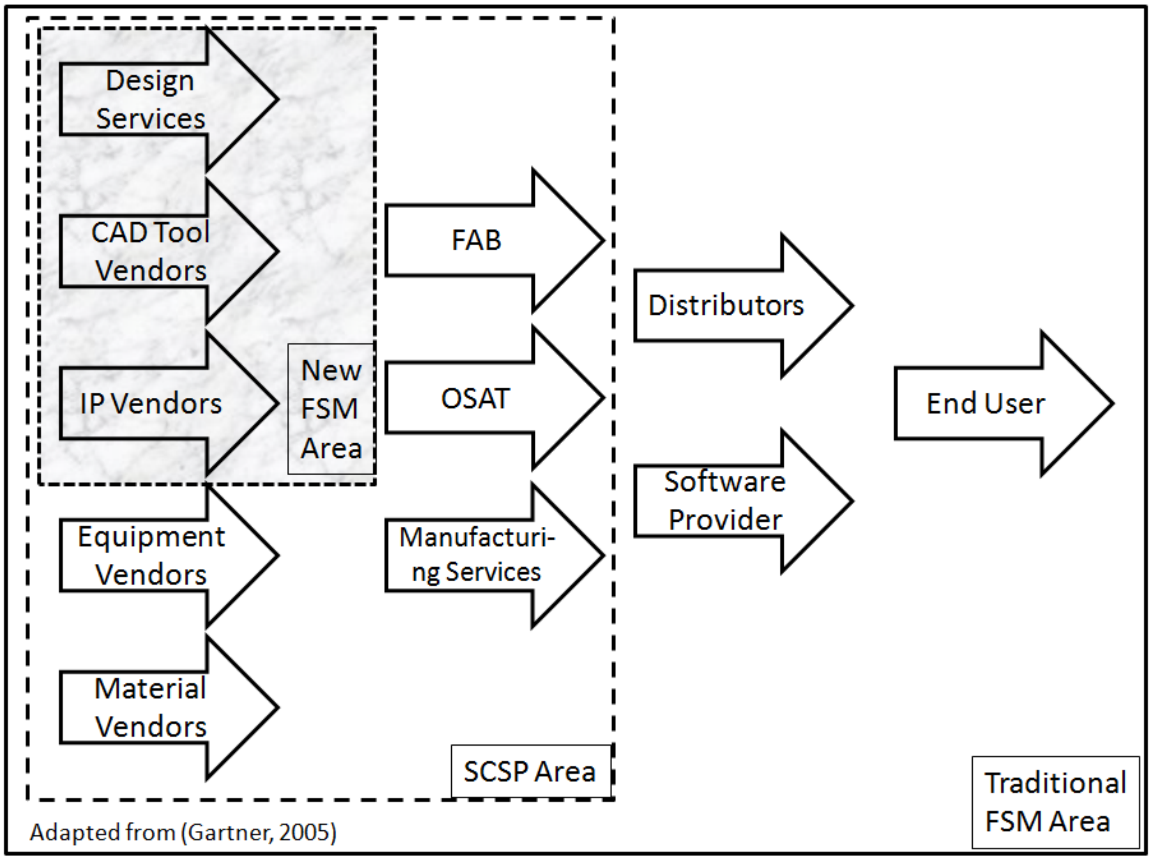


*Figure 5 Semiconductor Value Chain with SCSP*

## 2.8 Summary

The evolution of the semiconductor industry has been shown and using the Abernathy-Utterback framework it was determined the industry is in the specific phase. This phase gives rise to strong incumbents. However, the standardization of technology combined with the easier access to process synthesis knowledge, enables separation of the manufacturing and operations from the semiconductor company. The FSM model can exist in this specific phase and can be further enabled by the SCSP model.

The semiconductor value chain is centered around FABs and OSATs. Reducing their influence over an individual FSM is unlikely. Combining multiple FSM companies business, the

SCSP can increase its bargaining power against the manufacturing value chain providers and enable lower pricing for the individual FSM. FSM startups are also reluctant to create their own operations and manufacturing organizations which favours the usage of the SCSP model.

# 3: Semiconductor Business Cycle and Competitive Analysis

Over the past thirty years there have been several hundred FSM startup companies (Kumar, 2008, pp. 35) that have attempted to create a profitable business within the semiconductor industry. The attractiveness of the semiconductor industry is primarily due to the high gross margin in certain product segments within the industry. Segments that are attractive to FSM startups enjoy a high gross margin for their multi-year development efforts. For example, the ASICs noted in section 2.5.4 have a gross margin of approximately 50% (Model N, 2007). This is one of the highest gross margins in the technology industry and is similar to the software industry. As such, FSM startup companies receive among the largest amounts of venture capital (VC) annually, amounting to over one billion dollars in 2009 (PricewaterhouseCoopers & National Venture Association, 2010, pp. 3). Thus, investors are continually willing to back FSM startup companies at the same rate as software-based and biotechnology startups, which are two other popular investment areas.

Here, we will describe the key business features that are present in the semiconductor industry as a whole, with a focus on relevance to the FSM.

## 3.1 The Semiconductor Business Cycle

A common topic in the semiconductor industry is the reference to the semiconductor business cycle. This is in reference to the constant cyclical nature of the industry that is characterized with distinct peaks and valleys as shown in Figure 6. The business cycle is created due to an excess in inventory that causes a retrenchment of supply. As the supply draws down, due to demand as in (c) inventory shortages cause prices for components and manufacturing services to go up. The increase in prices drives down excess demand to (d) and further to (a). IC prices are driven lower and demand begins to pick up towards (c) again. In general, there has been no stable equilibrium in the cycle and it is expected that the cyclical nature of the industry will continue (Kumar, 2008, pp19). The IC market can be described to lag supply demand in sufficient time, due to manufacturing lead times that can be 4-6 months long. A cycle lasts approximately two years.

This regular pattern can be used to the advantage of a FSM company to plan product entry and phases where R&D should be intensified so a product can be launched when suitable demand is present. Introducing a new product when there is excess inventory of an existing product whose price is being marked down is not a desirable situation for a FSM startup company. It would be more prudent to delay product launch to add features not present in current solutions.

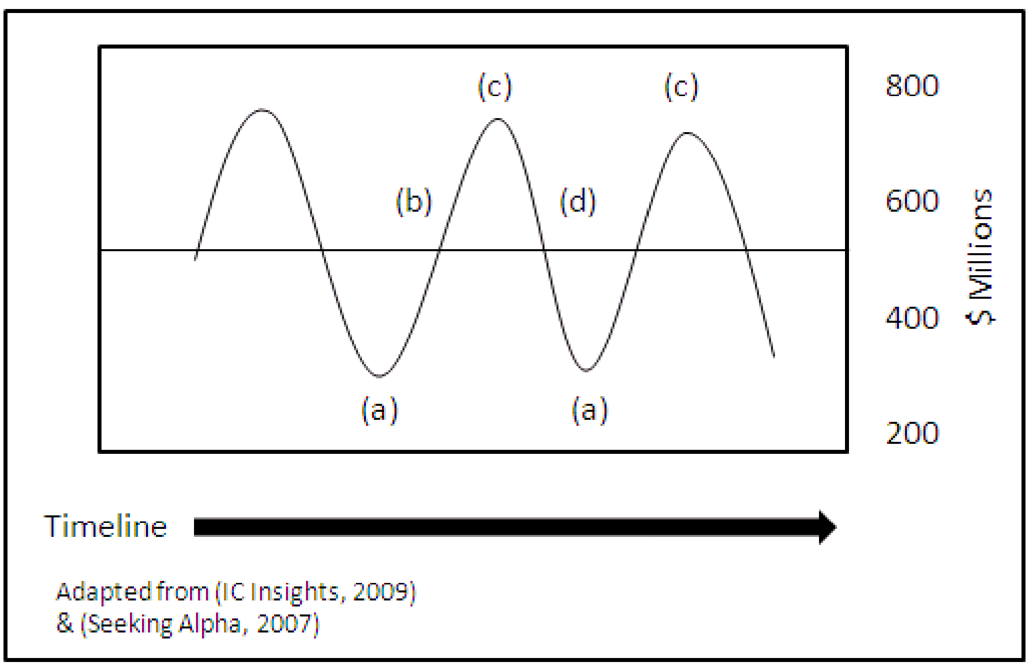


*Figure 6 The Semiconductor Cycle: Excess Demand in the Semiconductor Industry*

The predictability of the semiconductor cycle also means that delivery dates and schedules for R&D and product development must be adhered do. Delays in these activities may result in a product launch in a time where inventories are high. This is especially important for a FSM startup, where their VC funding typically allows them to pursue a single product to revenue. Missing a scheduled launch date may mean the demand for a particular product vanishes in favour of a newer product when the cycle is in a more positive phase. This can happen since the cycle may take up to 2 years to reverse itself. If the FSM startup company has missed its only opportunity to launch a product, it is possible for another company to enter the market at a more positive time in the cycle and with additional features.

For the SCSP it is important to work with their customers, FSMs, to understand their schedules. If the SCSP is in the position to pick which customer projects to prioritize, due to resource allocation or profitability, then a full understanding of their customer markets, launch and revenue timeframes is needed.

Impacts on the semiconductor cycle from excess manufacturing capacity also occur from the length of time it takes to build a FAB. Including planning it can take up to five years to build a FAB (Kumar, 2008, pp. 15) and there are often delays. Delays in building a FAB can result from R&D delays, building delays or investment delays. Due to the increased productivity and throughput of a new FAB, the enormous amount of capacity added can drive down material prices. In the case where the FAB is delayed, the reduced manufacturing capacity in the industry can drive up material prices. The introduction of a new FAB is of most benefit to the industry in an upward trend or peak in the semiconductor cycle since it avoids companies building large inventories to protect against FAB supply constraints. An increase in inventory is generally correlated with a peak or downward trend in the semiconductor cycle (Seeking Alpha, 2007).

Semiconductor companies face a primary challenge seen in most other industries: when is the best time frame to introduce a technology and whether to be a market leader for the technology or wait for the market to develop and then introduce an incremental technology. FSM startups are likely to aim to be market leaders for a particular technology, since they would like to edge out incumbent players before they have a chance to entrench themselves in a new market or product segment (Kumar 2008, pp 62). The SCSP should tailor their services to FSM startup by offering the latest in semiconductor manufacturing processes. Although, it is in the best interest of the SCSP to use the latest FAB technology, there is a risk to being an early adopter. The SCSP should evaluate the maturity of the newest process technology before investing time and capital in a new process. Picking the correct process technology to develop is a very complicated and multi-faceted problem that needs to consider several constantly changing factors (Kumar, 2008, pp. 102).

Some key company drivers and risks are shown in Table 1 and Table 2. All semiconductor companies take these primary views when planning their business and also have to examine where in the semiconductor cycle the industry and their segment in the industry is. Effective long-term business planning should employ these basic drivers as well as specific criteria for the products and technologies the company employs.

*Table 1 Company Drivers*

| Company Drivers | Impact | Measured By |
|---|---|---|
| Market share gains | Drives revenue and earnings increases | Units shipped vs. competition |
| Higher margins & profits | Absorption of higher fixed costs contributes to lower unit costs | Manufacturing process efficiencies |
| Higher product performance vs. the competition | Stimulates greater enthusiasm for end products and support | Performance results based on industry benchmarks |
| Adapted from (Investopedia, 2010) | | |

*Table 2 Company Risks*

| Company Risks | Impact on Fundamentals |
|---|---|
| Weak economy and/or product environment | Shipment volumes may be negatively affected |
| Delayed delivery of products | Loss of revenues, profits and competitive position; potential reduction in demand for current chips |
| Sever price competition | Shrinking profit margins |
| Failure to keep up with technology | Increasing chip complexity requires more advanced processes to keep costs under control |
| A slowdown in pace of electronic equipment replacement | Depresses industry organic growth rates |
| Adapted from (Investopedia, 2010) | |

## 3.2 Summary

It has been shown how the semiconductor business operates in a cyclical manner and the typical challenges faced by the companies in the industry to bring products to market.

During the analysis, it was also shown how SCSP can aid the FSM in bringing a product to market while preserving capital for product R&D functions. The SCSP also allows the FSM startup to compete against an incumbent large FSM or established FSM, by creating higher bargaining power against FAB and OSAT suppliers.

# 4: Semiconductor Consulting Services Provider

The semiconductor market is very competitive and to succeed, the best outcome is to get a working IC as fast as possible, with an optimal set of features to meet the market price and specification need. At every phase of development, there are significant obstacles to surmount: IC design complexity; multiple suppliers; integration challenges; and time-to-market pressures. These obstacles directly affect reliability, profitability and ultimately a company's reputation.

## 4.1 An Overview

To mitigate some of these challenges, especially those relating to manufacturing and operations, the SCSP business model presents a significant opportunity for new entrants. This model has been established since the year 2000 by eSilicon, whose current revenues are approximately USD $100 million (Yahoo, 2010b). There is considerable risk in pursuing an internal manufacturing and operations model. In order to engage with FAB and OSAT providers, considerable effort has to be made to show the future value of the FSM's business. By engaging with the SCSP, the FSM does not need to concern itself with such distracting inter-company marketing efforts. Using a SCSP with an established quality control methodology will also mitigate using technology that is not possible to manufacture in high-volume.

The overall semiconductor industry generates approximately three hundred billion USD in sales annually (IC Insights, 2010b). Semiconductors ICs are key components in almost every manufactured item and the breadth of applications is growing with disposable electronics and flexible electronics, which can be applied to clothing. The flexibility of the IC manufacturing model means that the SCSP can manufacture products for all these end-markets. Rather than focusing on one segment, as a FSM has to, the SCSP will have several customers from a variety of segments. This increases business resilience for the SCSP from one FSM company or IC end-market failing.

The customer focus of the SCSP is the FSM division of the overall semiconductor market. The main industry association for this segment is the Global Semiconductor Alliance (GSA), formerly the Fabless Semiconductor Alliance (FSA). The addressable market of the FSM part of the semiconductor industry is over one hundred billion US dollars (IC Insights, 2010a). As noted previously, there are several FSM startups annually and the SCSP would be well served to engage with these companies early on, so as to gain business at the time of production ramp up.

## 4.2 Key Success Factors of SCSP

The attractiveness of the SCSP primarily comes from two areas: FSM Startups, who do not have any infrastructure; and existing semiconductor companies (Fabless or Integrated Companies) (Industry expert #3, personal communication, July 9, 2010). The success of a SCSP company depends on its ability to attract new businesses from each of them.

FSM startup companies typically have one product that takes three to five years to get to the production stage. Therefore, the manufacturing and operations infrastructure (both human and capital) that is only used occasionally becomes a large drain on limited capital resources. It is advantageous to offload these activities or subcontract to someone who has already developed expertise in this area, especially when these activities will only be used occasionally. Successful SCSPs such as eSilicon and Open-Silicon develop complete expertise and systems in manufacturing and operations that are designed to work well in conjunction with FSM design environments. In this way, the handoff from product R&D to manufacturing is handled smoothly (eSilicon, 2010a).

Existing FSM or IDM companies may be in the same situation as the FSM startup, i.e., developing products with limited manufacturing resources. This can occur with the creation of a new product line or division, with a limited R&D budget and limited spare internal resources. Additionally, the IDM will be reluctant to disrupt its high volume manufacturing lines for the manufacture of a low volume prototype. Due to the standardized nature of IC manufacturing, the incumbent company can prototype with the SCSP and later transfer the IC manufacturing to the desired manufacturing flow.

Key success factors for the SCSP are (Industry expert #3, personal communication, July 9, 2010):

- Attracting business from FSM and IDM companies
- Developing complete expertise and systems in manufacturing and operations
- Delivering subcontracted services on time and to specification

Therefore, the attractiveness of the SCSP model can be summarized in Table 3.

*Table 3 SCSP Attractiveness*

| SCSP Customer | Attractiveness | Notes |
|---|---|---|
| Integrated Device Manufacturer | New product line in low volume does not interfere with mass manufacturing | IDM Manufacturing lines setup for very high volume. |
| Existing Fabless Company | Take mature product out of internal management | Frees up limited resources. |
| New Fabless Company | Avoid capital overhead of manufacturing & operations organization | Typically focused on one product. Operations infrastructure unused for long periods. |

## 4.3 Key Capabilities of the SCSP

The SCSP must maintain core capabilities that define its product offering. The fact that the FSM is using the services of the SCSP requires that the SCSP have experts in manufacturing, technology implementation, and operations. The FSM will have very minimal staffing in these areas. This is especially true for a FSM startup, where they is no staffing. Therefore, the SCSP becomes an outsourced replacement for those traditional FSM functions.

These core capabilities become comprehensive services and an infrastructure that are needed to meet market demands. The SCSP model is a flexible, low-cost, lower-risk way to IC manufacturing success. The power of the model is that it can even be flexible to most product segments. The overall structure of the SCSP will create an integrated approach that incorporates design, productization and manufacturing services into a seamless environment for customers. FSM customers, in particular, can benefit from the SCSP approach, since they can focus on R&D product design shown in Figure 2. With the superior predictability a SCSP offers, faster time-to-market for IC design is achieved for the FSM.

This approach also gives competitive advantages over traditional sub-contractors that only focus on a particular part of the IC design flow. Traditional sub-contractors partner with a subset of suppliers, and therefore, the technologies they offer are limited in scope and are not economically competitive. This results in dramatically reduced flexibility and higher operating costs, two factors that can keep the contracting company from its full potential success.

The SCSP therefore, must create an extensive network of Value Chain partners to make it possible to provide a competitive solution. The key partners are FABs and OSAT partners who compete with each other. This allows for market forces to dictate the best partner to solve a technical, logistics or pricing problem. Furthermore, if needed, an efficient and custom value chain can be created for each IC. This may result in further operational efficiencies or cost savings, for example if the IC end market is geographically close to its manufacturing location. The overall goal being on-time delivery and rapid adaption to market changes from FSM through to the SCSP. The key capabilities of the SCSP result in some major advantages for the FSM, which are shown in Table 4.

*Table 4 SCSP Advantages*

| Advantage | Notes |
|---|---|
| Reduced design, overhead and manufacturing costs | |
| Lower technical, financial, quality and delivery risks | |
| Ability to tailor value chain for specific customer needs | |
| Centralized resource of manufacturing and operations expertise | |
| Access to IP at reduced cost | Use economies of scale |
| Quick response to market needs | SCSP has supply contracts |
| Ongoing development of supply chain relationships | |
| Avoid distraction of FSM away from product R&D | |

## 4.4 Expansion of the SCSP Model beyond Manufacturing and Operations

There are cases where the FSM may consider using the SCSP for work in the design flow that is pre-manufacturing. An example of this work is a minor product revision. IC design and manufacturing is a complex process that involves large amounts of human expertise and computing power. Figure 7 shows some details of a general IC design flow, each step is related to a CAD tool operation. This figure represents steps (b) and (c) in Figure 2. To envision how the SCSP may interact with the design flow, a shaded box is shown where the design information may be passed to the SCSP. Due to the modular nature of the IC Design Flow, this step may be moved closer to the design specification stage, giving more value-added work to the SCSP.

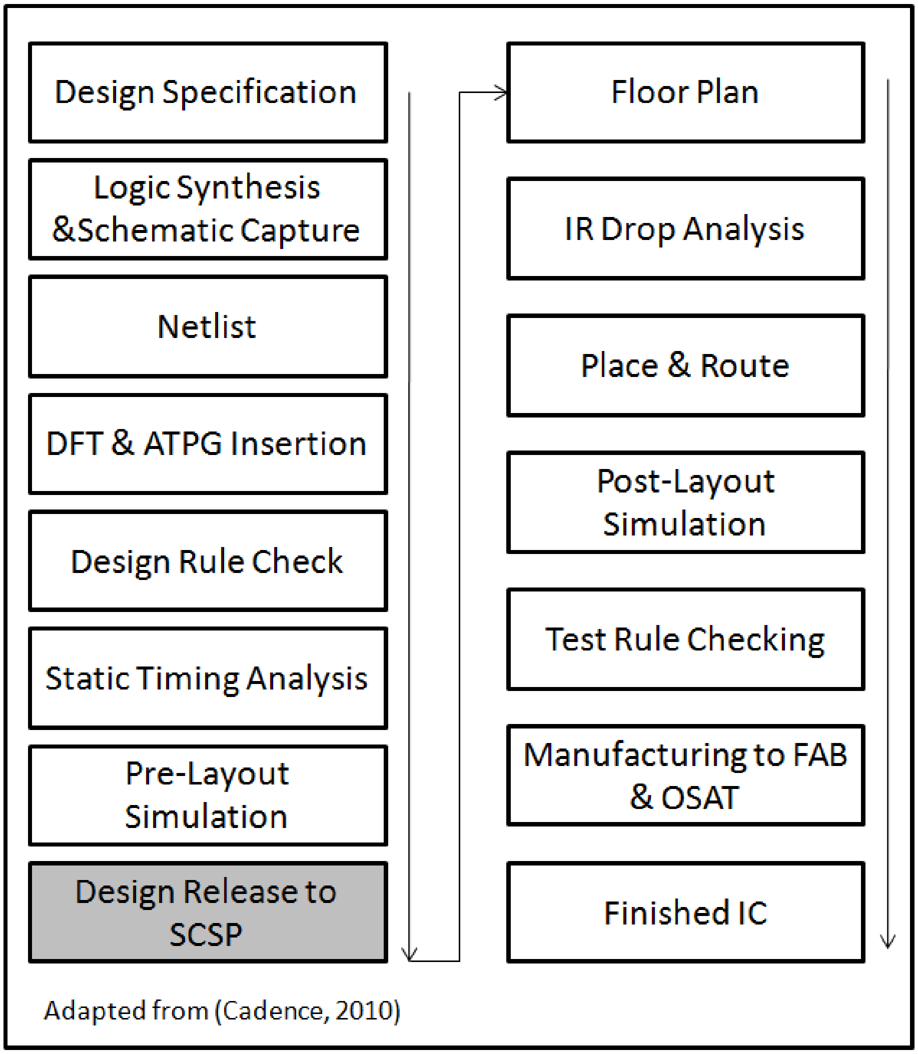


*Figure 7 General IC Design Flow*

Each IC design is different, so a rigid process is not compatible. Instead, an analysis must be done as to the design requirements and CAD tool flows that must be used. Based on these specific needs, a modification to a reference design flow (Cadence, 2010) can be created which combines both design and manufacturing aspects. Particular attention must be paid to:

- Design Services and third party IP adoption

- Pre-production readiness services
- Operations and Manufacturing Services

This can be tailored, depending on the engagement with the customer. When all of the above is fully integrated, the customer will realize full value in time and cost.

### 4.4.1 Design Services and Third Party IP

The customer can choose the scope of design services needed from the SCSP. This can range from R&D to simple implementation of a specification. In some cases, the customer may have performed most of the work and a simple revision is needed to the design of the chip to be followed by the requisite manufacturing steps.

Typical design services that are offered include:

- Physical implementation: place & route, timing analysis, extraction, verification and DRC, DFT/DFM: testability analysis, test development and manufacturing process analysis
- Package design: custom package design, thermal analysis and chip/package interface simulation

### 4.4.2 Pre-Production Readiness

These services are sometimes referred to as Test Engineering. This focuses on getting the IC design ready for mass manufacturing. The SCSP will have expertise in test and manufacturing-setup services that enable the smooth transition to the manufacturing stage. The services here interact closely with some aspects of the design service to ensure a smooth handoff. In cases where a revision is needed, data is generated from test engineering to be passed back to design for debug, analysis and revision implementation.

It is expected that the SCSP customer will engage all IC designs with this service since they are very closely linked with manufacturing services. Key tasks include:

- Device qualification: custom qualification programs, stress and life testing
- Fast/slow device characterization
- Yield ramp: test data analysis and process tuning

### 4.4.3 Operations and Manufacturing Services

The marketing of the SCSP as a viable alternative to in-house manufacturing operations requires the SCSP to engage fully with FAB and OSAT companies, on behalf of the SCSP customer. The engagement should be contractual and formal and include preferred pricing for services over what the SCSP customer would obtain if contracting the FAB or OSAT companies directly.

The SCSP will engage multiple suppliers to ensure that there is contingency for their customer base in the case of supply disruption. Geographic diversification is also needed since most manufacturing is in the Asian region, which has areas of political instability. For example, manufacturing in South Korea should be duplicated in another region (South Korea is under constant threat from North Korea).

Basic capabilities in this area include:

- Relationship with FAB and OSAT suppliers, enabling manufacturing with the latest processes
- Using multiple suppliers to address standard and custom IC design needs
- Relationships with testing facilities for effective support of chip requirements

## 4.5 Summary

An engagement solution for each project and customer is needed to get results on time and with predictable outcomes that meet the specifications agreed to in the contracting agreement between the SCSP and its customer. In time, the SCSP will develop a portfolio of successful projects, which will demonstrate the maturity of its manufacturing and operations systems expertise. Expansion of the key capability of the SCSP to IC design is possible. This effort would begin with minor product revisions.

# 5: Strategic Analysis of the SCSP

With respect to the SCSP, a strategic analysis will be performed to review both external and internal environments. This analysis can be used to develop strategic decisions in a formal business plan for the SCSP. It is expected that this analysis will lead to more focused strategy aligned with the core capabilities of the SCSP and market needs for the new SCSP venture. Here, we will perform a macro environment analysis (Grant, Robert M, 2005, pp. 68) followed by an industry analysis using Porter's Five Forces. Figure 8 illustrates this concept.

## 5.1 External and Macro Environment Analysis

We will now focus on the SCSP segment of the semiconductor market and examine the factors that exist regardless of the existence of the new SCSP venture for which this opportunity analysis is written. The factors considered are outside of the industry environment shown in Figure 8.

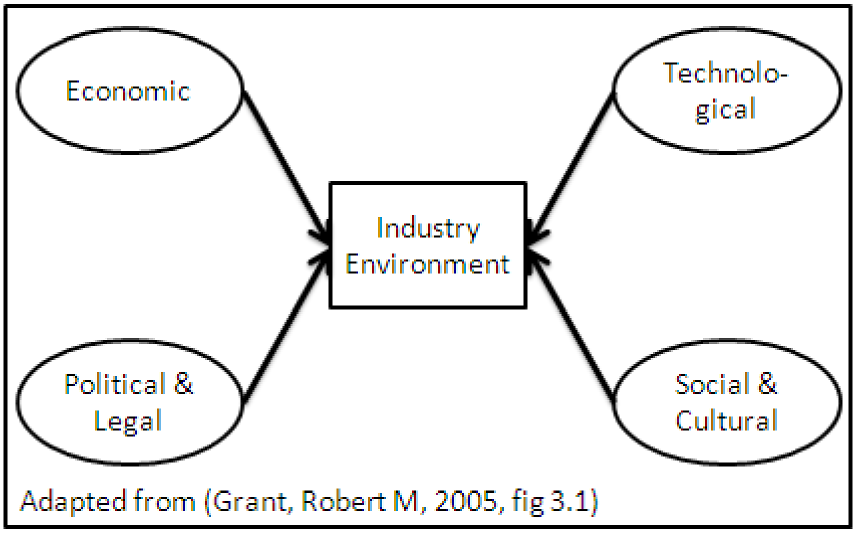


*Figure 8 Macro and Industry Environment Analysis*

### 5.1.1 Economic Trends

The semiconductor market and thus the SCSP market, follow the general economic trend of the global economy. Due to the intertwined manner with which trade follows between all continents, there is no economic isolation to the semiconductor market from any one geography. Almost every modern piece of goods or equipment contains semiconductors and there is a close correlation between the revenue in the semiconductor market and the overall global economy (Kumar, 2008, pp. 35). A healthy global economy will result in increased revenues in the semiconductor industry, and there will always be a need for semiconductor products.

Since the global economy is headed by major economic superpowers, USA, China and Japan, it follows that these are the major consumers of semiconductor products and services globally (Kumar, 2008, pp. 35). Any significant downturn in these economies will result in a large impact to the SCSP market. In particular, if the SCSP targets FSM companies there may be a delay in revenue realization as the pace of product adoption slows in a reduced economic-output period. In fact, in times of fiscal constraint, FSM companies are likely to reduce internal expenditures on operations and manufacturing, thereby, opting to choose a more cost-effective route of the SCSP.

### 5.1.2 Political and Legal Trends

#### 5.1.2.1 Environmental Considerations

A common agenda in developed and developing economies in the global conscience is to the environmental stewardship of resources and the handling of waste. Major conferences such as the Kyoto Conference have resulted in global accords such as the Kyoto Protocol (UN, 2010). The aim is to achieve global consensus on this matter. The semiconductor industry has been described as one of the most environmentally impactful industries of the modern age. Considerable amounts of chemicals and energy have to be expended in the manufacture of these miniature IC products. Until recently, lead was very common in the manufacture of IC products and special handling precautions were needed in the manufacture and use of these components.

Various regulatory requirements have been brought forward over the previous decade. The incipient legislation was the Regulation of Hazardous Substances (RoHS) of the European Union established in 2002 (EU, 2010). The regulation is phased in time to allow for the industry to develop suitable technological solutions to the elimination of hazardous substances, such as lead. The principal aim of the legislation is to eliminate the disposal of hazardous materials. Economies such as China, Japan and USA have also developed their own similar regulation.

Although the legislation to-date has been on the disposal of hazardous materials, a general shift in focus has been for electronics manufacturers to take cost ownership of the disposal of materials, rather than burden local governments.

The end result of all the regulation is to increase compliance costs in the semiconductor industry. This is particularly true of manufacturing operations since material manufacture and sourcing is the principal activity here. Since the SCSP focus is operations, a sufficient amount of effort needs to be paid to the regulatory aspects and compliance with them. For example, the EU and China have different labelling requirements for hazardous substances.

Technical risks in this area have decreased in recent years due to the development of alternative materials such as lead and other hazardous substances. As the sourcing markets for these alternative materials mature and volumes increase, the costs of these alternative materials are reducing towards the costs of the incumbent materials.

#### 5.1.2.2 Anti-Competitive Behaviour

Several large IDM companies have been targeted by legislators in the USA, Korea and Japan for anti-competitive practices, such as market manipulation, price fixing, supply restriction and misuse of influence due to a dominant position. Settlements have been issued and agreed upon for these infractions such as a recent one by Intel Corporation (Associated Press, 2010). In some cases, legislators have deemed that the penalty is to impose an import duty on certain types of semiconductor components. This behaviour is restricted to IDM companies. Some of the legislative action has also been prompted by protectionist sentiment to protect domestic industry, such as the memory segment in South Korea which is dominated by a few key IDMs (Rust Consulting, 2010).

The SCSP is largely immune to these forces, since the key target market are FSM companies which have not been involved in such litigation. The products that are the target of this behaviour are primarily in the microprocessor and memory segments, both of which are unlikely to be managed by either FAB/OSAT partners or the SCSP. The IDMs are likely to keep those contested segment manufacturing operations within their internal operations organizations, due to the reduced margins and specialized technological processes. This lack of transparency is also what masks the anti-competitive behaviour.

### 5.1.3 Technological Trends

The technological environment in the semiconductor industry favours the SCSP. The reorganization of the supply chain from one dominated by several large IDM players, to one with a large number of FSMs with few IDMs, is a result of the enormous technological R&D and capital cost involved with bringing a new technology node (ref. Section 2.3) to the manufacturing stage. As noted previously, the R&D and capital cost involved for each node is in excess of two billion US dollars. For each FSM to invest that capital in a manufacturing facility is not practical.

The core competency of the FSM is to focus on product R&D and design execution, with almost no investment in manufacturing and operations infrastructure. The VC funding a FSM startup will also be unwilling to finance a manufacturing infrastructure that will require enormous resources to maintain, especially since there are viable alternatives such as managing FAB and OSAT suppliers directly or engaging a SCSP to do so. Further, a SCSP is more cost-effective to the FSM company, since it requires no operations or manufacturing expertise to be developed by the FSM and it meets the VC goals of using capital for product R&D and design.

The main metric used to judge the semiconductor industry is Moore's Law. It is predicted that there are some technological headwinds to the continuation of this Law. However, other types of product topologies, such as Through Silicon Vias (TSV) are poised to become mature technologies (Kumar, 2008, pp. 172) which would still keep the current FAB and OSAT and supply chain structure intact for at least twenty years.

### 5.1.4 Social and Cultural Trends

#### 5.1.4.1 Consumer Electronics

Growth in the consumer electronics segment has increased exponentially in the past decade (IC Insights, 2010a). This has been the primary driver for semiconductor products, in particular, products that have mobile functionality such as mobile gaming and smartphones. As a result, revenues in the semiconductor industry are on track to their largest increase ever (IC Insights, 2010b). We will use the smartphone as an analog for consumer electronics in general.

The high semiconductor value within each of these devices is exemplified by a recent device, the iPhone 4, which carries a total manufacturing cost of $187.51 out of which over $100 is attributable to semiconductor-based components (iSuppli, 2010). Characteristically, most high value components within this Bill of Materials (BOM) are from FSM companies. Some commodity elements such as memory components also make up the BOM however, their value and margin do not amount to a high value with the smartphone.

Social trends also favour greater smartphone and mobile electronic device adoption. A highly mobile workforce, as well as one open to new technological innovation and constant renewal of devices, also bodes well. The smartphone has become a good indicator of consumer electronics mass adoption (Gartner, 2010). Mobile phone sales have increased globally 17% between 2009 and 2010, whereas smartphone sales are accelerating growth during the same period, at 48.7%. The strong growth in smartphone sales combined with the high semiconductor value components within, correlates with record semiconductor industry revenue. Therefore, the direct relationship between consumer electronics end-market growth and FSM companies is strong. Since the focus market of SCSPs is also FSM companies, this is a very positive factor to drive SCSP revenue and Total Addressable Market (TAM) growth. In particular, by focusing on FSMs that supply ICs into consumer electronics, end-markets will yield superior economies of scale for the SCSP, as well as large bargaining power with suppliers.

#### 5.1.4.2 Demographic Trends

A large percentage of the global population is under 30 (UN, 2010b) and will continue to be so past the year 2050. Further, many of the countries that are home to these people are have underdeveloped communications infrastructure. Some of these countries, such as India, Brazil and China are emerging industrialized economies. In choosing the build out of new telecommunications infrastructure, most are favouring a wireless infrastructure for its lower cost over a fixed-line infrastructure. The wireless infrastructure is being built to support a high amount of data traffic which supports smartphones.

The demographic trend in industrialized nations is for the age group under 20 to have high smartphone adoption (Marketing Charts, 2010). Continuing this trend to other economies and accounting for a higher age group to have the same adoption rate, the global smartphone adoption rate will continue to accelerate. Even if a large percentage of this demographic does not choose a smartphone, the semiconductor value component of a traditional mobile handset is significant. As economies of scale progress, smartphones will become cheaper and purchase of the smartphone will become the status-quo for mobile users, even in developing economies. This trend has already emerged in developed economies such as the US and Canada, with over 50% of new handset sales as smartphones (Gartner, 2010).

Following the analog of the smartphone as a consumer electronics device that is accelerating in growth it can be seen how the semiconductor industry can benefit. This phenomenon is very strong and has resulted in a reorganization of ranking within the top FSM companies (IC Insights, 2010a). In particular, the FSM company can benefit by creating ICs that target these end-markets. The SCSP can also realize this trend and tailor specific services towards these FSM companies.

Next we will use Porter’s Five Forces analysis (Porter, 1985, pp. 7) to focus on the SCSP environment in particular. It helps to competitively position the SCSP amongst its competitors, suppliers, and customers. The relative strength of each force to create competitive rivalry will be determined.

## 5.2 Porter's Five Forces Analysis

To show the attractiveness of the semiconductor industry, an analysis is needed to define the competitive intensity of the industry. The perspective taken here is to assess the relationship between suppliers, FSMs and IDMs. The following is an analysis using Porter's Five Force Framework as shown in Figure 9.

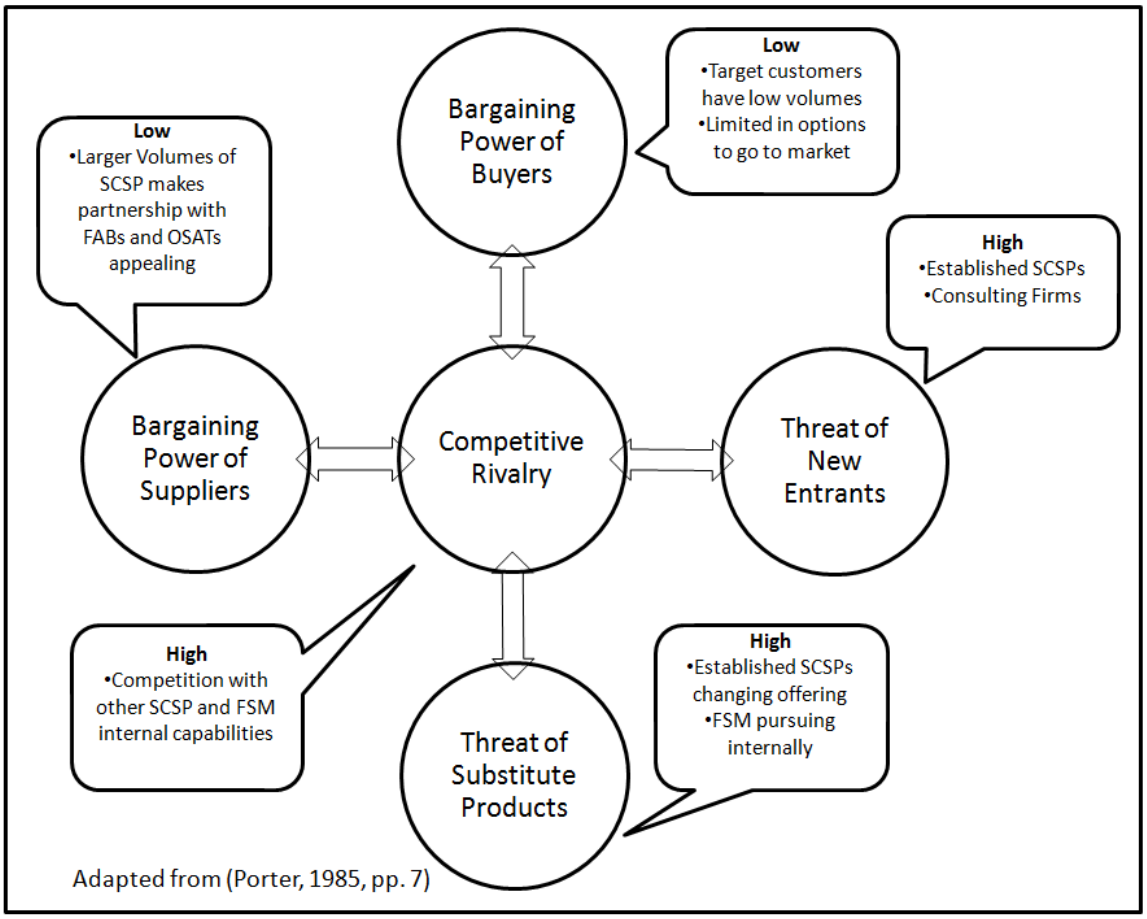


*Figure 9 Porter's Five Forces*

Five-Forces analysis is general for the value chain partners shown in Figure 5. The forces will be examined from the point of view of IDMs and FSMs and the impact of the SCSP entrant. In that view, the FSM or IDM manages all value chain relationships shown by the outer box.

### 5.2.1 Threat of New Entrants

The threat of new entrants in the current industry is high. The impact of the SCSP on the industry increases the competitive forces on both IDM and FSM companies. In turn, this increase may accelerate FSMs adoption of SCSPs, which would entice more potential SCSPs to enter.

Due to the fact that developing a modern semiconductor manufacturing capability would require billions of dollars in capital, there are no legitimate threats to an incumbent IDM company. In some cases, IDMs merge some product lines and operations to create a new IDM venture such as the case with Intel and Micron in the flash memory segment (IM Flash Technologies, 2009; Kumar, 2008, pp. 73). Therefore, new IDM entrants in the industry are only from IDMs spinning off parts of their business or FSM startup companies. Product segments that have lower margins are controlled by IDMs and are not attractive to FSMs.

In some cases, a FSM startup will form from the departure of key personnel from an IDM. Human talent and experience are very important in the semiconductor industry and VC investors will require a very experienced team, both managerially and technically, to lead the formation of a FSM startup. This model is favoured by VC companies since the focus of invested capital is in Intellectual Property (IP), rather than manufacturing and operations overhead. In current efficient capital markets, where multiple investment vehicles are available, VC investors can choose to invest their capital where there is highest return. These investment choices cause investment-hungry FSM startup companies to plan capital usage efficiently and reduce non-accretive investments, due to the limited amount of capital available (IC Insights, 2010a).

New entrants are possible, mostly via the FSM startup route. Starting product R&D requires relatively low barriers, only a computing infrastructure. Since FSM startups do not have a manufacturing infrastructure, they turn to FABs and OSAT companies that handle all the manufacturing activities of the FSM company. Typically the FSM company would have a very small operations team to manage the FAB and OSAT activities. It is typical for the operations team to be non-specialized and commonly the R&D project leader (Industry expert #2, personal communication, June 8, 2010).

This model has been further refined by having the FSM use a SCSP to manage all the FAB OSAT activities, which does not require any significant internal FSM human resources to switch between R&D and operations management roles (Industry expert #2, personal communication, June 8, 2010). It is not advantageous or capital-efficient for a FSM startup to build an operations team when their key task is to focus on R&D. SCSPs specialize in manufacturing operations and can also deliver a lower cost product due to economies of scale.

Summarizing, the threat of new entrants to compete against IDMs and FSMs is high. With the emergence of the SCSP, barriers to entry with respect to financial and technological requirements are lowered further, consequently increasing the competitive forces on IDMs and FSMs.

### 5.2.2 Power of Suppliers

Before the entrance of SCSP, power of suppliers is low against IDMs and FSMs. There are several suppliers of contract manufacturing services within the FAB and OSAT models, which allows the IDMs and FSMs to choose the lowest price supplier. The effect of the SCSP is to reduce competitive pressures on FABs and OSATs.

The SCSP can combine the volumes of multiple customers to create a compelling business proposition to the FAB and OSAT suppliers via formal supply contracts. Therefore, it would be more advantageous for the FAB and OSAT suppliers to engage with the SCSP rather than the multitude of FSM companies the SCSP is engaged in (Industry expert #3, personal communication, July 9, 2010). In this way, the FAB and OSAT suppliers will give preferential pricing to the SCSP over the individual FSM company. An example is the preferential contract that eSilicon has with the FAB TSMC (eSilicon, 2010a). In dealing with a reduced set of customers, via the SCSP, and higher volumes economies of scale will dictate higher efficiencies for the suppliers. This naturally leads into less competitive pressure from higher operating margins.

Since IDMs perform most manufacturing internally they will not gain directly from the SCSP entry. The IDM's base material suppliers do not enjoy any power. Since an IDM has its own FABs, suppliers typically provide raw materials such as chemicals and other commoditized items. The IDMs are effective in controlling these kinds of suppliers and maintaining competition between the suppliers to enjoy the best raw material pricing possible. The IDM is analogous to any mass-market vertically integrated industry.

It has been established that it is not capitally-efficient for a FSM to have its own manufacturing infrastructure. Hence, FSM companies rely on FABs and OSAT suppliers. Since a single FSM does not have a large revenue, when compared to the industry overall, it is difficult for FSM companies to have a very large influence on suppliers. In fact, FABs and OSATs are known to be very selective in picking the FSM companies they deal with, in order to maximize the productivity of their manufacturing operations (Industry expert #2, personal communication, June 8, 2010). Criteria such as business volume, product mix, and product lifetime are all considered by the FAB and OSAT company when initiating business with a FSM company.

FSM companies can obtain better power over their suppliers by joining operations with other FSM companies. However, this is most-often not possible due to IP and competitive concerns. A more suitable way is to use the SCSP where the SCSP will combine the business of a multitude of customers to obtain better pricing over the FAB and OSAT suppliers, as well as have a proposition that is more productive to the FAB and OSATs manufacturing processes. In general, since the majority of business of FABs and OSAT companies comes from FSMs, they have to strike a balance between having high margins and allowing the FSM company to flourish with preferred pricing in the early product stages. However, such opportunities are limited and working directly with those suppliers may cause a FSM to miss product schedules and pricing. This is a difficult balance, and the SCSP favours the FSM while largely still maintaining pricing and schedule targets at the FABs OSATs.

Summarizing, base material suppliers have little power against the large scale of a vertically-integrated IDM. The IDM will not be impacted by the SCSP. FAB and OSAT suppliers will have reduced competitive forces by engaging with the SCSP, while simultaneously gaining more internal manufacturing efficiencies and higher product volumes.

### 5.2.3 Power of Buyers

Before the entry of SCSPs, end customers in the semiconductor industry enjoy a competitive marketplace but typically do not have high power overall. The majority of volume in the industry is controlled by IDMs who dictate pricing and supply. The buyers will gain power by the SCSP entry since the barrier to entry for FSMs is lowered and alternative products to that delivered by IDMs are possible. Buyers can also gain power to dictate more product features to the FSM since the FSM now is focused on product R&D rather than manufacturing and operations development.

Some industry segments such as microprocessors are controlled by a handful of companies, such as Intel and AMD. The technological complexity of the microprocessor product has not allowed any other company to attempt to enter that market. Buyers are at such a disadvantage that government intervention has occurred in cases where unreasonable collusion has occurred. There have been several cases against Intel in this regard (Associated Press, 2010).

Nonetheless, there are industry segments where there is a significant amount of competition and buyers have significant power even to the extent of commoditized spot pricing. This is seen in the memory sector where there are several large IDM competitors building identical products in very large volumes and identical specifications. The market pricing of the products are based on spot market pricing and contract buys.

Other product segments in the semiconductor industry will have reasonable competition and in most cases, there will be several FSM companies building similar products (Kumar, 2008, pp. 39). Thus, buyers will have power to influence features and pricing and create competition between FSM companies targeting a particular segment. In some cases, a FSM startup engaged in a particular product segment will fail leaving only a small number of viable alternatives for the buyer. In that case, the power of the buyer may be reduced or eliminated. Common buyer practice is to ensure there are sufficient alternatives for the IC part they are procuring, examining the health of their suppliers as well as awarding business to several companies (Industry expert #2, personal communication, June 8, 2010).

Summarizing, buyers have limited power in certain segments, like microprocessors where incumbents have traditionally been IDMs and when there is very high R&D and technological complexity in implementation. In other segments where FSMs are incumbents or new startups, there is power for the buyers. For example, the buyer can create a specification and ask several companies to bid competitively against each other for the business (Industry expert #2, personal communication, June 8, 2010). The SCSP can enhance the power of buyers since internal resources of the IDM or FSM can be geared towards delivering the best specification independent of manufacturing and operations capabilities.

### 5.2.4 Threat of Substitutes

Due to the specific nature of the IC design flow, there are no practical technological alternatives to consider to achieve the same end goal of a finished IC with similar performance characteristics (Grant, Robert M, 2005, pp. 73). The IDM or FSM company may choose to pursue a substitute manufacturing process. However, alternatives would be at considerable expense and distraction to the product R&D focus.

Demand-side substitutes to IDM and FSM products may occur when reduced functionality is needed by customers. The customers will also anticipate that, using an elastic demand model, pricing for these substitute products will also be lower.

In certain product segments, such as the microprocessor segment, the technological complexity and manufacturing prowess needed is a complete barrier to entry but substitutes are available with reduced functionality and lower cost. In most other segments there are substitutes available with similar functionality. Due to buyer requirements to maintain multiple suppliers of important IC components, there are often two or more substitutes for a particular product. Pre-SCSP the semiconductor industry can be characterized as having a high threat of substitutes for the IDM and FSM products especially due to the demand-side considerations.

In segments where the product is a commodity, there are several alternatives to choose from as well as an almost infinite amount of performance levels. An example is the memory segment where IDM companies differentiate on price versus performance aspects, and operational effectiveness.

Intellectual Property (IP) and R&D expertise may allow for a barrier to entry in some segments with complex products. A profitable segment will attract interest, especially from FSM startup companies, who have R&D expertise or are able to make a next generation product with much improved performance. The end-customer will often encourage this behaviour and share key specification information with the competitive FSM company. That will enable a demand-side substitute.

The SCSP reduces the barrier to entry for new FSM companies and allows quicker creation of demand-side substitutes, such as lower functionality product variants. These startups may have products that can substitute products of both IDM and FSM companies. Hence competitive pressures will increase for both IDMs and FSMs. Technological substitutes for ICs are not economical feasible and do not pose a threat for IDMs and FSMs.

### 5.2.5 Competitive Rivalry

The entry of a SCSP into the semiconductor industry would create a great deal more rivalry between IDM and FSM companies. Before the entry of SCSP the semiconductor industry is intensely competitive. Due to the ever-increasing capital cost of accessing and maintaining manufacturing and operations flows, it is expected that new FSM startups will only look to SCSPs for services that do not fit within their product R&D focus (Industry expert #3, personal communication, July 9, 2010). Further, since some IDM companies, such as AMD, are converting to the FSM model, there is large amount of new business that is now accessible to the overall SCSP. An SCSP with a strong competitive position can enable a FSM to compete effectively against an IDM.

In all segments of the semiconductor industry there is competitive rivalry - even in the case of the two large IDMs in the microprocessor segment, Intel and AMD, where there has been a long-standing competition to create the best product. Segments where the end market is consumer-based tend to have the most rivalry (Kumar, 2008, pp. 30). The continual output of new consumer products on an annual basis forces supplying semiconductor companies into an intense competition to capture market share. The competition is renewed regularly due to the insatiable demand for consumer electronics. Therefore, FSM startups are regularly conceptualized with products targeted to the consumer end market.

The high profitability of lower volume segments in the semiconductor industry, such as the ASIC segment, also attracts new entrants and creates competition. Lower volume ICs often have high functionality and long development times, which allows competitive rivalry to emerge.

Often, a competitor may decide to enter the segment, driven towards higher profit margins (Industry expert #2, personal communication, June 8, 2010). If the competitor has considerable resources, such as a large FSM, it would create an intense situation of competition where large efforts are needed to convince buyers of the worth of the incumbent company's offering. The smaller incumbent can also focus on non-tangible aspects such as high-quality customer service.

The SCSP can help FSMs where the competitor has larger resources or is another FSM company. The SCSP can allow the FSM to focus on its product R&D efforts to reach to the manufacturing step. Next, regardless of the current revenue or operational strength of competitor company, the added bargaining power of the SCSP will aid the FSM market entrant to get the product manufactured quickly and at a reasonable cost. Therefore, the SCSP further lowers the barrier to entry in creating an IC especially for the FSM startup.

The intense competition in the industry is transferred to others in the semiconductor supply chain such as FABs and OSAT companies. These suppliers also have intense competition for business from the semiconductor companies with the highest volumes and revenues. The end benefit of this competition is to produce high-functionality products with substantial annual improvements in cost and performance. The negative aspect for FABs and OSAT companies is that this intense competition for standardized manufacturing processes drives down gross margins. The SCSP further intensifies the competition by pooling together FSM volumes to create an even bigger bargaining position.

The complicated interrelated relationships in the semiconductor industry create a high competitive rivalry among FSMs and IDMs. IDMs tend to compete with other IDMs, especially in the same segment, whereas FSMs typically compete with all other FSM incumbents or start-ups across segments. This is because FSMs have the flexibility to choose multiple product segments to enter using generalized manufacturing processes, whereas the IDM has somewhat specialized manufacturing processes for their segments. There are some cases (because of product or technological disruption) where a FSM may compete with a part of an IDM business. For example, Qualcomm (FSM) creates mobile microprocessors and so does Intel (IDM). The entrance of the SCSP will enable higher competition between IDMs and FSMs.

#### 5.2.6 Impact on the Semiconductor Industry by SCSP Entrants

Based on the above Five Forces analysis specific to the SCSP, Table 5 summarizes the impacts of competitive forces on each of the following players, namely, IDM, FSM, FAB and OSAT players. As previously shown in Figure 5, the focus area for the new SCSP is FSMs. On the one hand, the introduction of FSMs causes the relationships in the supply chain to change. Although the industry effects are noticeable, they are unlikely to cause material impact on IDMs because of the large size and strong presence of IDMs in the overall industry. On the other hand, the entrance of SCSPs will be most noted in the core FSM, FAB and OSAT areas, where the scale of the business is appreciated and understood. Companies in FSM, FAB and OSAT areas will most likely depend on SCSPs to succeed in order to deliver increasingly technologically advanced manufacturing processes to market.

The largest impact to the IDM is the potential conversion of other IDMs to FSMs. The converted entity has a large sum of operations and manufacturing business that is now available to SCSPs or directly to FABs and OSATs. Successful execution of this conversion may lead to increased pricing pressure to incumbent IDM. The contemporary example is from AMD’s conversion to a FSM in the microprocessor segment, leaving Intel as the sole IDM incumbent in that segment.

Another key development is increased competition due to a reduced technological barrier to market entry. With the SCSP working in conjunction with the FABs and OSATs to deliver manufacturable solutions, the comfort with which VCs can fund FSMs increases. Individual FSMs will have reduced prototype timelines and quicker time to market, further attracting VCs to the semiconductor market, with its already high profitability measures. Table 5 summarizes the pre-SCSP starting point and shows the impact on supply chain partners. In general competitive forces in the industry increase with the introduction of the SCSP model. In particular, the IDM will face a high degree of competitive forces overall.

*Table 5 Impact on Semiconductor Industry of SCSP Entrant*

| | | **Impact of competitive forces on each partner as a result of SCSP** | | | |
|---|---|---|---|---|---|
| | **Overall industry pre-SCSP** | **IDM** | **FSM** | **FAB** | **OSAT** |
| **Power of suppliers** | Low | Neutral<br>IDMs still maintain high power | -<br>SCSP aggregates multiple FSM giving FSM advantage | -<br>SCSP has greater negotiating power over FAB | -<br>SCSP has greater negotiating power over OSAT |
| **Power of buyers** | Low | +<br>Buyers have more semiconductor companies to select from | +<br>Better managed supply chain reduces inventory | +<br>Better managed supply chain enhances productivity | +<br>Better managed supply chain enhances productivity |
| **Threat of new entrants** | High | +<br>New entrants may create disruptive products | +<br>Easier for FSM entry. Clear alternative to spending internal resources. | +<br>Competition for more business, faster adoption of technology | +<br>Competition for more business, faster adoption of technology |
| **Threat of substitutes** | High | +<br>Substitutes may emerge for traditional IDM products such as microprocessors | +<br>Easier to switch, revise and do major modifications to product offerings | Neutral<br>TAM does not change with substitutes | Neutral<br>TAM does not change with substitutes |
| **Rivalry** | High | +<br>Increased rivalry between FSM and IDM. Especially between IDM converting to FSM. (eg. Intel and AMD) | +<br>More FSMs entering and easier to start and fund companies | +<br>Easier for VC to fund FSM startup. FAB gains additional manufacturing $ regardless of future success. | +<br>Easier for VC to fund FSM startup. OSAT gains additional manufacturing $ regardless of future success. |

## 5.3 SWOT Analysis

To organize the external and internal forces as well as analysis given in previous sections, a SWOT Analysis table is generated as shown in Table 6 The SWOT analysis can be used by the new SCSP venture to set objectives and flag any of risks in the environment.

### 5.3.1 Strengths

It has been established that the SCSP is an established model through industry expert statements and evolution in the semiconductor industry. SCSPs such as eSilicon have successfully created a business over the past 10 years. Cost advantages of the model have become clear as well as the close association between the SCSP and the FSM. The SCSP is able to use its total volume and business manufacturing revenue leverage to develop formal supply contracts with suppliers such as FABs and OSATs. These formal supply agreements enable FSMs to access technology they would otherwise be unable to access, due to low volumes.

### 5.3.2 Weaknesses

A potential weakness of the SCSP model involves accepting the expenditure of some capital costs that would have been otherwise borne by their customers. This weakness can be reduced by amortizing these capital costs across several customers, especially if the customers are targeting the same segment. Some process and manufacturing development will also have to be pursued by the SCSP. Again this cost can be amortized against many customers making the value proposition of the SCSP apparent through superior pricing to their customers.

If a FSM company that the SCSP is engaged in fails, then there will be lost time and opportunity, as well as capital equipment and material that may not be useable elsewhere, Whereas a healthier FSM should have been picked as a customer in conjunction with products for end-markets that are likely to enjoy high growth, such as consumer electronics. These statements are particularly true for a SCSP that has just begun business.

### 5.3.3 Opportunities

The evolution of the industry towards higher numbers of FSMs is apparent through the conversion of IDMs, such as AMD to FSMs. FSMs have manufacturing and operations business open to bid by FABs and OSATs. The SCSP can divert that direct business by providing a compelling case to the FSM to reduce any capital costs and manufacturing process development by allowing the SCSP to engage on those fronts. Engagement of the FSM and SCSP can lead to other value-added services such as design.

### 5.3.4 Threats

The large number of industry consultants and acceleration of IDM conversion to FSM likely means that there will be other SCSP entrants. Some FSM companies may be reluctant to outsource internal manufacturing and operations functions to the SCSP, much less design functions. Complex process technology may take a long time to develop and in some cases a FAB may take an unexpected extended period of time to properly develop a process node (LaPedus, Mark, 2010). The semiconductor cycle may also factor into the total volume of existing and new business that is available. Correct contingency and business planning can mitigate some of these factors as will be seen in the next section.

The SCSP should be very cognisant of the Semiconductor Cycle. Product deliverables and launch should be timed to coincide with a stable industry inventory condition. For new product areas, competitive product maturity should be judged as well as total product volume consumption. Judging the TAM will reduce the chance of inventory ‘hangover’.

*Table 6 SCSP SWOT Analysis*

| Strengths | Weaknesses |
|---|---|
| -SCSP is established model<br>-Cost Advantages<br>-Exclusive access to FAB and OSAT technology | -Credibility of new company<br>-SCSP customer fails<br>-Capital investment needed for some operations equipment |
| **Opportunities** | **Threats** |
| -IDM converting to FSM<br>-Offering value added design services<br>-VCs favour using SCSP | -Other SCSPs<br>-Internal FSM operations<br>-Manufacturing technology complexity<br>-Semiconductor Cycle |

## 5.4 SWOT Strategy Matrix

Using the SWOT Analysis table, a sample SWOT Strategy Matrix can be generated as shown in Table 7. Here each box summarizes key strategies to be employed from the combination of factors in the SWOT table, as well as the discussion prior to this point. Updating this SWOT analysis regularly is needed due to the fast pace of the semiconductor industry and potential changes to the industry supply chain structure. In particular, ensuring that the strategies to address weaknesses are executed will result in a balanced risk to the operation of the company, especially in the case of capital equipment expenditure.

*Table 7 SCSP SWOT Strategy Matrix*

| Strengths-Opportunities | Weaknesses-Opportunities |
|---|---|
| -Target FSM startups &VCs to generate business<br>-Formal supply contracts with FAB and OSAT technology to guarantee cost savings to customers | -Join industry associations to establish credibility and link to existing SCSPs<br>-Target customers in different end markets<br>-Target customers where capital expense can be reused |
| **Strengths-Threats** | **Weaknesses-Threats** |
| -Present at conferences and industry meetings to show how SCSP is better than internal FSM resources | -Work closely with FAB and OSAT partners to develop technology<br>-Monitor the stage of the semiconductor cycle and invest capital accordingly |

## 5.5 Summary

In this strategic analysis of the SCSP environment, external, internal and a SWOT analysis was presented. It was shown that the entrance of a new SCSP into the market is favourable and can be managed effectively through strategies shown in Table 7. The efficient and strategic use of capital for the new SCSP is important in order to become and established company in the SCSP arena. Targeting new customers by focusing on FSM startup and VC companies is likely to generate new business and establish credibility.

# 6: SCSP Addressable Market

The addressable market for this product offering is quite large. As noted, the total semiconductor industry has gross sales of over $300 Billion US Dollars. Although, the design flows and task associated with bringing an integrated circuit to production are compatible with almost all of the companies in the semiconductor industry, it is expected that the SCSP model will resonate greatest with FSMs.

## 6.1 Needs Assessment

Interviews were performed with three senior managers in the semiconductor industry to gather a set of needs that are currently not addressed sufficiently by current players. One senior manager stated that current SCSP companies do not offer point solutions to FSM companies (Industry expert #1, personal communication, May 3, 2010). Current SCSP providers aim to sell a complete solution by marketing full design services and operational services. However, the key IP that a FSM company has is contained in its IC design. All FSM companies are reluctant to release this information since gaining market advantage by fully developing the product internally before manufacturing is a main focus of their activities. A FSM company's VC investors consider this R&D capability a key capability that must be maintained internally to gauge progress and be able to adjust on short notice. By outsourcing this to a SCSP company under a contractual specification of the work to be done, control to change will be lost, without financial penalty. The best case would be to provide a point solution for managing manufacturing operations activities when the FSM startup company is ready to manufacture.

A second interview with a senior manager in a FSM startup company revealed that current SCSP companies are very selective as to the scope of customers they engage with

(Industry expert #2, personal communication, June 8, 2010). SCSP companies tend to be evaluative of the FSM company's end markets and pre-judge success. The current SCSP companies only focus on what they deem to be the most high-growth markets, such as consumer segments, and offer them preferential pricing over other FSM companies. It was stated that it is hard to get the full attention of the SCSP company when they do not believe that the product of the FSM company will not be eventually successful.

A third interview revealed that a lack of resources in the SCSP company can lead to less than ideal response time when an issue needs to be resolved (Industry expert #3, personal communication, July 9, 2010). It is desirable for the FSM company to outsource the manufacturing operational functions to the SCSP, however continual support is needed after prototype part delivery. Current SCSP providers view their responsibility as ending when the parts are delivered. Prototype parts in the semiconductor industry need attention during the prototype debug phase, some of which can only be obtained through the manufacturing supply chain - in particular, the test engineering functions. In some cases, the parts have to be returned into the manufacturing flow for debug. This flexibility in going back and forth between the FSM company and SCSP manufacturing flow, particularly in prototype debug, is lacking. This in itself may cause the FSM company to keep ownership of manufacturing operations in house.

In general, all respondents stated that if the SCSP executes well and there is good cooperation through all phases of product development, they would be willing to give further business to the SCSP and even expand the range of business offered. The FSM startup company is reluctant to share IP upfront, however, if minor revision is needed to the product, they could pass that to the SCSP while focusing their internal resources on new product development.

Thus, the appropriate strategy to follow for the SCSP to engage with a FSM startup would be to first enable manufacturing operations success, including excellent prototype delivery and development. Next, in further engagements the SCSP could be entrusted with some design work and execute on manufacturing and volume production. This two-phased approach may appear to the SCSP as a longer route to revenue, but in the long-term, would result in a better customer experience and the confidence needed to maintain a long-term relationship.  The SCSP can use this strategy to further grow the business.

## 6.2 Potential Customers

The two major categories of companies within the semiconductor industry are Integrated Device Manufacturers (IDMs) and Fabless Semiconductor Manufacturers (FSMs). IDMs typically have a large investment in infrastructure and maintain their own design, manufacturing and operations staff and facilities. FSMs do not have any manufacturing facilities, and outsource some or all of their manufacturing and operations activities.

Although the two major categories can be viewed as separate, there are some relationships and modifications of the structures that allow the SCSP model to fit well within either of these major categories. Here, we will further breakdown the categories and show how the SCSP model fits within these subcategories

### 6.2.1 Pure IDMs

Pure IDMs usually have multi-Billion dollar revenues and sell hundreds of millions of products each year. They have several large divisions with the company that focus on major market segments such as consumer and enterprise categories. A good example of a Pure IDMs is Intel Corporation.

Due to the high manufacturing efficiency the Pure IDMs have, they typically do not want to run lower volume production, since it would mean a disruption of their high efficiency. However, they have a need to do some lower volume production in new market segment that have not reached a volume that would meet the efficiency requirements of their manufacturing lines.

They handle this situation by outsourcing this lower volume manufacturing to Offshore Semiconductor and Test (OSAT) providers until the volume reaches a point that justifies bringing the manufacturing in-house to take advantage of internal manufacturing efficiencies.

The SCSP can work with the Pure IDM by managing all the operational and manufacturing requirements of this kind of lower volume product, since the IDM typically does not have the infrastructure to deal with manufacturing flows that are not internal. When the product hits a critical volume, the IDM can then bring the manufacturing in-house.

### 6.2.2 IDMs partially using FSM model

Some IDMs prefer to maintain their core manufacturing capabilities within the corporation and look to OSAT vendors to manufacture non-core products. An example of this kind of company is Texas Instruments (TI). TI makes highly specialized analog components that it manufactures itself, in high volume. For other components that may be of high value but lower volume, it uses FAB and OSAT vendors to manufacture them.

The SCSP can enter this model by taking over the operational product management for the high value, low volume products. In this instance, it may not be efficient for TI to deploy its own operations resources on these products. The SCSP can easily manage these products within its portfolio, since it would be an incremental addition. TI can benefit by better using its operations expertise to manage its vertical manufacturing process.

### 6.2.3 IDMs converting to FSMs

Due to the large investment to build their own Semiconductor Fabrication Plants (FABs), many IDMs, in recent years, have decided to divest their manufacturing operations and use outsourced FAB and OSAT services. As geometries involved in the manufacture of semiconductor devices get smaller, the cost of FABs has reached the multi-billion dollar mark. Justifying that kind of investment on the basis of an unproven product volume or revenue is very difficult. Hence, leveraging the manufacturing facilities of a FAB or OSAT, where multiple IDMs and FSMs are manufacturing, lowers the risk while still allowing the use of a high-technology process.

One recent example of this model taking shape is the divesture of AMD's FABs as Global Foundries. AMD is a major competitor to Intel, but does not enjoy the volume and revenue that Intel does. Therefore, in order to stay nimble and reduce capital expenditure, the part of the company responsible for FAB operations was divested as a separate entity. However, it should be noted that not all manufacturing operations were divested, hence the transition from IDM to FSM is still continuing.

Here, the IDM clearly would like to approach the flexibility of the FSM model, while still retain efficiencies afforded by being an IDM. The SCSP can help the IDM gain the flexibility and efficiency of the FSM by creating a plan to transition products and use the SCSP expertise to manage the transition. In this case, similar to the Pure IDM case, the IDM has expertise to manage internal operations but needs to transition to managing FAB and OSAT partners. The SCSP brings this expertise and can act as a consultant during this transition. The SCSP can also manage products that this type of IDM does not want to focus on during the transition, such as low volume or products with a limited lifetime.

### 6.2.4 Startup FSMs and existing FSMs

Startup and existing FSMs are an offshoot of reluctance to invest large amounts of capital in a manufacturing facility. The advantage of the FSM model is to quickly gather a business idea and the human expertise and proceed with product R&D. In the average case, manufacturing will proceed at least two years later. Traditionally, the operations staff were hired closer to the volume production date and a series of FAB and OSAT vendors were contracted to perform the various steps of manufacture. In general, the operations and manufacturing activities are not a focus of the FSM, and treated as an afterthought. Therefore, in the rush to get manufactured parts steps are often missed and the quality of the initial product may be lacking.

Using the SCSP model, the startup Fabless company can defer hiring any operations staff for any manufacturing by subcontracting the SCSP. The SCSP will provide all operations services until several products with known volumes are available. During this time, the FSM can hire the needed staff to interact with the FSM, which will be much less than if it had to manage the manufacturing itself.

Since the Fabless company often does not have a large amount of financial resources, it can stretch its internal resources by subcontracting its operations activities to the SCSP until a future date. In many cases, the Fabless company will not get to a critical mass where several high-volume products are present. Typically, the exit plan for the Fabless company will be to proceed with a transaction where a larger FSM or IDM purchases the company. In that case, using the SCSP model, the company becomes more attractive to investors since the amount of operations overhead is very low due to the usage of the SCSP as a turnkey provider. Therefore, the FSM can gain immediate, intermediate-term and long-term benefits by engaging with a SCSP.

## 6.3 Total Addressable Market

Based on the above discussion, the companies that are immediately addressable as customers are FSMs. The structure of the FSM naturally allows the SCSP model to flourish, since the FSM company does not want to invest in a large operations and manufacturing presence, and is actively looking at more cost-effective ways to proceed with manufacturing. Using the expertise of the SCSP, the FSM can quickly build prototypes at various timeframes without engaging in extensive operational and plant planning.

The FSM market revenue is approximately $40 Billion as seen in Figure 10. Using an average industry gross margin of 50%, approximately $20 Billion is materials costs. These materials costs are spent directly on FAB OSAT providers that deliver manufactured semiconductor devices. Therefore, the total available market for the SCSP will be, at most, $20 Billion.

| Company | 2009 Revenue ($M USD) |
|---|---|
| Qualcomm | 6,585 |
| AMD | 5,252 |
| Broadcom | 4,190 |
| MediaTek | 3,500 |
| Nvidia | 3,135 |
| Marvell | 2,700 |
| Xilinx | 1,675 |
| LSI | 1,445 |
| Altera | 1,165 |
| Avago | 870 |
| Novatek | 819 |
| Himax | 685 |
| Realtek | 615 |
| Mstar | 605 |
| CSR | 600 |
| Qlogic | 530 |
| Theros | 530 |
| PMC-Sierra | 495 |
| MegaChips | 480 |
| Silicon Labs | 440 |
| Zoran | 345 |
| SMSC | 280 |
| Semtech | 250 |
| Ricktek | 244 |
| Conexant | 240 |

Adapted From (IC Insights, 2009a)

*Figure 10 Top FSM Companies*

## 6.4 Market Entry Strategy

Based on the needs assessment, the product offering to a new customer can be tailored towards the nature of the customer - IDM or FSM. It will also be shown that the focus of the SCSP will, initially, be in the operations and manufacturing space.

### 6.4.1 Product Roadmap

As seen in Figure 11, the SCSP product roadmap includes phases to increase sophistication of the product offering. Initial capabilities will be focused on delivering productization, operations and manufacturing capabilities. Once FSM startup customers are established, next steps involve fully developing the design and Computer Aided Design (CAD) infrastructure capabilities. With an established track record, deployment of design and CAD infrastructure to existing FSMs and FSM startups can be pursued. This would aid FSMs who would like to start the R&D process quickly and not to develop this design infrastructure in-house, but would still like complete control of the R&D and design functions. Following the work to establish the product offering with FSMs, IDMs can be approached as customers.

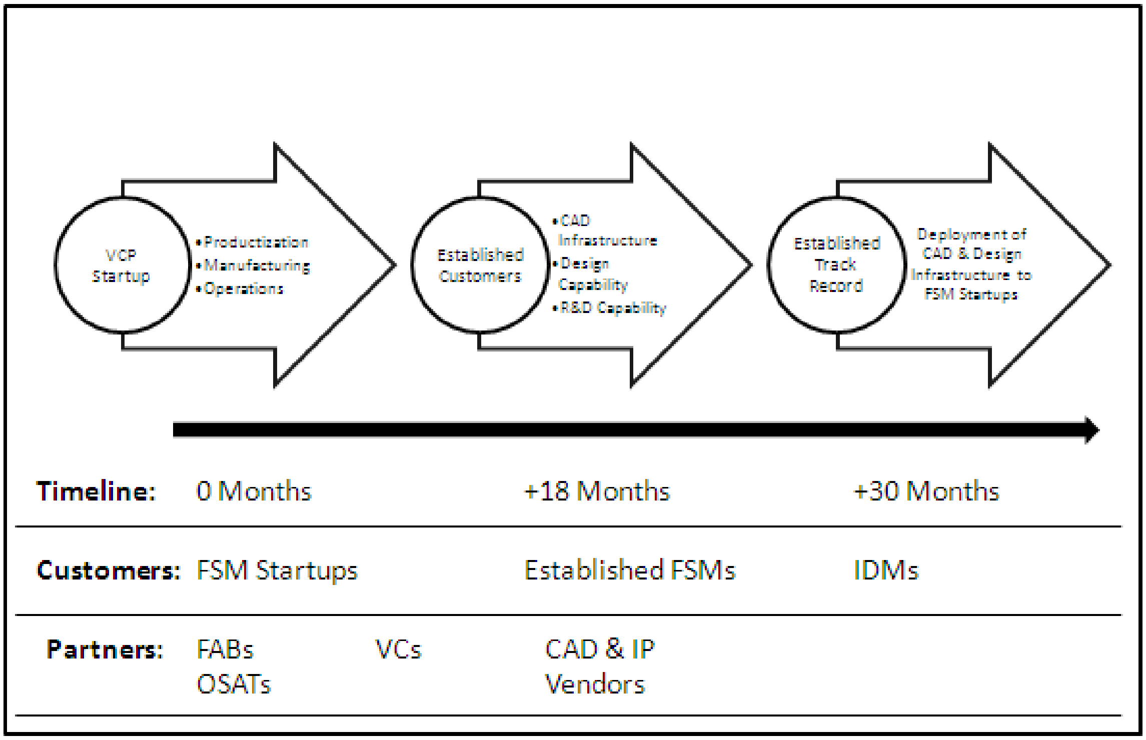


*Figure 11 SCSP Product Roadmap*

## 6.5 Customer Segments

Since the product roadmaps is phased to introduce different types of customers, a brief summary of the customer characteristics will be provided as well as customer expectations.

### 6.5.1 IDM customers

These customers have established design flows and internal operations activities. They are likely to be focused on outsourcing work that they do not have internal resources to manage. Such work would include low-volume prototype work that would disrupt their internal manufacturing activities. In some cases, an internal group will be involved in the design of a product that will be in the prototype phase for several years. The IDM does not want to disrupt its internal manufacturing activities to pursue the manufacture of this prototype product. However, this kind of low-volume manufacturing will fall within a suitable revenue stream for the SCSP. It is unlikely that the IDM will outsource any product design activity to the SCSP.

### 6.5.2 FSM customers

These customers do not have strong internal manufacturing operations capability. However, they have focused on developing strong R&D capability to design a product that is suitable for their end application market. The initial support they need is for prototype manufacturing and support, and will require a large amount of support for the debug and possible revision of the prototype. The SCSP can show their capabilities by delivering well on the prototype phase and taking on the design revision work. Successful execution of these activities can gain confidence in the FSM company to enable future business for the SCSP. As the FSM sees the capability of the SCSP and is more comfortable, the FSM can rely on the SCSP for design work it does not have internal resources for.

## 6.6 Marketing Strategy

Working in parallel with the product roadmap, marketing activities will keep the customer in focus as well as receive feedback that will aid in the definition of products and services. It is expected that the needs of the IDM and FSM are different, and will result in different mechanisms and methods of marketing as well as different product offerings.

### 6.6.1 Priority Market Segments

Initially, the SCSP will focus on the FSM startup customer market. These companies do not have any manufacturing operations capabilities. Thus, the SCSP product offering to these companies will be solely focused on productization and manufacturing activities. It is typical for a FSM startup to take at least 2 years to go from project initiation to the prototype manufacturing stage. Thus, the SCSP should engage FSM startups in various stages of this pre-prototype stage.

This will ensure a continuing flow of contracts to engage on. It is also expected that not all engagements will result in revenue due to the failure of some FSM startups to develop a product to the prototype stage. Secondly, some FSM startups will fail to secure a market regardless of making a prototype. A wide variety of engagements with FSM startups that have different end markets is necessary.

The second priority target customer market are existing FSM companies. These companies will find it attractive to outsource productization and manufacturing activities, rather than maintain the overhead of internal operations for a handful of products (Industry expert #3, personal communication, July 9, 2010). These companies may also be resource-limited to perform some minor design changes such as design revisions. The SCSP is capable of providing all these services.

The third priority customer market are IDMs. These companies have well developed internal operations and manufacturing capability and will only be willing to engage with the SCSP who has considerable expertise and proven experience (Industry expert #3, personal communication, July 9, 2010).

### 6.6.2 Market Expansion

Using FSM startups as a priority target area is suitable to expand the end market of the SCSP, since additional engagements with the FSM startup are possible. Once the FSM startup is satisfied with the SCSP engagement, more value-added business such as design work can be engaged on. Thus, the FSM startup will be able to focus on R&D and leave productization and manufacturing activities to the SCSP.

For the SCSP, gaining a successful track record is essential to engaging with existing FSM companies and IDMs. An initial engagement with these types of companies will likely involve the management of existing mass manufactured products. The IDM may also want to pursue prototype manufacturing with the SCSP, so as to not disrupt internal mass manufacturing lines for a low-volume new product development.

#### 6.6.3 Marketing Materials

Effective marketing can be achieved by meeting face-to-face with FSM and IDM companies. Due to the nature of the product, mass marketing in mass media will not be effective. There are key trade publications such as EETimes that have targeted advertisement to professionals in the semiconductor business, who will be aware of the general nature of a SCSP.

Secondary marketing activities are at trade shows and conferences. Seminars and speeches can enable widespread knowledge of the SCSP capabilities, and in particular, the differentiation that the current company brings to the SCSP landscape (Botten & McManus, 1999).

Other marketing activities involve meeting with VC companies who specialize in providing funding to the FSM startup companies. The key theme to be discussed is how the VC funding can be best used by using the SCSP, since internal resources do not need to be deployed in the operations and manufacturing areas.

Marketing with customer feedback and case examples will be effective once the company has a track record. Further credibility can be gained with feedback from IDM customers.

Constant visibility at semiconductor industry events is needed. Visibility at industry associations, such as Global Semiconductor Alliance is also necessary and has already been pursued by current SCSP companies such as eSilicon.

Differentiation through marketing can be carried out by tying credibility to the SCSP branding. Having key initial customers, likely FSM startups and their VC partners, and successful execution of deliverables, will build this credibility.

## 6.7 Establishing the Competitive Advantage of SCSPs

Using the Strategic SWOT Matrix of Table 7 in conjunction with the market description above the competitive opening and advantage becomes apparent. A combination of customer service differentiation as well as focused services for FSM startups will establish the competitive advantage of the SCSP. Strategically targeting a set of customers, beginning with FSM startups, is more likely to build a customer base in the SCSP initial phase of business operation. Partnering with VC firms who fund FSM startups will also be effective, since they will be interested in the effective use of their capital. Combined with strategic alliances with FAB and OSAT vendors to obtain preferred pricing will create a competitive advantage.

The competitive opening comes from a high-service model where the customer needs are assessed and catered to, based on the current capabilities of the SCSP. The increase in the FSM total addressable market, from IDM converting to the FSM model, also creates an opening for a larger SCSP presence in the industry. Increasing technological complexity also favours the SCSP since the FSM does not have to develop this capability in-house or defocus product R&D efforts.

Product differentiation from competitors can come from specialized services (Botten & McManus, 1999) to FSM startup types, such as Micro Electro-Mechanical System (MEMS) or RF companies. Developing a technological and operations infrastructure to cater specifically to FSMs under-served by current SCSP companies also creates a competitive opening.

## 6.8 Summary

The SCSP entrant should focus on startup FSM as well as lower revenue FSMs, since these will have less mature operations and manufacturing capabilities. They will also be the most cautious in deploying capital for internal operations and manufacturing activities. In most cases, these companies will have less than five products that do not each have a very high volume or revenue. This fits well within the SCSP model, since better pricing for the FSM can be obtained through the SCSP model.

By pooling the volumes of several lower revenue FSM companies into the SCSP model, economies of scale can be achieved for all the FSM companies that are engaged. Although the key intention of the FSM company is to reduce initial operations and manufacturing costs, during their mass manufacturing and higher volume phase they will continue to enjoy lower operations and manufacturing costs. Therefore, the engagement with the SCSP will continue as the maturity of the FSM products and revenue stream progresses.

The retention and continuation of business is essential to the continued growth of the SCSP, since that fuels further credibility and economies of scale for each incremental FSM product that is added to the SCSPs portfolio.

Once the FSM is fully engaged with the SCSP, additional design services can be discussed. These would be outside of the operational activities that were outsourced, and can include design and other new product investigation activities. Using the SCSP to the full capability of the model, allows the FSM to focus on key IP for its products as well as idea generation and management, and better application for its financial resources for high value-add activities such as R&D.

# 7: Technology Resource Requirements

For the SCSP, human resource requirements will scale with the amount of concurrent business generated. Next, the technical scope of the business generated will determine what kinds of human resources are required. Table 8 gives a breakdown of the type of personnel required for the different types of business generated by the SCSP. This section will expand on the figures and introduction given in section 2.2. Sections 7.1 to 7.3 refer to activities which the SCSP may engage in after an initial phase of business generation. Section 7.4 refers to the initial and core business activity of the SCSP.

*Table 8 Technology Resource Requirements*

| Function | Startup Phase | Growth Phase |
|---|---|---|
| Junior Designers | 2 | 6 |
| Sr. Designers & Architects | 1 | 3 |
| Operations & Manufacturing Technical Staff | 5 | 10 |
| Operations Management | 2 | 4 |

## 7.1 Product Specification

Experienced personnel are needed in digital and analog architecture as well as marketing and customer interfacing. At this stage of the product lifecycle, it is important to match customer needs with product specification. It is likely that the initial specification will change, but with the right flexibility it is possible to define a product that can accept the changes in scope.

The people involved in product specification are typically experts who have a large amount of experience and market knowledge on past IC implementations. They will define the product along with customer and market needs. They will also research any new technologies that need to be implemented to get the desired end result. For example, an algorithm may need to be implemented in an IC that has not been implemented before.

## 7.2 Product Design

Digital and analog design experts are needed. Typically, the design team will be headed by a senior designer who will lead and manage the design activities. Junior designers will implement the various sections of the IC using CAD software to write the code that will be turned into IC hardware later in the process. Using very well experienced design managers, it is possible for the junior designers to be in remote locations, where the labour rate is much lower and there is spare labour, such as India or China. In the US and Canada, junior designers are paid much higher and the labour market is tighter.

## 7.3 Product Implementation

In the semiconductor design flow, all the design activities are done using CAD software. The implementation engineers use the CAD information to create a physical device. Some of this work can be done by FAB and OSAT vendors, however, there are speed and efficiency synergies to keeping the work within the SCSP internal scope. The conversion of the design information to CAD requires specialized expertise that may need the development of internal CAD software. Hiring expertise in the deployment of the software as well as usage will result in successful product implementation

## 7.4 Operations and Manufacturing

The SCSP will have key relationships with FAB and OSAT suppliers. If the volumes are high, it is likely that some personnel will be stationed at the manufacturing plant of the FAB or OSAT supplier. Others may be stationed close to the customer. In the case of the semiconductor industry, most FSM companies are based in the Silicon Valley. It may also be beneficial to establish the base of operations and manufacturing in the region where the manufacturing occurs. In the case of the semiconductor industry, most of the manufacturing occurs in Asia. Typical places for the establishment of Operations and Manufacturing hubs are in Malaysia, Hong Kong and China (Industry expert #1, personal communication, May 3, 2010). It is also common to co-locate staff at the Asian manufacturing hubs for real-time troubleshooting and engineering services.

## 7.5 Summary

The above description focuses on technical employees and does not list basic functions every business must have. The executive structure is also not discussed since it will be similar to the executive structure in other technology industries.

As many Venture Capital investors will require the hiring of senior staff as the first personnel of the company - the above activity descriptions should lead to the hiring of Manager and Director-level personnel. Following that, junior personnel may be hired to implement plans and designs. Key specification and design activities should remain local to the geography of the SCSP customer. Some activities are better placed in lower cost jurisdictions, especially product design, operations and manufacturing.

The technical human resources to implement the SCSP venture are readily available, especially in areas like Silicon Valley where a cluster of semiconductor companies exist. The biggest hurdle is finding cost-effective junior designers. One way around this is to open some design centres in India or China. External relationships with FAB and OSAT vendors are very important, as well as having onsite staff to balance the use of internal and external resources.

# 8: Business Planning

Business planning is needed in order to continually monitor the health of the business and the critical relationships with FABs/OSATs and customers. Since the SCSP is managing these key relationships on both fronts, much attention needs to be paid to the image of the company, external interfacing, public relations and customer service issues. Since this document is a precursor to a detailed business plan, organizational areas of key relevance will be summarized below.

## 8.1 Market Research

Gathering market research data is vital to determining the correct marketing strategy and setting price, quality and service levels. Customers, competitors and the marketplace should be brought into more focus through continual market research, even after the initial business plan is complete. Performing substantial market research before the creation of a business plan will avoid scope redefinition after business initiation, which will likely result in the loss of human and capital resources. Examples of essential research are listed in Table 9.

*Table 9 Market Research Types*

| Type | Importance |
|---|---|
| Customer | Target the most successful and profitable companies |
| End-use markets | Focus on customers that sell ICs into high volume end markets |
| Competitive Pricing | Maintain competitive pricing vs. direct outsourcing to FABs/OSATs and other SCSPs |
| Customer needs | Determine areas where customers are underserved by FABs/OSATs/SCSPs |
| Product Offering | Expand or modify the SCSP’s product offering |

## 8.2 Competitive Business Strategy

In the face of competition, it is important to define exactly how customers will be targeted, with the products and services that are offered. Key areas are pricing, advertising and promotion, and distribution. Gathering data additional to the basic market research is needed and can lead to more focus on how to create a competitive marketing mix.

A specific strategic framework can be created to confirm the assumptions of the Market Research, customers, competitors and the business environment. Product modification to tailor to these needs as well as concentrating on specific customer segments should be explored. Some strategic aspects have been described in Table 7.

## 8.3 Operations

The heart of the SCSP model is the efficiency of the operations organization. One of the key expectations of any customer dealing with a SCSP is near-flawless execution of operational activities. The fact that the customer will have chosen to outsource most, if not all, of its operational activities leads to this basic expectation.

In the nascent stages of the SCSP, the operations organization is responsible for the execution of the core business strategy and the delivery of products generating revenue for the SCSP. It is likely that in this phase of the SCSP model, the operations organization may be the largest single department. Staff will be responsible for day-to-day interaction with customers and FAB/OSAT suppliers. All other departments should be cognizant that the success of the operations department will result in the ultimate satisfaction of customers and their return business. This is analogous to a retail establishment, where customer satisfaction is essential.

Since the SCSP is a conglomeration of several companies' operations activities, there will likely be some restriction in the sharing of knowledge and information between the activities of customer companies, especially if the customer companies are competitors. In particular, some customers may require the physical isolation of employees serving competitors. The additional cost due to this inefficiency may be able to be borne by the customer.

## 8.4 Financial Analysis

Taking into account key FSM metrics like gross margin, some determination can be made on the revenue and profit model that the SCSP will gain. For example, eSilicon, a current SCSP, has revenues of approximately USD $100 million (Yahoo, 2010b). The ability to make a profit determines on the advantageous pricing that the SCSP obtains from the FAB and OSAT partners.

In examining the manufacturing focus of a SCSP, we see the industry average gross margin for healthy companies is approximately 50%, as exemplified by Broadcom (Yahoo, 2010a). The FSM will also be saving on operating costs, due to reduced capital expenditure, hence improving its operating margins. Since companies in the SCSP market are privately owned, determining benchmark gross margins is not possible. Examining the Electronic Manufacturing Services industry in general a gross margin of 10-20% is expected (iSuppli, 2010b). However, in general, semiconductor industry gross margins are higher, due to specialized and value added services. Expanding the product offering of the SCSP to include pre-manufacturing services such as R&D will further increase gross margins. Using the competitive advantage of specialized technology offerings will also command a premium service price. An appropriate mix of products and services can support a healthy gross margin as well.

## 8.5 Summary

The business plan is the most important document to refer to during a business initiation for the SCSP. Short and long-term goals, products and services, as well as market opportunities should be well presented. Competitors and risks should also be focused on as this will drive better execution of marketing and product definition. For the SCSP, operations resources are of most interest, especially in the nascent stage. A large amount of focus will be given to this group both internally and from customers. The organization of the SCSP should embody superior customer service. The SCSP can also enable better financial performance of the FSM while creating a successful business for itself.

# 9: Conclusion

A history of the semiconductor industry was presented to show the current need for the SCSP business model. An overview of semiconductor design and manufacturing was presented to show the modular nature of the IC design flow, and how it enables the hand-off of tasks to the SCSP.

It was found that it is possible for a new SCSP to enter the semiconductor industry. Key drivers for this model are:

- High capital costs of creating and maintaining an internal manufacturing and operations infrastructure for both FSM and IDM companies
- Conversion of IDM companies to fabless companies
- FSM startup focus on product R&D
- Increase in IC implementation technological complexity with time
- Reusability of SCSP infrastructure to service multiple FSM or IDM companies
- Efficient use of VC capital for FSM startup

A strategic analysis was performed to address initiatives that can be taken in order to position the new SCSP entrant to gain a customer base and market share. Using an overview of key elements of a business plan, major points were highlighted which show the structure of the SCSP business as well as profit margins and drivers.

In summary, with further detailed research and a formal business plan, a new SCSP venture can be proposed to attract investors and founding partners. Existing SCSP companies have given credibility to such business model, which is now widely accepted. Still, the continuing increase in FSM market size, from startups to IDM conversion, implies a greater potential market for the SCSP services.

# Appendix

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## Interviews

Industry expert #1,  May 3, 2010.

Vice President Operations at a FSM startup located in Markham Canada, with over 25 years of industry experience. Direct experience working in IDM and FSM supply chains and interacting with FABs, OSATs and SCSPs.

Industry expert #2, June 8, 2010.

Sr. Manager Operations at an IDM that recently converted to a FSM in Markham, Canada with over 20 years of industry experience. Detailed knowledge of the industry and in depth knowledge of supply chain partners and semiconductor industry startups.

Industry expert #3, July 9, 2010.

Director Operations at a FSM in Vancouver, BC with over 30 years of industry experience. Direct experience working at IDMs as well as FSMs of varying revenue from USD $200 million to USD $2 billion and serving different segments of the semiconductor industry. Very good knowledge of semiconductor supply chains as well as working with SCSPs.

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