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The growth and capability development of electronics manufacturing service (EMS) companies

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Abstract

This paper describes the firm growth model in electronics manufacturing service (EMS) companies and its link with their internal capability developments. This research work, based on multiple in-depth case studies of EMS companies during the last 3 years, explores the EMS business and its capability growth processes in a supply network environment. It demonstrates that EMS companies usually start by selectively penetrating and positioning themselves along the supply chain. Business growth takes place along three intertwined dimensions: production, supply chain and capability development. The paper proposes the growth model of EMS companies from a capability perspective, which itself can be broken down into four stages of resource and capability development: penetration, accumulation, evolution and adaptation.

Keywords: Electronic manufacturing service (EMS); Firm growth; Capability approach

1. Introduction

Throughout the last two decades, global companies have been driven by new competitive demands, and have constantly been adding and discarding businesses in order to sharpen their strategic focus (Lei and Hitt, 1995; Nadler and Tushman, 1999). By strategically outsourcing and emphasizing a company's core competencies, a manager is able to leverage his company's skills and resources and thus achieve improved competitiveness (Quinn and Hilmer, 1994). The traditional vertical integrated business models have been replaced by collaborative virtual networks, which consist of companies whose focus is on diverse supply-chain functions (Chien and Shi, 2004). Understanding the sources of sustained competitive advantage achieved by firms has become a major area of research in the strategic management field (Rumelt, 1984; Porter, 1985; Prahalad and Hamel, 1990; Barney, 1991).

In terms of outsourcing, the emphasis is shifting rapidly from the outsourcing of parts and components to that of ideas (Quinn, 2000) and activities (Halvey and Melby, 1999; Quinn 1999). This outsourcing trend in the electronics sector has helped the growth of the subcontracting sector; in particular, modular production in the electronics industry has boosted the growth of the electronics

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manufacturing service (EMS) industry (Barnes et al., 2000; Salvador et al., 2002). Kim (2003) has pointed out that two types of contract manufacturer exist: one charges low prices yet has few improvement capabilities; the other charges more but has greater improvement capabilities, which in turn contribute to long-term developments (Kim, 2003). However, there has been little research concerning the evolution and development of EMS companies.

The EMS industry has achieved rapid growth throughout the last 10 years. The turnover of the global EMS industry grew from $59 billion in 1996 to $141 billion in 2000, with an annual growth rate of 20–25% (Sherman and Berry, 2005). Meanwhile, the whole IT industry only had a 7.5% annual growth rate for the same period. It is expected that the EMS industry will achieve a turnover of $203 billion in 2005 with an annual growth rate of 28.5%, whilst the whole IT industry's growth rate will be 9.1% (Sherman and Berry, 2005). Given that the data indicate a remarkable market growth rate, the developments of individual firms also raise interesting observations for research. The development of one of the world's leading EMS companies is presented here in order to explore further the topic of company growth:

Company O started up in the 1980s in the Far East region. At the beginning, the company had in 'arm's length' relationships with its OEM customers, and was purely a component provider at that stage. Those OEM customers might also offer some production orders as overflows in return. Hence, EMS companies existed to carry out consignment work for OEM companies. As OEM companies continued this trend for outsourcing, farming out not just production but also other activities along the supply chain, Company O grasped the opportunity to develop comprehensive capabilities along two dimensions: the production chain and the supply chain. Nowadays, the products it makes range from mobile phones to complex PC servers, and the services it offers span from new product design to logistics. The technology development trend in the electronics industry and the outsourcing activities of OEM companies have both been key external factors in the improvement in Company O's performance. But in general, the reasons behind the evolutionl trajectory of EMS companies, and the way in which they evolve their capabilities internally, have still not been clarified.

The names given to different types of company in the electronics industry have been mentioned in various circumstances and these names have been defined similarly (Barnes et al., 2000). This article adopts the following definitions for EMS companies, and for other relevant types of companies:

- OEM—original equipment manufacturer: the company which owns the brand name(s) and carries out the marketing of its final product(s).
- EMS—electronics manufacturing service (companies): companies who offer manufacturing related services to OEMs. A similar acronym, CEM (contract electronics manufacturer) was used widely to describe companies who concentrate more on production, while EMS companies are those which concentrate more on providing comprehensive services. In this research, CEMs can be regarded as one category of EMS companies.
- ODM—original design manufacturer: a company which designs and builds products using the brand name of its OEM collaborator (an ODM is also known as a CDM—contract design manufacturer)

By studying the data, and by looking at examples of the development of the EMS industry and of its individual firms, we can see that EMS companies have grown rapidly. However, little research has been carried out to understand this phenomenon. This research, by carrying out a series of case studies, seeks to address the issue of how EMS companies grow.

Firstly, we begin by describing the theoretical foundation which is used to address the research question. There are two major bodies of research, which have addressed the issue of company growth. Economic perspectives (such as industry organization, transaction costs, and the evolution theory) were the first to be adopted to enable an understanding of how firms grow and develop (Penrose, 1959; Jovanovic, 1982; Nelson and Winter, 1982; Tirole, 1988). These were followed by the use of stage models or life-cycle models (Greiner, 1972; Churchill and Lewis, 1983; Kazanjian and Drazin, 1989). Section 2 will review these two streams of firm growth research in more detail, as well as introducing the capability approach.

2. Literature review

2.1. Models of firm growth

Stage models of firm growth have a clear advantage when it comes to describing the process. Researchers in this field believe that a firm's growth depends on a clear strategy and plan, as well as good leadership and a passion for learning (Bartlett and Ghoshal, 2000), which is more of a company-level issue.

Based on a study of more than 100 manufacturing SMEs from 'high technology' industries, Hanks et al. (1993) presented a life-cycle model comprising four stages: start-up, expansion, maturity, and diversification. The growth life cycle was depicted as a unique configuration of variables related to organizational context or structure (Hanks et al., 1993). Similarly, Kazanjian and Drazin (1989) proposed a similar stage model, as shown in Table 1. This model is made up of four stages of firm growth: conception and development, commercialization, growth, and stability. This model specifically links the development of a firm with the products it creates. However, products are only one aspect of a company's development (for example, EMS companies not only produce products for OEM customers, they also provide supply-chain services).

Table 1
Four stages of firm development (Kazanjian and Drazin, 1989)

Stage 1—Conception and development
- Focusing on product development and design
- Securing adequate financial resources and developing a market
- Formality and procedures are non-existent

Stage 2—Commercialization
- Has a product that performs well and meets a need in the market place
- Has the capability to produce and sell
- Has some revenues and some backlog of orders

Stage 3—Growth
- Achieve high growth rates in both sales and marketing
- Focusing on how to produce, sell, and distribute products in volume while attaining profitability
- Has own products

Stage 4—Stability
- Development of second-, third-generation products and/or totally new product lines
- Securing growth funding, and market share
- Penetrating new geographic territories

More generally, Greiner (1972) utilizes a crisis model to depict general firm growth stages, as shown in Fig. 1. At each stage, firms need to solve different crises and adopt corresponding strategies. The author identifies five key dimensions which are essential for building a model of organizational development: age of organization, size of organization, stages of evolution, stages of revolution, and growth rate of the industry. To further address these five dimensions, Greiner proposes five stages through which firms grow, these being creativity, direction, delegation, coordination, and collaboration.

Other similar works include Scott and Bruce's (1987) firm growth life-cycle model, Churchill and Lewis's (1983) stage model, and Li and Tan's (2004) growth model for companies in the Far East region. These models all describe the issue rather than making predictions, and they lack sufficient detail to capture the internal dynamics of firm growth (Freel, 2000). Hence, it is necessary to bring in perspectives from other disciplines.

2.2. Origins and development of capability approach

The other stream of research concerning firm growth has its origins in Penrose's seminal work, *the Theory of the Growth of the Firm* (1959). Thereafter, other researchers have enriched the research field by providing several perspectives to aid the understanding of firm growth and industry evolution (Richardson, 1972; Nelson and Winter, 1982; Williamson, 1993). In the last two decades, these economics perspectives have focused more on a specific firm-level aspect—strategic management. Within the field of strategic management, two major pieces of research have used different approaches to address the issue of how firms achieve and sustain a competitive advantage. One approach is the positioning school, as exemplified by the five forces model (Porter, 1980), whilst the other is the resource-based view (RBV) (Wernerfelt, 1984; Barney, 1991). The former method mainly describes a firm's interaction with the industry in which it is based, and hence concentrates on the external factors. Meanwhile, the latter approach focuses on understanding internal factors.

Ever since the RBV became widely respected in the late 1970s, it has become a major contemporary approach in formulating strategy (Foss,

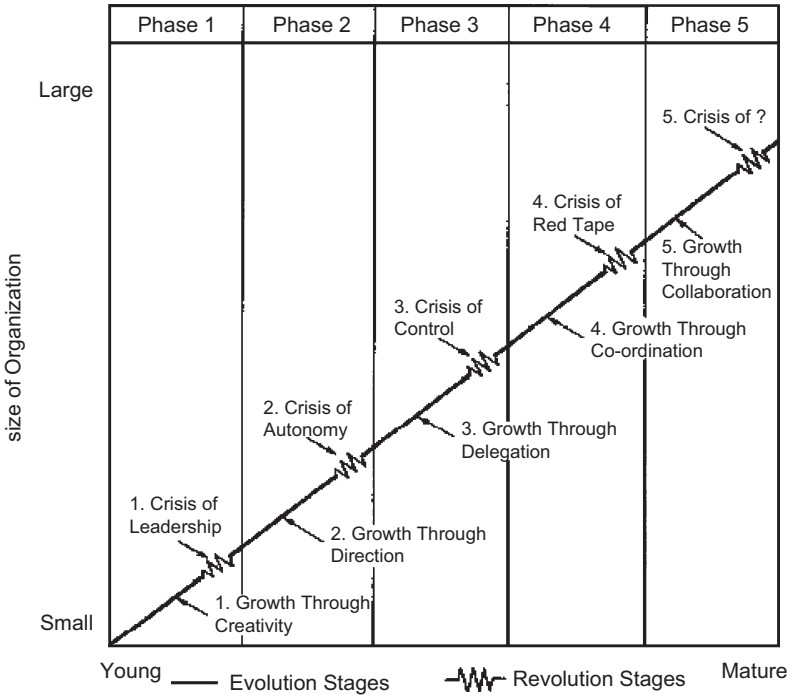

Fig. 1. Greiner model of five stages of firm growth (Greiner, 1972).

1997). The RBV tends to see differences in performance between firms not as the result of differences in market power, but as the result of differences in efficiency. To address these differences, researchers in the field tend to concentrate on resources and capabilities that are long lasting and hard to imitate (Conner, 1991). Despite its remarkable contributions to the field of strategic management, the RBV has long been criticized for its failure to address the dynamics of a firm's development (Dierickx and Cool, 1989; Teece and Pisano, 1994). Researchers have therefore introduced the concept of dynamic capability to fill the gap, and to enrich the dynamic dimension of the theory.

Dynamic capability has been defined as 'the firm's ability to integrate, build and reconfigure internal and external competences to address a rapidly changing environment' (Teece et al., 1997). Many researchers have, therefore, contributed to an understanding of the concept and its adoption in real business situations (Rindova and Kotha, 2001; Kylaheiko et al., 2002). However, a question has been raised as to whether or not the concept of dynamic capability is actually necessary (Helfat and Peteraf, 2003). Also, even given the research concerning dynamic capability, the research into the origins and evolution of capabilities still has not provided clear answers (Zollo and Winter, 2002).

In the wake of efforts such as Selznick's concept of 'distinctive competence' (Selznick, 1957) and the later more refined concepts of organizational routines (Nelson and Winter, 1982), absorptive capability (Cohen and Levinthal, 1990), architectural knowledge (Henderson and Clark, 1990), combinative capabilities (Kogut and Zander, 1992), and dynamic capabilities (Teece and Pisano, 1994), recent years have seen many attempts made to understand what leads to the variation in the degree of success of business organizations. However, the research has sought to characterize the phenomenon rather than to answer the question of how capabilities emerge and evolve. The capability evolution perspective has its roots in the classical RBV, which has been regarded as static (Helfat, 2000), because it concentrates on strategies for exploiting current firm-specific assets (Teece and Pisano, 1994; Teece et al., 1997). Meanwhile, the evolution perspective seeks to understand the dynamics of the process of building the advantage instead (Foss et al., 1995).

Early research into the evolution of firms has been linked strongly with the industry in which

it serves (Levinthal and Myatt, 1994), as shown in Fig. 2. Levinthal and Myatt argue that a firm's capability evolution is closely linked with the evolution of the markets that the firm serves. Many organizational capabilities emerge, are refined, or decay as a result of product market activity.

On the other hand, some researchers have put great effort into understanding the internal development of a firm's capability, which is more helpful in addressing the capability evolution issue at company level. Helfat and Peteraf (2003) adopt an evolutionary economics perspective to understand the evolutionary trajectories of capabilities in general. The fundamental argument is that since products and resources are two sides of the same coin (Wernerfelt, 1984), capability should undergo a similar development life cycle to that of products. The capability development life-cycle model is shown in Figs. 3 and 4.

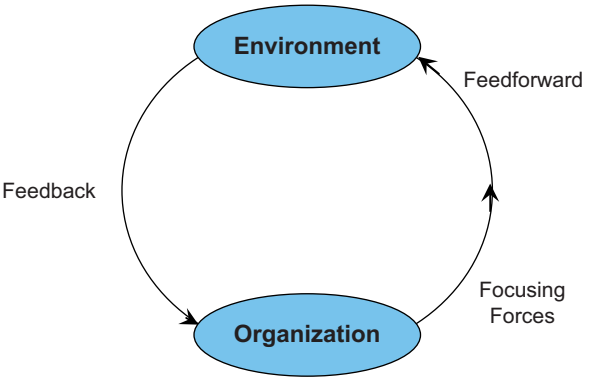

Fig. 2. Co-evolution of firm and industry (Levinthal and Myatt, 1994).

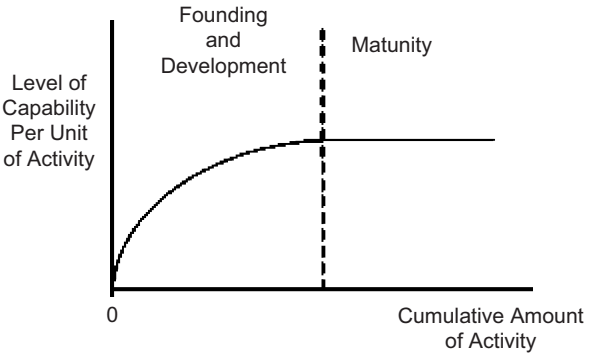

Fig. 3. Capability development life cycle (Helfat and Peteraf, 2003).

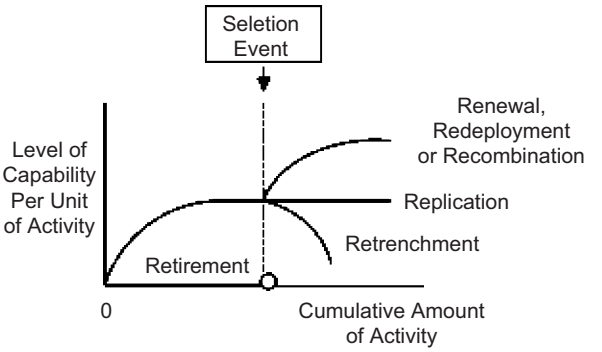

Fig. 4. Branches of the capability life cycle (Helfat and Peteraf, 2003).

The capability life-cycle model creatively depicts the development of capabilities in general. Several valuable characteristics of capability development have been identified, such as development stages, and the trend of capability development. However, the research does not make the link with knowledge in the operations management field, and hence does not address how to operationalize capability development in a real business environment.

2.3. Towards a capability approach for firm growth

From the literature, we can see that both the firm growth model and the capability approach need further enrichment. Also, neither of them is able to clearly illustrate the independent evolution of EMS companies. Enormous research effort into firms at operational level has gone into understanding companies' internal management activities, such as production system design (Francis and White, 1987), quality improvement (Deming, 1986), and supply-chain management (Harland et al., 1999). However, these issues have not been linked with the capability view in strategic management-level considerations.

In the capability-related research, several concepts from the field of operations management have been constantly mentioned, such as learning mechanisms (Zollo and Winter, 2002), continuous improvement (Paulk et al., 1993), and business process re-engineering (Ashayeri et al., 1998). These concepts are not sufficient to encompass all the operational activities that contribute to capability and the development of organizational routines, but these concepts are key to building up links between operations practices and the capability approach, and hence endowing more concrete meanings to the

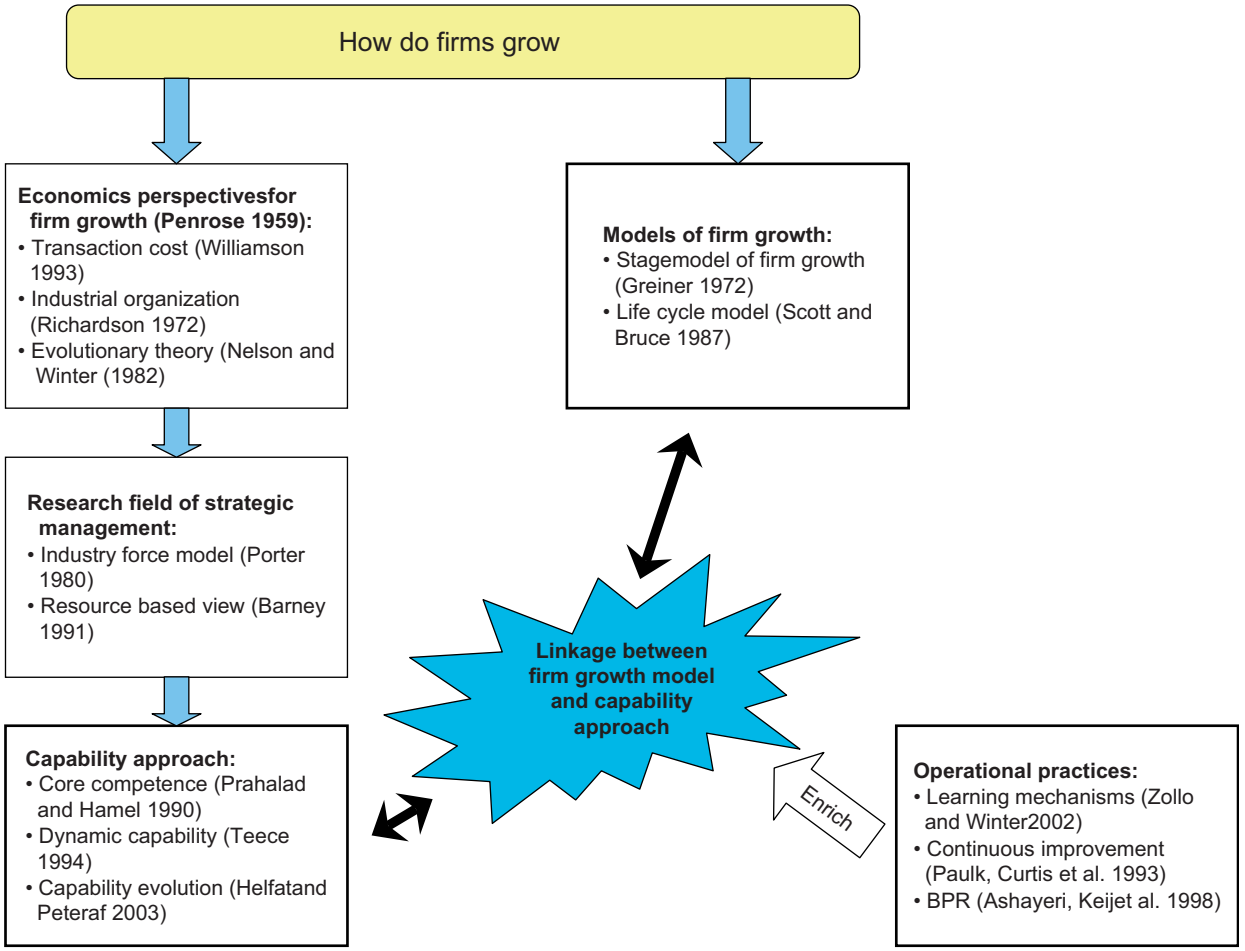

Fig. 5. Theoretical gap between capability approach and firm growth model.

latter. In this research, we try to understand firm growth using the capability approach, and we adopt concepts from the operations management field to enrich the content of the empirical study. The positioning of this research and the theoretical gap is shown in Fig. 5.

Given that EMS companies have achieved rapid growth in the last two decades, the characteristics of company growth will be easier to define than they would be if the companies had grown over a long period of time. Therefore, the phenomenon provides an ideal opportunity to understand firm growth and capability development.

Based on the literature review and on observations in the EMS sector, the refined research question is: *How do the capability developments of an EMS company contribute to its growth*? To address the question, the research design is proposed in Section 3.

3. Research methodology

Since the research seeks to answer a 'how' question, it is only proper to choose the case study as the main method of research (Yin, 1994). An analysis of both the research objectives and the research design is presented in the following sections.

3.1. Design of the research protocol

The first issue which needs to be addressed is how to capture or describe the whole process. Since EMS companies deal heavily with production and relevant services, the products/parts they make and the services they provide represent two types of final outcome. The case study will start by providing an understanding of the evolution of an EMS company's products. Then the evolution of these

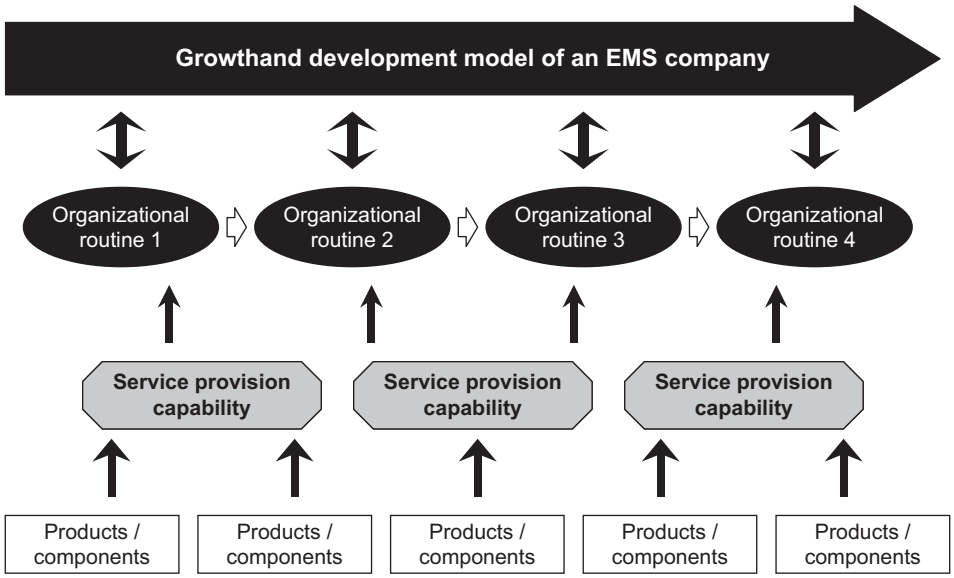

Fig. 6. Preliminary framework for understanding the growth of EMS companies.

products will be linked with the evolution of the manufacturing processes and services provided by an EMS company along the supply chain. The preliminary framework for understanding the growth of EMS companies is shown in Fig. 6.

By studying the development trajectories of both products and services, the organizational routines which contribute to the formulation and enhancement of the company's services are then identified and linked with the company's growth process. The three major issues which are key to successfully addressing the research question are described as follows.

3.1.1. 'Milestones' of EMS companies' growth and their linkages

EMS companies manufacture products for their OEM customers. Furthermore, the services relating to these products are also major deliverables of EMS companies. Since EMS companies combines supply-chain services (including production, logistics, and design) with the products they make, it is essential to understand the major products/components such companies deal with during their growth. That way, the services combined with those products can be mapped out accordingly and in chronological order. The key developments of products are marked out as milestones of an EMS company's growth. Hence, projects relating to the formulation and enhancement of services are identified as key projects, which in turn leads to an understanding of the development of organizational routines.

Data collection was mainly carried out via interviews, company history studies, and document studies. A mapping method was used to depict the process of product evolution and the provision of relevant services. The exploratory case shows that the complexity of products increases during the course of EMS companies' development. At the same time, EMS companies expand their service provision along the supply chain. Such observations are essential in order to demonstrate their improving performances.

3.1.2. Milestone projects and organizational routines

Here we adopt several theoretical concepts to help with the identification of organizational routines and capabilities from company projects. Although capability has been defined as a kind of resource (Daft, 1997), here we differentiate it from tangible resources by regarding capability as 'a high-level routine (or collection of routines) that together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type' (Winter, 2003). Since both 'capabilities' and 'organizational routines' must contain repeatable patterns of activities, the terms are interchangeable to some degree for the purposes of describing the issue. However, in this research, we address organizational behaviours that 'learned,

highly patterned, repetitious, or quasi-repetitious, founded in part in tacit knowledge—and the specificity of objectives' (Winter, 2003) as organizational routines. Meanwhile, the capabilities of EMS companies are reflected directly by the services they provide along the supply chain.

Relevant research into operations management and manufacturing systems helps with the identification of the development of organizational routines. In particular, several key issues have been frequently mentioned in the field of capability research, as well as in the field of operations management, for example learning mechanisms (Zollo and Winter, 2002), continuous improvement (Paulk et al., 1993), and business process re-engineering (Ashayeri et al., 1998).

Based on their definitions, the data collection seeks here to identify these activities and relevant processes as observations for the development of organizational routines. The patterns of capability development will be mapped with developments of products and services, and hence demonstrate EMS companies' growth.

3.1.3. External factors

External factors will be considered during data collection to study their links with companies' internal developments. Three major issues have been identified in the literature: technologies in the electronics industry, economic growth in the Far East region, and the outsourcing trend of OEM companies (Rumelt, 1991; Quinn, 1999).

3.2. Case study and data analysis

3.2.1. Case study

The case-study process was designed to ensure the comprehensive understanding of a company and to triangulate data sources. Three cases were chosen based on their performances (mainly based on their ranking in the industry and on comments from customers). The multiple case-study design is to improve the reliability and validity of research findings (Yin, 1994). In each case, a variety of people were interviewed (including company founders, senior managers, middle managers, engineers, and technicians), and different data collection methods were employed (such as interviews and history reviews).

The three cases involve companies from the Far East region, with two based in Greater China and one in Singapore/Indonesia. The reasons behind the selection of each company are as follows:

1. Data on the regional growth of the EMS industry show that America was originally the fastest-growing region, but since 2003 it has given up its position to the Asia Pacific region, as shown in Fig. 7. The selection of a rapidly developing industry to address evolution and growth issues

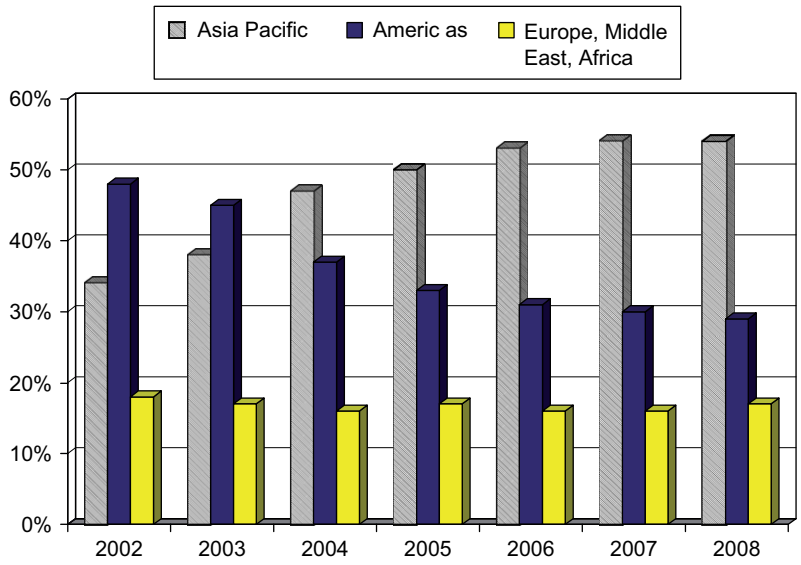

Fig. 7. Regional trends for the EMS industry (adapted from Sherman and Berry, 2005).

is similar to the method applied in the field of biology, where fruit flies are studied. The fast rate of evolution of this species provides greater opportunities for rapid learning, which can then be applied to other slower evolving objectives (Fine, 2000).

2. EMS companies in the Far East region developed relatively quickly compared with those in America and Europe. Although a small number of companies took their first steps in the 1970s, most EMS companies in the region started up and experienced rapid growth in the 1980s or 1990s. This enables previous data on company growth to be retrieved, leading to a better understanding of companies' growth processes.
3. The three cases attempt to describe EMS companies' growth from diverse perspectives. Company A enjoyed an early start-up in the 1970s and developed comprehensive supply-chain services for computer and IT products. Meanwhile, Company B enriched the growth process by providing more details of production system developments. Company C depicts how an EMS company penetrates the sector via the marketing and distribution stages. The case also provides more details of business activities relevant to company growth.

3.2.2. Data analysis

There has been little research in the area of company growth and the capability approach to address EMS companies, and hence the phenomenon was a new one. Empirical studies and ground theory methods were adopted partly to help with generating practical data. The data analysis methods including mapping and coding were utilized to analyse EMS companies' development tracks and trajectories.

Mapping: The mapping technique has been widely adopted in research relating to operations management (Adam and Swamidass, 1989). In this research, mapping is used to understand product development, services development, and relevant projects in chronological order. In each case, the horizontal axis of the mapping represents time, while the vertical axis represents the company's strategic changes, product milestones and services developments, key projects, and relevant activities.

Coding: The coding method is one of the central components of the grounded theory building process (Strauss and Corbin, 1998), which involves procedures to encourage researchers to break through hypotheses and generate new patterns from old. In this research, coding is used to tease out the developments of organizational routines and understand their patterns from the previous mapping, which is mainly based on the concepts provided in the 'Design of Research Protocol' section.

Based on the research design discussed in this section, Section 4 will present three cases in order to provide evidence for the research findings.

4. Case studies

4.1. Company A

The model used to illustrate Company A's development was known in the industry as CMMS, which stands for components, modules, moves, and services. When the Taiwanese electronics industry took its first steps in the early 1960s, electronics was targeted by the local government and people as a strategic technology, and was thus promoted through various policies. The company took this opportunity and started up as a plastics component provider specializing in connector and cable production (producing a range of products from peripherals such as serial and power connectors and cables to precision CPU/memory sockets). The company became the top provider of cables and connectors to the worldwide PC industry. It then continued its strategy of concentrating on labour-intensive production and tapped into PC enclosure production. The 'Module' stage was reached when the company combined the enclosures, connectors, cables, and power systems it produced to provide subsystems to its OEM customers. The movement towards more complex systems build-up has improved Company A's position in the supply network from that of a component provider, so that it now enjoys close partnerships with its OEM collaborators (Fig. 8).

Company A accumulated intensive manufacturing knowledge and achieved global expansion during the labour-intensive production period. The company's capacity and its outstanding manufacturing

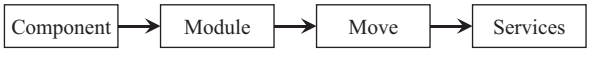

Fig. 8. CMMS model of Company A (adapted from Company A's annual report).

capabilities enabled it to further expand along the production chain, such as acquiring PCB production through merger and acquisition. Company A achieved 'Move' stage through moving along the production chain and finally became a full PC system integrator for world-class OEM customers.

At the same time, the company started to concentrate on comprehensive service provision along the supply chain. By utilizing its intensive knowledge of production methods, Company A began by merely providing suggestions to its customers regarding product designs, but evolved to the point where it was collaborating with them on the actual details. By leveraging its global network, Company A is able to synchronize the design houses around the world to fully exploit the 24-h working day. The whole network has also been restructured to reduce the time-to-volume ratio: its sites in the US mainly coordinate with customers regarding rapid design and prototyping for the purposes of volume ramp-up; the volume production process is then transferred to factories in the Far East region and Eastern Europe for low-cost production; global sites also work as warehouses to coordinate worldwide logistics for customers. In response to customer demand, Company A established a repair centre next door to one of the largest shopping malls, in Tianjin, Northern China, providing after-sales services to final customers, and hence better leveraging the company's manufacturing capability and providing more comprehensive services along the supply chain. Furthermore, according to Company A's plan, the CMMS model will be utilized as a business model to enable it to enter other arenas, such as the automotive and consumer electronics industries.

The observation of Company A has unveiled a clear picture of EMS companies' growth along both the production chain and the supply chain. However, Company A has a long development period, which led to difficulties in understanding the early stages of accumulation and evolution along the production chain. These details are expected to be backed up by evidence from other cases.

The development of services along the supply chain mainly happened along two dimensions, as shown in Fig. 9. The horizontal dimension illustrates the company's rapid expansion along the supply chain to provide design, production, distribution, and after-sales services. At the same time, the company has further exploited these services through its capability development along the vertical dimension by means of resource

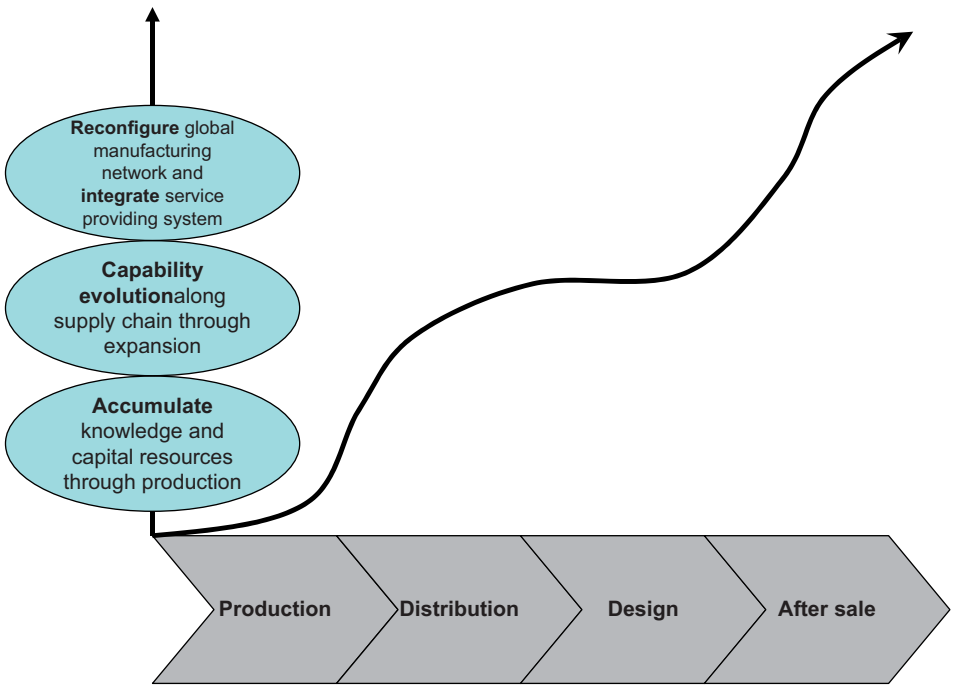

Fig. 9. Company A's expansion along the supply chain.

accumulation, capability evolution, resource reconfiguration, and integration.

4.2. Company B

Company B has grown more rapidly than Company A and has concentrated on developing its production capabilities. Thus the observations here have focused on the organic growth of the production capability development.

Batam Island is one of the most advanced industrial areas of Indonesia. Enjoying a convenient geographic location—1 h to Malaysia and Singapore by boat—the island has become a manufacturing centre in the area. An industry park was established in 1991, which attracted a number of well-known multinationals. The founder of Company B—a Chinese national—took the advantage of the location and established the company on the island in 1993. The company started by providing a labour-intensive PCB assembly service for its Japanese customers. What impressed these customers most was the company's quick grasp of the continuous improvement philosophy and its willingness to adopt it at a day-to-day management level. At the beginning, Company B mainly duplicated the production line used by its customers, who provided the company with engineers to help with its implementation. Then the founder, together with the company's own engineers, sought to improve the efficiency of the production lines by improving the speed of the operators. The assembly actions of the operators were further standardized and redundant actions were omitted. In this way, the company 'redesigned' the production line. The company's engineering department boosted the continuous improvement system further by delivering more helpful production methods, such as developing manual assembly tools. Following on from the technology development trend in the electronics industry, Company B upgraded its production-line methods from purely manual assembly to include the use of SMT machines. In addition, together with the local university, the company developed a semi-automatic machine to cope with PCB assembly. Each of the different types of production line was then arranged to enable it to deal with different type of PCBs. Properly identifying the balance between the cost of the different production lines and the complexity of the PCBs helped optimize the company's production system.

Company B continued to accept similar labour-intensive production orders from other customers for products such as rigid PCBs, flexible PCBs, and cables. At the same time, the company started to tap into production activities that possessed a low entry barrier but generated higher profit margins than the labour-intensive productions, for example plastic inject moulding. Whilst entering these new areas of production, Company B tried to win new orders from its existing customers, because it was felt that it would then be much easier to expand its operation to include new customers.

Company B's continuous improvement system for production lines went well until its engineers noticed that the key bottlenecks were no longer the individual actions required for each operation, but the sequences of those actions. This situation could not to be resolved without an overall redesign of the production line. The production process reconfiguration was carried out to maximize the speed of the production line. Company B was able to double the speed of the original line which it had copied from its customer, and thereby reduce its manufacturing costs by 50%. Moreover, the company established the process redesign as an organizational routine to improve its overall production system.

Further to the development of its process reconfiguration routine, Company B sought to embed the skill into the volume ramp-up stage to improve the time-to-volume ratio. Originally, the ramp-up was helped by its OEM customers. By duplicating a customer's existing manufacturing processes, a company can achieve ramp-up without any additional process design effort being required. However, the manufacturing costs remain at a higher level during the early stages of new production, and a company can not cope with new product ramp-up since it lacks process design capability. However, Company B was able to avoid this situation by integrating its knowledge and experience of process design to quickly adapt processes duplicated from its customers and thus to reduce manufacturing costs in the early stages of ramp-up. Also, the company offered suggestions regarding its customers' new process design to help reduce manufacturing costs. In these ways, Company B was able to achieve a 50% reduction in manufacturing costs in the first month of new PCB production.

Aided by its organizational routines such as process reconfiguration and rapid volume ramp-up, the company's performance encouraged customers to

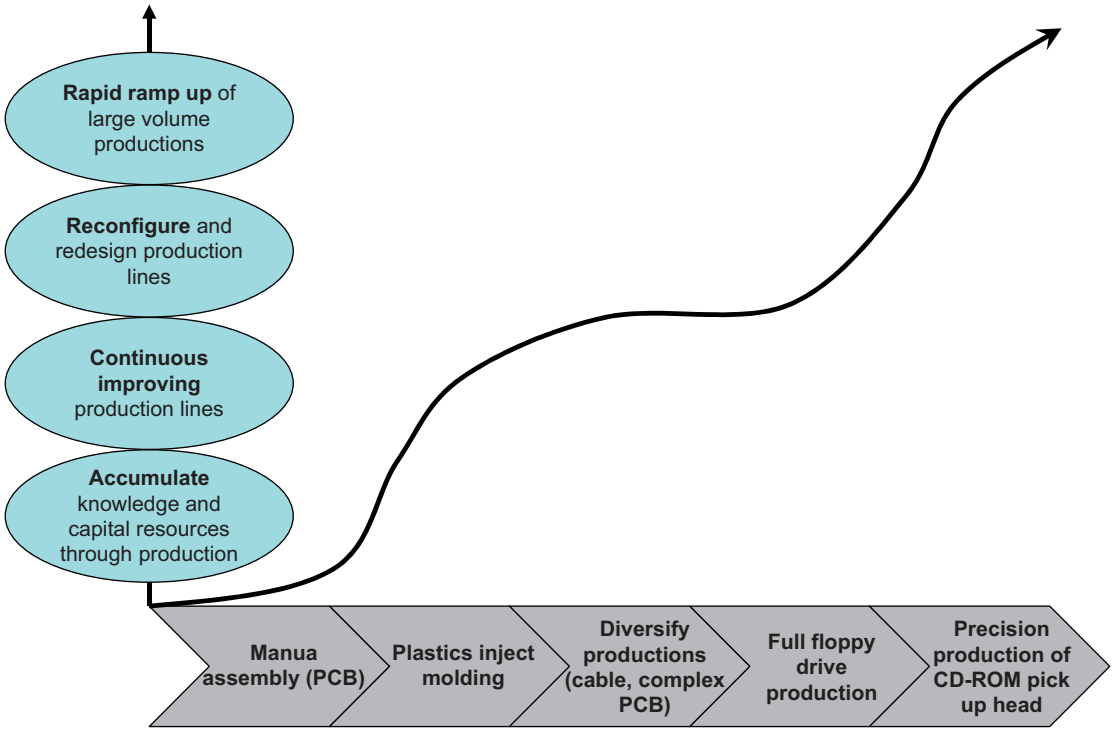

Fig. 10. Company B's development of products and production systems.

offer more manual assembly work. By integrating its existing PCB and plastic moulding capabilities, the company started to deliver full-system assembly services, ranging from videophones and baby monitors to floppy drives for computers. Company B's knowledge of production processes also earned it contracts for more complex and precise projects, such as CD-ROM pick-up-head assembly, which requires high-quality and accurate assembly skills. Further utilizing its knowledge and experience gained in the production field, Company B started to make suggestions to its customers from a manufacturing perspective regarding new product designs, a process referred to in the industry as 'design for manufacturing'. This new development has paved the way for the company to evolve into the upper stream of design service provision. At the same time, geographical expansion into China and Thailand will help it to achieve expansion along the whole supply chain in the same way as Company A.

Company B's development demonstrate an EMS company's capability evolution along the production chain. The company has continuously developed higher-value-added organizational routines to improve its production service provision. Because of its accumulation of knowledge and experience, the company has also been able to move towards the provision of a design service. Company B's development of its production system is shown in Fig. 10. The horizontal dimension represents the increased complexity of products and the production system. Meanwhile, the vertical dimension illustrates the continuous development of relevant capabilities.

Similarly to Company A, Company B penetrated the EMS industry through the labour-intensive production of components. Along with increasing the complexity of products and the production system, Company B has developed a series of organizational routines to enhance its production capability. Furthermore, the knowledge accumulated from its involvement in production has enabled the company to expand its supply-chain capabilities.

4.3. Company C

Both Company A and Company B started up as manufacturers in order to utilize low-cost production resources in the Far East region. Company C adopted a different approach to enter the electronics industry. In the late 1980s, when China was more closed off from the world, Hong Kong and the Pearl

River Delta (PRD) region became the bridge between China and the outside. If Western companies wanted to enter the Chinese market or utilize local manufacturing capabilities, they had to go via this 'bridge'. As a result of China's open door policy, this area became a Special Economic Zone. Both foreign companies and domestic enterprises enjoyed privileged policies, which enabled them to do business. The founder of Company C joined the 'big army of entrepreneurs' in the region and started a trading company in Hong Kong. The company's original role was to help foreign companies to distribute their products in China. After a short period of observation and selection, Mr. Ou, the vice-president, chose the inkjet printer as the product with which Company A would start its trading and distribution operation, and thus enable the world's leading brands to achieve distribution and sales in China.

The company's expansion along the production chain started from its key customer's willingness to follow the trend of 'making it in China'. Orders were received for the assembly of simple printer modules. The customer controlled the whole supply chain, while Company C dealt with the final steps of module assembly and distribution in China. With the implementation of the continuous improvement system, the company started to acquire some knowledge of production methods. The company expanded to other areas of component assembly, including that of plastic components and PCBs, thus achieving limited diversification in the field of printer production.

Company C adopted another strategy to build up its production capability. The company established an industry park near to its own factories to attract investors. The investors were required to own production facilities that could supplement Company C's existing manufacturing system along the production chain. These facilities included plastic inject moulding and metal processing technologies, which contribute to the final assembly of inkjet printers. Collaboration was made possible by means of components outsourcing or joint ventures. Thus, Company C achieved almost complete production-chain integration. Meanwhile, the company can concentrate on the final production of printers and on expansion along the supply chain.

Company C established its own design laboratory to provide new product-testing services based on its knowledge of quality control. In this way, the company gained a better understanding of inkjet printing and of related products. Company C also further expanded its distribution network in China so that it now owns more than 300 sites across the country. Its production knowledge has been utilized to enable it to provide after-sales services for its OEM customers. The distribution sites have recently been adapted to provide both after-sales services and repair services.

The integration of its marketing and product design capabilities has given Company C more knowledge regarding new product development than both Company A and Company B, since the latter does not provide sales services for their customers. Company C has since begun to help its customers by customizing existing products and designing new products for China's local market sectors. The company now possesses comprehensive service-providing capabilities along the supply chain and is willing to move towards becoming a brand owner. But as an EMS company, its first priority is to avoid head-to-head competition with its OEM customers. Thus the company has tapped into a niche market to produce tax-controlled machines for local government. The company's evolution from EMS to ODM represents the final destination on its development trajectory.

Company C penetrated the supply chain by providing distribution and sales services, which is typical of the business model used by Chinese companies in the early 1980s. As the company possesses this detailed knowledge of the local market, it is able to combine that knowledge with production knowledge to deliver ODM services to its OEM customers, both by customizing products for local markets and by building products bearing its own brand name. This case raises an interesting topic which merits further investigation, i.e. whether or not an EMS company will finally evolve to become an OEM company (Fig. 11).

5. Framework

Apart from product development, EMS companies grow along another two dimensions, these being services and capabilities. The 'product' dimension represents their deliverables, illustrating that along firm growth, EMS companies are able to cope with increasingly complex products. Meanwhile, along the 'service' dimension, EMS companies seek to vertically integrate services along the supply chain and to move to the upper stream (e.g., design services). What lies beneath these two

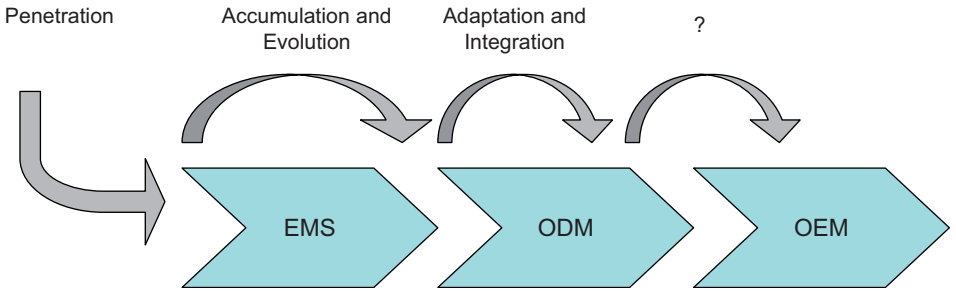

Fig. 11. A demonstration of Company C's growth trajectory.

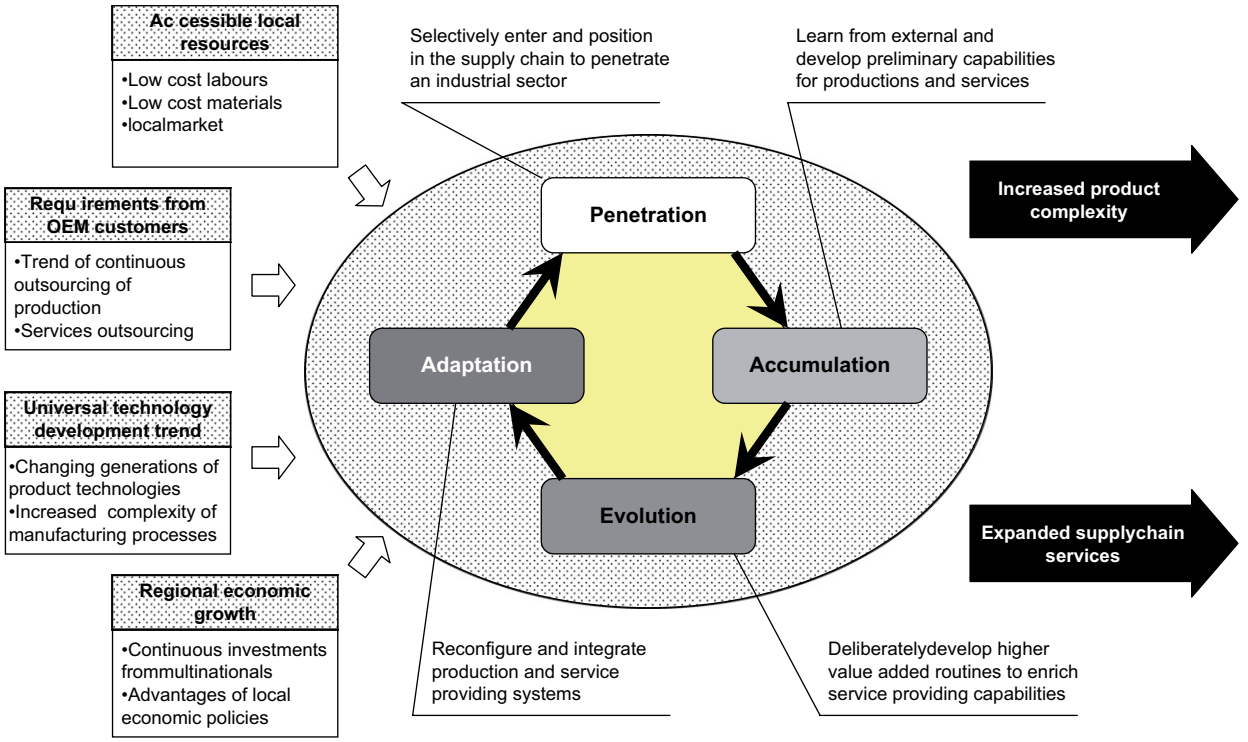

Fig. 12. Growth model of EMS companies.

dimensions, and provides energy for their developments is the 'capability' dimension. Only with the integration of all three dimensions it is possible to have a clear picture of the growth model of EMS companies. This growth model, which combines the external factors which set the macro-environment, is shown in Fig. 12.

Further to the growth model, the four stages of capability developments are shown in Table 2, these being accumulation, evolution, reconfiguration, and integration.

- *Penetration*: When a new company seeks to enter the EMS industry, it begins by leveraging existing resources, such as low-cost labour, or the educational backgrounds or personal networks of its founders. As EMS companies compete via both the production chain and the supply chain, their positioning for entry is key to their future development.
- *Accumulation*: During this stage, EMS companies start to gather resources for further development and to learn from outside. Typical practices include copying from customers or competitors, and utilizing existing external and internal resources (e.g., low-cost labour, personal contacts). Companies then seek initially to explore the production chain using repetitive practices

Table 2
Capability development in EMS companies along products and processes

	Penetration	Accumulation	Evolution	Adaptation
Products (complexity of manufacturing processes and technologies)	• Start production from labour-intensive component products • Leverage existing resources for production, e.g. founder's educational background, local economic policy and low-cost labour • Choose a product/component as core product/component for long-term capability development	• Production knowledge/experience accumulation through duplicate production processes/technologies from customers and repetitive practice • Diversify customers to learn from different production practices • Utilize existing production capability to access other components/products • Codify manufacturing knowledge • Improve production system and expand capacity incrementally • Follow universal manufacturing technology trend	• Deliberately build continuous improvement system • Develop process design and redesign capabilities • Codify knowledge of process design • Continuously develop new organizational routines to enhance production services (volume ramp-up, co-design production system with OEM customers)	• Integrate components production capabilities to manage full system manufacturing • Adapt production knowledge to address more complex components/products • Utilize production to enter new sector/industry
Services (servicing processes along the supply chain)	• Selectively position in the lower stream of supply chain with high-labour and low-technology contents (production, distribution) • Leverage existing local resources such as low-cost labour, personal networks, and privileged local economic policies	• Expand along the supply chain by providing more value-added services (mainly contain labour-intensive contents) • Adopt multiple methods (alliances, geographical expansion) to enrich service provision	• Continuously improve existing services along supply chain to add more value • Utilize existing process knowledge and experience to provide supportive activities to technology-intensive projects (design, procurement management, ODM) • Continuously develop new organizational routines to support or generate new services	• Restructure organization to address new services (international factory network, internal management structure) • Services (production network/supply chain/global design network) restructuring • Integrate services along the supply chain to provide comprehensive services as a service package

and limited diversification, and to expand the supply chain by providing more labour-intensive services.

- *Evolution*: After accumulating their initial resources, EMS companies start to formulate more 'repetitive patterns'—organizational routines based on a better understanding of both the production system and supply-chain system, such as continuous improvement, production-line reconfiguration, and production ramp-up. These routines are keys to EMS companies, further development, as they represent their ability to innovate independently. Alongside the development of capabilities, the capacities of these firms increase rapidly due to geographical expansion.
- *Adaptation*: During this stage, EMS companies have already accumulated remarkable resources and capabilities. Besides continuous learning, their major aim is to restructure the whole manufacturing system and integrate services in order to increase efficiency and reduce operations costs. Typical activities include integrating supply-chain services, integrating production capabilities for full-system build-up, and reconfiguring global manufacturing networks and product design networks. Further to the evolution activities described in the last stage, EMS companies further adapt their production knowledge to utilize in other services, such as morphing to become ODM service providers and generating after-sales services along the supply chain.

The capability development framework for EMS companies is presented in Table 2.

6. Conclusion

6.1. Contributions to theory

This research seeks to understand the growth of EMS companies from the combined perspective of firm growth and the capability approach. Some contributions to the research fields are as follows:

Previous research into firm growth mainly relied on the firm being driven by the development of its own products and technology. Meanwhile, in the EMS industry, penetration and positioning are keys during the early stages of EMS companies' growth. The growth patterns of EMS companies show further evidence of a growth model driven by capability developments. This model contributes to the research into firm growth and enriches the research into the capability approach. A comparison between the capability-based EMS company growth model and traditional firm growth models is shown in Table 3.

During the research, the evolution process of organizational routines has been identified in both Company A and Company B. The EMS companies continuously develop new organizational routines to add more value to the existing production system. According to the previous definition of dynamic capability as being one which does not directly create products but instead helps to create

Table 3
A comparison of this research with traditional firm growth models

Sources	Points and conclusions
Ansoff (1965)	Suggested a long-term planning process aimed at the development and the growth of the business
Greiner (1972)	Proposed firm growth life-cycle model and identified stages based on 'crisis' and methods for growth
Kazanjian and Drazin (1989)	Firm growth cycle is regarded from product and relevant capability developments points of view
Hanks et al. (1993)	Firm growth life cycle was depicted as an exclusive configuration of variables relevant to organizational context or structure
Li and Tan (2004)	In different growth stages, SME firms adopt various strategies/approaches to help their growth, namely: breath-on-top-of-death, transformation, and diversification
Firm growth from a capability development view in this research	EMS companies growth stages can be identified based on the patterns of their capability developments. EMS companies follow four stages of growth: penetration, accumulation, evolution and adaptation

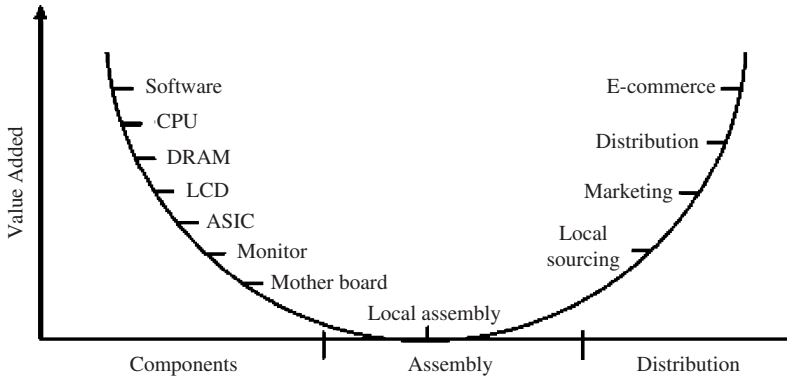

Fig. 13. Stan Shih's smiling curve (Bartlett and Ghoshal, 2000).

operational-level capabilities (Winter, 2003), some organizational routines should be addressed as dynamic capability routines, for example production-line reconfiguration and production volume ramp-up. Also, as EMS companies evolve, they continuously restructure their production systems and supply chains, and integrate production capabilities to address more complex systems build-up. We argue that these 'reconfiguration and integration' activities can be regarded as the results and processes of continuous capability development. Meanwhile, higher-level business activities, such as the CMMS growth process used by Company A, can more appropriately be described as corporate-level dynamic capability routines, such as those which combine, leverage and adapt all firm capabilities in order to address the change in the market and contribute to company growth. Hence, we propose that further research into dynamic capability should be linked closely with a company's business model and strategic changes to address more organizational routines at a higher level of firm development.

6.2. Implications for practice

This research delivers an exploratory study into EMS companies' growth and capability evolution. It reveals how EMS companies grow along three dimensions (products, services, and capabilities), and provides practical guidance for the business management of EMS companies.

- *Products*: This dimension illustrates the development trend towards products and components, which involve more complex manufacturing processes and technologies. EMS companies start by producing components production possess a low-technology entry barrier, and they make use of existing local resources (such as low-cost labour in the Far East region). As EMS companies continue to develop capabilities along the production chain, they tend to tackle more complete products. If one follows Stan Shih's smiling curve model shown in Fig. 13, the product development trend is moving to the upper left-hand side of the curve.
- *Services*: Since EMS companies are more capable of dealing with full-systems production along their development, they seek to provide more services along the supply chain to add value to their production services. Most EMS companies start from labour-intensive service stages (e.g., production, distribution) the downstream in the supply chain. They then move upstream in the supply chain to provide technology-intensive services (e.g., design, ODM).
- *Capability*: What lies beneath the developments along the product and process dimensions mentioned above is the evolution of the companies' internal capabilities and organizational routines. Along the four stages of resources and capability development, the company penetrates the EMS industry via a low-technology entry barrier. By accumulating knowledge and capital resources, EMS companies need to achieve an 'imitation to innovation' of process and supply-chain capabilities in order to compete. As EMS companies possess more capabilities and resources, adaptation is required to optimize the whole business system and dynamically fit with the changing market for future growth.

6.3. Future research

The research provides an exploratory insight into EMS companies from the combined perspective of firm growth and capability development. Several practical and theoretical issues need to be addressed in the future:

- In the future, more attention needs to be paid to developing an understanding and initiating research into the capability approach in order to link strategic management research with operations management research, and hence to endow more concrete meanings to concepts such as capability and organizational routine.
- More research is needed to understand EMS companies' business systems from a variety of perspectives, as the field has been largely ignored until now. The results of studies into EMS companies will have an impact on many other disciplines, such as supplier selection.
- This research raises an interesting issue, which is also a concern of OEM companies, and that is whether or not EMS companies will develop into OEMs? If so, how can this transform best be achieved? The dynamics of EMS companies' growth and development will have a great impact on the development of the whole manufacturing industry, and provide a new business model of firm growth.

References

Adam, E.A., Swamidass, P.M., 1989. Assessing operations management from a strategic perspective. Journal of Management.

Ashayeri, J., Keij, R., Bröker, A., 1998. Global business process re-engineering: a system dynamics-based approach. International Journal of Operations and Production Management 18 (9/10), 817–831.

Barnes, E., Dai, J., Deng, S., Down, D., Goh, M., Lau, H.C., Sharafali, M., 2000. Electronics Manufacturing Service Industry. Georgia Institute of Technology, National University of Singapore.

Barney, J.B., 1991. Firm resources and sustained competitive advantage. Journal of Management 17, 99–120.

Bartlett, C.A., Ghoshal, S., 2000. Going Global: Lessons from Late Movers. Harvard Business Review (March/April).

Chien, C.-F., Shi, Y., 2004. Global manufacturing network and supply chain management for the electronics industry. International Journal of Business 9 (4), 327–328.

Churchill, N.C., Lewis, V.L., 1983. The Five Stages of Small Business Growth. Harvard Business Review (May/June), 30–50.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly 35, 128–152.

Conner, K., 1991. A historical comparison of resource-based theory and five schools of thought within industrial organization economics: do we have a new theory of the firm? Journal of Management 17, 121–154.

Daft, R.L., 1997. Organization Theory and Design. International Thomson Publishing, South-western College Publishing.

Deming, W.E., 1986. Out of the Crisis: Quality, Productivity and Competitive Position. Cambridge University Press, Cambridge.

Dierickx, I., Cool, K., 1989. Asset stock accumulation and sustainability of competitive advantage. Management Science 35, 1504–1511.

Fine, C.H., 2000. Clockspeed-based strategies for supply chain design. Production and Operations Management 9 (3), 212–221.

Foss, N.J. (Ed.), 1997. Resources, Firms, and Strategies: A Reader in the Resource-based Perspective. Oxford University Press, Oxford.

Foss, N.J., Knudsen, C., Montgomery, C.A., 1995. An Exploration of Common Ground: Integrating Evolutionary and Strategic Theories of the Firm, Resource-based and Evolutionary Theories of the Firm: Towards a Synthesis. Kluwer, C.A. Montgomery, Norwell, MA, pp. 1–18.

Francis, R.L., White, J.A., 1987. Facility Layout and Location: An Analytical Approach. Prentice Hall, New York.

Freel, M.S., 2000. Towards an evolutionary theory of small firm Growth. Journal of Enterprising Culture 8 (4), 321–342.

Greiner, L., 1972. Evolution and revolution as organizations grow. Harvard Business Review 50 (July–August), 37–46.

Halvey, J.K., Melby, B.M., 1999. Business Process Outsourcing—Process, Strategies, and Contracts. Wiley, New York.

Hanks, S.H., Watson, C.J., Jansen, E., Chandler, G.N., 1993. Tightening the life-cycle construct: a taxonomic study of growth stage configurations in high-technology organisations. Entrepreneurship Theory and Practice 18 (2), 5–29.

Harland, C.M., Lamming, R.C., Cousins, P., 1999. Developing the concept of supply strategy. International Journal of Operations and Production Management 19 (7).

Helfat, C.E., 2000. The evolution of capabilities. Strategic Management Journal (Special Issue) 21 (10–11), 955–959.

Helfat, C.E., Peteraf, M.A., 2003. The dynamic resource-based view: Capability lifecycles. Strategic Management Journal 24, 997–1010.

Henderson, R.M., Clark, K.B., 1990. Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. Administrative Science Quarterly 35, 9–30.

Jovanovic, B., 1982. Selection and the evolution of industry. Econometrica 50 (649–670).

Kazanjian, R.K., Drazin, R., 1989. An empirical test of stage of growth progression model. Management Science 35 (12), 1489–1503.

Kim, B., 2003. Dynamic outsourcing to contract manufacturers with different capabilities of reducing the supply cost. International Journal of Production Economics 86 (1), 63–80.

Kogut, B., Zander, U., 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. Organization Science 3, 383–397.

Kylaheiko, K., Sandstrom, J., Virkkunen, V., 2002. Dynamic capability view in terms of real options. International Journal of Production Economics 80 (1), 65–83.

Lei, D., Hitt, M.A., 1995. Strategic restructuring and outsourcing: the effect of mergers and acquisitions and lbos on building firm skills and capabilities. Journal of Management 21, 835–860.

Levinthal, D., Myatt, J., 1994. Co-evolution of capabilities and industry: the evolution of mutual fund processing. Strategic Management Journal (Winter Special Issue) 15, 45–62.

Li, H.-H.J., Tan, K.H., 2004. SMEs business growth model: a medium to big effort. International Journal of Management and Enterprise Development 1 (3), 195–207.

Nadler, D., Tushman, M., 1999. The organization of the future: strategic imperatives and core competencies for the 21st century. Organizational Dynamics 28 (1), 45–60.

Nelson, R.R., Winter, S.G., 1982. An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge, MA.

Paulk, M.C., Curtis, B., Chrissis, M.B., Weber, C.V., 1993. Capability Maturity Model for Software, Version 1.1. Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA, USA.

Penrose, E.T., 1959. The Theory of the Growth of the Firm. Basic Blackwell, London.

Porter, M., 1985. Competitive Advantage. Free Press, New York.

Porter, M.E., 1980. Competitive Strategy. Free Press, New York.

Prahalad, C.K., Hamel, G., 1990. The core competence of the corporation. Harvard Business Review 68 (3), 79–94.

Quinn, J.B., 1999. Strategic outsourcing: leveraging knowledge capabilities. Sloan Management Review 40 (4), 9–21.

Quinn, J.B., 2000. Outsourcing innovation: the new engine of growth. Sloan Management Review 41 (4), 13–29.

Quinn, J.B., Hilmer, F.G., 1994. Strategic outsourcing. Sloan Management Review, 43–55.

Richardson, G.B., 1972. The organisation of industry. Economic Journal 82 (327), 883–896.

Rindova, V.P., Kotha, S., 2001. Continuous 'Morphing': competing through dynamic capabilities. Form and function. Academy of Management Journal 44 (6), 1263–1280.

Rumelt, R.P., 1984. In: Lamb, R.B. (Ed.), Towards a Strategic Theory of the Firm, Competitive Strategic Management. Prentice-Hall, Englewood Cliffs, NJ.

Rumelt, R.P., 1991. How much does Industry matter? Strategic Management Journal 12 (3), 167–185.

Salvador, F., Forza, C., Rungtusanatham, M., 2002. Modularity, product variety, production volume, and component sourcing: Theorizing beyond generic prescriptions. Journal of Operations Management 20, 549–575.

Scott, M., Bruce, R., 1987. Five stages of growth in small business. Long Range Planning 20 (3), 45–52.

Selznick, P., 1957. Leadership in Administration: A Sociological Interpretation. Row, Peterson, and Co., Evanston, IL, USA.

Sherman, R., Berry, S., 2005. The Worldwide Electronics Manufacturing Services Market. Electronic Trend Publications.

Strauss, A.L., Corbin, J., 1998. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. Sage, Thousand Oaks, CA, London.

Teece, D.J., Pisano, G., 1994. The dynamic capabilities of firms: An introduction. Industrial and Corporate Change 3 (3), 537–556.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strategic Management Journal 8 (7), 509–533.

Tirole, J., 1988. The Theory of Industrial Organization. MIT Press, Cambridge, MA, USA.

Wernerfelt, B., 1984. A resource-based view of the firm. Strategic Management Journal 5 (2), 171–180.

Williamson, O.E., 1993. Transaction cost economics and organization theory. Industrial and Corporate Change 2 (2), 107–156.

Winter, S.G., 2003. Understanding dynamic capabilities. Strategic Management Journal (Special Issue) 24 (991–995).

Yin, R.K., 1994. Case Study Research: Design and Methods. Sage, Thousand Oaks, CA, USA, London.

Zollo, M., Winter, S.G., 2002. Deliberate learning and the evolution of dynamic capabilities. Organization Science 13 (3), 339–351.