VIRTUAL FACTORIES AND DYNAMIC CORE COMPETENCY: A CASE STUDY OF ADVANCED SEMICONDUCTOR ENGINEERING

Charles Chen
Fooyin University, chen2202@hotmail.com

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Chen, Charles, Fooyin University, 151 Chin-Hsueh Road, Ta-Liao Hsiang, Kaohsiung Hsien, 83102 Taiwan, R.O.C., ft027@mail.fy.edu.tw; National Kaohsiung First University of Science and Technology 811 No. 2, Jhoyue Rd., Nanzih District, Kaohsiung City, Taiwan, R.O.C., u9228905@ccms.nkfust.edu.tw

Abstract

Due to globalization, advanced information and communication technology has fuelled competition, and building and sustaining of competition advantages are major concerns of companies. Developing dynamic core competency has become a new competition strategy and an important way to help companies remain flexible and able to respond quickly to unpredicted changes in the environment. The development of dynamic core competences requires accumulation of technology and skill over time. In turn, companies can exploit these invisible assets to develop new products and new markets and to out-compete competitors. The Internet could provide value-added service to allow companies to communicate with each other. As such, the Internet-based virtual factory had been implemented to facilitate connections among partners. Taiwan based company Advanced Semiconductor Engineering (ASE), one of the world’s largest integrated circuit assembly and testing manufacturers, has constructed its virtual IC factory to strengthen bonds with upstream customers. Customers are able to directly access ASE’s information system and thereby receive immediate status reports of their orders or other types of feedback. In this paper, the framework of ASE’s virtual IC factory is introduced, and the competitive advantages resulted from this virtual factory are investigated. Implications of ASE’s experience are then discussed.

Keyword: Virtual factory, Internet, Electronic commerce, Dynamic core competency
1 INTRODUCTION

Many companies face intense pressure caused by capricious market demand, rapid changes in technology, short product life cycle, and severe global competition in today’s business markets. It is increasing important for companies to develop the dynamic core competency to quickly integrate and reconfigure internal and external capabilities to address rapidly changing environments, such as to change production plans as market demands dictate or to set up a wide variety of complementary strategic technology alliances with different partners. In today’s semiconductor industry, it is often inefficient for any single company to produce a whole product. Instead, individual companies will focus on their core competencies in order to avoid investment risk and enhance competition.

Integrated circuit (IC) production is a capital- and technology-intensive industry. Figure 1 shows the overall IC manufacturing and application flow. It includes the design activity, wafer fab activity, probing activity, assembly activity, final test activity, and board assembly. In order to provide better information in time, implement the total turnkey solution, achieve higher levels of customer service, and build or sustain competitive advantage, many IC design houses, Fab manufacturers, and Assembly/Test manufacturers build partner alliances and share processing information. The implementation of VF helps in strengthening the alliance relationships, operational efficiency, and finally enhances dynamic core competency. This results in competitive advantages and firm performance.

![Figure 1. Overall IC manufacturing and application flow](image)

There are many potential uses for the Internet, such as being a source of information, a communication tool, and a distribution channel, depending on the objectives and capabilities of the users (Ranchhod & Gurau 1999). In the system-to-system business exchange model, Internet works as the media for information exchange. Via defined information exchange standard of computer platform, companies are able to conduct businesses through electronic means with their partners, suppliers, and buyers, and thus enjoy benefits of reduced inventory costs, flexible operation process, shorter time to market, and lower transaction costs. The Internet technology-based virtual factory extends interoperability from within an enterprise to information systems distributed among business partners. Despite the perceived importance of the Internet, there are still only limited amounts of empirical studies which seek to examine ways in which the Internet-enabled virtual factories can help build firms’ dynamic core competency.

According to the resource-based view, core resources and core capabilities are the major factors which allow an enterprise to sustain the competitive advantage (Wernerfelt 1984, Hamel & Prahalad 1990). Those resources and capabilities must be valuable, rare, imperfectly imitable, and non substitutable (Barney 1991). The building of Internet based VF can allow companies to help customers’ or allied partners’ businesses to change production plans as market demands dictate. In this situation, companies can allow customers easy access to and control of the elements throughout the manufacturing process, build a value chain alliance with customers, help strengthen customers’ dynamic core competencies, and finally help to create path-dependent competitive advantages, which are hardly to imitable and substitutable.
However, due to the dynamic environment change, enterprises need to adjust or enhance their core resources and core capabilities to match current environmental evolution. It is important to note that today’s competition is not just between single enterprises but between joined alliances. According to the knowledge-based view, the dynamic core competence will be the major factor for enterprises’/alliances’ ability to sustain the competitive advantage in today’s value chain (Grant 1996, Teece et al. 1997). Via learning and knowledge/information sharing, the enterprise can enhance its dynamic core competence. The Internet based VF system can be the platform for corporate learning, knowledge sharing, and information sharing.

During the past decades, semiconductor industries have become one of the fastest growing businesses in the world. The importance of and the amount of competition in this industry is projected keep growing in the near future. In order to sustain competition and achieve higher levels of dynamic core competency, the world’s largest IC assembly and testing manufacturer, Advanced Semiconductor Engineering (ASE), has constructed its own VF. The implementation of VF helps in improving the dynamic core competency and operational efficiency, and, as a result, brings competitive advantages.

The intention of this paper is to contribute to the understanding of the Internet as a catalyst in building a VF that can enhance the dynamic core competency. More specifically, the purposes of this study are (1) to introduce the framework of ASE’s VF; (2) to explore the factors of VF development; (3) to investigate the relationship between VF and dynamic core competency; and (4) to discuss how dynamic core competence can help sustain the competitive advantage.

In the following sections, we will first review the past research dealing significant capabilities of Internet communication and the literature on virtual factory and dynamic core competency. Next, we will describe our methodology—the case study—and ASE’s existing VF framework. Then, we will propose a model of the Internet-enabled VF and illustrate the resulting competition advantages. Finally, we will provide some implications and directions for future research.

2 LITERATURE REVIEW

2.1 Internet Technology

Since the exploding development of Internet, several empirical studies have been conducted to explore the influence of its capabilities on doing business. Berthon et al. (1997) pointed out many important characteristics of Internet, such as high level of interactions, elimination of the limitations of time and location, high speed information transfer, and high levels of flexibility and ubiquity. According to those characteristics, several institutions such as RosettaNet have worked to build an information exchange standard and several software companies such as Extricity Software, Inc. have developed a software package to allow any two systems to talk to each other over the Internet regardless of file format or business rules. Through system-to-system communication over the Internet, joined allied partners can accomplish several supply-chain management processes such as sharing forecasts, managing orders, issuing work-in-progress report, and transmitting shipping notices and engineering design changes. The benefits include far shorter product lead times, more direct control over processes by the customer, and more accurate capacity planning. The real-time on-line nature of the Internet makes interactions between business and customers more effective and efficient (Dutta & Segev 1999). A highly-interactive Web site can help in collecting customer opinions and complaints. It is also a convenient medium to deliver customized products/services based on understandings coming from long-term interactions (Peppers et al. 1999, Prakash 1996). Such a highly interactive Web site can create a higher termination cost for customers. The more confidential data customers disclose on an interactive Web site and the more they are acquainted with this environment, the higher the termination costs (Hsieh et al. 2002). Switching to another service provider companies would have to rebuild their data and mutual understanding with the new service provider, which could decrease their switching willingness (Ghosh 1998). Moreover, a highly interactive Web site helps customers to
develop trust toward the service provider. Customers’ trust relies on the formation of their expectations about the motives and behaviors of the service provider (Donney & Cannon 1997), and repeated interaction enables customers to interpret prior outcomes better, providing a basis for assessing predictability (Doyle & Roth 1992).

2.2 Virtual factory

Upton and McAfee (1996) defined the virtual factory, “a community of dozens, if not hundreds, of factories, each focused on what it does best, all linked by an electronic network that would enable them to operate as one—flexibly and inexpensively regardless of their locations”. According to this definition, we know that a VF is a computer-constructed application system which represents a company’s business process. And, which electronic network technology can companies best use to link dozens or hundreds of factories together, regardless of their locations? Internet technology is the best answer to this question. According to study of Tang, Shee, and Tang (2001), the development of electronic interconnection has dramatically reduced the time and cost of information exchange, effectively linking the processes and allowing close integration of parties in the value chain. McGehee, Hebley, and Mahaffey (1994) also stated that virtual manufacturing environments can assist a company to rapidly and effectively react to changes in market conditions and technology. Also Koc, Ni, & Lee (2002) have defined E-manufacturing as “a system methodology that enables manufacturing operations to successfully integrate with the functional objectives of an enterprise through the use of Internet, tether-free (i.e. wireless, web, etc.), and predictive technologies”. Therefore, we can simply say that VF is an Internet-based application system which provides real-time business activity and process information to allied partners or customers in order to operate effectively in turbulent and often chaotic environments.

2.3 Dynamic core competencies

According to a resource- or skilled-based view, Lei, Hitt, & Bettis (1996) defined a firm’s core competence(s) as a set of problem-defining and problem-solving insights that fosters the development of idiosyncratic strategic growth alternatives. Markides and Williamson (1994) defined core competences as a pool of experience, knowledge, and systems that together could act as catalysts that create and accumulate new strategic assets. These strategic assets, which are imperfectly imitable, constitute a firm’s competitive advantage. However, in light of today’s globalization and turbulent and often chaotic environments, companies need to adjust or enhance their core competences to match the evolution of environment. The competition is changed from single enterprises to an alliance supply value chain. According to the Resource-based view and Knowledge-based view, firms need to build their dynamic core competences to sustain the competitive advantage in today’s value chain competition. Dynamic core competences are based on their integration into systemic meta-learning of universal and tacit knowledge through information transfer, redefinition of heuristics, and continuous improvement based on experimentation and the development of firm-specific skills based on dynamic routines (Lei et al. 1996). Dynamic core competences can be leveraged to create growth alternatives for global diversification, new applications of existing technologies and/or the development of new lines of business (Lei et al. 1996). Finally, dynamic core competences can be used to reduce uncertainty and to induce path dependencies that create causal ambiguity (making imitation from other firms difficult). In so doing, they can form the basis of competitive advantages (Lei et al. 1996). Therefore, Teece, Pisano, and Shuen (1997) mentioned dynamic core competence (dynamic capabilities) as the firms’ ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. Leonard-Barton (1992) also stated that dynamic core competences (dynamic capabilities) thus reflect an organization’s ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions.
3 CASE METHODOLOGY

Case studies place more emphasis on a full context analysis of fewer events or conditions and their interrelations. A single well-designed case study can provide a major challenge to a theory and provide a source of new hypotheses and constructs simultaneously (Copper & Schindler 2003). Eisenhardt (1989) argues that case study research leads researchers to find new theoretical relationships and question old ones. McCutcheon and Meredith (1993) posted that case studies are typically used to: (1) describe a heretofore unstudied situation; (2) explore current theory more thoroughly; and (3) support, expand or raise questions about existing theories. Since the Internet-based VF is a quite new concept, more observations are needed before any theory can be developed. It is suitable to use case study to explore the situations and problems when the VF concept is implemented, and perhaps begin to develop the new hypotheses.

In this study, data was collected by using the following steps. First, we gathered information about the background of the firm and how it got started on VF from its homepage (http://www.aseglobal.com/) and other publications. Then, we conducted several in-depth interviews with IT managers and engineers of ASE. Each interview lasted about an hour. During the first meeting, the managers and engineers were asked to describe the framework of VF and the questions focused on the pros and cons they have thus far faced. During the meetings that followed, the questions focused on the changes that have been implemented since ASE adopted the VF model.

4 STUDY PROFILE

The ASE Group is the world's largest provider of independent semiconductor manufacturing services in assembly and testing. Positioned as a complete back-end manufacturing service provider, ASE offers customers turnkey services for integrated testing, packaging, design manufacturing services (DMS) and direct shipment. Porter (1985) presented a value chain model that examined the primary activities between suppliers and customers. In the value chain of IC industry, customers want to be informed of updated data about their order status, so that they can decide the promise date to their customers and make adjustments when market demand changes. In addition, a corporate design strategy for IC packing can be implemented between the fabless designed houses and IC assembly companies before the real production. As such, VF is proposed by this industry to reduce design risk, and market uncertainty. In order to sustain the competitive advantage, ASE developed its VF functions to enhance its dynamic core competency and customer service quality since 1999.

5 THE FRAMEWORK OF ASE’S VF

ASE defines itself as a customers’ VF. Figure 2 is the Internet-based virtual factory framework of ASE. Through interaction with ASE systems, customers can have all of the benefits of in-house IC testing and assembly without the risks of capital investments. In order to provide back-end data to alliance partners or customers, ASE constructs its information technology infrastructure that can integrate the business process system information such as Manufacture Executing System (MES), Enterprise Resource Plan (ERP), Supply Chain Management (SCM), and Product Data Management (PDM)/Product Information management (PIM) to a centralized data warehouse. The RosettaNet definition-based B2B server provides data process definition standard, common exchange protocols, and transmission certification between alliance partners’ systems. Through definition of those e-business process standards, companies’ back-end systems can directly talk to each other.

In addition, ASE also designs and developments its Web-based e-Packing service. This service is intended to speed up the development process in IC packing. Through interactive windows, users can assign simulation models to derive the optimal results according to the specifications in electrical and thermal performance. ASE’s e-packing service is composed of five major parts: they are iTDAS
(Internet Thermal Data Automation Service), iEDAS (Internet Electrical Data Automation Service), iBDS (Internet Bonding Diagram Service), PSE (Package Selection Engine), and OLES (On-Line Entrusting Service). The iTDAS, in service since 1999, allows users to conduct thermal simulation for IC packages from a remote site. By simply entering the design parameters, users can obtain the thermal resistance of any package within three hours. Based on finite element methods (FEM), iTDAS adopts popular commercial software—ANSYS, for the thermal calculations. Once the basic dimensions and conditions of a package are acquired from the remote site, iTDAS collects this data and then calls the ANSYS server. After completing the simulation, the results are e-mailed back to the user. The iEDAS allows users to obtain electrical characteristics for IC packages from a remote site via the Internet. After accessing the iEDAS Web page, the users can select the preferred package type and key in size of die, size of package, and other related information. Simulation will then be performed to extract the resistance (R), inductance (L) and capacitance (C). The values are calculated via a 3D structure in Ansoft Maxwell Spicelink. Once the calculations are completed, the results will be automatically e-mailed to the user. The iBDS enables automatic real-time B/D (bonding diagram) generation over the Internet. The integration of the open-tool drawings of lead frames and substrates with the CAD tool provides a prompt channel for customers to link to the production line. By following step-by-step instructions, customers first choose the most appropriate L/Fs (lead frames) or substrates which are extracted from the database according to customer specifications. The PSE is intended to link customers' applications with the packaging solution. Users simply type in keywords on the web page, e.g. the I/O number, the criterion of power dissipation, the working frequency, or the IC application. PSE will deduce the corresponding packages and list the priority for customers' review. The OLES provides an avenue for customers to entrust the characterization cases to ASE labs. To ensure the clarity of each entrusted case, customers are requested to provide required information as accurately as possible. Once ASE assesses and accepts the case, an acknowledgement receipt is e-mailed to customers with the completion date.

Reference: http://www.aseglobal.com

Figure 2. Internet-Based Virtual Factory Framework of ASE

6 THE COMPETITIVE ADVANTAGE OF IMPLEMENTATION VIRTUAL FACTORY

In recent years the resource-based theory of the firm (Wernerfelt 1984) and related contributions (e.g., Teece 1982, Rumelt 1984, Barney 1986, 1991) have focused on the importance of understanding company performance as a result of the efficient use of unique company capabilities that create sustained performance differentials within industries. Similar approaches are found in evolutionary economic theory (Nelson & Winter 1982) and the theory of dynamic firm capabilities (Nelson 1991) that analyze inter-firm differentials in terms of strategy, structure, and core capabilities. From examining the VF experience of ASE, we can see some competitive advantages from the implementation of VF (Fig. 3). Competitive advantage can be seen as a result from the implementation of a strategy which is not implemented currently by competitors or from better implementation of the
same strategy as competitors and can be expected to lead to superior marketplace performance and financial performance (Bharadwaj et al. 1993). In this paper, some hypotheses are proposed in following paragraphs and analyzed from the viewpoint of RBV & KBV. In turbulent and often chaotic environments, firms need to develop and nurture a unique set of resources to build a competitive advantage. These unique sets of resources are built into skill and capabilities, often referred to as core competences. The turbulent and changing nature of the environment suggests that these core competences cannot remain static. They must be continually evolving and developing. Therefore, firms must continue to invest in and upgrade their competences to create new strategic growth alternatives. Development of dynamic core competences requires technological and skill accumulation over time. In turn, these invisible assets can be exploited and leveraged to develop new products and new markets and to out-compete competitors. Dynamic core competence helps firms remain flexible and able to respond quickly to unpredicted and thereby unexpected changes in the environment. Additionally, dynamic core competences help firms partially enact their environment. In other words, firms with dynamic core competences are able to partially shape the environments in which they operate and compete. In so doing, they are better able to achieve desired outcomes. If firms do not continue to invest in and develop their core competences over time, thereby making them dynamic, their competences may become outdated, and this may limit future strategic alternatives for the firm.

![Figure 3. Research model of the competition advantage of VF](image)

### 6.1 The factors of VF development

According to the VF definition of Upton and McAfee (1996), VF is a computer constructed application system. The Internet based VF system is a platform for corporate learning, knowledge sharing, and information sharing. It helps companies’ back-end systems talk directly to each other. Based on above discussion, we propose:

**Hypothesis 1. Improvement of IT technologies helps the development of VF.**

In today’s capricious market environment, companies face intense pressure from volatile demand, rapid technological evolution, and short product life-cycle. The competition is not just single company competition, but value chain competition. In order to obtain a competitive advantage in the market, companies need to strategically ally together. The implementation of VF provides an information and knowledge sharing platform, strengthens the alliance relation and operational efficiency, and in doing so provides the competitive advantage. Based on above discussion, we propose:

**Hypothesis 2. Hyper-competition pushes the development of VF.**

### 6.2 Virtual factory and dynamic core competency

According to Duysters and Hagedoorn (2000), core competences can be classified into two categories: endogenous core competences and externally acquired competences. Technological competences, technical skills, learning, and knowledge developed within companies can be classified as endogenous core competences. Mergence and acquisitions (M&As) and strategic technology alliances can be seen as instruments used by companies to externally acquire capabilities developed by their “partners” in
order to complement existing core competences. According to the research of Hagedoorn (1993 & 1995), and Harrigan (1985), the setting up of a wide variety of complementary strategic technology alliances with different partners has a more positive effect on company performance than a concentration of alliances in fields in which a company has already established considerable strength. This research suggests that complementarity is a major driver of partnering behavior. Therefore, a strategy aimed at creating a rather broad set of alliances that are complementary to endogenous capabilities could have a more positive effect on company performance than the formation of alliances that parallel existing capabilities. Henderson and Cockburn (1994) consider “idiosyncratic research capabilities” to be a major source of strategic competence that has a positive effect on company performance in high-tech industries. However, Meeks’ (1977) overview of studies on the economic effects of M&As performed during the late 1950s and 1960s reveals that there is substantial ex-post evidence that M&As have negative effects on the profitability of firms. Also research by Porter (1987), Odagiri and Hase (1989) found no evidence that in general M&As improve the performance of companies. We should also consider the merged case of Hewlett-Packard and Compaq. The integration problems of different company cultures and management styles can have a negative impact on company performance. This causes acquisitions absorb too much attention from management and also increases debt and appears to multiply financial controls instead of stimulating the search for strategic opportunities (Hoskisson and Hitt 1994). But, the companies that implement VF strategy are focused on their core technology and competence. They are strategic alliances with different complementary technology partners. The value of their core competences can be enhanced by combination with the appropriate complementary partners. We can observe companies’ such as Adaptec Inc., TSMC, and ASE use of Extricity Alliance to connect two otherwise out-of-step internal systems via the Internet to create a smoothly choreographed virtual factory that stretches halfway around the globe. Via the VF solution, the California-based company Adaptec, Inc. can focus on its silicon chip design and outsource chip production to TSMC instead of investing US $1.2 billions to build its own fab plants. Via the VF solution, the Taiwan-based contract semiconductor foundry TSMC can focus on its fab manufacturing technology and process flow innovation and offer its major customers a virtual manufacturing environment. Via the VF solution, the Taiwan-based contract semiconductor assembly and testing company ASE can focus on its assembly and testing technology research, development, and processing flow innovation and offer the turnkey solution to its major customers with a virtual manufacturing environment. In addition, core competence cannot remain static: companies must continue to invest and upgrade their competences in order to create new strategic growth in today’s rapidly-changing environment. Therefore, through system-to-system communication over the Internet, these different technology complementary companies can accomplish several supply-chain management processes: sharing forecasts, managing orders, issuing work-in-progress reports, and transmitting shipping notices and engineering design changes. The benefits include far shorter product lead times, more direct control over processes by the customer, more accurate capacity planning, and more organizational and inter-organizational learning capability in the turbulent, often chaotic, varied and high competition market environment. Thus the building of VF strengthens company’s dynamic core competencies.

Hypothesis 3. The implementation of VF helps strengthen firms’ dynamic core competencies.

6.3 Sustainable competitive advantage

Barney (1991) listed four requirements (valuable, rare, imperfect, and inimitable) to qualify a skill as a source of sustainable competitive advantage. Coyne (1985) pointed out that the competitors own the same resource as you do. There can still be a source of sustainable competitive advantage if there is a capability gap making difference to customers or competition value chain. Competitive imitation of a firm’s core competence is often difficult and frequently requires the imitator to undergo a similar set of “irreversible” investments and learning (Barney 1991). As a result, core competences are largely inimitable and may provide the basis for sustainable competitive advantage. However, core competences cannot remain static: only those firms that continue to invest and upgrade their
competences are able to create new strategic growth alternatives. The VF can help gather, disseminate, apply, exchange information, build the capability to learn, and finally strengthen the dynamic core competency. The building of VF is also an irreversible investment and results in path dependencies and is difficult to imitate. This will make the firms or alliance value chain partners own the uniqueness and build sustainable competitive advantage. Based on the above discussion, we propose:

Hypothesis 4. Strengthened dynamic core competencies through VF are a source of sustainable competitive advantage.

6.4 Strategic flexibility

Successful in the 21st century organization will depend first on building strategic flexibility (Hitt et al. 1998). To develop strategic flexibility and competitive advantage, requires exercising strategic leadership, building dynamic core competences, focusing and developing human capital, effectively using new manufacturing and information technologies, employing valuable strategies (exploiting global markets and cooperative strategies) and implementing new organization structure and culture (horizontal organization, learning and innovative culture, managing firm as bundles of assets) (Hitt et al. 1998). The technological revolution and increasing globalization present major challenges to firms’ ability to maintain their competitiveness. In facing those multiple discontinuities, firms must develop new strategies and new ways of organizing to deal with this exceedingly complicated landscape. It requires that firms use the latest technology, continue to develop new technology, actively participate in global markets, structure themselves to gain advantage in these markets, develop and maintain strategic flexibility, and build a long-term vision that allows managers to balance short-term performance with long-term needs. The development of information and communication technologies and the globalization of industries have produced a blurring of industry boundaries that amounts to a massive reordering of business (Hitt et al. 1998). Therefore, in this new competitive landscape requires a continuous rethinking of current strategic actions, organization structure, communication systems, corporate culture, asset deployment, investment strategies, in short every aspect of a firm’s operation and long-term health. This requires a firm to achieve strategic flexibility. Strategic flexibility is the capability of the firm to pro-act or to respond quickly to changing competitive conditions and thereby develop and/or maintain competitive advantage (Hitt et al. 1998). When firms are sensitive to their customers and their competitors, building dynamic core competences can better help them serve their customers and gain advantages over their competitors. Thus strategic flexibility is a kind of dynamic core competences. The VF, an interactivity and information-rich system providing the vertical and horizontal information between alliance partners or customers, helps firms building their strategies such that they can simultaneously manufacture products of high variety at low cost, design and commercialize new products in much shorter time cycles to match market’s demand. Based on the above discussion, we propose:

Hypothesis 5. The greater the strategic flexibility, the greater the relationship between VF and dynamic core competencies

6.5 Organizational learning

Dynamic core competences are developed from organizational learning. Such meta-learning is systematic, complex, dynamic, and necessary, particularly in complex, turbulent, and often chaotic environments (Lei et al. 1996). According to Lei et al. (1996), individuals/companies go through three learning process phases: information transfer and retrieval, experimentation or promotion of change, and the development of dynamic routines, can create a meta-learning and help in the development of dynamic core competences. According to the research of Teece, Pisano, & Shuen (1997), the concept of dynamic capabilities as a coordinative management process opens the door to the potential for inter-organizational learning. The Internet-based VF with dynamic routines capability can provide the platform for those three learning phases within a firm or between alliance partners. It is used to work
as a coordinative management process to provide real-time order status and production information to
the alliance partners or customers, and allows product change due to the market’s demand. Organizational learning must be focused on building effective, complex problem-defining and
problem-solving heuristics that become the basis of competitive advantage (Itami 1987, Nonaka
1991). Organizational learning alone does not translate into a core competence; rather, the firm must utilize and convert the learning efforts into firm-specific resources and skills. Successful organizational learning depends on the acquisition and assimilation of diverse new bases of knowledge for subsequent actions. The construction of VF can provide an IT system platform of company’s business activity and process flow to interact with strategic alliance partners. It facilitates organizational learning between strategic alliance partners, allowing them to share information, knowledge and technology skills (ex. IC cooperate design), and set up a wide variety of complementary strategic technology alliances. The VF also provides a quick response mechanism to adjust product process due to market environment change. The construction of VF can work as a medium to convert learning to the status of core competency. Based on the above discussion, we propose:

Hypothesis 6. The greater the organizational learning, the greater the relationship between VF and dynamic code competencies.

7 CONCLUSION

This is the first paper to study the relationship between Internet-based VF and dynamic core competency. We have attempted to utilize both “Knowledge Based View” and “Resource Based View” theories as the theoretical foundation, and point out 6 Hypotheses in this study. Over the past few years, ASE has become the world’s largest and fastest growing dedicated IC assembly and testing company. This article has attempted to describe the contents of ASE’s VF, which is one of the important factors leading to success. After the implementation of VF, strategically allied partners or customers can have all the benefits of in-house assembly and testing service without the risks of capital investments. Alliance partners or customers can track their orders and make requirements through the Internet on real time to meet their specific needs, get all information in different stages such as product design, order placement, wafer production, yield analysis, and testing and assembly, which lowers the entry barrier and transaction cost for its customers. Cunningham (2007) states that if a company can model the entire manufacturing operation on screen at an early stage, then it can build the flexibility from the start and make the best use of the available resources. This can squeeze out every bit of efficiency from a facility and get competitive advantage. Through the implementation of VF, ASE allows its allied partners or customers to remotely conduct thermal simulation, electrical characteristic simulation, bonding diagram generation for IC package at the early design stage, to remote simulate the virtual manufacturing process. Based on the simulation result and virtual manufacturing process, ASE can allocate and manage resources effectively, avoiding bottlenecks and other unforeseen production problems. Those capabilities of consolidation of information exchange through Internet in engineering and logistics can significantly reduce the interaction cost (Chen et al. 2006), thus providing ASE and its alliance partners or customers with the competitive advantages of an enterprise-wide value chain.

Due to innovations in IT technology, the new concept—virtual factory—is receiving much attention from recent researchers. Via the ASE case study, we can understand the different aspects of implementation of a virtual factory. While this methodology has its limitations in generalizing its findings across business settings, the insights gained could be of value to different business situations. Much more knowledge may hopefully be added to this subject through accumulating examples of case studies.

In an uncertain environment, VF is more likely to be a source of competitive advantage, and at the same time, leads to dynamic core competence development. Further research can continue to test this research model through interviews with firms which may utilize both the case study and sampling
survey. Thus, through these two research methodologies we may investigate the impact of VF on building dynamic core competence and the impact of information sharing, knowledge sharing, organizational, and inter-organizational learning among firms. In addition, ways in which management philosophy may or may not influence the success of VF implementation and dynamic core competence development is also worth researching in the future.

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