NICHE EXPANSION BASED VIEW OF INTERNATIONALIZATION: EMPIRICAL EVIDENCE IN THE INTERNATIONALIZATION AND CATCHUP OF THE CHINA PRECISION OPTICS MANUFACTURERS

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Niche Expansion Based View of Internationalization:

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Abstract

This dissertation develops and tests theories on niche expansion based view of internationalization in the context of the internationalization and catchup of China precision optics manufacturers. I apply insights from the organizational ecology theory and pay special attention to the roles of niche expansion which is observed in both international and technological dimensions. I use niche expansion perspective to explore how China precision optics manufacturers have pursued different niche strategies and how the different niche expansion strategies have influenced firm catchup performance. Six firms from China's precision optics industry were chosen for comparative case study. The major findings include (i) firms internationalization and catch up follows international generalist or international specialist niche expansion strategies; (ii) the success and failure of firms internationalization and catch up depends on the realized niche expansion and the process, according to the principle of cross allocation, follows an upward spiral mode in the international/local and product/technology dimensions; (iii)the different International Business theories can be applied and integrated to the niche expansion perspective accordingly to the different stages of firms' internationalization. These findings thus: (i) provide further insight in firm internationalization, late-industrialization and catch-up;(ii) reveal how niche expansion influence firm internationalization and catchup performance; (iii) cast light on the Goldilocks debate by integrating the different International Business theories.

Key words: niche expansion, DMNE internationalization, DMNE catch up

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Statement of Copyright

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1. Introduction

China precision optics manufacturing industry was reshaped by the influence from the international market during the last three decades. Now China has become the world manufacturing center for precision optics manufacturing. How these China precision optics manufacturers pursue different strategies during their internationalization and how the different strategies influence their catch up performance remain as a secret for international business researchers. Some companies have enjoyed rapid growth and soon became global market leaders in consumer optics manufacturing, others focus on technology niche grew successfully into niche players in their special areas. There are also a lot of unsuccessful cases of companies who struggle to survive in face of competitive international environment. The dynamics of China precision optics manufacturing for consumer and non-consumer applications created an interesting case for the world of international business. In a competitive environment, what are the different internationalization strategies and how different strategies affect companies' catch up performance?

In order to understand the success and failure of internationalization of these precision optics manufacturers in the real competitive world, we proceed as follows in the remainder of this article. First, drawing on the latest internationalization literature, we briefly analyzed the strength and weakness of the current micro theories on different firms with different country of origin and size. In the second section, we presented the niche expansion based view of internationalization as a macro theory and applied the theory in the following case study of China precision optics manufacturing industry as a whole and six different China precision optics manufacturers in particular with regard to their internationalization strategy and process. Third, we discuss the research and managerial implications of our findings in testing of the niche expansion based view and integrating of the different micro theories. At last, we conclude with an identification of the article's limitations and implications for further research.

2. Literature review

In setting out to investigate the internationalization strategy and process of firms, numerous literatures could provide insights and may be construed as relevant. In this article, we inform our study by drawing on selected areas and insights from the internationalization literature. With the increasing attention from the international business studies on developing country multinational enterprises (DMNEs), new theories and models were developed to explain why and how developing country multinational companies catch up through internationalization. DMNE theories such as LLL framework and springboard theory all try to identify distinctive developing country multinational companies' internationalization strategies. However, scholars from the study of advanced economy multinational companies (AMNEs) argue that DMNEs are not different and the existing theories from AMNEs can already explain the success of DMNEs. Goldilocks debate remains for the international business study providing an opportunity for researchers to use developing country multinational companies as laboratory to test all different theories in international business study. Therefore our literature review covers not only the study of DMNEs but also study of AMNEs and small and medium sized multinational companies (SMNEs).

The goal of literature review is to analyze the strength and weakness of these different theories. We start with an overview of all current different theories related to firm internationalization for AMNEs and SMNEs; we then move on to the overview of all current different theories for DMNEs. Both overviews cover the theories on firm internationalization strategy and process. At last, the Goldilocks debate was presented together with a critique of current literature with the finding of major gaps for future research.

2.1 Firm internationalization theories

Firm internationalization is an area full of research opportunities. There are different topics and issues under research about firm internationalization, new market entry strategy, management of network during the internationalization process, the influence of entrepreneur's international experience on the performance of firm internationalization, just to name a few. With all the different topics and issues regarding firm internationalization, one can group them into two broad main topics, i.e., firm internationalization strategy and the process of firm internationalization. In other word, as Weisfelder (2001) indicated that underlying all the different approaches to internationalization are two major questions: "why do firms internationalize?" and "how do firms internationalize?" Both questions are important questions to researchers and practitioners. They are also questions must be answered at the same time as internationalization strategy provide firms with the directions of their internationalization process and the internationalization process will provide more inputs that might help firms to adjust the strategy over time.

Researchers from different fields looked at firm international strategy and firm international process with their own perspectives. The beginning of internationalization research in the late 1950s and 1960s focused on large multinational companies and their international activities often called the economic approach, resulted in a vast body of theoretical and empirical data. Some of the main theories on the internationalization of AMNEs resulting include: the transaction cost theory or the internalization theory, the eclectic paradigm, and the monopolistic advantage theory. In 1976 John Dunning presented the eclectic paradigm of international production to offer a holistic framework to identify and evaluate the significance of the factors influencing both the initial act of foreign production by enterprise as and the growth of such production (Dunning, 2003). In early 1970s researchers from small and open economies in the Nordic countries such as Sweden and Finland started to study the internal process of SMNEs internationalization. The

representatives of this research group Johanson and Vahlne developed the Uppsala internationalization model. Bilkey and Tesar (1977), Cavusgil (1980), Reid (1981) and Czinkota (1982) considered the internationalization of a firm to be a process analogous to the stages of product adoption (Rogers1962), Based on Vernon's (1966) product (life) cycle model, the innovation-related models of internationalization consider each subsequent stage as an innovation for the firm. Both of the Uppsala model and Innovation-related model focus on the process of SMEs internationalization and are referred as stage theory (Ruzzier, 2006). In 1990, Johanson and Vahlne extend their study and developed the network perspective of SMEs internationalization. According to their model, SMNEs internationalization can be regarded as a process that the firm establishes and develops positions in relation to other counterparts in a foreign network. In 1994, Benjamin M Oviatt and Patricia P McDougall developed a new research area of international entrepreneurship by focusing the new phenomena of born-globals. The international entrepreneurship group view SMNEs internationalization as an innovative, risk-seeking behavior that crosses national borders and intended to create value in organization.

With the recently renewed interest in developing country multinational companies (DMNE) since 2000s, some authors argue that DMNEs behave differently from AMNCs and, thus, require new theories and models to explain their behavior. With the growing importance of Chinese MNEs in the international market, there is a lot of research on CMNEs（Chinese Multinational Enterprises）. For example, Mathews (2006) introduces the linkage, leverage, learning (LLL) framework as an explanation of the differing behavior of DMNCs. He argues that DMNEs are part of a second-wave, accelerated internationalization using pull factors that challenges existing theories. The LLL framework proposes that DMNCs internationalize using linkage (acquiring advantages externally, via outward orientation and strategic asset access), leverage (connecting to partners to obtain resources and using networks), and learning (upgrading via repetition and improvement). Luo and Tung (2007)

propose a springboard investment perspective, in which DMNEs invest abroad to obtain strategic assets needed to compete more effectively against AMNEs and avoid home country institutional and market deficiencies. “DMNEs use their international expansion as a springboard to compensate for competitive disadvantages, overcome latecomer disadvantage, counterattack global rivals’ major footholds in their home country market, pass stringent trade barriers, alleviate domestic institutional constraints, secure preferential treatment offered by emerging market governments, and exploit their competitive advantages in other emerging or developing markets”. Guillen and Garcia-Canal (2009) discussed the DMNEs’ accelerated mode of internationalization, arguing that DMNEs have weak competitive advantages but strong political capabilities and high organizational adaptability. DMNEs simultaneously enter developed and developing countries, using alliances and acquisitions to expand abroad.

Before we can integrate all different AMNEs, SMNEs and DMNEs theories in international business studies, it is worthwhile for us to group the different theories and summarize the main ideas for each theory. First of all, we group the theories into two categories: one is theories for firm internationalization strategy and the other is theories for firm internationalization process. For each category, we identify different perspectives. For firm internationalization strategy, we group the theories into the economic perspective, the strategic management perspective, and entrepreneurship perspective. For firm internationalization process, we group the theories into the economic perspective, the strategic management perspective, and entrepreneurship perspective.

Figure 1: Grouping of current theories on firm internationalization

Type of Firm	Strategy	Process
AMNE (Advanced economy multinationals)	Transaction cost theory Eclectic paradigm (OLI) Monopolistic advantage	FDI
SMNE (Small and Medium Sized multinationals)	International Entrepreneurship (IE) Resource based view Industry based view Institution based view	Stage theory (U-model and I model) Network theory IE
DMNE (Developing Country multinationals)	LLL paradigm Springboard Accelerated internationalization	LLL paradigm Springboard Accelerated internationalization

As we can see from figure 1 above that the mainstream AMNE internationalization theory of transaction cost theory (or internalization theory) and eclectic theory focus mainly on the strategy of firm internationalization while the studies on SMNEs such as stage theory and network theory seem to focus more on the process of firm internationalization. There is a clear separation among the study of AMNE internationalization， SMNE internationalization and DMNE internationalization. The theory of international entrepreneurship covers both the question of firm internationalization strategy and process with new perspective viewing internationalization of firms as an entrepreneurial effort within the international markets. There is also attempt to combine resource-based, industry-based and institution-based views to form a holistic framework to answer the question why SMNEs follow an international strategy. However, there is no clear effort in the field of firm internationalization to combine the studies on AMNEs and those on SMNEs.

There is also a clear separation between the study of AMNEs internationalization and DMNEs internationalization.

AMNE internationalization theories

AMNE Internationalization strategy – economic perspective

The eclectic paradigm, the transaction cost theory and the monopolistic advantage theories are also based on economics analysis of firm internationalization strategy. They are used for the analysis of MNE internationalization strategy. They also view firm internationalization as an alternative solution to the market imperfection while the eclectic paradigm tries to combine all the theories from the economic perspective.

Transaction cost theory

Referring to the transaction cost approach, Teece (1986, cited in Gilroy, 1993, p. 82) remarked, "At one level the internalization school and the transaction cost approach are one and the same. Both see the firm as a response to market failure. Profit-seeking firms internalize operations when by so doing the costs of organizing and transacting business will thereby be lowered". The difference of both theories is that in the transaction cost approach the unit of analysis is the transaction itself (Williamson, 1975; Gilroy, 1993). Internalization theory centers on the notion that firms aspire to develop their own internal markets whenever transactions can be made at a lower cost within the firm and will continue until the benefits and costs of further internalization are equated to the margin (Buckley and Casson, 1993). Internalization can involve a form of vertical integration bringing new operations and activities, formerly carried out by intermediate markets, under the ownership and governance of the firm especially when natural markets are imperfect or missing. Internalization of transactions beyond national borders leads to the creation of the

multinational enterprise. Antecedent to market internalization is a process of information gathering and assessment, through which management determines the best foreign expansion approach.

Monopolistic advantage theory

Monopolistic advantage theory holds that MNEs exist because a firm has unique sources of superiority over foreign firms in their own markets (Hymer, 1976, cited in McDougall et al., 1994). The advantages belong to the MNE and cannot be acquired by other firms. One type of monopolistic advantage is superior ability. Hymer (1976, cited in McDougall et al., 1994) argued that MNEs have superior knowledge, as found in the form of superior manufacturing processes, brand names, differentiated products, organizational talents, or patented technology. Monopolistic advantage theory holds that once a firm has developed this superior knowledge, it can exploit this advantage overseas at virtually no additional cost over that of exploiting that advantage in the home market (Caves, 1971, cited in McDougall et al., 1994). Because local entrepreneurs have to pay the full cost of developing this knowledge, they are unable to compete with the foreign firm despite their advantage in local market knowledge.

Eclectic paradigm

The eclectic paradigm, also known as the OLI Paradigm, is based on different economic theories and tries to explain the different forms of international production as well as the selection of a country for FDI (foreign direct investments). According to Dunning (1988), the internationalization of economic activity is determined by the realization of three types of advantages. First, ownership advantages which are specific to the company and related to the accumulation of intangible assets, technological capacities or product innovations. Second, the internalization advantages stem from the capacity of the firm to manage and coordinate activities internally in the value-added chain. These are related to the

integration of transactions into multinational hierarchies through FDI. Third, location advantages referring to the institutional and productive factors present in a particular geographical area. These arise when it is better to combine products manufactured in the home country with irremovable factors and intermediate products of another location. It was meant to convey the idea that a full explanation of the transnational activities of enterprises needs to draw upon several strands of economic theory; and that foreign direct investment is just one of a number of possible channels of international economic involvement, each of which is determined by a number of common factors (Dunning, 2003).

AMNEs internationalization process – economic perspective

FDI

The FDI theory was developed first by Hymer in 1960. According to Hymer, multinational company is a creature of market imperfection (transaction cost theory). Multinational company use international operation to separate markets, to remove competition and to exploit advantages (Dunning and Rugman, 2001). Kojima (1973) argues that FDI originated from Japan focuses on host country's comparative advantage and result in a trade promotion effect. This is in contrast with Hymer's FDI theory which suggests that FDI only comes from oligopolistic firms processing some kind of firm-specific assets. But, both the Hymer and Kojima FDI theories are applicable to the international process of small and medium sized multinationals (SMNEs). FDI theory explains the pattern of foreign direct investment as a form of SMNE internationalization. It is viewed as a mechanism that empowers firms to combine firm-specific-advantage with location-specific-advantage under internal system in form of FDI.

SMNE internationalization theories

SMNE Internationalization strategy – strategic management perspective

As a cross-section of internationalization business research and corporate strategy research, the research on firm internationalization strategy has drawn from theories from both research fields. Basically, the resource-based view, industry-based view and institution-based view, drawn mainly from the strategic management field, each focus on different aspects to analyze why firm pursue an internationalization strategy. They help us to analyze both internal and external factors to formulate an internationalization strategy (Yamakawa, 2008).

Resource-Based View

The resource-based view (Barney, 1991) developed in the field of strategic management field has become an influential perspective in international business research (Peng, 2001). It suggests that heterogeneity or firm-specific differences drive a firm's strategy and performance. The firm-specific differences refer to sustainable, unique and costly-to-copy attributes of a firm as its economic rent. The resources include tangible assets and intangible assets including knowledge and organizational learning capabilities. The resource-based view leads to a better understanding of firm's diversification strategies, internationalization being one of them (Ruzzier at al, 2006). As firms' internationalization requires resources and capabilities that are sustainable, rare and difficult-to-copy, the internationalization can be a sound competitive strategy for firms. DMNCS internationalization theories including LLL paradigm, springboard theory and accelerated internationalization theory are all based on the resource based theory. All these theories argue that the reason why DMNEs adopt international strategy is because DMNEs need to look for external resources that are sustainable, unique and costly-to-copy from the international market. The differences among these theories are more on how DMNCs internationalize and how their internationalization processes are different from those from AMNCs.

Industry based view

Industry-based view argues that conditions within an industry, to a large extent, determine strategy and performance (Porter, 1980). Based on the five forces analysis of an industry, three generic strategies are identified as cost leadership, differentiation and focus for firms within that industry. Internationalization can be combined with either one of these strategies so that such strategies can be extended to global market rather than just within the domestic market. Industry life cycle also explains why firms in a mature industry in one country might involve in international operation in another country where that industry is still developing. There also many other industry structure variables help to explain why firms pursue an internationalization strategy. Fernhaber at al (2007) has identified industry structure variables to explain drivers for new venture internationalization. In a competitive environment, it is important to view firm internationalization strategy in the context of the specific industry from which the firm is part of. Firm internationalization can be viewed as a strategic choice for firm to compete in its industry.

Institution based view

The institutional environment includes political institutions such as the regime type, the national structure of policy-making and the judicial system, economic institutions such as the structure of the national factor markets and the terms of access to international factors of production and socio-cultural factors such as informal norms, customs, mores and religions. All these elements constitute the institutional environment of a given country (Mudambi and Navarra, 2002).Institution-based view considers strategic choice, such as internationalization, as the outcome of dynamic interaction between firms and institutions. Strategic choices are not only driven by firm-specific capability and industry competitive environment but also institutional imperfection especially in the case of transitional economy (Peng, 2006).

The institution-based view of firm internationalization was proposed as one leg that helps to sustain the tripod of the firm internationalization strategy (the other two legs consisting of industry-based view and the resource-based view). The institution based view put the firm internationalization in the context of a specific country where institutional factors are significant for firm performance and survival. There is no doubt that institutional factors are important drivers for the strategic choice of firm internationalization.

SMNE internationalization strategy - entrepreneurship perspective

The concept of international entrepreneurship is developed over the last decade as an intersection of international business research and entrepreneurship research. While Zahra and George (2002) define international entrepreneurship as firms' process of creatively identify and exploit opportunities outside a firm's domestic market that can be sources of competitive advantage, McDougall and Oviatt (2006) define international entrepreneurship as "a combination of innovative, proactive and risk-seeking behavior that crosses national borders and is intended to create value in organizations". International entrepreneurship scholars found that international new venture as a business organization that, from inception, seeks to derive significant competitive advantage from the use of resources and the sale of outputs in multiple countries.

The distinguishing feature of these start-ups is that their origins are international, as demonstrated by observable and significant commitments of resources (e.g., material, people, financing, time) in more than one nation. The focus here is on the age of firms when they become international, not on their size. In contrast to organizations that evolve gradually from domestic firms to MNEs, these new ventures begin with a proactive international strategy. However, they do not necessarily own foreign assets; in other words, foreign direct investment is not a

requirement. Strategic alliances may be arranged for the use of foreign resources such as manufacturing capacity or marketing. Thus, consistent with Buckley and Casson's (1976) definition of the multinational enterprise, the definition of the international new venture is concerned with value added, not assets owned (Casson, 1982). The fact that international new ventures are international from inception implies that some decision must inevitably be made about when inception occurs. Therefore, firm-specific advantage is no longer a necessity to be leveraged for firm internationalization. The focus is more on the entrepreneurial opportunities from an international perspective. Firm internationalization is not only a strategy to leverage their resources and capabilities by engaging in business activities in multiple geographic markets but also a strategy to take advantage of the internationalization of the industry and certain country to develop unique competitive advantage.

SMNE internationalization process

The internationalization process of firms has been subjected to widespread empirical research (Cavusgil and Godiwalla 1982; Dichtl et al. 1984), and seems to benefit from a general acceptance in the literature (cf. Bradley 1991; Reid and Rosson 1987; Welch and Luostarinen 1988). However, as Wind (1979) described more than a decade ago firm internationalization process is an area in which empirical work by practitioners is often more advanced and insightful than academic contributions. The major theories regarding SMNE firm internationalization process include, stage models (Uppasala model and Innovation model) and network model from international business perspective and the IE model from the international entrepreneurship perspective.

The literature on the process of SMNE internationalization has tended to use a “push-oriented” concept, with the outward movement of the firm propelled by some strategic objective. Thus Welch and Luostarinen (1988: 36) define

internationalization as " the process of increasing involvement in international operations." This definition implies that internationalization is a linear sequential process of "increasing" involvement—which excludes the cases where firms actually cut back on their international exposure, or follow an "oscillatory" trajectory of increasing then diminishing international involvement—as in the case of the Swedish SMNE, Alfa-Laval, for example (Zander and Zander, 1997). Calof and Beamish (1995) sought a way around this problem with their definition of internationalization as being "the process of adapting firms' operations (strategy, structure, resource, etc.) to international environments" (1995: 116). This would appear to be a superior formulation, in that it does not pose any specific direction on the process of engagement with the international economy.

SMNE internationalization process – international business perspective

At least there are three major theatrical frames with direct implications to SMNE internationalization from the international business perspective: stage model, FDI model and network model (Etemad and Wright, 1999). They are drawn from different schools of international business research: behavioral school, economic school and sociology school respectively.

Stage model

There are two primary stage models, one is the Uppasala model (U-model) and the other is Innovation-related model (I-model). The stage theory is also categorized as topic under the field of organizational behavior, to be more specific, organizational learning behavior. The innovation-related model focus on the export development process of small and medium-sized firms and regard each subsequent stage of internationalization as an innovation from the firm. The two types of models (Uppasala model and Innovation-related model) have been the mainstream in the study of internationalization applied mainly to small and medium-sized firms.

The Uppasala Model was based on the hypothesis is that the internationalization process is a gradual knowledge acquisition process about the foreign market and companies with internationalization strategy follow a trial and error process (Forsgren, 2002). The Uppasala model believes that internationalization is the product of a series of incremental decisions, i.e., decisions to start exporting, to establish export channels, and to set up offshore subsidiary. Internationalization is presented in I-model as an innovation of the SMNE, a learning approach. I-Models differentiate between the internationalization process in large and small firms. Cavusgil (1980) puts forward a five-stage process of internationalization starting with the establishment of a domestic market (stage one) with varying incremental stages of internationalization until the firm has committed involvement (stage five). Bilkey and Tesar's (1977) six-stage process, Czinkota's (1982) six-stage process and Reid's (1981) five-stage process are all similar in the stages they present from a purely domestically oriented firm, to gaining export-information, through the varying degrees of export to being an experienced exporter. They differ in the number of stages and how the stages are described but they essentially represent a gradual pattern of internationalization based on the adaptation of the firm. The role of psychic distance is also consistent in each of the four I-Models above in that firms first export to psychologically close countries before exporting to more psychologically distant countries.

Network

According to the network perspective, the internationalization process of SMNEs depends on its network relationship rather than firm-specific advantage. The network research school draws on the theory of social exchange and resource dependency. It focuses on the non-hierarchical systems where firms invest to strengthen their position in international network (Johanson/Mattsson 1988, 1992, Sharma, 1992). Johanson and Mattsson (1993) described internationalization as a

“cumulative process, in which relationships are continually established, maintained, developed, broken and dissolved in order to achieve the objectives of the firm”. Sharma and Johanson refer to the network of international relationship as “bridge to foreign markets”. The network theory has particularly implication with firms as they lack the experience and knowledge in international operation when competing with MNEs.

Firm internationalization - entrepreneurship perspective

International Entrepreneurship

The concept of international entrepreneurship (IE) is developed over the last decade as an intersection of international business research and entrepreneurship research. While Zahra and Gorge (2002) define international entrepreneurship as SMNEs’ process of creatively identify and exploit opportunities outside a firm’s domestic market that can be sources of competitive advantage, McDougall and Oviatt (2006) define international entrepreneurship as “a combination of innovative, proactive and risk-seeking behavior that crosses national borders and is intended to create value in organizations.” The publication of 'Toward A Theory of International New Ventures' (Oviatt and McDougall, 1994) 10 years ago attracted worldwide attention to the growing role of young firms in the global marketplace. While researchers have long recognized the valuable contributions of SMNEs to international trade (Cannon and Willis, 1981; Douglas et al., 1982), Oviatt and McDougall (1994) highlighted the importance of smaller and younger firms and their distinguishing characteristics that position them to internationalize and create value quickly. Arguing that existing theories do not explain the formation of INVs, Oviatt and McDougall challenged and revised some existing and powerful paradigms about the process of internationalization, especially the stage theory (Johanson and Vahlne, 1977).

DMNEs internationalization theories

With the recently renewed interest in developing country multinational enterprise (DMNE) since 2000s, some authors argue that DMNEs behave differently from AMNEs and, thus, require new theories and models to explain their behavior. With the growing importance of Chinese multinationals in the international market, there is a lot of research on Chinese multinational enterprises (CMNEs) or so called dragon multinationals. For example, Mathews (2006) introduces the linkage, leverage, learning (LLL) framework as an explanation of the differing behavior of DMNEs. He argues that DMNEs are part of a second-wave, accelerated internationalization using pull factors that challenges existing theories. The LLL framework proposes that DMNEs internationalize using linkage (acquiring advantages externally, via outward orientation and strategic asset access), leverage (connecting to partners to obtain resources and using networks), and learning (upgrading via repetition and improvement). Luo and Tung (2007) propose a springboard investment perspective, in which DMNEs invest abroad to obtain strategic assets needed to compete more effectively against AMNEs and avoid home country institutional and market deficiencies. DMNEs use their international expansion as a springboard to compensate for competitive disadvantages, overcome latecomer disadvantage, counterattack global rivals' major footholds in their home country market, pass stringent trade barriers, alleviate domestic institutional constraints, secure preferential treatment offered by emerging market governments, and exploit their competitive advantages in other emerging or developing markets. Guillen and Garcia-Canal (2009) discuss the DMNE model of internationalization, whereby these firms follow an accelerated internationalization, have weak competitive advantages but strong political capabilities, simultaneously enter developed and developing countries, use alliances and acquisitions to expand abroad, and have high organizational adaptability.

LLL paradigm

Mathews introduced the notion “dragon multinationals” and the LLL strategic framework a decade ago. According to Mathews, DMNEs adopt a light, flexible and lattice structure during internationalization process and focus on connecting with established partners in the target market (Linkage), gaining access to strategic resource through “resource leverage” (Leverage) and building the capabilities and global reach by repeated application of linkage and leverage (Learning). The LLL strategic framework explains why DMNEs can internationalize faster that their counterpart AMNEs. The LLL paradigm can be viewed as the extended network theory from the Scandinavia school of SMEs internationalization. It can be also viewed as the extended resource-based perspective for DMNEs internationalization process of looking for external resources that are sustainable, unique and costly-to-copy from the international market. Through repeated applications of linkage and leverage and the learning during the internationalization process, DMNEs built up competitive advantage and catch up with AMNEs. The critical starting point for the latecomer and newcomer is that it is focused not on its own advantages, but on the advantages which can be acquired externally, i.e. on resources which can be accessed outside of itself. Thus a global orientation becomes a source of advantage—since the opportunities through which it can expand are likely to be found in the global market rather than in its domestic environment.

Springboard perspective

Luo and Tung developed the springboard perspective in 2007 and it became an important theory for DMNE internationalization. According to springboard perspective, international springboard is a global strategy to improve a firm’s global competitiveness and catchup with AMNEs through strategic asset- and opportunity-seeking, and by benefitting from favorable institutions in foreign countries. Springboard view argues DMNEs use international expansion as a springboard to “(1) acquire strategic resources to compensate for their capability voids, (2) overcome laggard disadvantages, (3) exploit competitive advantages and

market opportunities in other countries, (4) alleviate institutional and market constraints at home and bypass trade barriers into advanced markets, and (5) better compete with global rivals with augmented capabilities and improved home base after strategic asset acquisition"(Luo & Tung, 2007). Is Springboard perspective unique for DMNEs? The answer is no. Actually some advanced economy SMNEs share similar strategy. More recently Luo and Tung tried to put the springboard perspective in the general contextualization arguing that springboard strategy is not unique to DMNEs, SMNEs and AMNEs also use springboard strategy and not every EMNEs use springboard strategy. Guillen and Garcia-Canal (2009) proposed the accelerated internationalization mode for DMNEs arguing that DMNEs leveraging on political capability and organizational adaptability to enter both developed and developing countries with alliance and acquisition. While DMNEs have weak competitive advantage, they catch up through accelerated internationalization and become successful. Government support is mentioned as a key point for the success of the DMNEs.

2.2 Critique of literature on firm internationalization

The current international business theories are mostly micro-level theories. They take only limited perspectives from the perspective spectrum from market to entrepreneur with a limited focus on MNEs or SMNEs, AMNEs or DMNEs. They can only be used to explain the success of dragon multinationals and the catch-up strategy of DMNEs on a micro-level. DMNE theories such as LLL framework and springboard theory have tried to identify the distinctive features of DMNE catch-up theories. The LLL framework and springboard theory in particular focus on how DMNEs learn from AMNEs to acquire advanced technologies and innovation capabilities. AMNE theories such as OLI paradigm argue that firm needs to leverage its competitive advantages across boarder. The separations of country of origin created a biased perspective for each theory. Although country of origin is very important when it comes to internationalization, AMNEs, DMNEs and SMNEs are all

relative and it would be unsuitable to label a firm AMNE or DMNE or SMNE during the life cycle of a particular industry. In the real world, all AMNEs, DMNEs and SMNEs co-exist in the same industry competing for all kind of resources and may change positions over the life cycle of the industry. Competitive environment assumption requires a more macro-level ecological study that can include the dynamics of competitive international market.

The micro level studies, no matter whether they come from AMNEs theories, DMNE theories or SMNE theories, normally do not cover the full history of a firm and its industry. Following their detailed study, McDougall and Oviatt (1996, pp.34–35) concluded that ". . . more longitudinal research on venture internationalization is needed. . . . Not only should the research period be longer than two years . . ., but the sample size should also be relatively large in order to withstand inevitable losses of data over time and to detect any patterns in what may be rather disparate venture behaviors." For example, Hermann Simon, the author of "hidden champions" described the internationalization process of a company in the industrial supply market: "Founded in the UK in 1989, the company is now active in 17 European countries and has plans to expand into every European country in the next ten years. It will have taken 25 years to become a fully-fledged European company. Their next steps will be to enter the American and global markets and they anticipate this will take two generations." As firm internationalization process might takes decades and strategic implication of firm internationalization affect the competitive environment, in order to better understand the nature of firm internationalization, macro-level ecological study that cover the full history of the whole population of a particular industry in a particular country is needed.

The micro level studies might have a large sample size for their study. But, there is a lack of focus on the whole population of a particular industry. Large sample size from different industry cannot reveal the implication of firm internationalization on firm

performance and competitive dynamics of the industry. Within the two major research issues, namely internationalization strategy and internationalization process, while some of the theories were mainly developed for MNEs and others only focused on SMEs, some of the theories were mainly developed for AMNEs and others only focused on DMNEs, there is no unifying theory that tries to cover all firms of different sizes and at different ages within a particular industry. Figure 2 summarizes the different current theories and models on firm internationalization based on the perspective spectrum from market to entrepreneur. All the theories and models provide good insights from their own perspectives. What is missing is the academic effort to combine all the perspectives to form a full ecological perspective covering all the important factors regarding firm internationalization.

Figure 2: Grouping of theories and models from conventional perspective on firm internationalization

	Market	**Industry**	**Firm**	**Entrepreneur**
Strategy	Transaction cost theory; Eclectic paradigm; Monopolistic advantage; Institution based view	Industry based view	Resource based view; International entrepreneurship	International entrepreneurship
Process	FDI		Stage theory (U-model，I model); Network theory; International entrepreneurship LLL Springboard	International entrepreneurship

The conventional research on firm internationalization mainly coming from researchers in internationalization business, strategic management and entrepreneurship all trying to answer the question why firm adopt internationalization as a strategy. The conventional theories on firm internationalization based on economic analysis did not take into account the competitive interaction and dynamics with the industry. Sometimes, companies' internationalization strategy cannot be explained by economic analysis but can be a good strategy as it changed the landscape of the competitive environment. Firms need to develop their own international strategy trying to maintain and gain competitive advantage in the international markets. Firm internationalization strategy was developed not only based on economic analysis based on internal factors but often based on external market situation. Every firm need to face the challenge of globalization and form their internationalization strategy based on external factors such as the availability of resources in the foreign markets. So, topics around internationalization strategy of firm comes from the analysis on both the external factors such as industry variables and institutional variables and the internal factors such as human resource, market knowledge, R & D and etc. However, based on the current literature, different theories regarding firm internationalization only focus on limited factors and cannot give a full picture of the firm internationalization strategy and an ecological perspective is needed to cover all factors, internal and external.

International business researchers tend to focus on either external factors or internal factors when they study firm internationalization. The international business researchers that focus on the economic analysis and with a limited focus on AMNEs tend to focus on the firms' internal factors. While, international business researchers that focus on SMNEs and the early stage of firm internationalization tend to focus on the external factors of these firms. Either theory cannot capture all the factors

needed for the study of firm internationalizations. Moreover, the impact of globalization on firms cannot be explained just on the economic level analysis. The eclectic paradigm believes that the internationalization of economic activity is determined by the realization of three types of advantages, the ownership advantage, the internationalization advantage and the location advantage. However, firms need not only to combine firm-specific advantage with local-specific advantage in the form international operation but also to take advantage the opportunities created by globalization and internationalization of their industry. With smaller companies and startup firms, there is not much firm-specific advantage. The internationalization strategy of these firms cannot be explained with eclectic paradigm. The transaction cost theory believes firm internationalization is internalization of operations because of market imperfection. While, a lot of AMNEs internationalize just to capture the market opportunities created by free trade and globalization. With globalization and the recent internet application in most of the industries, the transaction cost has been minimized and firm internationalization is not limited to internalization of operations.

The internationalization process of firms has long been the focus of study for international business scholars. Theoretical work on the firm internationalization process is extensive, but it is difficult to find any characteristic common to all the approaches. Instead the field can be described as being rather fuzzy (Cited Boter and Holmquist, Bartlett and Ghoshal 1991; Melin 1992).The models of stage process, FDI and network were all mainly developed from the international business field with assumptions about firms' making process based on behavioral theories, with little or no influence from competitive behavior and market factors. Firm internationalization process was viewed as firm’s incremental decision based on knowledge. However, empirical design must be adapted to the theoretical model. These models can be described as lacking of explanatory power as they are more or less a reflection of the phenomenon rather than formal theories. As these same models cannot explain the

growing phenomenon of new ventures go international from day one, the international entrepreneurship research emerges with a focus on the entrepreneurial effort of firms. However, there is no micro level ecological theory or model that can combine all the key resources, both internal and external, for firm internationalization process.

Major gap in literature

Based on the literature review, we believe there is a gap in the literature: there is no macro level ecological theory to capture the firm internationalization and catch-up in the competitive international market and consequences of firm internationalization on firm catchup performance and industry dynamics. What are the positive and negative effects of internationalization on the different firms in an industry over the industry's life cycle? What are the different catchup strategies and how do firms from different strategic groups interact within the industry in face of globalization? What are the competitive consequences of firm internationalization on catchup performance and industry dynamics? All the existing international business theories are limited to the micro level study of firm internationalization. There is no existing macro level ecological theory that focuses on these questions and provides insight of the competitive dynamics of internationalization. There is no existing macro level ecological theory that can integrate all the micro level theories on firm internationalization and provide insight to the competitive dynamics of internationalization on a macro level.

Lack of formalized theoretical framework on firm Internationalization

First of all, the word "internationalization" is not a scientific/theoretical term, but a commonly used term to designate fairly different processes. Therefore it is unlikely to find a good definition for firm internationalization. However, what is missing in the current study of firm internationalization is a good theoretic framework that can better capture the internationalization strategy and process in a theoretical manner.

Mathew (2006) admitted that neither OLI nor LLL are “theories” of the international firm. They are, at best, conceptual frameworks that bring together the elements of an explanation as to how firms become international competitors. International business research is cross-disciplinary in nature, different models and frameworks stem from different disciplines. The OLI framework is comparative static in its formulation and emphasizes the ownership and internalization of prior resources as the primary explanation for the advantages of the MNE. It depends on transaction-cost reasoning. The LLL framework is dynamic and emphasizes the capture of external resources (e.g. through “asset augmentation”) as a strategic goal of internationalization. It depends on a strategic, resource-based view for its reasoning - but an open-ended resource-based view suitable for an open, evolving global economy. All the theories on firm internationalization came from existing theories. However, these micro level theories are high specific and cannot accommodate all the different processes of different firm internationalization at different stage in different industry and within different institutional environment.

Lack of macro level theory on firm internationalization strategy

With all the current theories and models of internationalization taking only limited perspectives from the perspective spectrum from market to entrepreneur with a limited focus on either DMNEs or SMNEs or DMNEs, there is a gap in the literature that macro level theory regarding firm internationalization strategy covering all the perspectives including market, industry, firm and entrepreneur. Each of the current theories and models on firm internationalization strategy was drawn from other research fields including economic field, international business field and entrepreneurship field. Theories from traditional strategic management field take firm internationalization more as a corporate diversification strategy and did integrate firm internationalization into the discussion of business strategy. Therefore, a macro level ecological theory on firm internationalization strategy is still lacking.

Lack of integrated model on firm internationalization process

The research in internationalization process of firm should be more integrated. No single, established model adequately explains firm international process. There is a need of better theory in which insights drawn from existing theoretical models including stage model, FDI model and network model can combined. The internationalization process of firm is dynamic process. All current theories on internationalization process of firm only capture part of the truth, while part of truth can be not truth. Both internal factors and external factors should be studied. Not only should the role of entrepreneur be studied but also the role of specific industry and specific institutional environment. There is limited research on organizational behavior side of the internationalization process firms. Not only should the early stage of internationalization be studied but also the growth stage and other stages of firm internationalization. There is a lack of integrated model on firm internationalization process that can capture the different aspects of firm internationalization at different stages

3. The niche expansion based view

Organizational ecologists, sometimes also known as corporate demographers, have drawn attention to the positive and negative interactions among populations of firms drawing on the same resources (e.g., customers, employees, suppliers, subcontractors, investors and etc.), investigating not just how these forces influence organizations but also how they change over an industry's life cycle. This perspective has emphasized the importance of demographic rates, primarily the births and deaths of firms, growth rate as in our study, as measures of company performance and industry vitality. As the study cover all members in an industry over its life cycle, organizational ecologists have brought a truly enormous amount of data into the picture, avoiding many of the methodological problems inherent in cross sectional studies or in small samples of unrepresentative firms.

Niche theory

The niche theory first emerged in 1984 in the works of Hannan, Freeman and Carroll. The niche concept has been proven to be extremely valuable for specifying competitive processes and environmental dependencies in organizational analysis (Hannan, Carroll, and Polos, 2003). As organizations compete for scarce resource, the niche structure of each organization will determine its competitive standing in the population. An ecological niche is defined as the n-dimensional resource space within which a population can exist. Niche width measures the range of environmental dimensions across which a population exits. Populations that depend on a wide range environmental dimensions for survival are known as generalists. In contrast, populations that survive in a narrow range of environmental dimensions are called specialist. Resource partitioning make the market in equilibrium as if generalist and specialist are operating in completely distinct market space. Besides the conventional generalist/specialist dimension, internationalization can be defined as firms' niche expansion in the geographical dimension, expansion of business activities over a national country's border, including import and export, foreign direct investment and other business activities.

To clarify the relationship between niche width and size, it is useful to distinguish between the fundamental niche and the realized niche (Carroll, 1985).According to niche theory, the fundamental niche defines the region of a resource space in which an organization or an organizational population can persist in the absence of competition. The realized niche is the subset of the fundamental niche in which an entity can sustain itself in the presence of competitors. In classic biotic, while beak size limits the sizes of the seeds that birds can harvest, migrating capabilities limits the geographic locations birds can habitat. By definition, the fundamental niche of an international generalist is wider than that of a local specialist. So, if organization can achieve maximum size within fundamental niche and the resources are even

distributed across the environment, international generalist should be bigger in size than local specialist. However, because resources and competition is sometimes not even distributed, it is possible that the size a local specialist can be bigger than that of an international generalist because of the difference in realized niche and fundamental niche.

Niche expansion based view of internationalization

I try to apply the theory of niche and resource partitioning in the international context to study firm internationalization. Resource partitioning model was developed by Glenn Carroll in 1985 when studying the newspaper industry in US. However, the newspaper industry is by nature a local industry. One of the important resource partitioning is geographic partitioning (catchment area). In the international context, national borders partition resources. Just as there are general and specialized markets because of resource partitioning, there are also international and local market with the nature resource partitioning of country border. However, because of the globalization trend and development of regional common market, local firms now are facing two markets: local market and international market, there are more and more across border economic activities. So I put the resource partitioning model under the international context and try to explain the competitive consequence of internationalization on organizational catchup performance. To do that, I add the international vs local dimension of niche resource space into the resource partitioning model. According to the resource partitioning model (Glenn R Carroll, 1985), generalist and specialist differ in niche width (Freeman and Hannan 1983). The width of a niche measures the range of environmental dimensions across which a population exits. Populations that depend on a wide range of environmental resources for survival are known as generalists. Populations that depend on a narrow range of environmental resources for survival are known specialists. Obviously, Glenn Carroll did not include the international dimensional resource space in the resource

partitioning model as he claimed that resource-partitioning model may be lessened by the increased sales of imported beers when he applies the model to the brewing industry. However, in age of globalization, international resource space is a resource space that populations can depend on for their survival. Therefore, it is necessary to include the international dimension in the discussion. How does internationalization modify competition and competitive interaction? In an international industry, as the environment that firm can draw resources from changed from local to international, the geographic niche dimension (the international-local continuum) need to be added into the framework. Now the strategic choices of generalists and specialists become international generalists, international specialist, local generalists and local specialists.

With the international dimension being added into the resource partitioning model, the strategic choices of firm in the international competitive environment includes: international generalist, local generalist, international specialist and local specialist (see figure 1). The international generalist occupies the market center of the international market and international specialist take the international peripheral position; while the local generalist stays in the market center of the local market and local specialist stay in the local peripheral position as shown in figure 4. With niche expansion based view, internationalization is a strategic choice from firms in face of the changing global environment. It is a strategic choice of the niche width in term of international vs local dimension. With the change in environment, firms need to be not only competitive locally but also competitive internationally. Firm can choose to be an international generalist or a local specialist and try to develop its fitness accordingly. Based on the new theoretic framework, firm internationalization strategy and process can be viewed as niche expansion in the international vs local dimension. It is a strategic choice of niche width (the international generalist – local specialist continuum) in term of environmental dependence and fitness function based on the principle of allocation.

With the globalization trend and the internationalization of technology industries, the nature resource partitioning of country border is broken down and niche width can be treated in two dimensions: technological niche and geographic niche. The resource partitioning theory can be extended into the internationalization context with new framework thinking about niche width (the international generalist-local specialist continuum). The new model is based on the same conditions as the original resource partitioning model. The new model stresses that the internal organization resources is also finite. Based on the finite external and internal resources for firms to draw for their growth and inertia of firm strategy, the strategic choices of firm in the international competitive environment includes: international generalist, local generalist, international specialist and local specialist (see figure 1). The international generalist occupies the market center of the international market and international specialist take the international peripheral position; while the local generalist stays in the market center of the local market and local specialist stay in the local peripheral position as shown in figure 2. The strategic choice of a firm in the two dimensions of niche determines its fundamental niche. The differences in fundamental niche generate four strategic groups: international generalist, local generalist, international specialist and local specialist. The process of firm internationalization of international generalist and specialist is to carry out the international strategy and maximize the realized niche. For example, the literature of the international entrepreneurship tries to explain the “born global” as an entrepreneurial phenomenon. However, any new company, local or international, is an entrepreneurial effort. According to the niche theory, what differentiate the born global companies are their fundamental niches. The born global companies have a fundamental niche either as an international generalist or an international specialist.

Figure 1

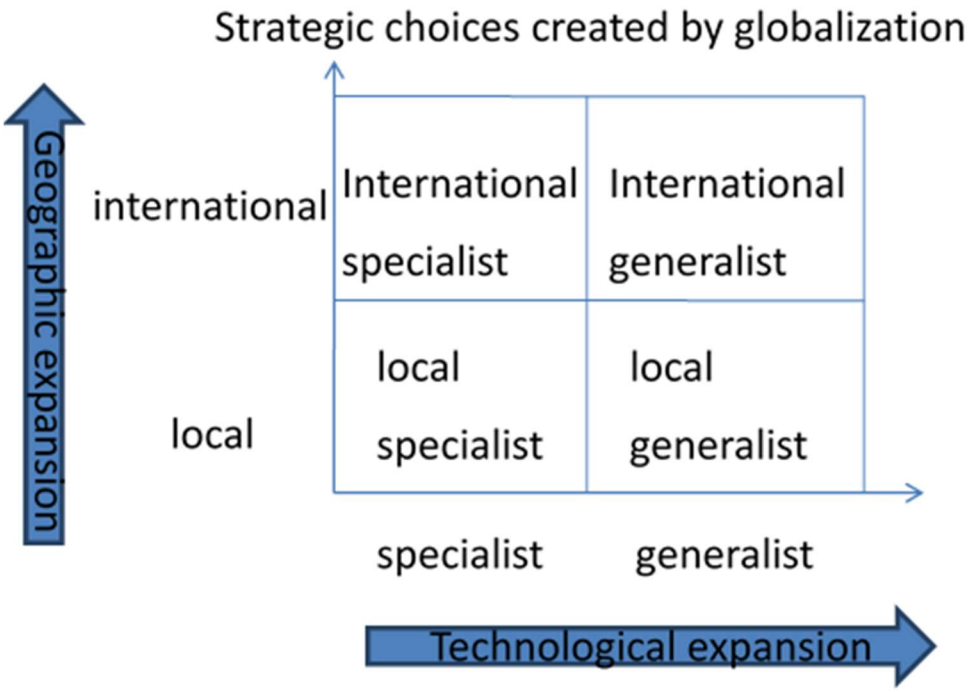
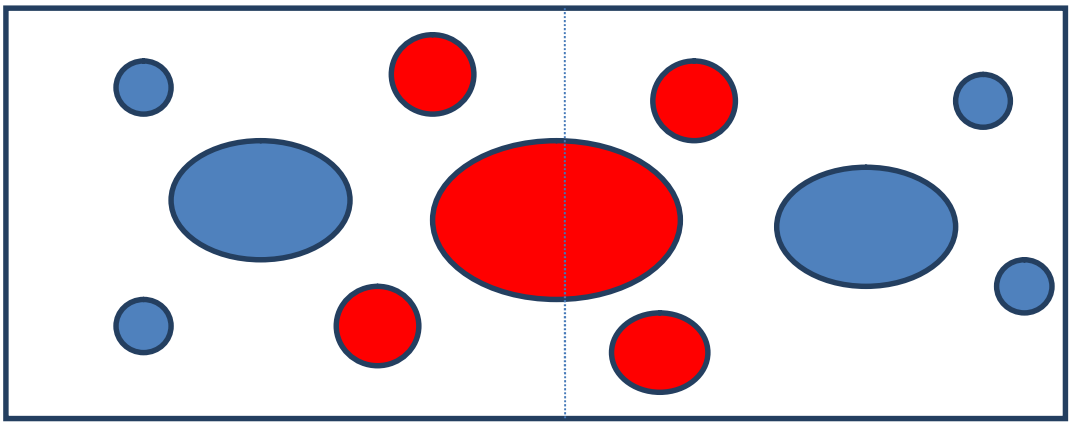

Strategic choices created by globalization
Geographic expansion
international
local
International specialist
International generalist
local specialist
local generalist
specialist
generalist
Technological expansion

Figure 2

Strategic choices created by globalization



Note: dotted line means country border under globalization;

red color means international, blue means local;

oval shape means generalist, round means specialist.

The theoretical framework can be developed based on niche expansion theory to explain the firm internationalization. The argument is that with the process of globalization, industries is moving from the age when industry remain segmented by country borders to the age the industries are international with the country border becoming less and less of barrier of resources. So, international generalist and international specialist firms with their fundamental niche cover broad geographic scope now can expand its realized niche to international market. The international strategy of firm is driven by the desire of these firms to expand its realized niche in the international market. The internationalization process of firm can be viewed as the niche expansion process of these firms when its fundamental niche remains as the same. As resource partitioning makes markets in equilibrium, the international

generalist and local specialist firms can operate in distinct resource spaces. Because international firms and local firms rely on different resources now, their fates were previously inversely related to each other are now directly related.

Based on above theoretic framework, firm internationalization strategy and process can be viewed as niche expansion in the international geographic dimension or context. It is a strategic choice of niche width (the international generalist – local specialist continuum) in term of environmental dependence and fitness function based on the principle of allocation. The process involves interactions with multiple audiences from different markets: product, services, suppliers, job market etc. The success and failure of internationalization depends on the focal firm's understanding of the demands and expectations, tastes (more abstractly the schemata) of all these different audiences in the different geographical contexts and on the ability to comply with their expectation and to satisfy their demands. As the total amount of organizational resources are finite, and organization might use the resource for the engagement route, but that limits their ability to broaden their appeal, or to use their resources to broaden the appeal but not without consequences for their ability to broaden the engagement. Therefore, the internationalization of enterprises can potentially chose between two different trajectories: they might opt for expanding their niches in the classical sense and consider new products and technologies to make their offer appealing to international audiences, or they can focus on their engagement pattern, and increase their international engagement.

4. Research questions and Methodology

Our research focuses on the competitive dynamics of internationalization on firms and industry. The primary research question is: how China precision optics manufacturers in a competitive environment, have pursued different niche expansion strategies and how the different strategies have influenced their catchup performance. We apply the niche expansion based view to analysis of six precision optics manufacturing industry in China to find out the influence of different niche expansion strategies on their catchup performance. Here, catchup and growth are used interchangeably and we measure catchup by the growth in revenue of firms. Normally export was used as a reference indicator of international niche expansion with limitations. However, in our case studies, we measure the international niche expansion more by different level of internationalization activities including export, partnership, overseas investment, FDI, merger and acquisition. On the technological niche dimension, we measure different level of technological advancement both in terms of vertical integration in the value chain and horizontal integration in market applications.

In light of the niche expansion based view, we explore why the firms choose different growth strategies in face of internationalization of industry and forming different strategic groups, namely international generalist and international specialist; and how international generalist and international specialist grow through internationalization in the competitive environment; why firms from the same strategic group perform differently in face of the internationalization of the industry; and how the firms from different strategic groups interact with each other in the industry. As cases are useful in exploring evolutionary processes and the industry we choose is the precision optics manufacturing industry in China. We use comparative case study to investigate the competitive consequence of internationalization on organization catchup performance and industry dynamics of China precision optics industry. We apply all different international business theories in the case study and

try to combine all different international business theories under the niche expansion based view while giving our own perspective on the Goldilocks debate.

Why China precision optics manufacturing industry

There are good reasons why we choose the precision optics manufacturing industry in China. First of all, precision optics industry is characterized by its international reach and technological diversity. The supply chain in precision optics manufacturing is highly international. There are both successful AMNEs and DMNEs in precision optics manufacturing. There are also a lot of successful SMNEs from different countries, both advanced economies and developing economics. These MNEs, together with local players, form the international landscape of precision optics manufacturing. China became the world center for precision optics manufacturing. For consumer precision optics manufacturing, China dominates the global manufacturing. Foreign international generalists and international specialist in consumer precision optics manufacturing move into China; while Chinese international generalists and international specialists expand into international market. Although companies from advanced economies still dominate the non-consumer precision optics manufacturing, China become more and more important both because of the catchup of Chinese multinationals and foreign multinationals investment in China. In this case, as Chinese international generalists and international specialist expand into international market, the foreign international generalists and specialists also became more and more active in China. Another important characteristic of this industry is technology diversity. In precision optics manufacturing industry, it is very common that specialist players occupy majority of global market share in their special technological niche. As technologies are multi-disciplines in precision optics, it is very difficult for one company to have all technologies needed to satisfy customers' need. Collaboration is very common in precision optics industry. We can see partnership between companies from different countries and different strategic groups. We can see companies working together

with university and institutes. Because of the nature of international reach and technology diversity, precision optics manufacturing in China provides an interesting case for the study of Chinese multinationals in hi-tech industries.

Secondly, the precision optics manufacturing industry in China reshaped by the influence from the international market created a dynamic environment for the players in different strategic groups. The case study on this industry and 6 case studies have shown how these companies from different strategic groups catch up within the technological and international niche matrix. The niche expansion based view explains why and how DMNEs in technology industries internationalize. Based on the different strategic groups, the strategic development paths are different and so are the competitive consequences. In precision optics manufacturing which is an international technology industry, the international generalists focus on the development of both international expansion and technological advancement. The success of the international generalists depends on how they can manage to catch up in both niche dimensions and be competitive in the center of international market. The international specialists might catch up differently with same level internationalization and become internationally competitive in their niche market. The situation of the local generalists and local specialists also changed because of the competitive dynamics created by the internationalization of the industry. The strategic choice of catchup in the international dimension does not mean the local generalist and local specialist are not affected by the internationalization of the industry. On the contrary, their strategy is a direct reaction to the internationalization of the industry by focusing on the local market and avoiding direct competition from international market. In many cases, local specialists get access to the international resource through working with international generalists. The relationships among the different strategic groups help to explain the competitive dynamics of internationalization on the firms and the industry.

Comparative study approach

As case study is suited for the in depth study of sets of contemporary events within real-world context (Yin, 1981), the method was commonly used in international business studies. Mathew's case study of wind turbine industry, for example, demonstrate how different wind turbine producers in China grow rapidly through internationalization. Case study is also particularly suited for "why" and "how" questions to illuminate set of decisions over which a researcher has little or no control. As our research questions: why the firms choose different growth strategies in face of internationalization of industry and forming different strategic groups; how international generalist and international specialist grow through internationalization in the competitive environment; why firms from the same strategic group perform differently in face of the internationalization of the industry; and how the firms from different strategic groups interact with each other in the industry. All these research questions are "why" or "how" questions.

We use comparative cases study with pattern matching method to explore the value of international theories in the empirical study. Six companies were chosen for case study from precision optics manufacturing industry in China to show why and how companies from different strategic groups grow through internationalization with different results. Within the 6 companies chosen for the comparative study, 4 of them are from consumer applications and 2 from non-consumer application. The 6 precision optics companies were chosen because there is a strong correlation between the success and failure of catch-up and the niche expansion strategy and process of these firms (see Table 2). Phenix, Sunny Optical and O-film are the major international generalists in the consumer optics manufacturing but with different catchup performances. While being an international specialist, Crystal Optec has achieved good catchup performance in catch-up. Both CASTECH and MLOPTIC have done well in catch-up in the non-consumer optics market with different strategies, one as an international specialist in the crystal optics and the other as an

international generalist in the precision optics. By applying different international business theories for AMNEs, DMNEs and SMNEs to the analysis of these cases, we found that different theories have different perspectives can be used the different stages of DMNEs internationalization. These theories include AMNE theories such as OLI paradigm, DMNE theories such LLL framework and SMNE theories such as international entrepreneurship. As we applied all the theories to DMNE internationalization, we also try to give an answer to the Goldilocks debate.

The cases are based on both primary data and secondary data. The primary data came from interviews with the precision optics manufacturers. Secondary data from annual reports, company web pages, magazine and newspaper articles, published interviews by company officials, and books on the Chinese precision optics industry were also collected, to support our primary data collection. This afforded us opportunities for further insights into how different niche expansion strategy from different strategic group shaped international expansion and technological advancement, the relationship among companies from different strategic groups, and speed of internationalization, as well as more generally the reasons and routes of internationalization.AS the 4 precision optics manufacturing companies from consumer application are public listed companies, we can get a lot of public information. In addition to the public information, we also Phenix was the first public listed precision optics manufacturing company in China. , Sunny Optical and O-film and one international specialist Crystal Optech. We have followed the internationalization of Sunny Optical over ten years. As Sunny Optical is a public listed company in Hong Kong, we can get access to the financial information from their annual reports. We have also conducted 2 personal qualitative semi-structured interviews in the autumn of 2016 with the international sales manager. These interviews lasted on an average of 60 minutes. We have collected information on Crystal Optics since 2008 through public information and participant observation in a number of strategy meetings and roadmap meeting. We have gained our insights in

the CASTECH case on internationalization through an involvement that has now lasted for almost seven years. We conducted close to 10 personal qualitative semi-structured interviews in the summer of 2014 with the CEO of CASTECH and with the general manager of three different technological divisions. These interviews lasted on average 120 minutes. Further, in this case we used a broad range of qualitative methods such as participant observations of a number of strategy meetings, board meetings, roadmap activities and other workshops, and we applied extensive document analysis of minutes, annual reports, master plans and roadmaps over the last ten years to gain detailed insight into the internationalization and technological development of CASTECH. In the MLOPTIC case, four qualitative semi-structured interviews were conducted in 2014/2015 with the founder, the CEO, and with international sales director, who has been the head of MLOPTIC Optics international sales team for over fifteen years. Moreover, a number of internationalization activities were observed (board meeting, international trade show) and documents analyzed. In October 2016 and in July/August 2017, a mix of representatives of locals ME, large companies, universities, and regional industry associations were interviewed. Three of the central representatives were interviewed twice in order to catch up with the more recent developments and to extend the data gathering on topics we were particularly interested in.

Table 2: Background of Case Study

	Background information	Data collection	Why we choose this company
Phenix	Phenix is a leading precision optics manufacturer for consumer applications. It was once the largest precision optics manufacturer in the 1990s. It was the first public listed precision optics manufacturer in China. The company is engaged in design and manufacturing of optical lenses, optical lenses, metal processing, microscopes, etc. The main applications are cameras, camera phones, surveillance equipment, automotive, etc.	As Phenix is a public listed company in China, we can get access to the financial information from their annual reports. We have also conducted 2 personal qualitative semi-structured interviews in the autumn of 2016 with the international sales manager and the chief engineer. These interviews lasted on an average of 60 minutes.	Phenix was an international generalist who experienced ups and downs in face of the internationalization of the industry. We can see from the case study an internationalist with broad fundamental niches do not necessarily grow successfully in terms of actual realized niche expansion in the competitive environment.
Sunny Optical	Sunny Optical is a leading precision optics manufacturer for consumer applications. It is the largest precision optics manufacturer in China in term of market capital valuation (over 100billion HK Dollar), also a Hong Kong Stock Exchange Blue Chip company. The company is engaged in design and	As Sunny Optical is a public listed company in Hong Kong, we can get access to the financial information from their annual reports. We have also conducted 2 personal qualitative semi-structured interviews in the autumn of 2016 with the sales director and division general manager. These interviews	Sunny Optical, grow successfully from a local specialist into an international generalist. We can see from the case study how it grow with continuous niche expansion in both international and technological niche dimensions in the competitive environment.

	manufacturing of optical and related products including optical components (lenses), optoelectronic products (camera modules), and optical instruments (microscopes). The main applications include mobile phones, digital cameras, in-vehicle imaging systems, security monitoring systems and optical measuring instruments.	lasted on an average of 60 minutes.	
O-film	O-film is a leading precision optics manufacturer for consumer applications. It is the largest precision optics manufacturer in China in term of revenue (over 30billion RMB), also a China Fortune 500 company. The company is engaged in design and manufacturing of micro camera modules, touch screen and touch display full-fit modules, and fingerprint recognition modules. The main applications include optoelectronics business (including touch display business, optical	As O-film is a public listed company in China, we can get access to the financial information from their annual reports. We have also conducted 2 personal qualitative semi-structured interviews in the autumn of 2016 with the marketing manager and R&D manager. These interviews lasted on an average of 60 minutes.	O-film transformed itself from an international specialist in coating technology to an international generalist technology platform for photonics. We can see how international niche expansion help the technological advancement.

	products business and biometric business) and smart car business (including intelligent central control business, ADAS business and body electronics business).		
Crystal Optech	Crystal is a leading precision optics manufacturer for consumer applications. Crystal is the largest filter manufacturer in the world. The company is engaged in design and manufacturing of low-pass filter, infrared cut-off filter and assembly, LED sapphire substrate, micro-projection, reflective materials and other products. The main applications include optical, LED sapphire, reflective materials and new display four business segments.	As Crystal Optech is a public listed company in China, we can get access to the financial information from their annual reports. We have also conducted 2 personal qualitative semi-structured interviews in the autumn of 2016 with the sales manager and R&D director. These interviews lasted on an average of 60 minutes.	Crystal adopted international specialist strategy and expanded through aggressive international market expansion to achieve economy of scale in the niche market segment. The case study showed that the success of CrystalOptec's catch-up was due to its niche expansion strategy by focusing on coating technology via horizontal and vertical integration and expanding the international market niche expansion.
CASTECH	CASTECH is a leading precision optics manufacturer for non-consumer applications. It is the largest crystal manufacturer in China. Unlike typical DMNEs, CASTECH enjoyed competitive	As CASTECH is a public listed company in China, we can get access to the financial information from their annual reports. We conducted close to 10 personal qualitative semi-structured interviews in the	CASTECH is an international specialist in the crystals technology. The case study show how CASTECH leveraged its technological competitive advantage in the global market by international niche expansion.

	advantage technologically in the global market. The company is engaged in design and manufacturing of nonlinear optical crystal components, laser crystal components, laser optical components and laser devices. The main applications solid-state lasers and fiber lasers.	summer of 2014 with the CEO of CASTECH and with the chief engineer. These interviews lasted on average 120 minutes.	
MLOPTIC	MLOPTIC is a leading precision optics manufacturer for non-consumer applications. The company is engaged in design and manufacturing of optical components (lenses), optical modules (lens assemblies) and optical instruments (microscopes). The main applications include industrial (semiconductor inspection), biomedical (DNA sequencing), aerospace and other fields.	In the MLOPTIC case, four qualitative semi-structured interviews were conducted in 2014/2015 with the founder, the CEO, and with international sales director, who has been the head of MLOPTIC Optics international sales team for over fifteen years. Moreover, a number of internationalization activities were observed (board meeting, international trade show) and documents analyzed.	As a born global, MLOPTIC's catch-up can be explained by its international generalist strategy. The case study show us the interaction between technological niche expansion and international niche expansion.

5. Case Study of Precision Optics Industry in China

A research setting of precision optics industry in China during 1980-2016 was chosen for the study of DMNEs internationalization in technology industry. The precision optics industry is a typical industry that has gone through big changes with the development of globalization. Precision optics industry used to be a very local industry with very little influence from the international market. Nowadays, almost all precision optics firms are involved with some level of cross border activities.

5.1. Research setting of precision optics industry in China

The proposed research analyzes the influences of DMNE international strategy on the organization catchup performance and industry dynamics by studying precision optics manufacturing manufacturers in China from 1980 to 2016 for three reasons. First, the precision optics manufacturing industry offers an appropriate context for the study of firm internationalization and its implication on the different strategic groups within the industry because the industry is international by nature. Some industries are more international than the others. For example, the newspaper industry is less international because of language, culture and social reasons. One would not image that a newspaper in China would compete with a newspaper in India for example. However, the precision optics as a technical product has no social or cultural features; therefore, the industry is international by nature. So a precision optics manufacturing company in China can sale its product and service to a US customer as long as all the technical parameters meet the need of the US customer. As the technical parameters can be clearly defined, the transaction is not much different for the customer whether the goods come from US or China. Second, the precision optics manufacturing industry in China 1980-2016 has been reshaped by the international market. The influence of internationalization on the precision optics industry in China is huge. There are a lot of new companies with internationalization strategy that have enjoyed high growth. There are also a lot of old companies that

keep local and went out of business. The international market created a great platform for all the different strategic groups that focus generalist market vs specialist market and international market vs local market. Precision optics manufacturing industry used to be a very local industry with very little influence from the international market. Nowadays, almost all precision optics manufacturing firms are involved with some level of cross border activities. At the same time, certain application of optics such as defense and aerospace remain relatively local. In some country, foreign companies are not allowed to serve in such areas. The existence of both local and international market of the precision optics manufacturing industry creates a typical resource partitioning scenario in the international context. Third, in the period between 1980 and 2016, the industry saw big change both from the international market such as the market changes in consumer optics from digital camera to smart phone, ups and downs in the optical telecom market and local market such as the substantial increase in demand from the defense and aerospace market. These big changes created a dynamic environment for the study of different strategic groups.

Overview of precision optics industry

Precision optics is a high-tech field that has recently received a lot of managerial and political attention and which is often considered the key technology for the 21st century. According to Spectaris, by 2005 the world precision optics market has catch up n to 120 billion USD and is expected to double in 2015. Although the field is new, it has already been subject to serious research (Hassink and Wood 1998; Hendry et al. 1999; Hendry et al. 2000). The word precision optics and optics is used interchangeable in the industry. Optics industry is both a new industry and old industry. The Photonics Directory (www.photonics.com) defines precision optics as “the technology of generating and harnessing light and other form of radiant energy whose quantum unit is the photon”. Precision optics, also referred to as optoelectronics, is developed since 1960s after the discovery and development of

new light sources such as laser and light-emitting semiconductor diodes. As an enabling technology, precision optics has vast applications in both consumer and industrial products. It is leading the world to the age of light. Digital camera, digital projector, LED lighting, high power laser, and optical communication are just some examples how precision optics technology brings changes to the world. New as it is, precision optics has the centuries-old field of optics as its technological root. Traditional optics has a limited application including eyeglass, telescope, microscope and camera as it deals with only natural lighting. However, it has built a full value chain including optical material producers, optical component producers and optical system producers. The precision optics technology development has changed the optics industry fundamentally; with traditional optics industry moving to all the different applications areas across different industries, opened great opportunities for all members along the value chain with a lot of them now call themselves precision optics companies.

By defining the industry as precision optics manufacturing, we not only exclude companies that offer design service but have no manufacturing capabilities or trading companies that only buy and resell optics, but also exclude companies that has in-house optical manufacturing but their main business is in the application area of precision optics, for example a camera company whose revenue coming mainly from sales of cameras is not a optics manufacturing company even if it has in-house optics manufacturing for its own camera lens. Precision optics manufacturing technology originates in the development of traditional optical instruments including microscope, camera and telescope in the 1700s, and modern optical applications start to emerge when laser was introduced in 1960s. Nowadays the market for precision optics manufacturing is segmented in a number of ways, and firms differ in the scope of their offerings as precision optics manufacturing is sold with varying degrees of completeness. Precision optics manufacturing can be a single lense or a system that includes hundreds of loose optics. Companies may specialize in design

and manufacturing of precision optical components, or they may provide complete systems. Companies may also be independent providers or captive producers making precision optics manufacturing for their own optical systems. In 2010, over 5000 companies worldwide offered optical components, optical coating service, and optical systems. The industry is quite segmented. There are big international generalists such as Zeiss and Jenoptic in Germany and II-VI and New Port in USA there are also thousands of local specialists that offer just a particular optical component.

Here we need to address the difference between precision optics manufacturing and application of optics. Precision optics manufacturers engage in the technological activities within the extraordinarily broad spectrum of means and ways of generating, amplifying, transmitting, measuring and utilizing light. The traditional optics manufacturing technology includes optical material foundry, optical fabrication, optical coating and optical assembly with their products in form of optical components or optical modules and optical systems. With the fusion of optics with mechanics and electronics, the products can cover a much broader range including light sources such as laser, LED, OLED and etc., imaging system such camera module, microscopic system, telescopic system, laser scanning system and etc., motion control system such auto-focusing system. As an enabling technology, precision optics manufacturing has many application areas. The traditional applications include telescope, microscope and camera. With technology development since 1960s, especially after the discovery and development of new light sources such as laser and light-emitting semiconductor diodes, precision optics manufacturing finds increasing new application in different technology products. It can be used both in consumer products such as mobile phones, laser tools and LED lighting, and products for business such as semiconductor sensor, x-ray equipment and DNA sequencing equipment. Precision optics manufacturing are sold in four identifiable primary markets: the medical and life sciences market (e.g., ophthalmology, dental imaging,

laser surgery, endoscopy, x-ray imaging, microscopy, DNA sequencing, flow cytometry, clinical diagnostics and other biomedical applications), the industrial manufacturing market (e.g., machine vision, laser industry, semiconductor industry, projection and pre-press, photography and cinematography), the defense and aerospace market and research and development market.

The precision optics industry is characterized by the different optics clusters in the world. Optics and photonics clusters are, according to SPIE, "concentrations of optics-related firms and universities that maintain strong research and workforce ties, create quality jobs, share common economic needs, and work with government and stakeholders to strengthen the industry" (SPIE 2006).Photonics can therefore be seen as an international field with regional concentrations. A number of established traditional clusters (in the past being based on classical optics) can be identified: Jena in Germany; Rochester, New York, and Tucson, Arizona, in the U.S. All of these are based on a long tradition of developing optics capabilities in the region. On the other hand, fairly recently a large number of newly developing photonics clusters have been observed. This development can partly be attributed to the advancement, differentiation and specialization in photonics technology and the perceived need to work closely together with other competent actors, but also to local and national governmental initiatives that promote regional clustering activities. Kunming, Changchun and Fuzhou in China are the major traditional clusters where precision optics manufacturing companies are concentrated. However, the development of the Yangtze Delta and Pearl River Deltas the most important clusters in China was largely driven by the shift of consumer optics manufacturing to China from the international market.

Figure3

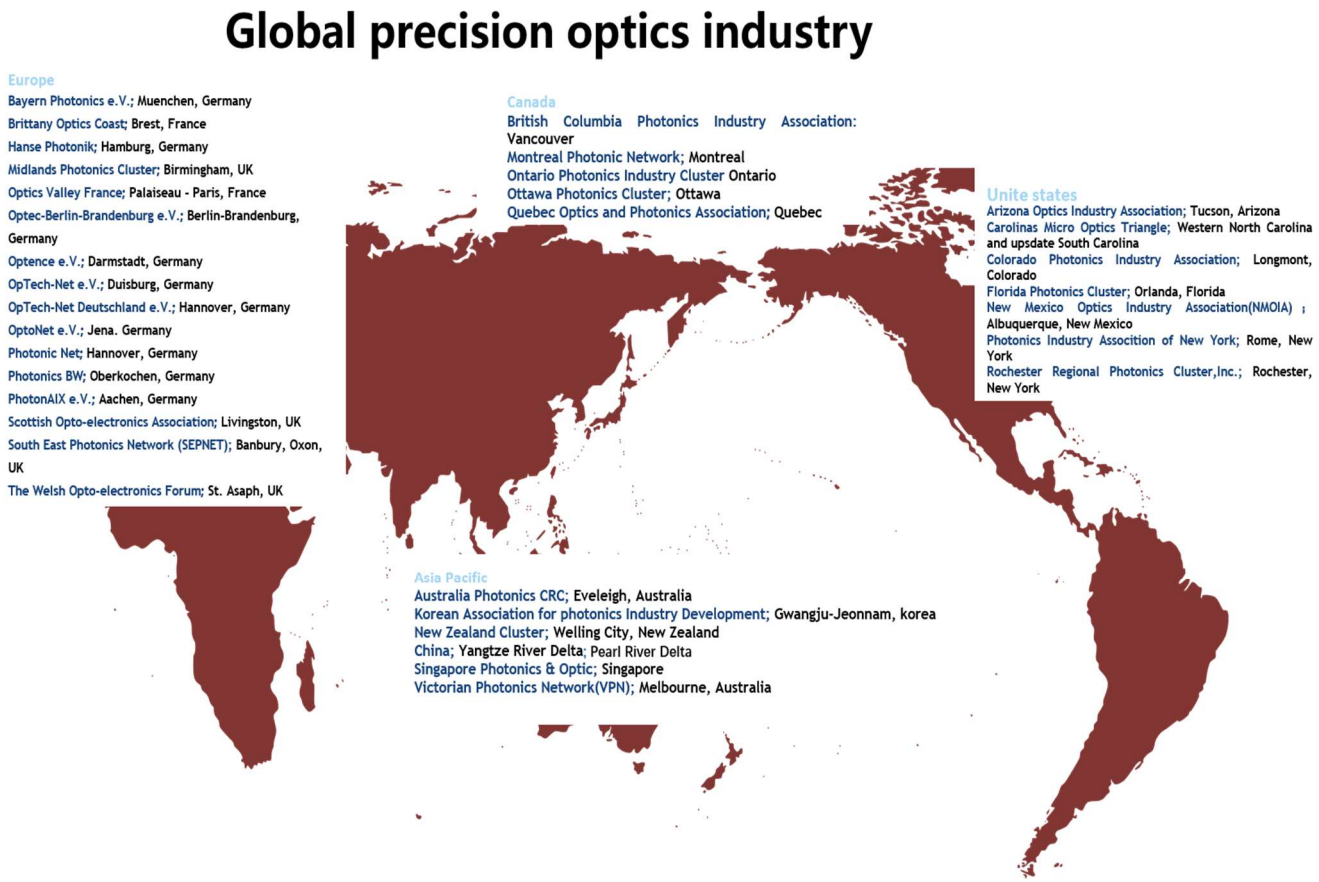
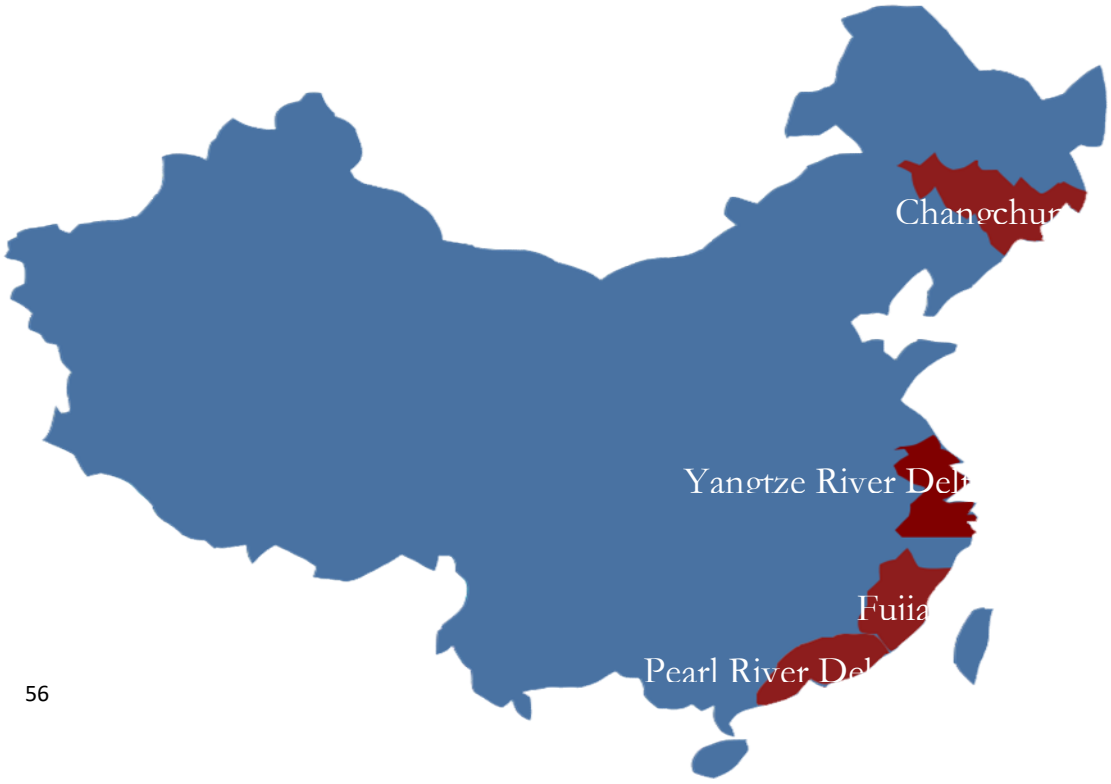


Figure4

China Precision Optics Industry



The precision optics manufacturing industry has a dynamic population with a lot of SME sell over the world and limited number of big MNEs in major industrial countries. Over 90% of population is SMEs. SMNEs are very common in precision optics manufacturing. Most SMNEs are under 100 million US dollar in sales. Any company with USD 100 million or above is definitely a big player. There are hundreds of companies with annual revenue between USD 10 million to USD 50 million. There are thousands of SMNEs with yearly sales below USD 10 million. Only the top of the 10% of population including DMNEs such as Sunny Optical in consumer optics and AMNEs such as Zeiss in non-consumer optics can have annual sales over 1 billion USD dollar. Co-operation between large and small companies as well as between firms and research organizations is very common. On a global level, itis obvious that in the optics industry large volume production has been moved to the low-cost countries, predominantly in Asia. High value-added engineering and complex systems level integration are still based in advanced economies. It is fair to say the segmentation is due the nature of the business and institutional reasons. Due to high value and high complexity, the customers in advanced economies are reluctant to source at the low-cost countries. On top of that, the other important reason of the segmentation is government regulation. For example, a lot of advanced machineries made in advanced economies are restrictedly by the local government for export to China. Without these machines, it is difficult for Chinese companies to develop capabilities in high precision area. US ITAR regulation restricts military related precision optics to be sourced from China. One of the major precision optics companies in US got million US dollar penalties simply because they were found to outsource US military jobs to China.

The precision optics industry is characterized by its high technology and international reach. This is because innovations in optics or photonics are often interdisciplinary in nature and one organization rarely has all of the resources and competences

necessary in the innovation process. Even very small photonics companies with a special competence have international reach and may control a significant share of the global market for which maybe only one or two (if any at all) other companies or even research organizations compete. As a consequence, it is a characteristic of this industry that there are rarely entire supply chains present within a specific region. Therefore, companies, big or small, have to co-operate with and learn from each other based more on the international market than on their local markets. For international players in the precision optics industry, it is not rare that the international sales represent a large percentage of their total sales. This, however, depends largely on the specific technology and the fields of application in question. In the area of devices for telecom and other industrial applications, for instance, customers generally follow a global sourcing strategy when it comes to precision optics, whereas in the defense and security, and even in the scientific instrumentation sector, due to government regulation and market protection, national and regional suppliers are preferred.

It is not always easy to set the boundaries for the precision optics population. Here in this paper, we set the categorical boundaries of the population as precision optics companies that produce optics. To make the discussion more precise, the author further categorizes the population into two sub-populations shown in Table 1 below:

Table 3: sub populations with precision optics manufacturers

Sub populations	characteristics
Consumer optics	Producers of optics for consumer applications such as mobile phone and digital camera. They produce in large quantities and compete with each other on price. The total market of low-end precision optics is quite large but concentrated. The major player is the Taiwanese optics company such as Largen. It is the generalist with products ranging from

	components to subsystems and services ranging from design, prototype to volume production. All the specialist companies can cover only part of the products and services.
Non-consumer optics	Producers of optics for non-consumer applications such as laser, telecom, machine vision and semiconductor. They produce in much smaller quantity and compete with each other on technology. The total market of precision optics is smaller and the players are still segmented. In China, there is no generalist that already takes the market center with many small specialists wants to move to the market center.

Demography of the population

The internationalization of Precision Optics in China

The history of precision optics in China started from the military application. Traditional optics industry is quite strong in China with major producers of microscope, film projector and military optics products in China. During the last decades, the technological development in precision optics changed the population dramatically. Traditional optics producers, except for some military companies, have lost their competitiveness and a lot of start-up companies emerge to join the national and international supply chain of precision optics. Foreign companies also set up factories in China producing optical components, making China a center of precision optics manufacturing. As there is neither major optical material producer nor major optical system producer in China and most optics companies in China are optical components producers, China's status as a precision optics manufacturing center, especially for consumer electronics applications, is well recognized by the international precision optics society.

The precision optics manufacturing industry in China was reshaped during the

internationalization of the industry. Since China started the open-door policy and economic reform in 1980s, as traditional precision optics industry met the new applications from international market, China soon became the world center of precision optics manufacturing. The internationalization of precision optics in China started in consumer electronics applications. Major consumer optics manufacturers from Japan and Taiwan started to open factories in the Pearl River Delta and Yangtze River Delta in digital camera age. This was an international niche expansion effort from foreign MNEs to take the advantage of low-cost labor force in China, which can be explained by the OLI paradigm as why and how the AMNEs expand into China. However, from the DMNEs perspective, it can also be viewed as inward-outward-linkage according to the updated LLL model to explain why and how DMNEs catch up benefiting from these FDI from AMNEs into China. From the industry level, these FDI from AMNEs helped the development of precision optics manufacturing in China, creating a pool of skilled workforce including well-trained engineers and managers. This also help to explain why later on in smart phone age the major OEMs including companies such as Samsung and Apple started to work with local optics manufacturing companies in China. China's precision optics manufacturers grew rapidly as they joined the value chain of the international new applications from the international market. China soon became the largest optics manufacturing center in the world for consumer applications. The contribution of the inward investment from AMNEs was largely on the manufacturing rather than research and development. Most of these foreign factories in China were manufacturing side and the R&D activities remained in the home countries.

As DMNEs consumer optics manufacturers in China grew rapidly as it joined the value chain of the international of consumer electronics market, the same thing happened to the high-end value added DMNEs precision optics manufacturers in China join the international non-consumer market. However, DMNEs precision optics manufacturers for non-consumer applications did not enjoy the same speed of catch

up as DMNEs for consumer optics applications. The high-end precision non-consumer optics manufacturing is still dominated by AMNEs from US, Germany and Japan. Only by joining the international market, the Chinese DMNEs can get access to both the market resource of non-consumer industrial applications that were still dominated by the advanced economies and the latest technology in precision optics manufacturing. As cheap labor is not the most important resource in the high-end precision optics manufacturing and the companies in the advance economies still enjoy technological advantage, there is not much incentive for them to move production to low cost regions such as Asia and China. These AMNEs were very conservative in expanding into China even when they find China became an important market for their products. They were concerned about the IP protection in China and were afraid of any learning from DMNEs. So, the value chain of high-end precision optics manufacturing remains international and the companies in the advanced economies still dominate the market. However, as China catch up in the industrial applications area, China became more and more important as a market that companies in the advanced economies cannot ignore. AMNEs began to move into China via FDI and acquisition. Fabrinet bought Casix in 2000, II-VI set up its Suzhou factory in 2000 and bought Photo in 2008, New Port opened its Wuxi factory in 2000, Thorlabs opened its Shanghai office in 200 and Zeiss open its Suzhou factory in 2004 and its Shanghai R&D center in 2010. All these inward investments make China international not only as a supply base for the global precision optics market but also a battlefield for local precision optics market.

Over the last 8 decades, we see growth of the population of precision optics companies in China, especially during the last 3 decades. There are 3 major changes in the environment over the last 7 decades which have great impact on the population:

1936-1980

In 1936, defense department of the central government at that time set up an office to prepare the establishment of China's first optics manufacturing factory. China started to build its own optics manufacturing industry in Nanjing, Kunming, Wuhan, Shanghai and Chongqing for military purpose. Yunnan Optical Instrument, as the first precision optics manufacturer in China, started to produce the first military use binocular and first gun sight in China. Nanjing Survey Instrument produced the first optical level in China. These military optics factories became the foundation of the modern precision optics industry for China. After the founding of People's Republic of China, China still keep these precision optics manufacturers for military applications. Nowadays, most of these optics' factories are still in existence. However, most of them cannot catch the opportunities from the non-military market and some have lost their competitive advantage when in direct competition with the market driven optics manufacturers. The ones that still survive grow into pure military companies. Yunnan Optical Instrument went bankrupt in 2005 and was acquired by the local military group. Nanjing Survey Instrument became a pure military factory producing sub-system with much narrower technological niche for bigger local military groups.

The main traditional non-military applications of precision optics were film-based camera, telescope, microscope and projector. Under the planned economy, most of the precision optics manufacturing was captive within these state-owned camera companies, telescope companies, microscope, and projector companies. Because of strong tie with Soviet Union, a lot of the technology was transferred from Russia to China. However, there was no linkage with western technology and international market. A lot of state-owned companies were established during 1950-1980 period serving only the local need. For example, Nanjing Movie Equipment was established in 1952 to produce projector for movie industry and was once one of the biggest movie projector producers in China. However, with strong competition from overseas with digital technology, now the company is no longer in existence. Because of lack of international expansion, most of these traditional optics manufacturers, generalist

or specialist, have lost their competitive advantages. There are also some exceptions with these state-owned precision optics manufactures. CDGM was one of them. CDGM Glass was established in 1956 and later on engaged in a serial of international and technological niche expansion after China's reform and became the largest glass material manufacturer in China and major player in the world market.

1980-2000

There are two major environment changes during the 1980-2009 periods, one is China's reform and the other is the shift of precision optics manufacturing to China. China reform started in the 1980s and there is a social movement called "jumping into the sea". In late 1990s, the central government started reform on state-owned companies. Medium sized firm's non-military optics firms in China were no longer subsided by the government and started to lay off people. A lot of former employees from state-owned companies started their own companies to "swim in the sea of marketplace". This social movement was supported by the media to promote entrepreneurship in the economy. Thousands of new private companies emerged during this period. You see a lot of father-son and husband-wife optics companies as their source of endowment is the family and other social capital. The mortality is low as the industry is still growing and new capacity always finds its new application. Most of the start-up optics companies produce components only. They tend to be specialist companies in one particular application area of precision optics and with specialized capabilities. What you see is the old craftsman shop instead of company in the modern sense. They tend to be specialist precision optics companies. Some of the specialists engaged in international expansion and became very successful.

In China, there are a number of cities all label themselves as "optics valley". Wuhan is probably the best known to world due to a lot of publicity. Actually, based on the definition of precision optics manufacturing we set above, the Yangtze Delta, Pearl River Delta, Kunming, Changchun and Fuzhou are the cluster where precision optics

manufacturing companies are concentrated.

The non-consumer optics manufacturers are quite stable and growing steadily in China, most of them survive quite well in face of the ups and downs of general economy. Their mortality rate is much lower than those who joined the volatile consumer optics industry. As the world precision optics industry is still dominated by Europe, U.S. and Japan, those who has an engagement in the world precision optics market seems attract more resource both from the customer market and the labor market. These global players tend to be generalist occupying the market center with the precision optics population. The state-owned military factories who are system producers are the generalist in the larger precision population of precision optics and became local generalists.

As precision optics market catch up s (according to Spectaris, by 2005 the world precision optics market has catch up n to 120 billion USD and is expected to double in 2015), so does the precision optics manufacturing industry. The change in the optics industry worldwide is that the low-end consumer optics is moving from developed economies to Asia countries, especially China. China became the largest consumer optics producer in the world. This change in world market place also affected China optics population. Taiwanese consumer optics Company Lagan set up its operation in China in 1992. It was one time the largest optics company in China in terms of size of operation. We can see emergence of two sub-populations with the optics population in China, one is consumer optics and the other is non-consumer optics. The consumer optics populations show resource partitioning as generalist companies such as Lagan and Asia Optics who have a wide technological niche ranging from design to fabrication, coating and assembly are positioned at the center of market with more realized appeal with the audience. Some specialist companies from the precision optics population move into the consumer optics business to join the transfer of production from developed country to China. Due to their limited

scale and scope of offering, they are more valuable to the market fluctuation in the consumer optics industry.

2000-2017

During 2000 to 2017 periods, there are some of major changes in the environment including the boom in consumer electronics and the boom and burst in telecommunication industry. The boom in consumer electronics industry has hastened the transfer of production of consumer optics manufacturing for applications such as digital camera, digital projector, and mobile phone to China. This change has created some big players in consumer optics manufacturing in China. Phenix became the first public listed optics company in China. Sunny Optical has catch up n from a small optical instrument factory in Yuyao, a small town in Zhejiang Province, to a billion dollar company in 20 years. O-film, a coating specialist, grew into a platform technology company for consumer electronics applications. China became the world manufacturing center for large volume, low cost optics. What happened in the consumer optics manufacturing did not happen with non-consumer optics manufacturing. With the boom of optical telecommunication industry in the international market in the early 2000s, a lot of precision optics manufacturing companies were set up to meet the demand. As China became an important market for non-consumer applications, optics manufacturing companies in advanced countries started to set up their operations in China to meet that demand. Company such as JDSU and Oplink in telecom started to invest in China and precision optics companies in advanced economies followed these customers to China. In 2000s, industrial applications such as the laser industry and IR imaging applications grew rapidly as China began to catch up with in these areas and became important players in the market. Companies such as Hans in laser industry has become an important player in the international market and the optics demand from domestic market has attracted players both home and aboard. Due to higher technological barriers in non-consumer optics industry, the majority of the market place, both for China

market and international markets, is still occupied by players in Europe and US. Same thing applied for life science and semiconductor. The international major players in both industries are companies in advanced economies. Although the supply chain of these industries is international, the companies in the advanced economies still prefer to use precision optics companies in advanced economies. Chinese precision optics companies have limited market share in these markets. However, successful DMNEs precision optics manufacturers are catching up in the non-consumer applications through international niche expansion. International specialists such as CASTECH catch up by focusing on special technological niche and expanding the market by international niche expansion. There are also international generalists such as Outworking on catch up through both technological and international niche expansion. These DMNEs might not enjoy the same level of success as the consumer optics DMNEs due to the different competitive situation in the international market.

5.2. Comparative Case Study

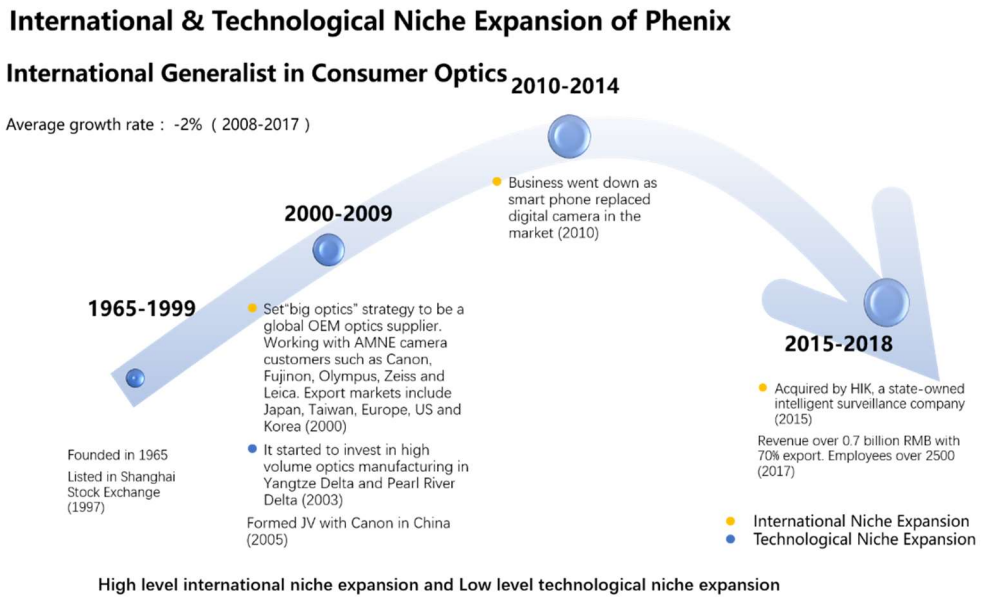
We analyze six DMNEs from China's precision optics industry, representing different international niche expansion strategies in both consumer optics category and non-consumer category. Consumer camera lens manufacturers, Phenix and Sunny Optical, followed international generalist strategy but with one being very successful and the other not so successful in catch-up. O-film and Crystal who started as coating specialists followed different strategies as international generalist and international specialist respectively with different level of success in catch-up. Non-consumer precision optics manufacturers, CASTECH and MLOPTIC, followed different strategies as international specialist and international generalist respectively with different level of success in catch-up.

Phenix

Phenix Optics was the first public listed precision optics company in China. The change in Phoenix Optics reflected what happened to the precision optics industry in China in general. As such, it is interesting case to consider. Phenix Optics was founded in 1965 in Jiangxi as a result of relocation of part of different optics companies in Shanghai and Nanjing including Shanghai No. 2 Camera and Jiangnan Optical Instrument. Phenix Optics was set up to produced cameras, microscopes and other traditional optical instruments. Phoenix brand was a well-recognized brand in China. However, as China adopted open door policy in 1980s, Phenix cannot compete with world famous brand in camera, microscope and other optical instruments. Instead, Phenix began to supply precision optics components and assemblies to international brands in digital camera industry. As Phenix changed from a local camera brand to an international optics component supplier, it has expanded in the international niche with a much narrower technological niche. In 1997, Phenix Optics was listed in Shanghai Stock Exchange and became the first listed precision optics company in China. As digital camera started to replace traditional camera in the market, Phenix started to invest in modern technology for low cost and high-volume optics manufacturing and became the No. 1 OEM optics manufacturing company in China in 2000s. Phoenix sales jumped from 273 million RMB in 2010 to the peak of 1.483 billion RMB in 2011, and became one of the world's three major optical manufacturers. However, the company's product niche dimension was too narrow and its business relied heavily on OEM optical lenses and optical modules for Japanese cameras manufacturers. Neither expanded to other international optical markets, nor invested in the research and development of latest optical technology, had Phenix faced big risks in its business. One of the biggest changes in consumer electronics market in 2010s was the replacement of digital camera by smart phone in consumer photography. Phoenix Optics did not catch this market change as its technology is not catching up with the new

application of smart phone. Phenix's sales plunged from a peak of 1.483 billion RMB in 2011 to a peak of 698 million RMB in 2013 and suffered a continuous loss for the following four years. Eventually it was acquired by HIK Vision, the largest intelligent surveillance company in China.

Figure5



The success and failure of Phenix was both related to the international market of consumer optics. As a state-owned company engaged in the market driven consumer electronics, Phenix cannot compete with Japanese competitor as a camera producer because it did not catch the digital camera technology. Therefore, it developed an international expansion strategy in the 1980s after China adopted the open-door policy. In2000, Phenix set "big optics" strategy to be a global OEM optics supplier. Phenix started to work with AMNE camera customers such as Canon, Fusion, Olympus, Zeiss and Leica. Export markets include Japan, Taiwan, Europe, US and Korea.2003: it started to invest in high volume optics manufacturing in Yangtze Delta and Pearl River Delta. In 2005, Phenix formed JV with Canon in China. By working Japanese camera producers as a precision optical supplier, Phenix soon

caught up in the precision optics manufacturing technology. With a narrower technological niche, it grew itself by international expansion. As a new comer in the international market, its international expansion helped Phenix to catch up in technology. Its learning was through active linkage and leverage with its AMNE customers. The institutional factor did not play much role in Phenix's catch-up through international niche expansion. The consumer electronics market is a competitive market, China government did not support consumer precision optics manufacturing just as it did not support the digital camera producers. Phenix's international expansion is purely due to market reasons rather than institutional reasons. The relationship between the DMNEs and AMNEs in this case was a win-win situation. The DMNEs grew by learning from AMNEs the latest technology in precision optics manufacturing while AMNEs benefited from developing a low-cost supplier who could be a competitor in the first place. This kind of mutual beneficial cooperative relationship was the basis of the linkage, leverage and learning. The international expansion of Phenix was also entrepreneurial as it was changing its business strategy from serving the local end-user market to serving the international business market. It was an opportunity seeking activity as it could survive as camera producer in face of the strong competition from Japan. The only advantage it can leverage is the cheap labor in China. The technological basis was also very important for its catch-up. With more efficient machine and low-cost labor, Phenix developed itself to be an international generalist consumer optics manufacturer. The learning in this case is in term of technological niche width but updated technology that suited for mass production of consumer optics. As Phenix was among the first group of precision optics manufacturers who adopted international expansion strategy, it soon became very successful. However, with all success Phenix did not keep investing technology. The other side of coin is that, by focusing on manufacturing, Phenix was losing its technological capabilities in R&D. That also explained why Phenix cannot catch the change in consumer optics market

changed from digital camera to smart phone. The failure of Phenix was also market driven. As more and more players joined in the consumer optics manufacturing, the market became competitive. When new and even big opportunity of consumer optics came, Phenix was taken over by other DMNEs including Sunny Optical who invested heavily smart phone applications.

Sunny Optical

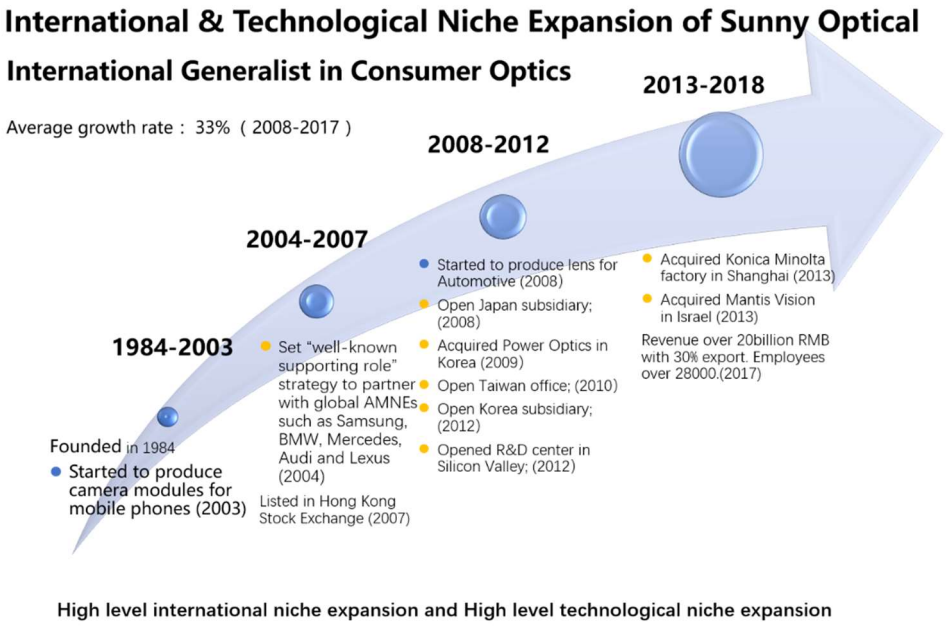
Sunny Optical was a small optics company located in the countryside of Zhejiang province. However, as Sunny Optical joined the international market trend of smart phone and became the largest lens supplier in China for major OEM home and abroad, it took the position of Phenix Optics as the No. 1 OEM optics manufacturing company for consumer electronics in China. Sunny Optical caught up quickly with its international generalist strategy working with major consumer electronics multinationals in western countries and local multinationals in China providing optical components, lens assemblies and camera modules.

Sunny Optical, a global leading optic manufacturer listed in Hong Kong, was founded in 1984 and was used to be Yoyo second optical instrument factory. Sunny Optical produced optical instrument such as microscope and competing with local microscope companies on the low-end market in China. However, as Sunny perused its international and technological niche expansion strategy and joined the international market for lens assemblies for smart phone, the situation changed dramatically. At first, Sunny Optical primarily produced glass optical lenses for smart phone. In 2003, the company switched the technology path from glass lenses to plastic lenses and started to produce mobile camera modules. With so-called “well-known supporting role “strategy, Sunny Optical is dedicated to becoming an internationally renowned optical supplier of compact module camera, lens sets for mobile devices and automotive lenses to major AMNEs in the consumer electronics

market. The company continues to develop world-renowned customers, set up subsidiaries in foreign countries. The company has five production sites in Yangtze River Delta, Pearl River Delta, Bohai Bay and Central Plain Areas, respectively. There are also R&D center and local customer support offices in North America, Japan, South Korea, Singapore, and Taiwan. In consumer electronics market, it has been a long-term supplier of Samsung, Panasonic, Konica Minolta, Lenovo, Olympus, Carl Zeiss, LG, Sony, Sanyo, and Nokia. Beside smart phone and digital camera applications, Sunny Optical was also engaged in automotive application and became optical lens supplier for major AMNEs such as BMW, Mercedes, Audi and Lexus. Sonny's sales also jumped from 901 million in 2006 to 14.612 billion in 2016, with a CAGR of 28.80%. The percentage of sales from mobile camera and module in Sunny 'total revenue increased from 47% in 2011 to 86% in Q1 2017, making it the main engine of the company's rapid growth. In 2016, the sales volume of its mobile camera modules ranked the first in the world and the second in the world in terms of volume of shipments. The sales of Sonny's mobile camera lenses accounted for around 12% of the world's total, ranking Sunny the second in the world mobile camera lenses market. Apart from international market expansion, Sunny also made great effort in technological niche expansion through investment inbred and acquisition. It has established its leadership in special coating technology in lens production, aspherical optics auto-focus and zooming, development in chalcogenide glass material, embedded software, 3D scanning and imaging, 3D ultra-precision vibration measuring, trace element analysis, ultra-high pixel camera modules design and manufacturing. The research and development investment on mobile camera lens and modules increased from 12million RMB in 2006 to 694million RMB in 2016. Technology advancement is combined with its international expansion, the company adopted international cooperation such as joint development with Korean company in order to accelerate the research and development of mobile camera lens. The company also strengthened its capabilities

of developing and producing mobile camera lens through acquisition of some assets from Konica Minolta. With the acquisition, Sunny has acquired a large number of patents in smart phone lenses.

Figure6



High level international niche expansion and High level technological niche expansion

Sunny Optical's successful catch-up can be explained by its international generalist strategy. Through it "well-known supporting role" strategy, Sunny Optical has positioned itself as an integrated optical device manufacturer and an optical imaging system solution provider. On the international niche dimension, Sunny Optical built up strong relationship with major AMNEs in the international consumer electronics market and automotive market. It also works very closely with local DMNEs such as Huawei and Xiaomi. By working with all the AMNEs and local DMNEs in the market place, Sunny Optical has successfully taken the market center of the international market for consumer optics applications. The strong DMNE-AMNE relationship was based on Sunny Optical's strong non-competing commitment with the AMNEs and local DMNEs. The "well-known supporting role"

strategy shows that Sunny Optical has no intention to compete with its customers. All linkage, leverage and learning with international AMNEs and local DMNEs are based strong business relationship. As we can see not all DMNEs who have an international generalist strategy can succeed and occupy the market center. The key success factor is the execution of the international generalist strategy. Sunny Optical 'success lies in that it has been able to expand its technological niche during its international niche expansion process. In 2008, Sunny Optical opened Japan subsidiary for R&D activities. In 2010, Sunny Optical opened Taiwan office also for R&D reasons. In 2009 Sunny Optical acquired Power Optics in Korea to enhance the technical strength in camera module design. In 2012, Sunny Optical set up its R&D in Silicon Valley. In 2013 Sunny Optical acquired Konica Minolta's factory in Shanghai. In 2013, it acquired Mantis Vision in Israel to get access to the algorithm of 3D imaging. It has successfully expanded its technological to cover all the vertical process of optical manufacturing including optical material, optical fabrication, optical coating and optical system integration. This make Sunny Optical a "one-stop" shop for optical lens assemblies for major OEM customers in the consumer electronics and automotive industries. Sunny Optical's catch-up is also a true entrepreneurial success story. Once a tiny small optics factory in a very small town in China, when faced with the market opportunity of the transfer of consumer optics productions from Japan and Taiwan to China, it took an entrepreneurial approach to catch this new market opportunity. It was competing with Japanese and Taiwanese precision optics manufacturers who moved their factories to China for resources. Compared with these Japanese and Taiwanese factories in China who are only off-shore manufacturing centers, Sunny Optical's operation in China covers both R&D and manufacturing. This gives Sunny Optical competitive advantage as a fully vertically integrated solution provider. The technological niche expansion was driven by the international niche expansion. However, the actual technological advancement never comes easy and is not a gift from the learning from the AMNEs

customers. It is rather achieved by heavy investment in R&D both in term of organic growth and in terms of overseas acquisition. The overseas activities are mostly based on pull strategy to get access to strategic resources including customers and technology. There is no clear indication that these overseas activities get any government support.

O-film

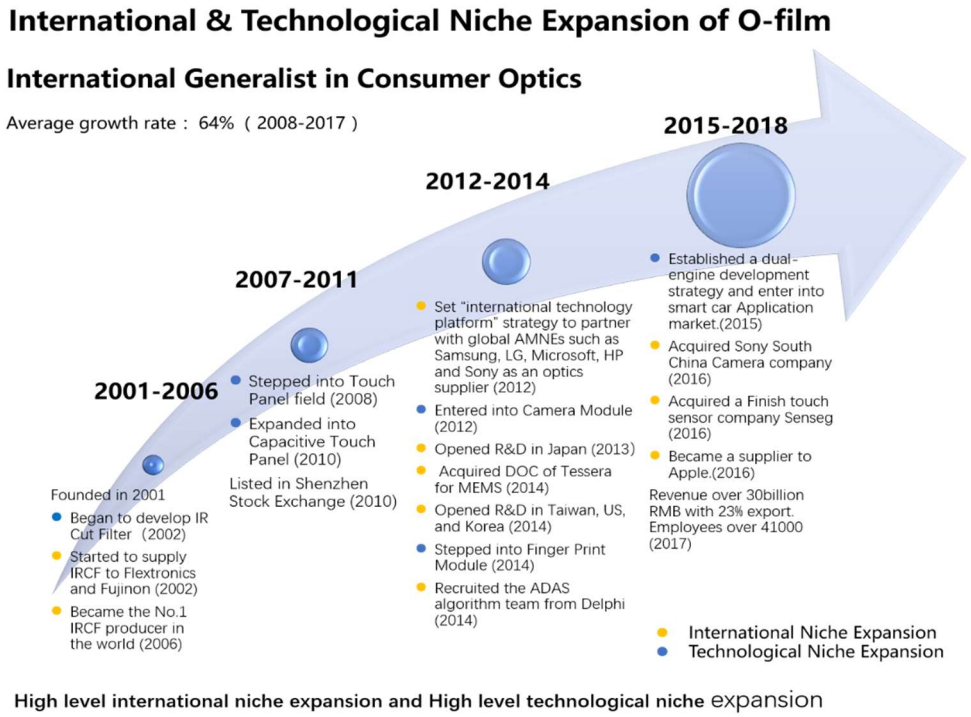
O-film is another success story of Chinese companies that joined the international market of consumer electronics. With international expansion and technology advancement strategy, O-film grew from a coating specialist for IR cut-off filters into a photonics generalist, with sales jumping from million dollars to billion dollars in ten years. In the consumer electronics market, it has been a long-term supplier of AMNEs such as Samsung, LG, Microsoft, and some and local DMNEs such Huawei, Xiaomi, and Lenovo. Besides photonics applications, O-film was also engaged in automotive application and became tier one supplier for major DMNEs such as Changan, Greely and SAIC. The company went listed in China Stock Exchange Market in August 2010.In 2018, O-film has almost 40 thousand employees, total assets of over 30 billion RMB.

Since 2002O-film began to develop and produce Irfan became the largest manufacturer in the world in 2006 with 1/3 of global market share. In 2008, O-film stepped into field with RTP production, the shipment volume kept being number one in China. From 2010, O-film expanded into CTP, and became the biggest CTP supplier in the world with the biggest global shipment volume since 2013. In 2012, O-film entered into CCM field and managed to be domestic first-tier in 2013. With automatic production lines, O-film became the top in CCM industry. In 2014, O-film

stepped into biometrics field and set up the biggest FPM factory in Chin with the biggest monthly shipment volume in the worldwide. For photonics application, O-film did not stop from touch screen, the company copied the successful business model which used in touch screen field and entered into the imaging system and biometrics fields. As the customers of both mobile camera modules and fingerprint identification are highly overlapped with the customers of the touch screen module, the company relies on the original global customer base and the low cost brought by the integration of the whole industry chain to realize the heavy volume sales on mobile camera module business and the fingerprint identification business. In 2012, the company entered the field of imaging system. By the end of 2016, the monthly output of the mobile camera modules reaches the highest in the world. In 2014, the company entered the field of biometrics. The fingerprint module ranked the first in the world in terms of monthly shipment in the fourth quarter of 2016. O-film focused on research and development as well as new technology reserves. The R & D investment jumped from 65 million in 2010 to 1,448 million in 2016, with a 22-fold increase in R & D investment. In the field of touch-screen, the company developed Metal Mesh technology, which can lower material cost and enhance good conductivity. In the field of imaging system, the company acquired MEMS camera-related assets and patents from Digital Optics Corporation in the United States. These actions have helped the company gain technological advantages in the field of touchscreens and cameras and quickly capture the related industrial market which was booming with the popularity of smart phones. In 2015, O-film adopted “two engines strategy” and started to enter into smart car field, established Shanghai O-film Intelligent Association and strove to become a core supplier of intelligent automobile manufacturers and a competitive first-tier brand internationally. In December 2016, O-film invested to set up virtual reality research institute to strength the arrangement in this industry. In 2017, O-film built a long-term strategic partnership with the Israeli 3D algorithm company, Mantis

Vision Ltd. in the field of 3D imaging technology. In April 2017, O-film completed the acquisition of Sony Electronics Huanan Co., Ltd. in 100% shares in order to strengthen the arrangement in the field of camera. The number of company patents also increased from 23 in 2011 to 1,542 in 2016. Through full industrial chain integration, internationalization strategy and huge R & D investment, the company's sales revenue jumped from 372 million in 2009 to 26.746 billion in 2016, with a CAGR of 70.64%.

Figure7



O-film's successful catch-up can be explained by its international generalist strategy. In 2002, it started to supply IRCF to Flextronics and Fusion. In 2012, O-film set "international technology platform" strategy to partner with global AMNEs such as Samsung, LG, Microsoft, and Sony provide photonics solutions. O-film has successfully transformed itself from an international specialist in coating technology to an international generalist technology platform for photonics. The coating business has a rather high technological entry barrier. But the growth potential from coating business is limited. Therefore, O-film set its strategy to be an international generalist. With the strong relationship with AMNE customers O-film built as coating specialist, it already has the customer resources developed for the wider technological niche products where the bigger opportunity lies in. Based on the leverage from earlier international expansion as coating specialist, O-film

expanded the technologies from coating to touch screens and cameras with heavy investment in R&D. The company entered into the touch screen field in 2008, through huge R&D investment and efficient integration of the entire industry chain, the company developed rapidly and successfully occupied the market. With that, main products of O-film changed from infrared cut-off filter to touch screen and mobile camera modules. In 2013, O-film opened R&D in Japan. In 2014, it acquired DOC of Tesserae for MEMS technology. In the same year, O-film opened R&D in Taiwan, US, and Korea. In 2016 it acquired Sony South China Camera Company and a Finish touch sensor company. All these international expansions can be described as a pull strategy to acquire strategic assets from the international market. Through these international expansion activities, O-film has successfully grown from an IR cut-off filter specialist to the total solution provider for touch screens and camera modules. It has used the international market as a springboard to get access to both the market and technological resources from the international market. All these were achieved through linkage, leverage and learning in the early stage. It became the suppliers of AMNEs such as Samsung and Sony and local DMNEs such as Huawei and Lenovo becoming a world leader in touch screens in 2013. Beside touch screens, O-film also entered into other technologies such as for imaging systems for biometric and camera modules smart car. The international customer base is an important leverage and driving force for O-film's technological development. However, the benefit from linkage, leverage and learning from AMNE customers on the technological side is very much limited. The actual catch-up was through a serial of technological niche expansion activities from O-film itself. The whole process of catch-up can be described as entrepreneurial and strong pull strategy to get resource from the overseas was apparent. As O-film grew stronger in the market, it was able to leverage the low-cost capital that China Stock Market provided to buy overseas technology companies. In this sense, the springboard also came from China side as both low cost capital and low-cost labor are unique

resource for Chinese firms. In 2016, O-film became a supplier to Apple which is also an evidence of its competitiveness in the international market place.

Crystal Optech

Crystal Optech was founded in August 2002 in Taizhou, Zhejiang province. Crystal Optech was started as a coating specialist company. In2003 The IR-cut filter for camera and cell phone was developed successfully and started to supply to camera module companies in Taiwan and Japan. As the market for camera and cell phone grew, Crystal Optech grew quickly and went on listed in Shenzhen Stock Exchange in 2008. After IPO, revenue increased rapidly with a CAGR of 28.1% from 2008 to 2016. In 2016, the yearly revenue reached 2.1 billion RMB. Crystal Optech's catch up can be explained by its niche expansion both in the market and technology dimension.

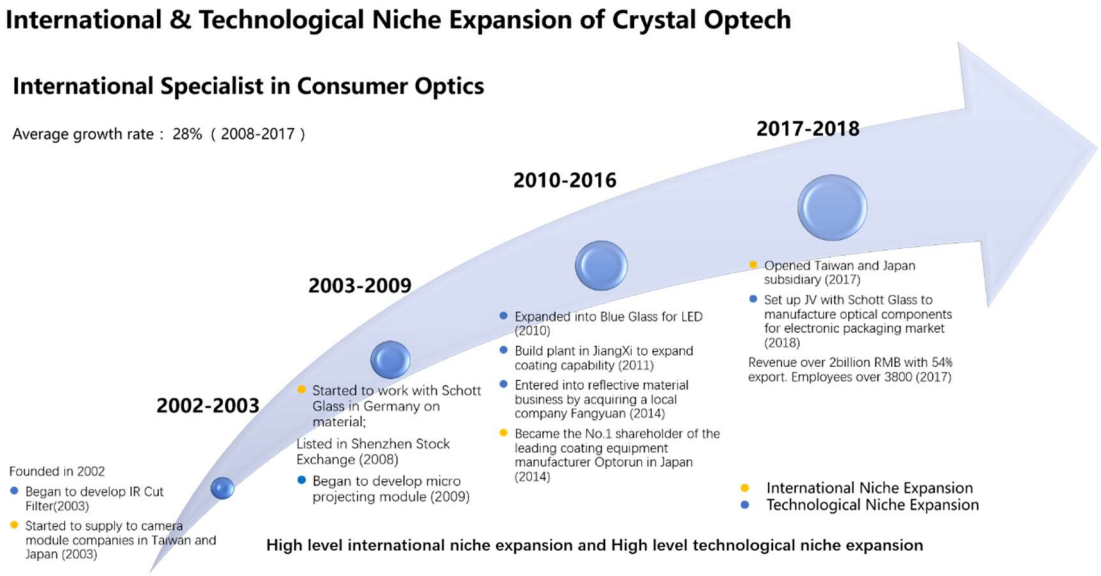
The market expansion started from infrared cut-off filters and narrow-band filter technology for mobile phone into cameras and biometrics application. The company has formed business segments which are optical, sapphire and reflective-materials as well as virtual display. The thin film components represented by OLPF and IRCF are the main business of the company, accounting for 78.3% of the total revenue. Within that, Blue Glass IRCF is the main source of income and profits. IRCF used in smart phones, mainly serving international well-known customers such as Apple, Huawei and OV. OLPF are used as a core component of digital camera and security surveillance camera. The main products of the company are applied to the digital camera, mobile phone camera, security monitoring camera, computer camera and other digital camera lens, semiconductor illumination, micro projector, smart glasses, road traffic mark and safety protection. The sales volumes of two leading products: optical low-pass filter (OLPF) and

infrared cut filter (IRCF) are among the highest in the world. The company is the main supporting supplier of lots of international famous or leading enterprises in digital industry and cell phone communication industry.

With technological expansion, Crystal Optec, became horizontally and vertically integrated in thin film technology for consumer electronics market. Since listing, the annual investment on research and development of Crystal Optech stabilizes at about 5% of total sales. Apart from its own research and development activities, Crystal Optech also grew through merger and acquisition. In 2009 the company invested and founded Hangzhou Optical Crystal Co., Ltd. to research, develop and produce the micro projecting module products. In 2010 Crystal Optech purchased 60% equity of Zhejiang Taiji Electronic Information Technology Co., Ltd. and became the controlling shareholder. In 2014 the company purchased 100% equity of Zhejiang Fang yuan Reflective Material Co., Ltd. In November 2014, Crystal Optech used 20million USD to purchase 20.38% equity of Opteron in Japan, one of the leading coating equipment manufacturers for precision optics and touch panel in world, became the No. 1 shareholder of Opteron. All these investments further enhanced Crystal Optech's position on thin film technology for the international consumer electronics market. The core technology of the company includes precision optical fabrication technology, super-hard material optical process technology, precision optical film, semiconductor process, coating, and other embedding core technologies. And the key products have expanded into optical low-pass filter, the infrared cut filter and components thereof, the narrow-band pass filter, thermal diffusion panel, the LED sapphire substrate, the micro projector and the reflective material series products are in the domestic and international leading level. By focusing on advanced thin film technologies and grew vertically integrating research & development and manufacturing, Crystal continues to expand to other emerging application fields such as 3D imaging and virtual reality.

In 2018, Crystal Optech set up JV with Schott Glass to manufacture optical components for electronic packaging market and for AR and other consumer electronics applications. As the Crystal Optech have already achieved horizontal and vertical integration through R&D and acquisition in term of coating technology, the technological niche expansion has reached some limitation. Whether Crystal Optech will keep its international specialist strategy in the thin film coating technology or it will change its strategy from international specialist to international generalist like O-film did is an interesting topic.

Figure8



Crystal Optec's successful catch-up can be explained by its international specialist strategy. The coating industry was quite segmented with a lot of specialist players around the world. With huge demand from the consumer electronics market, the industry is full of opportunity but also under great competition. Therefore, Crystal Optech expanded through aggressive international market expansion to achieve economy of scale in the niche market segment. It became a global leader in OLPF

and IRCF market. With the strong relationship with AMNE customers, Crystal Optech enjoyed the customer resources to invest in technology. Crystal Optech successfully focused on coating technology and invested both vertically and horizontally. The coating business is a technological intensive business. By investment in latest technology and equipment, Crystal Optech not only became an international specialist in coating technology but also built up the entry barrier of new comers. Based the technologies advantage, Crystal Optech further expanded its technology in new applications such as digital camera, mobile phone camera, security monitoring camera, computer camera and other digital camera lens, semiconductor illumination, micro projector, smart glasses, road traffic mark and safety protection. The success of Crystal Optec's catch-up was due to its niche expansion strategy by focusing on both international market niche expansion and horizontal and vertical niche expansion in coating technology. The international customer base is an important leverage and driving force for Crystal Optech's technological development. However, the benefit from linkage, leverage and learning from AMNE customers on the technological side is very much limited. The actual catch-up was through a serial of technological niche expansion activities from Crystal Optech itself. The whole process of catch-up can be described as entrepreneurial and strong pull strategy to get resource from the overseas was apparent.

CASTECH

CASTECH was founded 1988 by FJIRSM. FJIRSM (Fujian Institute of Research on the Structure of Materials) was a government research institute specialized in crystal optics. FJIRSM was founded in 1960 by LU Jixi, famous scientist, educator and member of the Chinese Academy of Sciences (CAS). The institute is an influential, comprehensive research base in structural chemistry and new crystal materials. The endowment of CASTE Chas a new company was the intellectual property and early

overseas marketing activities of FJRSM on crystal material. With the innovative products such as LBO, BBO, Nd: YVO4 and KDP, CASTECH started to sell the products to major laser producers such as Coherent and Spectra Physics in U.S.A. and grew as a vertical integrated specialist in the field of crystal optics and precision optics with a focus on the application area of laser and telecommunication. As it found the application of crystal optics in laser and telecom industry, CASTECH grew quickly both in term of technology and international market. CASTECH started from material growth, and moved into fabrication and coating technologies. After 30 years rapid catch up, CASTECH became a recognized leading supplier of crystals, optics and laser components in the world.

The development of CASTECH in its international strategy can be broken to 3 periods:

Early internationalization period: 1990-1997

CASTECH's early stage of international expansion was more based on the intellectual property from FJIRSM rather than entrepreneurial effort. Actually, the international expansion of CASTECH started well before CASTECH was founded. Although FJIRSM as a well-known research institute in the field of crystal optics with no experience in international business, because of the breakthrough in crystal technology, the early entrepreneurs started to market the product in the international market with immediate success. In 1981, FJIRSM began to export PET crystal to U.S.A. In 1982, FJIRSM began to export ADP and KDP crystal to U.S.A. In 1983, FJIRSM began to export KAP crystal to U.S.A. Also, in 1983, FJIRSM attended the CLEO international photonics trade show in San Jose USA for the first time. In 1985, FJIRSM attended the Laser show in Munich Germany for the first time. In 1986, BBO crystal won the special award from the Chinese Academy of Science and was offered to the market by FJIRSM the same year. In 1987 BBO crystal was

evaluated as one of ten most important products by the American journal laser. The innovative product of BBO and LBO was an immediate success in the international market. In 1988, the international sales of BBO and LBO reached over 1million USD. On August 20th 1990, Fujian Crystals (later renamed as CASTECH) was officially established by FJIRSM as dedicated enterprise to further commercialize its research result in crystals for industrial applications. On the same year, LBO was awarded the national prize for invention and was awarded as one the ten most important laser products by the American journal Laser.

CASTECH's early internationalization was market driven. As a born global company, CASTECH applied its technology into the international laser and communication market. As these markets were dominated by overseas players, CASTECH's early internationalization started from these overseas markets including US, Europe and Japan. As BBO and LBO became widely used in the laser industry, CASTECH started to market the product in global laser industry. Because the laser and telecommunication industry in China is still at early development stage, there were not much local Chinese companies that need product from CASTECH. Due the market condition, CASTECH was an international player right at the beginning. Right in the beginning, CASTECH is appealing to major overseas laser companies, such as Coherent and Spectra-Physics. These overseas laser companies were forced by the technological pressure to source from CASTECH. In this period, CASTECH's engagement with the international audience in the international market place as an international crystal company with China manufacturing. The main products included crystals of different types. The main market communication channels included international trade shows in photonics and laser, company website in English and professional journals in the industry. In this period, the percentage of international sales of CASTECH is close to 100% out of the total sales, with the US and Europe 70/30 split. 100% of the sales came from crystals including LBO and

BBO while material growth became the core technologies. CASTECH became an international specialist in the international market place for crystals. CASTECH became more and more appealing to crystals users in advance economies including US and Europe because of CASTECH's innovative products.

The internationalization process or the geographical niche expansion process was also technology driven. BBO and LBO were patented in China by Fireman 1988 and 1990 respectively. KTP was patented in China in 1993. In 1996, BBO was patented in Japan. However, the technological niche was still fragmented in the early stage of CASTECH internationalization. The crystal products only include BBO and LBO and the technology were limited to material growth. In 1992, CASTECH developed new crystal material Nd: YVO4 and YVO4. CASTECH started to volume production for both products. In order to fill the gap in the technological niche, CASTECH started to get involved with material processing. In 1994, crystal processing operation was set up in Maryland USA to help serving the local market. In 1998, a low power crystal Nd: YVO4+KTP was developed. During the technological niche expansion process, the international specialist position, brought mainly from the geographic niche with strong engagement in the international market, helped CASTECH to expand quickly in the technological niche dimension. First of all, CASTECH was able internalize the operation with the same jobs that it used to buy from local suppliers because of international specialist position. CASTECH soon moved into crystal processing. Secondly, the international specialist image helped to attract both business partners and key employees from the local industry. Thirdly, the international specialist image helped also to build the supply relationship with local specialists. With the technological niche expansion by itself and the supply chain network in local industry, CASTECH enjoyed much better position in the industry to meet the demand of international customers in the technological niche dimension. This is an important step for a "born global" technology company to leverage the key

resource to acquire technological advantage in the early stage of its internationalization process. All these were done with limited financial resource from the company so that the company built up its capability soon in the endowment period and become a true international specialist company in the international environment. Its international position remained the same in this period while the technological position was established quickly.

However, CASTECH's internationalization process was not smooth at all. With all the success in the laser market, CASTECH as a state-owned company founded by FJIRSM, was faced with major corporate governance problem. Mr. Wang Hong Rui was the general manager of CASTECH. With all his entrepreneurial effort with CASTECH, he was not motivated under the stated owned enterprise system. In 1992, under Mr. Wang's management, CASTECH, set up a joint venture company with Hummin Co. and Hong Kong Phoenix Co. The new company was called Fujian Phoenix Laser Co. Ltd., later on known as CA six in the international market. Hong Kong Phoenix was a US based laser company. Hummin is the investment vehicle of Fujian Province in Hong Kong. It is a state-owned investment company of Fujian Province. Each party in the joint venture held a third of the total shares of the joint venture. CASTECH use its intellectual property as investment and the other two companies use 5 million USD as investment respectively. Mr. Wang was appointed as the general manager of the new company. This joint venture which was promoted as a success story of foreign direct investment later on was found to be a big mistake for CASTECH in IP protection and became a direct competitor to CASTECH. Given all the IP protection effort, CASTECH still face IP infringement. However, the joint venture company Fujian Phoenix Laser started to produce BBO and LBO right after its founding in 1992 and later Fujian Phoenix Laser started to produce YVO4. Although CASTECH held 34% of Fujian Phoenix Laser, the other partners of joint venture, Humanin and Phoenix, did not respect the IP of CASTECH and supported the

general manager of Fujian Phoenix Laser Mr. Wang Hong Rui. Mr. Wang was removed from the general manager position of CASTECH and Mr. Wang immediately quit his position from the mother institute of FJIRSM. Mr. Wang broke up with its former employer and lead Fujian Phoenix Laser to be in direct competition with CASTECH. Mr. Wang has taken 38 researchers from FJIRSM and Fujian Phoenix Laser became a major threat to CASTECH. In 1995, without notifying CASTECH, Phoenix Laser sold its 33% share to Hummin and Hummin became the major shareholder of Fujian Phoenix Laser with 66% in total. As Hummin is a Hong Kong based investment vehicle of the Fujian Province, now the conflict between CASTECH and Fujian Phoenix Laser became an “internal conflict” between two Chinese companies. Although CASTECH tried to use legal power to fight against the IP infringement of Fujian Phoenix Laser, the law suit was cancelled by itself under the pressure from the Provincial government. In 1996, the Chinese international trade committee arbitrated for the second time that Hummin Co. should compensate FIRSM12 million RMB for contract-breaking, and Fujian Phoenix Laser was logout. CASTECH withdrew from the joint venture with all its IP. However, Hummin just renamed Fujian Phoenix Laser as Casix which was founded by Hummin as early as in 1995. CA six was the trade name for Fujian Phoenix Laser and already an international brand. Casix continued to produce and sell YVO4 in the international market. In 1997, the Chinese international trade committee arbitrated for the third time that Hummin Co. should compensate FIRSM8.5 million RMB for contract-breaking. Although CASTECH got back some compensation from Hummin, the leakage of IP was inevitable. In 2000, CA six was sold to JDSU for 60 million USD and JDSU was the largest optical component producer for communication in US. In 2005, JDSU sold CA six to Fabrinet, a contract manufacturer for telecommunication equipment producers. Eventually, CA six became a foreign owned company and CASTECH has lost control over some of its intellectual property.

In summary in this period, the percentage of international sales of CASTECH is close to 100% out of the total sales, with the US and Europe 70/30 split. 100% of the sales coming from crystal materials, including BBO, LBO, KTP, Nd: YVO4, YVO4 and KDP+Nd: YVO4, while technology cover mainly by crystal material growth and material processing. During first 2 years, 100% of CASTECH's business was for export. The percentage of export remained over 80% during the early internationalization period. CASTECH's niche expansion in geographical and technological dimension resulted in catch up in revenue. The fighting was IP infringement from CA six was a major challenge for CASTECH. The institutional environment and the corporate governance of the state-owned enterprise did not help CASTECH in its early internationalization. This has forced CASTECH to keep investing technology. Total sales grew from 1million RMB in 1990 to 10million RMB in 1997. CASTECH became an international specialist for crystal material in the international market place. CASTECH became the synonym of "China Crystals".

Accelerated internationalization period: 1997-2008

The acceleration of internationalization of CASTECH was driven by the telecom boom in the international market. The telecom boom started with the US Telecommunications Act in 1996 to introduce competition to the local telephone service. There was tremendous investment from 1996 to 2000 into international optical communication industry. Laser and optical fiber technologies, as the two most important enabling technologies for the telecom boom, were faced with great growth opportunities. CASTECH's growth in this period was driven by increasing demand for laser and optical components from the laser and optical fiber applications.

The accelerated internationalization process of CASTECH was market driven. In this period, CASTECH adopted a global brand strategy. On the one hand, CASTECH kept

its strong position in the advanced countries including US, Germany and Japan. CASTECH has established strong partnership with major players in the global solid-state laser companies. Top 5 customers including Coherent, Specta-Physics and Rofin-Sinar from US and Trump from Germany accounted for 30% of the total sales of CASTECH. The percentage of international sales remained over 80% of the total sales. United States was by far the largest market for CASTECH accounting for half CASTECH's global sales. In the accelerated internationalization period, CASTECH further strengthened its sales network in the major industrial nations and direct relationship with key customers. United State is the number one market for CASTECH. In the United States, CASTECH used two distributors, Conex systems and Skytel Corp. to cover the US market. In 2004, CASTECH set up 'CASTECH INCORPORATION' in U.S.A to further strengthen the presence in US and to provide local service to key customers in USA market. In both USA and Japan, CASTECH products were the patented; while in Europe, CASTECH products were not patented. In early internationalization period, CASTECH used agents in Europe. In this period, CASTECH combined the sales through agents with direct sales in Europe. In 2005, CASTECH built up Customer Relationship Management systems to improve its serve quality to the customers. CASTECH also started its 6-sigma training plan to improve its product quality continuously. All the effort has resulted in a continuous growth of international sales for CASTECH. Apart market from advanced economies, CASTECH also started to market its products to emergent markets.

The accelerated internationalization process of CASTECH was also technology driven. CASTECH continued to develop crystal material and crystal processing technology. In 1998, CASTECH successfully developed Nd: YVO4 +KTP glued crystal module for low power laser application. In 2002, CASTECH obtained Chinese patent (Patent number 94106609.6.) for AR-coating on LBO crystal surface and the craft. In 2003, CASTECH obtained the significant breakthrough on the new craft of growing

LBO single crystal to produce high quality crystal with low absorption. In2004, CASTECH researched and successfully developed the growing technology of the Nonlinear Optical Crystal BBO in 2004, CASTECH build up the largest production line in the world for annual 300,000pcs Nd: YVO4 +KTP glued crystals for low power green laser. In 2004, CASTECH succeeded in the new technique of machine-polishing for LBO crystal. Also, in 2004, CASTECH expanded its growing line of Nd: YVO4 crystals by 10 sets of ovens. In 2006, CASTECH successfully developed Optical-Contact cemented products and began mass production. Also, in 2006, CASTECH successfully developed GTR-KTP crystal. In2007, CASTECH introduced optical thin film product(OTF), including: CWDM，DWDM, FT TX, GFF and other filters. In 2007, CASTECH expanded its production line of mini-power green laser kit product to 1 million units per year and Q-switch also was introduced product the same year. In 2008, CASTECH introduced new LBO coating technique with high damage threshold, long life time and low reflectivity (R<0.05%@1064, R<0.1%@532). With all the technology advancement, CASTECH not only has broadened its product line but also has become more vertical integrated into crystal material processing and coating. For the vertical integration process, beside in-house research and development activities, CASTECH also use merger and acquisition to get access of coating technology. In 2002, CASTECH Invested and hold 55% shares of Qingdao CRYSTECH Inc., with registration capital of 11 million Robin 2003, CASTECH invested and held 35% shares of Qingdao CRYSTECH coating Inc., with registration capital of 20 million Mbaqanga CRYSTECH used the capital to invest in coating technology. It bought 4 coating machines in 2003 and started produce coated optics and crystals. With all the investment, CASTECH turned Qingdao CRYSTECH specialist in KDP crystals. Besides KDP, Qingdao CRYSTECH also started to produce KDP Pockets Cell and RTP Q-Switch In 2007, Qingdao CRYSTECH became the largest producer of KDP in the world. CASTECH invested and hold 30% shares of Hangzhou Kiting Optical Technology Inc. with registration capital of 21

million RMB. Hangzhou Kiting was founded by professors from Optical Instrument School of Zhejiang University, one of top universities in China. Hangzhou Kiting is very strong in coating technology. By adding Hangzhou Kiting, CASTECH got direct access to the latest coating technology.

CASTECH has catch up on in this period into a world-famous crystal technology company with international quality standard. So, soon after the start of the company, CASTECH quickly filled in most of the gaps in technological niche for crystal processing and coating and became a vertical integrated international specialist in crystals and precision optics with dominant market position. All the development in the international market and technology innovation were supported by CASTECH's financial strategy. 2002, CASTECH got the investment from Shenzhen Innovation scientific and technological investment Co., Ltd., Shanghai Dongfeng Science & Technology Development Co., Ltd. and Fujian Hoaxing investment company. The total registration capital reached 90 million RMB. In 2005, CASTECH got the further investment; the total registration capital reached 95 million RMB in 2008, CASTECH went IPO in China Shenzhen Stock Exchange (SSE:002222). CASTECH raised 347 million RMB from the IPO.

In this period, CASTECH saw the opportunities of precision optics business from the market and started to invest into precision optics. CASTECH market the two businesses as two divisions. Optical component division focus on the manufacturing of optics and the crystal materials division focus on the design and manufacture of crystal materials. The fundamental niche expanded greatly as offering is much more comprehensive so that one stop shopping is possible for potential customers. The realized niche is limited in terms of application areas. These application areas included laser, telecommunication and defense applications.

In summary in this period, the percentage of international sales of CASTECH was

over 80% out of the total sales, while sales from the US accounted for 50% of the total sales. 60% of the sales coming from patented products and 40% coming from non-patented products while precision optics became CASTECH's key product. CASTECH became an international specialist for crystal material and precision optics in the international market. CASTECH became less dependent on the patented products and has expanded into precision optics and became vertical integrated solutions for OEM customers in the international laser and telecommunication market.

New internationalization period: 2008-2016

In the new international period CASTECH further strengthen its dominating position through its balanced global strategy and technology expansion strategy. As a market leader in crystal optics industry, CASTECH already enjoyed dominant position for crystal materials in the global market; therefore, CASTECH continue its vertical integration strategy focusing on strengthen its market position by providing a total solution for OEM customers from crystal material, precision optics, optical assemblies and optical device. In2009CASTECH began to build up its new facility of total 40,000 square meters and moved into the new facility in 2013. Most of the capital from the IPO of 347 million RMB was used to increase its production capacity of its crystal and precision optics. In 2010 CASTECH invested 39 million RMB with its partner to build up new company "Fujian Waban Optoelectronics Technology Co., Ltd", which engages in manufacturing and sales of LED lightning product. This investment is the only investment that is somewhat unrelated to its main business.

During this period and especially after the global financial crisis in 2008, CASTECH start to adopt a more balanced global strategy and put more effort in domestic market. As the laser and telecommunication in China grew rapidly in this period,

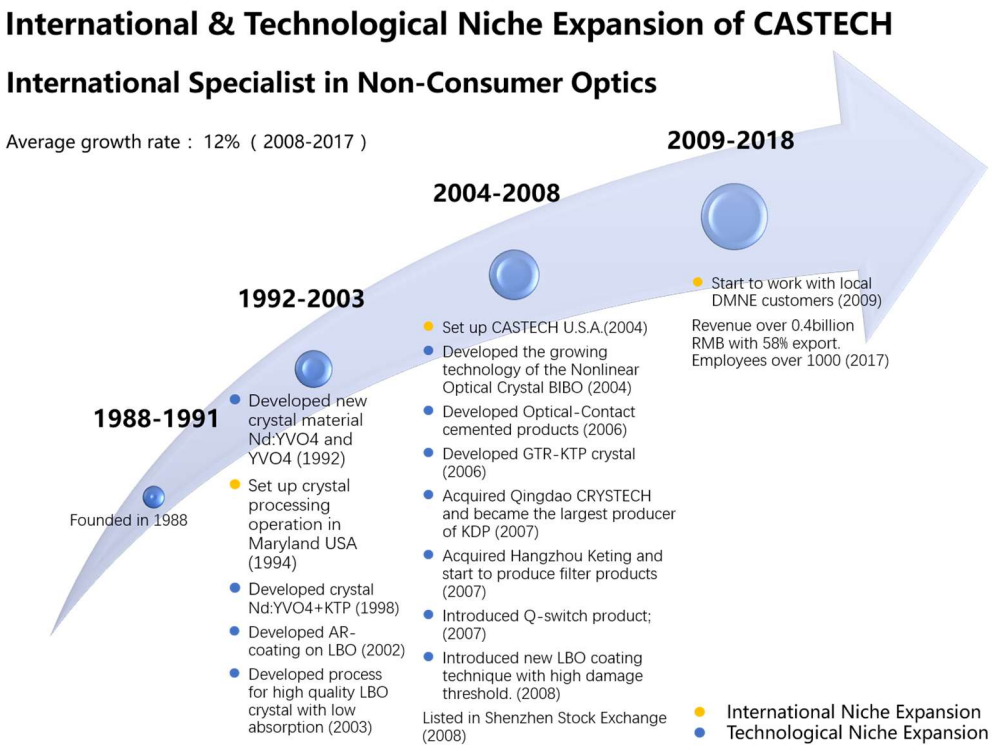
CASTECH's product soon found market locally. Companies such Hans Laser and Celink became major players in the global laser and telecommunication market. CASTECH's local sales grew quickly to over 20% of its total sales. In this period, the international sales of CASTECH went down from 80% to around 60%, as a lot of the laser business came from local customers. The proximity to the local market is actually a good advantage when it comes to solution business. The growth of business was actually coming more from the local market. However, the benefit of being a global player and learning throughout the years from international business is the reason why CASTECH can win a lot of business from the local market. The overseas competitors now find CASTECH as a major competitor both in local and international market. CASTECH became an international specialist in crystal optics, precision optics and laser modules.

CASTECH's expansion strategy happened also in the technological dimension. CASTECH further expanded in the niche width in terms of offering from crystals to precision optics and laser components. According CASTECH's technological niche strategy in this period is to strength its leading position as a global specialist in the global crystal market covering the full vertical chain of material composition and crystal growth, crystal orientation, cutting and grinding, polishing and coating. CASTECH kept investing in the crystal growth technology and has developed flux, Kochanski, water solution and bridge crystal growing technology, becoming a worldwide leading supplier with largest mass production lines in the world for LBO, BBO, Nd: YVO4 and KTP. In addition, CASTECH also provide Nd:YLF, Nd:YAG, KDP, KD*P, Ti: Sapphire, TGG and other crystals for laser and telecom industries. Today CASTECH enjoys 60% of the global LBO market, 40% of the global BBO market and 30% of the global KTP and Nd:YVO4 market, dominating the crystal market. As the global market for solid state laser grew, CASTECH's crystal business grew over 40% in 2016. CASTECH has also expanded into the precision optical component business.

CASTECH manufactures a wide range of high precision spherical, cylindrical and flat optics components for OEM customers from Industries such as Laser, Telecom, Biomedical instruments and Analysis instruments. CASTECH utilizes different manufacturing processes including CNC, rotational, double-sided polishing and thin film coating with IBS, IAD, EB technique. The accuracy level reached 1/20 wave in terms of surface accuracy, 10-5 scratch/dig in terms of surface quality up, and up to 2 angstroms in terms of surface roughness. Catechus also developed high laser damage threshold coating technology. As the global market for fiber laser grew, CASTECH's precision optics business enjoyed high growth. In 2013, CASTECH expanded its production lines for laser and telecom components including high-power isolators, collimators, F-Theta lens etc. CASTECH moved down stream along the value chain to provide more integrated products, i.e. subassemblies. In 2016, CASTECH re-organized its organization structure and formed new crystals, optics and laser components divisions.

In summary in this period, CASTECH international and local sales became more balance. The total revenue has doubled in this period while the percentage of international sales of CASTECH went down from 80% to 60%. The international sales kept growing steadily while the domestic sales increased rapidly. The sales from different products are also balanced with 40% of the sales coming from non-linear crystal material and 20% coming from laser crystals, and 30% from laser components. CASTECH maintained strong position as an international specialist for crystals, precision optics and laser components. CASTECH's slogan in the period is "integrated optical solutions".

Figure9



Low level international niche expansion and High level technological niche expansion

We can learn from the CASTECH case that the DMNEs niche expansion process follows an upward spiral path in the international and technological dimensions. During the early internationalization period, CASTECH successfully get access to the international market for its innovative products. In this stage the niche expansion was focused on international niche dimension as the technology advantage gave CASTECH a monopoly position technologically. During the accelerated internationalization period, the niche expansion was both in the international and technological dimension. The huge demand from global telecommunication market, CASTECH established a global sales network and invested in manufacturing and further enhanced its market position in the global crystals market. During the slowdown period, as the demand from the international market was declining, CASTECH focused on technological niche expansion and started to develop local market. CASTECH adopted a more balanced approached regarding international

and local market and started to work with local DMNE customers. The speed of international expansion was slowed down. However, the technological niche was still on-going as CASTECH moved into precision optics manufacturing. Although the process was more or less the same, CASTECH expand the material from crystals to optical glasses.

CASTECH's catch-up can be explained by its international specialist strategy. As photonics company, CASTECH was a specialized in the crystals business. However, in this case unlike typical DMNEs, CASTECH enjoyed competitive advantage technologically. So CASTECH'S catch-up was not on the technological niche dimension but international niche dimension. CASTECH has successfully applied its innovation products into the global market. With strong sales network, CASTECH was able to enter into US, Europe and Japan market where applications of crystals are. With both ownership advantage and location advantage in China, CASTECH focused its operation in China in order to keep its IP protected. However, the local institutional environment in terms of IP protection was not favorable to CASTECH. Although CASTECH has won the law suit with CA six, the later was still able to grow and later on was acquired by AMNEs. So, in this case, the relationship between DMNEs and AMNEs are more of a competitive nature. The linkage, leverage and learning from AMNEs cannot be seen in this case.

MLOPTIC

MLOPTIC was founded 1999 with endowment from the trading business with Europe and U.S. in precision optics. Over the last 16 years, MLOPTIC has successfully moved its position in the market as a precision optics components provider that was trading mainly with other precision optics companies in the US and Europe to a fully vertical integrated precision optics company serving the major OEMs in the major application areas. This process in the organization ecologist's

eye is a niche expansion process. MLOPTIC has positioned itself as an international generalist at the founding period and quickly filled in all the gaps in the technological niche and geographic niche to be a major player in the international market. The international expansion and technological expansion interacted with each other and promoted MLOPTIC from peripheral position in the market place to the center of the market place. The process of the niche expansion in the technological and geographic dimension is a dynamic one. The niche expansion in the geographic dimension begins first, the niche expansion in the technological dimension follows; the niche expansion in the technological dimension then by return helps the further niche expansion in the geographic dimension. The process is like a spatial escalation. Niche expansion happens also on multiple markets: product, services, suppliers, job market etc. This exposes organizations who try to internationalize to multiple audiences, customers, suppliers, subcontractors, investors, etc. The success and failure of internationalization depend on the focal firms' understanding of the demands and expectations, tastes (more abstractly the schemata) of all these different audiences in the different geographical contexts and on the ability to comply with the expectation satisfy the demands. Throughout the internationalization process, MLOPTIC has been able to meet the demand and expectations of different audiences in different geographic and technological contexts.

The development of MLOPTIC in its international strategy can be broken to 4 periods:

Early internationalization period: 1999-2004

MLOPTIC's early stage of niche expansion of was entrepreneurial. The international experience of the entrepreneurs meets the expectations of the international customers and investors. The fundamental niche of MLOPTIC is determined by the

nature of the entrepreneurship. The early stage of internationalization of MLOPTIC can also be explained by the international entrepreneurship theory as being a born global. Almost of gaps in the technological niche and geographic niche being filled up in this period, the realized niche has been expanded to capture the market center of global precision optics industry. Both entrepreneurs speak good English with overseas education and one of them has 4 years' experience in exporting precision optics from China to US and Europe. The entrepreneurial opportunity is actually created by overseas demand of precision optics made in China. Due to the increasing labor cost in Europe and US and the opening up of China market, precision optics end-users started to source their precision optics in China. However, to buy optics in China is not easy and only big companies have enough resource to source precision optics in China. Small companies have to rely on local precision optics companies who have the expertise in precision optics to do the sourcing in China. On the other hand, local Chinese precision optics companies do not have experience in international business and cannot deal with foreign customers. There is a demand for companies which understand precision optics and international business to bridge the gap between the overseas customers and Chinese local precision optics industry.

MLOPTIC was set up as a professional precision optics manufacturing company in China aiming for overseas market. The technological niche was fragmented as the operation did not cover optics manufacturing in the beginning and the product quality was not stable. However, the business has attracted attention both from its peers and from its European and U.S optics companies, both dealers and manufacturers because of its geographical niche started from overseas. Some end-user customers also started business with MLOPTIC. The company was utilizing its endowment to gain more resource both from international end-user customers and precision optics companies in advanced countries. As a born global company,

MLOPTIC is an international player right at the beginning. Because there were not many local Chinese precision optics companies that can-do business with foreign companies and have strong appeal to the international market, this situation created opportunities for the entrepreneurs. So, the internationalization process of MLOPTIC is an important part of the entrepreneurial process. During first 2 years, 100% of MLOPTIC's business was for export. The percentage of export remained over 95% during the early internationalization period of 1999-2014. In the beginning, MLOPTIC is mainly appealing to overseas smaller companies, mainly overseas precision optics companies. These overseas precision optics companies were forced by the market pressure to source in China. Some of these overseas precision optics companies are pure trading companies, others are precision optics manufacturer. In this period, MLOPTIC's engagement with the international audience in the international market place as an international optics company with China manufacturing. The main products included optical components of different types. The main market communication channels included international trade shows in precision optics, company website in English and professional journals in the industry. In this period, the percentage of international sales of MLOPTIC is close to 100% out of the total sales, with the US and Europe 50/50 split. 100% of the sales coming from optical components including lens, prisms while precision polishing and optical coating became the core technologies. MLOPTIC became an international generalist in the local market place for optical components and the relationship with local partners is complementary. The slogan in the period is "OEM optics from China". MLOPTIC became more and more appealing to precision optics users in advance economies including US and Europe because MLOPTIC met their expectation on quality and cost. The entrepreneurs and the US partner promoted MLOPTIC as a Chinese optics company with international quality standard. So, soon after the start of the company, MLOPTIC quickly filled in most of the gaps in technological niche for optical component manufacturing and became a true

international generalist in this niche space of optical components business. The niche expansion in geographical and technological dimension resulted in growth in revenue. Total sales grew from USD 100 thousand in 2000 to USD2 million in 2004.

The internationalization process or the geographical niche expansion process was also a network building process with overseas partners and customers. The most important overseas partner at the early stage of internationalization of MLOPTIC is Northern Optics. Northern Optics was the biggest customer for MLOPTIC in this period of early internationalization. Right after the founding of MLOPTIC, Northern Optics was invited to invest in MLOPTIC and represent MLOPTIC in U.S. and Canada. The partnership with the US based Northern Optics further enhanced the credibility of MLOPTIC as an international player. Northern Optics was a small precision optics company with specialized in the production of glass window for the laser construction industry. The owner of Northern Optics had been doing business with the founder of MLOPTIC before the founding of MLOPTIC and was committed to the growth of MLOPTIC. Northern Optics realized that precision optics manufacturing in US became less competitive as countries in Asia especially China joined the global supply chain of precision optics. However, the risk of doing business in China for a small company like Northern Optics is quite high. With the trust being built in the past, Northern Optics decided to move its production to China and invested in MLOPTIC. The glass window production was transferred to ML Optic and Northern Optics became MLOPTIC's agent in US to bring optics components business from U.S. to MLOPTIC. More and more customers were introduced to MLOPTIC because of the partnership.

The geographical niche expansion process was a network building process both in the international and local product market place but also in the international and local supply chain. Especially at the early period of MLOPTIC's internationalization,

the local supply chain enabled MLOPTIC to be able promote itself as an international generalist even MLOPTIC has a lot of gap in the technological niche dimension. The technologic niche started from window and prism fabrication and expanded into lens fabrication and coating. The main application area was limited mainly to the construction laser industry because the U.S. partner was supplying optics for construction laser industry in U.S. However, with intensive marketing activities such as advertisement and promoting itself as a Chinese precision optics manufacturer, it has started attract more and more customers from other application of precision optics and end users. The local supply chain of precision optics built by the founder of the company helped MLOPTIC to fill in the gap in manufacturing. The international image of MLOPTIC was appealing to the local suppliers. MLOPTIC outsourced some of the optics from local specialist companies and then inspected the goods and packed in international standard package before shipping to overseas customers. The local specialist companies have no access to the international market and no knowledge about international standard of precision optics. They were willing to support MLOPTIC to explore the international market.

The technological niche expansion was driven by the international niche expansion during the first years of Morticing this period, the company started to build manufacturing to fill the fragment left from the previous period. In 1999, the U.S. partner transferred the glass window technology to MLOPTIC. With the technological transfer, MLOPTIC became engaged in cutting and grinding technology. In 2000, by acquiring a small local optics fabrication company, ML moved into the lens polishing. In 2001, with the join of one local coating engineer as a shareholder, it has set up coating operation. The first coating machine was purchased to meet the demand of one of MLOPTIC's biggest customers at that time, Leica Geosystems. The prism polishing was set up in 2001also to meet the demand

of Leica. In 2002, right after the owner of the US partner invested in MLOPTIC, an international standard optical metrology instrument was brought into MLOPTIC so that MLOPTIC's metrology technology was established very early with an international standard.

During the technological niche expansion process, the international generalist position, brought mainly from the geographic niche with strong engagement in the international market, helped MLOPTIC to expand quickly in the technological niche dimension. First of all, MLOPTIC was able internalize the operation with the same jobs that it used to buy from local suppliers because of international generalist position. Secondly, the international generalist image helped to attract both business partners and key employees from the local industry. Thirdly, the international generalist image helped also to build the supply relationship with local specialists. With the technological niche expansion by itself and the supply chain network in local industry, MLOPTIC enjoyed much better position in the industry to meet the demand of international customers in the technological niche dimension. This is an important step for a "born global" technology company to leverage the key resource to acquire technological advantage in the early stage of its internationalization process. All these were done with limited financial resource from the company so that the company built up its capability soon in the endowment period and become a true international generalist company in the international environment. Its international position remained the same in this period while the technological position was established quickly. As MLOPTIC moved into optical coating in 2001 and the company offered more advanced coating products to local market, it soon built its technological reputation in the local population although the international reputation was still the main image of the company.

The niche expansion process in the technology dimension also has an international perspective. The niche expansion in technological niche helped the company to be able to serve end-user customers directly rather than go through dealers or agents. The company's appeal to the overseas end-user precision optics customers was getting stronger and less business go through other optics companies in Europe and U.S. The level of credibility of MLOPTIC as precision optics supplier was increasing as it kept investing in technology and was absorbing technological resources from its partners in US and Europe. For example, the first metrology equipment was brought from a leading U.S. manufacturer and this gave a lot of credibility to the quality control standard in the eye of the foreign customers. The US military standard was introduced by the US partner to MLOPTIC.

In summary in this period, the percentage of international sales of MLOPTIC is close to 100% out of the total sales, with the US and Europe 50/50 split. 100% of the sales coming from optical components, including lens, prisms, cylindrical, windows and filters while precision polishing and optical coating became the core technologies. MLOPTIC became an international generalist for optical components in the local market place and the relationship with local partners is complementary. The slogan in the period is "OEM optics from China".

Accelerated internationalization period: 2004-2008

The acceleration of internationalization of MLOPTIC from 2004 to 2008 was driven by strong partnership in Europe and USA. The partnership with US partner M started in the early stage of MLOPTIC internationalization became stronger and the new partnership with the UK partner helped MLOPTIC to get access to the European market and latest technology in precision optics manufacturing. The partnership also helped MLOPTIC moved from precision optical components to precision optical assemblies. The partnership with overseas partners brought a lot

of credibility to MLOPTIC and MLOPTIC became appealing to big end customers that were not accessible in the early internationalization period. The niche expansion in technological dimension was both markets driven and entrepreneurial. This can be explained by Mathews' LLL framework. Through linkage, leverage and learning, MLOPTIC quickly became an integrated optics supplier.

The internationalization process accelerated as MLOPTIC expanded further into the most important geographical markets of precision optics: U.S. and Europe. In this period, the company formed strategic partnership with a major U.K. precision optics company as its strategic partner and shareholder. Resources both in term of technical capability and market access were introduced by this partnership. The technological expansion also accelerated as MLOPTIC expanded from precision optical components to precision optical assemblies due to international expansion. The assembly business included optical sub-assemblies and opto-mechanical sub-assemblies. As MLOPTIC began to attract bigger customers in the accelerated internationalization period, the demand of these bigger customers extended business service in sub-assemblies. One of the most important customers was Leica Geosystems in Switzerland. The relationship with Leica Geosystems started when Leica Geosystems acquired one of MLOPTIC's biggest customers in US, Laser Alignment in 2004. MLOPTIC was a major precision optics components supplier for Laser Alignment and then introduced into the supply chain of Leica Geosystems. Leica is a market leader in the Survey industry and was looking for precision optics suppliers in China. Leica established Singapore operation in 2013 and set up its China facility in 2014. MLOPTIC became a global supplier for Leica supporting Leica's production in US, Singapore, Switzerland and China, not only precision optical components but also precision optical assemblies. As Leica moved its production of lower end survey instrument to Asia, it need establish its local supply chain in China to support this shift of production. MLOPTIC has grown big enough

both in terms of technological and international dimension to support Leica's global strategy.

In this period, the biggest customer of MLOPTIC is the UK partner Span optic. Span optic was a well-established precision optics company. It was one the largest independent precision optics component manufacturers in the UK. Based on the same reason of cost and pressure from local customers to source in China, Span optic decided to form strategic alliance with MLOPTIC. The company was founded by JB in the 1970s. Over 30 years, Span optic was been kept investing in the latest polishing technologies and have grown into a 20-million-pound company with 50 employees. The level of accuracy of Span optic is well above MLOPTIC. However, a lot of jobs with normal accuracy requirement, Spanoptic simply cannot meet cost requirement from the local customers in Europe especially for non-military applications where competition is global. When MLOPTIC became a reliable supplier for Span optic, MLOPTIC decided to form a strategic alliance with Span optic to secure the European market. Span optic also need a stronger partner in Far East to meet demand of its local customers. With technological advance of Spanoptic, some of its older equipment's were transferred to MLOPTIC as investment. Those German machines not only filled in the technological gap of lens polishing but also increased the international image as a precision optics manufacturer. The technological transfer was actually both ways. MLOPTIC helped Spanoptic to set up its coating capability. This partnership worked well as Span optic and MLOPTIC strategic alliance helped both companies. For Span optic, the strategic alliance helped to keep most its non-military customers happy and keep its own margin; for MLOPTIC, the strategic alliance helped it enter into the European market and get access to the advance lens polishing capabilities.

In this period, the founder of MLOPTIC saw the opportunities of optical assembly

business from the market and started MLOPTIC Instrument. This is was an entrepreneurial effort from both a business perspective and an internationalization perspective. The idea first came from Leica's international expansion strategy into Asia. When Leica decided to move its US operation to Asia, one the option is to work with a local supplier as an outsourcing project. Although this did not happen, the founding of MLOPTIC Instrument helped to meet the demand of MLOPTIC's existing customers to buy assemblies rather than just loose optics. Although, Span optic did not have assembly capabilities, with the strategic alliance, it promoted the assembly business and won some major business which was taken by its competition because its lack of assembly capabilities. MLOPTIC market the two business as two businesses as two divisions. Optical component division focus on the manufacturing of optics and the optical assembly division focus on the design and assembly of optical systems. The fundamental niche expanded greatly as offering is much more comprehensive so that one stop shopping is possible for potential customers. The realized niche is limited in terms of application areas. These application areas included survey and metrology instruments, semiconductor inspection equipment's, medical inspection equipment, and defense applications. As the company grew, its peers both home and abroad regard MLOPTIC as a major player in China. It became an international generalist in precision optics in China. As the world precision optics industry is like a small community, the network role as explained by the IPM model also explains the change of MLOPTIC's position in the international market.

The expansion in technological niche was driven by the accelerated internationalization .The partnership with Spanoptic brought MLOPTIC the latest technology on CNC grinding and polishing. Span optic transferred some of its older machinery to China and MLOPTIC used these machines to produce parts that used to be produced in Spanoptic with a lower cost. This kind of win-win situation

benefited both parties. Through this kind of transfer of technology and business, MLOPTIC started to develop its own technical team and buy latest German machines the same way as Span optic. The latest technology in aspherical grinding and polishing was also introduced from Germany directly with learning from Span optic. One thing that is worth noting is that the technology transfer happened actually both ways. Although Span optic was very strong in optics fabrication, it had no coating capability. The first coating machine that Span optic bought was actually from China through MLOPTIC. MLOPTIC also send engineers to Spanoptic to train people on how to use the machine.

In summary in this period, the percentage of international sales were close to 100% of the total sales which was close to USD 5 million, with 30% in US, 40% Europe and 30% Asia. 60% of the sales coming from optical components and 40% coming from optical assemblies, including lens systems and opto-mechanical systems while precision polishing, optical coating and optical assemblies became the core technologies. MLOPTIC became an international generalist for optical components and assemblies in the local market place and the relationship with local partners is complementary. The slogan in the period is “optical components and assemblies”.

Slowdown of internationalization period: 2008-2013

MLOPTIC internationalization process faced major challenges in this period. In this period, the internationalization process continued, but the speed of that process slowed down. The percentage of international sales out of the total sales went down from close to 100% to around 90%. The growth of international sales was also limited. There were two major events happened with the two foreign partners separately in this period that negatively affected the speed of the internationalization of MLOPTIC. The technological niche, however, continued to expand rapidly. The added technological capabilities included optical design,

mechanical design, electronics design, system integration and metrology. The expansion in technological niche was a strategic move in the first place, but the driving force of the technological expansion was the internationalization process in this period. As MLOPTIC started to provide extended assembly service to more and more existing customers, the added technological capabilities were recognized by overseas customers that need more extended products and services than just pure optical components. This evolving process of interaction between international business and technological expansion was entrepreneurial and spatial escalating.

Although the idea of assembly business started with Leica's move to Asia, the actual first assembly business started from UK. The first assembly job was a camera lens build for an existing customer in the UK. The customer had been buying optical components from the UK partner J for many years and was building the assembly in house. With increasing pressure of competition from Asia, the customer decided to outsource the assembly job to save cost. MLOPTIC started with this first opto-mechanical assembly job based on the customer's drawings. Similar cases happened with other existing customers in the UK. Although none of these assembly businesses involved any design activity from MLOPTIC, these kinds of OEM assembly jobs allow MLOPTIC to build up its capability in fine mechanics and opto-mechanical assembly. MLOPTIC built its supply chain in mechanics and also started its own machine shop in this period. Other capabilities related include system level metrology. The first MTF testing instrument was bought during this period to test the optical performance of a lens system. With all the capabilities, MLOPTIC was able to attract bigger assembly jobs. In 2008, the first big assembly business around USD1million came from Optos, a medical company based in UK. The business was brought by the UK partner J. J was the optical supplier of Optus at the early stage and as J did not have assembly capabilities so the business went to J's competitor in UK who has assembly capabilities. J won the business back

together with MLOPTIC as the partnership brought a lot of competitive advantage in term of cost. With the learning from opto-mechanical assembly business, MLOPTIC decided to enter into the OEM lens assembly business, i.e., design and build lens systems based on customers' specification. Although the first effort with some existing customers who need lens solutions was not successful, this strategic move into lens design later on brought in much bigger business opportunities. From the US side, then Morpho became the largest customer for MLOPTIC. Morpho is a global leader in the biometrics and digital identification business supplying total solutions for government and business customers over the world. Morpho grew from Europe and acquired the biggest competitor in US. MLOPTIC started business with Morpho US as it designed and manufactured lens systems to Morpho in US for its document scanning division. This is both a new customer and new application area of precision optics for MLOPTIC. With its capabilities built out through the years, MLOPTIC turn out to be a perfect solution for Morpho. The interesting part of story was when Morpho US decided to outsource the complete hardware assembly, MLOPTIC was able to get the job because of its good performance in lens assembly as key components of the complete system. Now, MLOPTIC expanded the assembly business to a complete product level. With the OEM complete hardware business, MLOPTIC was able to develop its supply in electronics and PCB and plastics. With that, MLOPTIC expanded its technological capability in electronics design and testing. The business with Morpho reached the peak in 2012 as Morpho wanted to consolidate the operation globally and MLOPTIC became a global partner for Morpho. The total business volume reached USD3million with Morpho in 2012. Besides Morpho, Illumina, one of the bio-tech companies turned out to be a major breakthrough for technology advancement in terms of system level design and manufacturing. Illumina is the biggest DNA sequencing machine producer in the world and acquired one of the startup companies which MLOPTIC started to work with in 2009 on the optical engine for its PCR instrument. This is the first time that

MLOPTIC gets a chance to work on the design job a complete optical system integrating optics, mechanics and electronics. This involves technology in imaging, light source, and motion control. Although business with Illumina was reduced as the PCR business was sold to a UK scientific instrument company in 2013, the technology developed because of the international business helped MLOPTIC to catch the local business opportunities when the largest DNA sequencing company in China was looking for optical solutions in 2014.

With all the successful advancement in technology in this period, the internationalization process met huge challenges. The first event happened to the US partner in 2008. M invested in the real estate and went broke when the financial market in US collapsed in 2008. This is a big event for M personally both also for the internationalization process of MLOPTIC. The personal situation had big impact on M and he was no longer committed to the business and was looking for exit from the business to save his financial difficulty. After discussions back and forth, he decided to stay with the company as a representative for North America and the company will find way for his exit. M stayed with the company for 2008 and 2009; then, he quit and MLOPTIC changed several representatives from 2010 to 2013. None of them stayed for more than one year. This created a discontinuation of the sales activities in the North America. There were very limited number of new customers was developed in this period. The linkage with the US market was weakened in this period. The learning continued there were still projects going on in the US market and a lot of the learning was directly from international customers. The second event happened with the partner in the UK. J was over 60 at the time and was planning his retirement. Because none of his daughters were interested in the business and the management was not able to convince J for a buyout deal, JB eventually decided to sale the company to a local public company. The deal was done in 2013, however with all the problems J faced to minority shareholders and

management, J was not devoted to the business of Span optic and the partnership with MLOPTIC. One of the major customer Optos has moved to the competition and the assembly business was seriously affected. The linkage with European market was weakened and MLOPTIC's learning from European market was also very limited in this period. The only highlight of internationalization in this period is the development of Israel market. The Israel market is quite fragmented and there are a lot of agents for optics business. These agents bridge the demand of optics in the local market and the supply of optics in China. As MLOPTIC was already established with international standard of optics manufacturing, a lot of these agents came to MLOPTIC and present optics in Israel. This situation did not continue long and MLOPTIC decided to hire a local partner and go direct in 2013. The local partner K was the employee of MLOPTIC's first Israel customer and she has a lot of contacts in the local market. Because of the joining of Keren, MLOPTIC started to work with companies like Bio-Rad and other international firms that have R&D in Israel. The development of international business in Israel in turn helped international business elsewhere, especially business in US.

In summary in this period, the percentage of international sales of MLOPTIC is close to 80% out of the total sales, with 30% from US, 40% from Europe and 20% from Asia. Total sales grew over USD 10million. 60% of the sales coming from optical components and 40% coming from optical assemblies, including lens systems and opto-mechanical systems while opto-mechanical design and system design, precision optics fabrication and coating, optical assemblies and metrology became the core technologies. MLOPTIC became an international generalist for integrated optical solutions in the international market place and the relationship with local partners became less important as the supply chain was much more complex and international. The slogan in the period is "integrated optical solutions".

New internationalization period: 2013-2016

MLOPTIC's niche strategy in this period is to change its position in market from a local generalist to a global generalist. As all the global generalists in the photonic market are all optical solution providers rather than optical manufacturers, MLOPTIC changed its position from an integrated optics manufacturer to a global optical solution provider to move the market center. The previous niche expansion strategy involved both the expansion in technical capability and the expansion on geographical market place. This further expansion in the niche width was in terms of offering from optics to fine mechanics and to optical system. According to Richard at all (2006), precision optics producers can be further categorized into precision optics producers who produce glass-made devices according to customers' drawings; precision optics value added producers who design and produce sophisticated optical instruments and precision optics subsystems producers who stay in between the above two. However, the author thinks that the second category should not be included in optics population as it is more instrument than optics and the precision optics producers consist of just two subsets: optics manufacturers (optics fab) and optical solution providers. The linkage and leverage and learning in this period happened more with end-user customers as MLOPTIC became more a solution provider and the old partnership structure no longer support its new internationalization strategy. In this sense, the linkage, leverage and learning model changes with the international process. Different stage of internationalization requires different kind of Linkage, Leverage and Learning.

In this new period, MLOPTIC started to develop its own international business under hierarchy structure. The two events that happened with US and Europe have a major impact on the internationalization of MLOPTIC. In 2013, when JB sold his company to G&H, he transferred the partnership with MLOPTIC to G&H. G&H was a public traded company in London. Its main business was fiber optics. With a serial

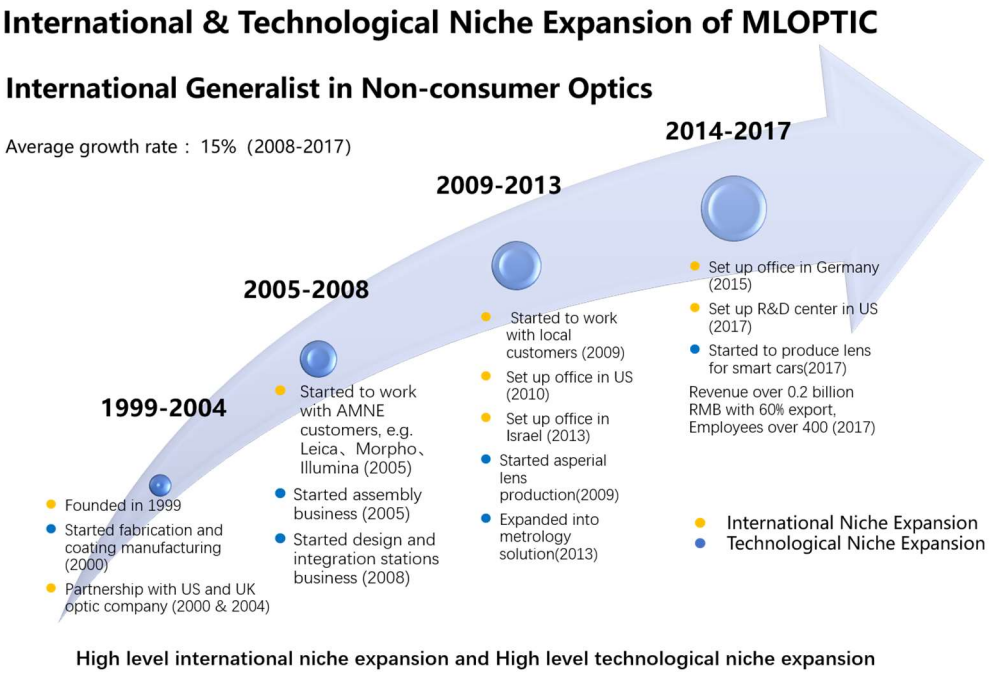
of acquisitions, G&H moved into precision optics. The partnership with MLOPTIC was valued by the stock market and G&H wanted to leverage the partnership to help its strategy to move up in the value chain to be system integration. However, the co-operation between G&H and MLOPTIC was not successful and the business between the two companies did not catch up after 3 years while during the same period the sales from direct customers in Europe has catch up on 30%. So, after the 3-year contract ended, MLOPTIC has decided to develop the Europe market with its own sales force. The de-linkage strategy from G&H actually open the door for MLOPTIC to link with end-user customers directly. The Israel market was looked after by the general manager who has a lot of experience in opto-mechanical and opto-electronics systems. Although there was a serial of change in personnel, MLOPTIC's effort in establishing its own sales force in US have never stopped. In 2016, the new general manager US has over 20 years of experience in precision optics business and was the sales manager of a US precision optics company which was a customer for MLOPTIC in the early years. In the same year, a new European sales manager was chosen. So, after over 17 years, MLOPTIC finally has established its own direct sales network.

The change in the business strategy happened both in terms of technological and geographical niche. Technologically, MLOPTIC is moving from a supplier of precision optical components and assemblies to an integrated solution provider for precision optics, precision opto-mechanical and opto-electronics systems. This change leaves no much room for any agent as interactions with customers is part of the value creation activity and the existence of agent can block the interaction. Geographically, MLOPTIC needs more local support in US and European markets for new customers and new projects. Geographically, the niche width expanded to deeper penetrations into the global market. However, the position change from an optics fab to an optical solution provider is a more fundamental change. The

capability in the value-added service is what changes the identity of the company to its position as an optical solution provider. With the deeper customer interaction, the products and service expanded from OEM to ODM and pre-sales and after-sales became more and more important. With deeper customer interaction, the appeal of company to the global marketplace increased and it has a better position to compete with western competitors rather than be a supplier to them. Actually, MLOPTIC stopped doing business with western competitors. As a solution provider, MLOPTIC is actively developing optical solutions in some major application areas of precision optics, including micro-fluorescence imaging for DNA sequencing and micro-imaging for semiconductor inspection. The effort to develop OBM business is also under way. The first trial with interferometer as MLOPTIC brand instrument was not successful due to technical complexity and limited market potential. However, the entrepreneurial effort to push MLOPTIC to the next level of technology and international market position never stopped.

In this period, the international sales of MLOPTIC went down from 90% to around 70%, as a lot of the solution business came from local customers. The proximity to the local market is actually a good advantage when it comes to solution business. The total sales reached over 0.2 billion in RMB (about 30million in USD). The growth of business was actually coming more from the local market. However, the benefit of being a global player and learning throughout the years from international business is the reason why MLOPTIC can win solution business from the local market. The overseas competitors now find MLOPTIC as a major competitor both in local and international market. MLOPTIC became an international solution provider in precision optics and the slogan in this period is “innovation through photonics.”

Figure10



High level international niche expansion and High level technological niche expansion

MLOPTIC's catch-up can be explained by its international generalist strategy. Without the international market as an important market for resources including customers, technology, supplier and labor, MLOPTIC will not be able to grow into an international generalist. Without the technological niche expansion, the appeal to the AMNE customers will not sustain. In the early days, MLOPTIC developed its international expansion through linkage and leverage and learning with Western partners who are local specialist in their home country. As MLOPTIC quickly filled the gap in technological niche, it started to work with AMNE customers which require much wider technological niche. With wider technological niche, MLOPTIC was able to further its international expansion by establishing overseas sales office and R&D center. As AMNE competitors such as Zeiss has already occupied a good position in the international market, MLOPTIC face strong competition from overseas. The realized niche space in AMNE customers is still limited. Moreover, MLOPTIC's catchup is also constrained by strong technological control over Chinese companies from Europe and US. The local resource of cheap labor and local talents provide good competitive advantage for MLOPTIC to grow. The whole process of

catch-up can be described as entrepreneurial as all the niche expansion happened based a pull strategy. So, the technological niche expansion was driven by the international niche expansion and there was always good interaction between the niche expansions of the two niche dimensions. As the precision optics industry is both technology intensive and capital intensive, international generalist needs to get access to the capital resources to leverage its growth. As MLOPTIC move to the next stage of catch-up, it needs to leverage on capital to achieve much larger realized niche space as an international generalist.

We can learn from the MLOPTIC case that the niche expansion process follows an upward spiral mode in the international and technological dimensions. During the early internationalization period, MLOPTIC worked with Western partners in US and UK to get access to the international market and quickly built up its technological strength. With linkage, leverage and learning from its Western partners, MLOPTIC was able to focus the niche expansion on technological niche dimension to be more appealing to AMNE customers. During the accelerated internationalization period, with the strong relationship with AMNE customers in place, MLOPTIC further expanded both in the international and technological dimension. MLOPTIC started to build its own sales network and invested in the latest technology in optics manufacturing and system integration. During the slowdown period, as the demand from the international market was declining, MLOPTIC focused on technological niche expansion and started to develop local market. MLOPITC adopted a more balanced approached regarding international and local market and started to work with local DMNE customers. The speed of international expansion was slowed down. However, the technological niche was still on-going as MLOPTIC moved into new technological areas including advanced metrology and microscopic imaging. In the new period, MLOPTIC started further expand its technological niche to provide solutions to major AMNE and DMNE customers. MLOPTIC started to compete

directly in the market center with AMNE competitors. During the whole process of catch-up, we can see there was always good interaction between the niche expansions of the two niche dimensions. In some period, the catchup was mainly driven by international expansion, and in some period, the catchup was mainly driven the technological niche expansion.

6. Discussion

The case studies of the internationalization of China's precision optics manufacturers provide a lot of information. There were no such case studies for China precision optics industry neither from the international business literature nor from the organizational ecology literature. Therefore, the case studies are of academic value by itself in terms of originality. What makes the case studies more academic is the application of the niche expansion based view of internationalization in the following discussion. The discussion started with analysis of the case study result (see table 4) using the model of niche expansion based view of firm internationalization. Then, the Goldilocks debate was revisited under the niche expansion based view of firm internationalization. Finally, academic and practical contributions were summarized based on the case study result and the discussion.

Table 4: Case Study Results Summary

	Catchup performance	International Niche Expansion	Technological niche expansion
Phenix	-1965: founded as state-owned camera manufacturer; -1997: listed in Shanghai Stock Exchange; -2017: revenue over 0.7billion RMB with 70% export. Employees over 2500. Average growth rate over last ten years is about -2%.	-2000: set “big optics” strategy to be a global OEM optics supplier. Work with AMNE camera customers such as Canon, Fujinon, Olympus, Zeiss and Leica. Export markets include Japan, Taiwan, Europe, US and Korea. -2005: formed JV with Canon in China. -2010: business went down as smart phone replaced digital camera in the market; -2015: acquired by HIK, a state-owned intelligent surveillance company.	-2003: it started to invest in high volume optics manufacturing in Yangtze Delta and Pearl River Delta.
Sunny Optical	-1984: founded as a private-owned microscope manufacturer; -2007: listed in Hong Kong Stock Exchange. -2017: revenue over 20billion	-2004, set “well-known supporting role” strategy to partner with global AMNEs as an optics supplier. AMNEs include Samsung, BMW, Mercedes, Audi and Lexus. -2008: open Japan subsidiary;	2003: started to produce camera modules for mobile phones; 2008: started to produce lens for automotive.

	RMB with 30% export. Employees over 28000. Average growth rate over last ten years is over 33%.	-2010: open Taiwan office; -2009: acquired Power Optics in Korea; -2012: open Korea subsidiary; -2012: opened R&D center in Silicon Valley; -2013: acquired Konica Minolta's factory in Shanghai; -2013: acquired Mantis Vision in Israel.	
O-film	-2001: founded as a private-owned IR-cut filter manufacturer; -2010: listed in Shenzhen Stock Exchange. -2017: revenue over 30billion RMB with 23% export. Employees over 41000. Average growth rate over last ten years is over 64%.	-2002: started to supply IRCF to Flextronics and Fusion; -2006: became the No.1 IRCF producer in the world; -2012: set "international technology platform" strategy to partner with global AMNEs such as Samsung, LG, Microsoft, Sony as an optics supplier; -2013: opened R&D in Japan; -2014: acquired DOC of Tesserae for MEMS; -2014: opened R&D in Taiwan, US, and Korea; -2016: acquired Sony South China Camera company; -2016: acquired a Finish touch sensor companies;	-2002: began to develop IR Cut Filter; -2008: stepped into Touch Panel field; -2010: expanded into Capacitive Touch Panel; -2012: entered into Camera Module; -2014: stepped into Finger Print Module; -2014: recruited the ADAS algorithm team from Delphi; -2015: established a dual-engine development strategy and enter into smart car application market.

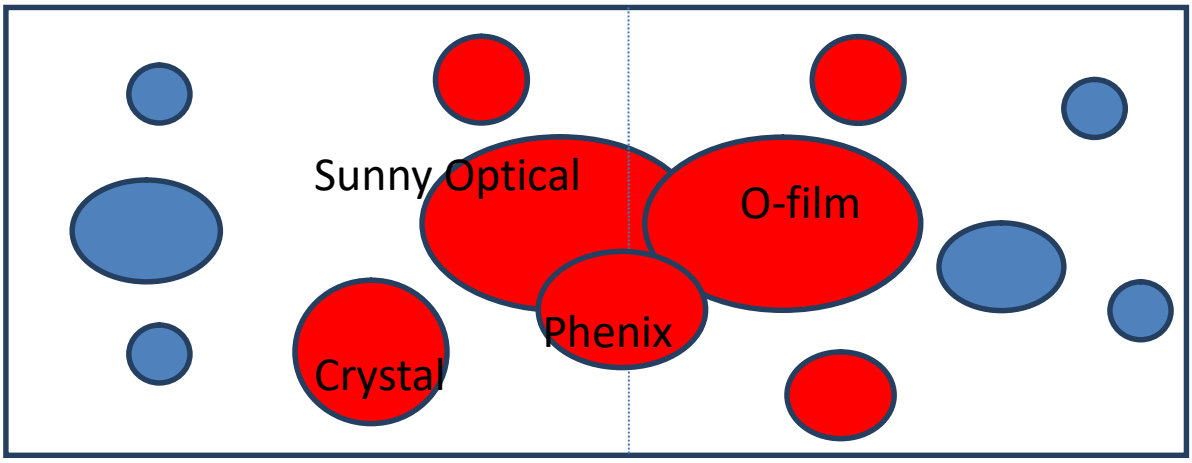
		-2016: became a supplier to Apple.	
Crystal Optech	-2002: as a private-owned -2008: listed in Shenzhen Stock Exchange. -2017: revenue over 2billion RMB with 54% export. Employees over 3800. Average growth rate over last ten years is over 28%.	-2003: started to supply to camera module companies in Taiwan and Japan; -2003: started to work with Schott Glass in Germany on material; -2014: became the No.1 shareholder of the leading coating equipment manufacturer Optorun in Japan; -2017: opened Taiwan and Japan subsidiary; -2018: set up JV with Schott Glass to manufacture optical components for electronic packaging market and for AR and other consumer electronics applications.	-2003: began to develop IR Cut Filter; -2009: began to develop micro projecting module; -2010: expanded into Blue Glass for LED; -2011: build plant in JiangXi to expand coating capability; -2014: entered into reflective material business by acquiring a local company Fang yuan; -2014: became the No.1 shareholder of Optorun in Japan;
CASTECH	-1988: founded by FJIRSM, a government research institute specialized in crystal optics; -2008: listed in Shenzhen Stock Exchange. -2017: revenue over 0.4billion RMB with 58% export. Employees over 1000.	-1988: export to major overseas laser companies, such as Coherent and Spectra-Physics in US and Trump from Germany; -1994: set up crystal processing operation in Maryland USA; -2004: set up CASTECH U.S.A.	-1992: developed new crystal material Nd: YVO4 and YVO4; -1998: developed crystal Nd: YVO4+KTP; -2002: developed AR-coating on LBO -2003: developed process for high quality crystal with low absorption; -2004: developed the growing technology of the Nonlinear Optical Crystal BIBO. -2006: developed Optical-Contact

	Average growth rate over last ten years is over 12%. It focused on crystal technology and became a vertically integrated crystal specialist with over 1000 employees and over 1 billion RMB revenue.		cemented products; - 2006: developed GTR-KTP crystal. -2007: acquired Qingdao RSTechED became the largest producer of KDP; -2007: acquired Hangzhou Keting and start to produce filter products; -2007: introduced Q-switch product; -2008: introduced new LBO coating technique with high damage threshold.
MLOPTIC	-1999: founded in as a private-owned optics trading company. -2017: revenue over0.2billion RMB with 60% export. Employees over 400. Average growth rate over last ten years is over 15%.	-2000: partnership with US optics company Northern Optics; -2004: partnership with UK optics company Spanoptic; -2004: started to work with AMNE customers such as Leica, Morpho and Illumina; -2010: set up office in US; -2013: set up office in Israel; -2015: set up office in Germany; -2018: set up US R&D center.	-2000: started lens manufacturing; -2001: started coating manufacturing; -2004: started optical assembly; -2008: started lens design; -2009: started aspherical manufacturing; -2009: started life science applications; -2012: started extra-precision optics; -2013: started metrology business; -2014: started DNA business; -2016: started semiconductor inspection business.

For the analysis of the cases, we follow the classification of two sub-population: consumer precision optics manufacturers and non-consumer precision optics manufacturers.

Figure 11

consumer precision optics manufacturers in China



Note: dotted line means country border under globalization;

red color means international, blue means local;

oval shape means generalist, round means specialist.

Within sub-population of the consumer precision optics manufacturers, both Phenix and Sunny Optical adopted international generalist strategy as camera lens manufacturers in the global market. However, the environment resources can only support limited number of international generalists. The execution of strategy became important. International generalists who focus on niche expansion at both dimensions can maintain its position. In the digital camera era, Phenix invested in the manufacturing technology for digital camera lens and became very competitive in the industry and therefore appealing to major AMNE customers. However, in smart

phone era, as Phenix lagged behind in the smart phone camera lens manufacturing technology, it lost its appeal to major AMNEs customers. With heavy investment in R&D and manufacturing technology, Sunny Optical soon became an important supplier of smart phone camera modules for major AMNE customers and local DMNE customers. The success and failure of Sunny Optical's catch-up stories tell us that, in a competitive market, international generalist must always keep expanding in both geographical and technological dimension to remain its position in the market center. With the same fundamental niche, only successful international generalist can achieve the expected realized niche place.

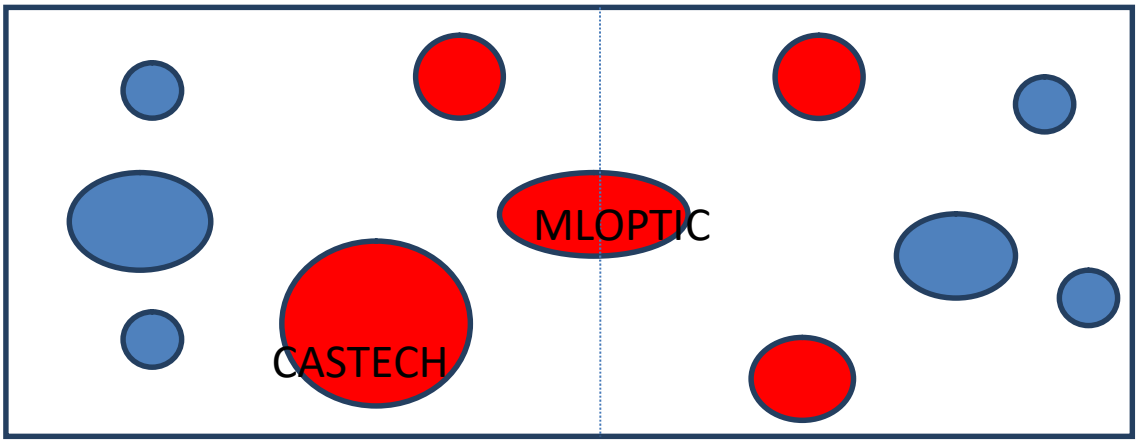
Both O-film and Crystal Optech started as an international specialist in coating technology. However, their catch-up followed different paths. O-film followed international generalist strategy and expanded in both international dimension and technological dimension. Crystal Optech followed international specialist strategy with aggressive international expansion but focused technological expansion in coating technology. For both, the international customer base is an important leverage and driving force for the technological development. However, the benefit from linkage, leverage and learning from AMNE customers on the technological side is very much limited. The actual catch-up was through a serial of technological niche expansion activities through investment in R&D both in China and overseas including merger and acquisition of international technology companies. The whole process of catch-up can be described as entrepreneurial and strong pull strategy to get resource from the overseas was apparent.

The cases from consumer precision optics manufacturers in China tell us that both international generalist strategy and international specialist strategy help DMNEs to catch up. We can see companies such Sunny Optical and O-film grew rapidly through international niche expansion and technological niche expansion becoming successful international generalists. We can also see companies such as Crystal

Optics and CASTECH adopted international expansion strategy while focusing on a narrow technological niche as successful international specialists. Of course, there are also unsuccessful cases such as Phenix. Phenix adopted an international generalist strategy just as Sunny Optical. Given the same fundamental niche, Sunny Optical expanded its realized niche in both the international dimension and the technological dimension while Phenix failed to expand its realized niche in both dimensions. In a competitive environment, only successful international generalists and international specialists can realize the niche expansion strategy. In other words, the execution of niche expansion strategy has a great influence on DMNE's catchup performance and the industry dynamics.

Figure 12

Non-consumer precision optics manufacturers in China



Note: dotted line means country border under globalization;

red color means international, blue means local;

oval shape means generalist, round means specialist.

Within sub-population of the non-consumer precision optics manufacturers, both CASTECH and MLOPTIC are optical technology companies serving the non-consumer

applications. CASTECH adopted an international specialist strategy and became the market leader in crystal optics business with large percentage of market share. MLOPTIC adopted an international generalist strategy and catching up in the precision optics business with increasing market share but still small compared with AMNEs who enjoy the market center position. Therefore, CASTECH is bigger in size than MLOPTIC. We can learn from the CASTECH and MLOPTIC that the DMNEs niche expansion process follows an upward spiral mode in the international and technological dimensions. During the early internationalization period, DMNEs successfully get access to the international market through innovative products or linkage with Western partners. In this stage the DMNEs niche expansion was more in the international niche dimension while building up the technology advantage in parallel. During the accelerated internationalization period, the niche expansion was both in the international and technological dimension with escalated interaction between the niche expansions in the two dimensions. During the slowdown period, as the demand from the international market was declining, DMNEs focused on technological niche expansion and started to develop local market. DMNEs adopted a more balanced approached regarding international and local market and started to work with local DMNE customers. The speed of international expansion was slowed down. However, the technological niche expansion was still on-going to keep their appealing to both AMNEs and DMNEs customers.

The expansion at both dimensions are interactive and both inter-dependent during the catchup process. The niche expansion process follows an upward spiral mode in the international and technological dimensions. As companies compete, they compete for the same resources from the environment. According to the law of ecology, they choose whichever dimensions that gives them most growth possibilities during different stage of growth period. Just like plants grow toward where sunlight is in an ecosystem, companies expand in the niche dimension that can provide most of resource for their growth. When the international market

provides the better growth opportunity, DMNEs grow internationally. In an international market, to be internationally competitive, the international niche expansion strategy can help DMNE get access to resource in a much larger environment and the international niche expansion can have positive influence on DMNEs niche expansion in other dimension, especially the technological dimension. This idea of cross-allocation principle serve as a mechanism during the firm internationalization process. At the early stage of firm internationalization, firms expand in the international niche dimension in order to avoid their home country institutional deficiency and get access to resources from favorable institutional international market. During the accelerated internationalization stage, firms grow both in terms of international niche and technological niche when they can satisfy the demand of their target audience from multiple markets. During the slowdown internationalization stage, DMNEs find it difficult to expand through internationalization as their learning from the international market reach the limit and the gap between the DMNEs and AMNEs become much small. In this stage, the DMNEs internationalization slowdown and the expansion on the technological niche continue with both international and domestic resources. As DMNEs have international competitive advantage and become major players in the international market, they reach the mature stage of internationalization. In the mature stage, they act more like AMNEs and grow through FDI and merger and acquisition. We use the niche expansion based view to analyze the whole life cycle of the firm internationalization and combine all different theories in MNEs studies.

The niche expansion of the different strategic groups in the industry form the different relationships which build the basis of the competitive dynamics of industry. As the industry become more and more international and, during the process of industry internationalization, each firm develop their own niche structure and form one of the four strategic standings, i.e. international generalist, international specialist, local generalist and local specialist. The competitive dynamics of the

industry also changes. Although the relationship among players within the same strategic group is competitive, there are different kinds of relationships between different strategic groups. The international generalist and international specialist, although they are both international players, they can co-operation in the international market if there is no overlap in technological niches between them. The relationship between them can be described as co-competitive. For example, international specialist Crystal Optech and international generalist O-film have technological niche overlap in IR-Cut Filter business and are competitors in this niche market. However, Crystal Optech is a supplier to Sunny Optical who is also an international generalist but has no technological niche overlap with Crystal Optech. The same applies to the relationship between the international generalist and local generalist. However, as international generalist and local specialist have no overlap in geographic niche and technological niche, their relationship is typically co-operative. Although international specialist and local specialist might have niche overlap in technology, they can still co-operate they do not compete in the same geographic niche space. As international specialist and local generalist have no overlap in both geographic and technological niche, their relationship can be co-operative. However, as they are in different market segments due to resource partitioning, in the real world, the relationship can be non-operative and non-competitive. For international generalist, competition is on a cluster level, i.e., the competition for international generalist often comes from other international generalist from other clusters. Firm internationalization process is also limited by the international market situations. For the international generalist, competition from other international generalists from other clusters is an important limiting factor to the local cluster.

The Goldilocks debate

It is worth comparing the OLI model with the LLL model in the case of internationalization for DMNEs in China precision optics industry. The eclectic paradigm, the transaction cost theory and the monopolistic advantage theories are

all based on economics analysis of firm internationalization. For most DMNEs, the reason why they go international is not based on economic reasons but strategic reasons. They do not have the ownership advantage, the internalization advantage and the local advantage of AMNEs; most of DMNEs do not have advantages in technology and cannot expand through technology transfer by FDI. Typically, DMNEs do not have ownership advantages which are specific to the company and related to the accumulation of intangible assets, technological capacities or product innovations. DMNEs internationalize because they lack these intangible assets, technological capacities and product innovations and only through internationalization they can get access to these resources from the international market. However, for DMNEs with technology advantages, they adopt internationalization because market and institutional reasons. In the case study, the expansion in technological dimension of the precision optics company in China was driven by the expansion on the international dimension. Through the internationalization strategy, DMNEs start to build intangible assets, technological capacities and product innovations. DMNEs leverage location advantages in a different way than AMNEs. AMNEs might set up factories in emergent countries due to cost reasons. However, DMNEs might internationalize because of other institutional and productive factors not available in their home county, for example, DMNEs might internationalize because the institutional condition in advanced countries provide better business environment. CASTECH enjoyed key technological advantage right at the beginning and its internationalization is more to apply the technology to the international market. All its research and development, most of its production is based on China. As CASTECH is leading the technology, it is focus is to keep all the technology in China and apply the technology to the international market expect applications that is related to national security. In most cases, the internationalization of DMNEs is typically by co-operation with partners and customers in advanced countries not by FDI. In the case study, MLOPTIC worked with European and US partners to exploit the market. DMNEs might not have the

internalization advantages stem from the capacity of the firm to manage and coordinate activities internally in the value-added chain. These are related to the integration of transactions into multinational hierarchies through FDI. But, DMNEs still adopt international strategy, because through international expansion they can learn from their partners and customers and build or strengthen their capacity to manage and coordinate activities internally in the value-added chain. In the case study, we see very clearly how MLOPTIC built all the capacity vertically during the international expansion. The international expansion provides opportunities for MLOPTIC to build and strength activities internally not the other way around in the case of AMNEs.

The OLI model explains the major three reasons why AMNEs internationalize, namely the ownership advantage, the location advantage and the internalization advantage. Basically, the AMNEs push the competitive advantages across the international border. However, the reason why DMNEs internationalize is because they want to pull the strategic resource from international market. The LLL model developed by Matthews explains how DMNEs acquire the strategic resource through linkage, leverage and learning. The DMNEs might also have OLI advantage; however, the reason why they internationalize is because they wanted to gain competitive advantages through internationalization. The pull strategy of the LLL model is a catch-up strategy while the push strategy of OLI model is a copy and paste strategy. DMNEs in technology industry started internationalization because of low cost advantage over their AMNEs counterpart especially in lower end products; however, as DMNEs draw resources from international market through linkage, leverage and learning both in terms of market access and technology, DMNEs begin to catch up with the AMNEs. The speed of internationalization reflects also the speed of technology catch up through learning from overseas. In the case of precision optics manufacturers in China, most of the international players' international strategy can be explained by the LLL. However, the assumption from the LLL model that all

DMNEs lack key technology is not always true. In the case of CASTECH who enjoys monopoly position in the crystal technology, the linkage and leverage with AMNE customers are more for business reasons rather than technological learning.

The case study of precision optics manufacturing industry in China reveals that the FDI theory or the OLI model that explain why and how AMNEs internationalize does necessarily explain the DMNEs internationalization process. AMNEs push strategies and DMNEs pull strategies are different strategies of AMNEs/DMNEs based on different resource situation in face of the international market. The two strategies are fundamentally different, therefore, the process of internationalization for DMNEs are fundamentally different from that for AMNEs. From the case of precision optics manufacturing industry in China, we can see that international expansion process of DMNEs can be better described as a process of continuous learning process through linkage with foreign partners and leverage of international resources. This process can be explained by the stage theory and the network theory as the process is both a step-by-step development process and a network building process. The international expansion process can also be explained by the international entrepreneurship theory because of the pull factor in the DMNEs internationalization. The springboard theory emphasizes that the institutional deficiencies from the home country force DMNEs to look for resource in the international market. This is also a very important reason why DMNEs adopt international strategy even at its early stage when they are still in stage of building their core competencies. The international market provides resources that DMNEs need in order to grow while these resources are simply either difficult to get or not available from their home market. As we can generalize from the case study from the precision optics manufacturing industry in China, neither the LLL model based on the RBV nor the OLI model based on economics seems to combine all different theories and give a comprehensive explanation on how DMNEs internationalize. In the case of China precision optics industry, firms such as Sunny Optical and MLOPTIC has followed the path of linkage through partnership, leverage

through partnership and learning through partnership. The resource acquired through linkage, leverage and learning included technology and market access. What has been discovered by the case study is that the linkage, leverage and learning also evolve as DMNEs grow. The partners change from other overseas trading companies to overseas manufacturers and then to key OEM customers. The change also reflects different resource is needed as company evolves. However, firms that have key technologies such as CASTECH did not follow the path of linkage and leverage during international process, they internationalize not to acquire technology but to get access to the market. They followed the OLI model leveraging their ownership advantage, local advantage and internalization advantage during their internationalization process. Both the LLL model and OLI model are quite general and lack of theoretical structure and cannot be quantified.

The different opinions regarding the "Goldilocks debate" resulted from the separation of international business study in the first place. In my opinion, the international business study is biased by western scholars. Even the scholars from east are trying to fit into the western perspective. If we put internationalization in the broader sense, the international trade began at least thousand years ago. At that time, who are DMNEs and who are AMNEs? The western world believes that they are AMNEs and the players from the eastern world are DMNEs. However, in different industries and in different time of the history, AMNEs and DMNEs can come from any country in the world. Japanese firms used to be DMNEs after the Second World War are now AMNEs for sure. To label a company DMNE, AMNE or SMNE is also biased in the first place. Although our study is focused on DMNEs, we do think it is inappropriate to use "country of original" label and size for MNEs study as all MNEs with different country of original and different size consider the global market place as their battlefield to develop their strategies. We see too many cases that SMNEs turn into MNCs and DMNEs become true global player just as AMNEs. So, I think the institutional environment is important, but to label DMNE and AMNE for the study of

firm internationalization is not always helpful. A better approach is to study why and how firm grow through internationalization at a global industry level as a whole with institutional environment as background throughout the history of the industry. DMNEs might change to AMNEs when the home country developed from developing country into advanced economy. A lot of successful AMNEs or DMNEs leverage the global resources might have their major product market in one country and go listed in stock market in another country and their employees coming from different countries. For SMNEs, we need also distinguish SMNEs with fundamental niche as international generalists and SMNEs with fundamental niche as international specialist. As internationalization is a long-term process, these SMNEs might be just at their early stage of internationalization. Or they are already at mature stage of internationalization and the reason why they remain small is because they adopted international specialist strategy in the first space and niche expansion is limited with the strategy. Or they are international generalist that could not expand successfully with international and technological niche so their realized niches remain small. With niche expansion-based view of firm internationalization, we categorize firm according to their niche strategy rather than size or country of origin. With niche expansion based view of internationalization, we try to combine all the different international business theories.

Theoretical contributions

The case study of the internationalization of Chinese precision optics manufacturers provides insight to the study of firm internationalization. The focus on an industry dynamics excludes unrelated international expansion which were observed by Western scholars in developing country multinationals. The theoretic framework of firm internationalization and the case study of China precision optics manufacturers not only provide an ecological perspective to the study of firm internationalization; but also enrich the niche concept and organization ecology theory in general. The study not only reveals how niche expansion influence firm internationalization, firm

catchup performance and industry dynamics; but also provides an unified framework for different international theories and give new insights to the Goldilocks debate.

Niche expansion based view

The niche expansion based view of firm internationalization offers an organizational ecology perspective to the international business field. It is achieved by a further development on the niche concept. The niche theory first emerged in 1984 in the works of Hannan, Freeman and Carroll. The notion of niche has been enriched, augmented in several ways. Initially it captured the resource configuration that allowed the organization to operate towards the structure of the audience served by the organization. These resource configurations included the set of routines the organization develops and maintains. As the routines are not publicly observable the range of routines go operationalized as the range of products and service the enterprise offers. In the first decade of the 21st century the notion of organizational niche shifted towards the structure of the audience served by the organizations. The socio-demographic space became relevant and the specific population served was identified as realized niche of the organization. What has been missing is a bridge between these two, considerably different, though obviously related notions of organizational niches. Our study of internationalization of China precision optics manufacturers exposes theoretical considerations connecting these notions to empirical tests. The notion of four different strategic groups from the niche expansion based view of firm internationalization connect the two niche concepts under the same theoretical framework. With international/local dimension, the structure of audience is classified. With the generalist/specialist dimension, and structure of internal resource configuration is addressed.

The niche expansion based view of firm internationalization provides a unified theory integrating all the different theories in the field of international business

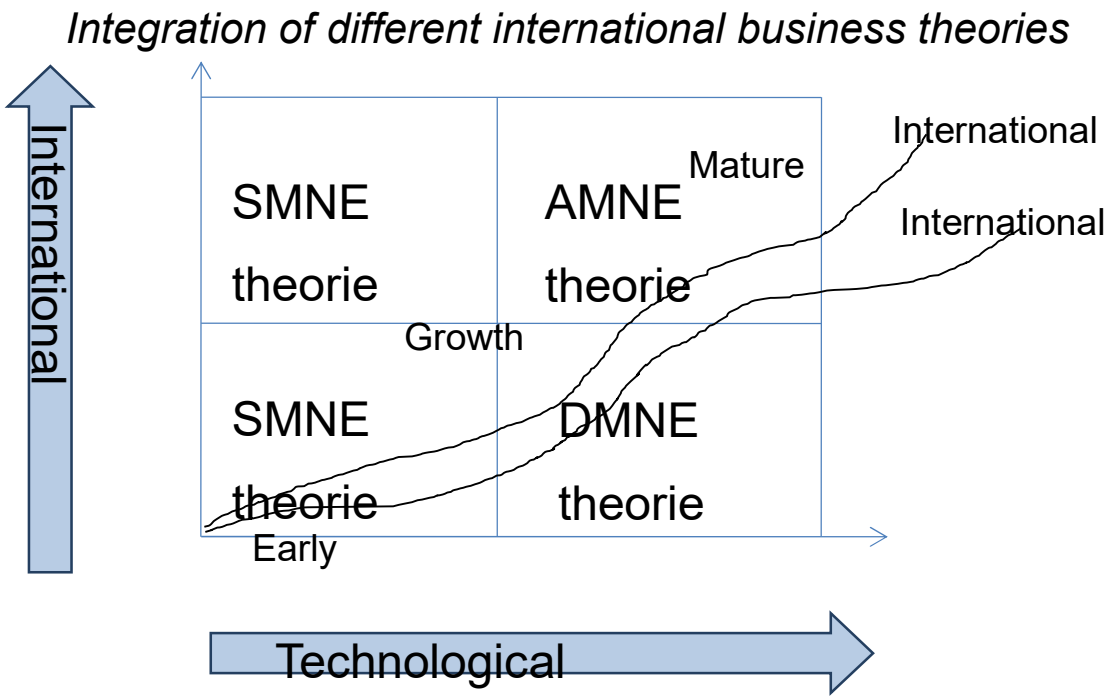
study. China precision optics manufacturers enjoyed rapid growth by joining in the international market place where they can get access to the most important resources for their growth, customers and technology. This is an important strategy for firms as newcomers and latecomers in the international market. By niche expansion in both the international/local dimension and the product/technology dimension, international generalist gradually expand and gain competitive advantage against their counterparty in advanced economies in the international market. International specialists follow a different path and achieve growth by applying more organizational resource in the international/local dimension. By studying the niche expansion during firm internationalization process, we can see clearly that the development of China precision optics manufacturers were driven by the niche expansion both in the international dimension and technological dimension. Given that the total amount of organizational resources are finite, organizations might use the limited organizational resource for the engagement route, but limits their ability to broaden their appeal, or to use their resources to broaden the appeal but not without consequences for their ability to broaden the engagement. Therefore, the principle of cross-allocation leads to an upward spiral mode for the niche expansion of these firms when they expand in the international/local and product/technology dimensions.

Integration of international business theories

We believe firm internationalization follows international generalist or international specialist niche expansion strategies. At different stage of firm of niche expansion, different international business theories including LLL framework and OLI model can be applied. The niche expansion-based view of internationalization explains why and how developing country multinationals can catch up rapidly in a global environment by international expansion and technological expansion. Firm internationalization strategy can be viewed as niche expansion in the international geographic dimension

or context. It is a strategic choice of niche width (the international generalist – local specialist continuum) in term of environmental dependence and fitness function based on the principle of cross allocation. The niche expansion happened in two dimensions. Different strategic groups, international generalist, international specialist, local generalist and local specialist, might have different strategy in term of international expansion and technological expansion. The different strategic groups have different fundamental niche, which will determine the long-term growth of the companies. Within each strategic group, at the different stage of firm internationalization, companies have different strategic choices in term of international expansion and technological expansion in their own niche space and the realized niche expansion will determine the short-term growth the company. With the case study of firm internationalization in precision optics manufacturers in China, all different perspectives are tested in the analysis of firm internationalization strategy. At different stage of the growth, the expansion in international dimension and technological dimension are different, which can be explained by different theories. In summary, the niche expansion based view of firm internationalization provide a unified theory for the international business study in three ways (i) the strategic groups of international generalist or international specialist provide a unified theory for SMNEs, DMNEs and AMNEs; (ii) the fundamental vs realized niche differentiation provide a unified theory to explain the success and failure of DMNEs internationalization; (iii)the different international business theories can be applied and integrated to the niche expansion perspective accordingly to the different stages of firm internationalization.

Figure13



During the early stage of DMNEs internationalization, the institutional deficiency creates import and export and international business capability as a scared resource for born global DMNEs, giving these companies access to the international market as international entrepreneurship. International entrepreneurship explains that internationalization of SMNEs is an entrepreneurial behavior. McDougall and Oviatt (2006) define international entrepreneurship as “a combination of innovative, proactive and risk-seeking behavior that crosses national borders and is intended to create value in organizations”. DMNEs internationalization at the early stage is innovative, proactive and risk-seeking behavior that crosses national borders and is an intended behavior to create value in organizations. DMNEs adopt internationalization strategy because international market provides better entrepreneurial opportunities. For the early stage of DMNEs, the most important thing is survival. International entrepreneurship is just a form of entrepreneurship. International entrepreneurs have the ability to capture the business opportunities from the international market. Through the survival game, DMNEs start to build their

capabilities. For the early stage of internationalization, DMNEs focused not on its own advantages, but on the resources, which can be acquired from the international market to build their competitive advantage. Thus, a global orientation becomes a source of advantage—since the opportunities through which it can expand are likely to be found in the global market rather than in its domestic environment. The global outlook which is an unnecessary luxury for the AMNEs is a necessity for themes' outward orientation carries higher risks and uncertainties than a more conservative inward focus. The firm seeking to acquire resources and complementary assets in foreign markets has to overcome problems of market intelligence and uncertainty regarding the quality of knowledge potentially available.

During the growth period of internationalization, while the external resources gained from linkage, leverage and learning help most DMNEs to catch up rapid both in terms of market and technology; DMNEs with technology advantage would catch up based their internal resources and leverage their ownership advantage, local advantage and international advantages. At this stage, the role of the entrepreneurs become less important as the company accumulates more resources. At this stage, most DMNEs are still relatively small so the internationalization of DMNEs is still based on a pull strategy, i.e., to draw resources from the international market. However, the internationalization of DMNEs with technology advantage is based on a push strategy. DMNEs in the case of precision optics industry in China, MLOPTIC expanded in its product offering and technological capabilities through partnership with US and UK partners. All the linkage and leverage of resource is achieved through international networks. This growth period DMNEs internationalization can be explained by the network theory developed by IB scholars in Scandinavia. The network view of internationalization is a profound departure from conventional views. As Mattson (1998) rightly insists, the international networks formed by global firms is a "hybrid" governance structure located somewhere between markets and hierarchies. The hybrid governance structure provides resource linkage and leverage

for DMNEs. The transactions cost view of network structures is comparative static. However, in the case of Dunseith dynamic considerations might lead firms into becoming part of global networks which bring strategic resource for the newcomers in the global marketplace. The conventional transaction cost theory was developed based on internalization that involve a form of vertical integration bringing new operations and activities, formerly carried out by intermediate markets, under the ownership and governance of the firm especially when natural markets are imperfect or missing. Internalization of transactions beyond national borders leads to the creation of the multinational enterprise. In the case of CASTECH during the growth period, it expanded its product offering and technological capabilities through organic growth and merger and acquisition. The strategy is focused on internal advantages rather than external resource; the hierarchy governance provided more control over CASTECH's IP. The bad experience with network approach created a leakage of its key technology. In this case, as the DMNE have internal advantages, it behaved the same ways as the AMNEs and focusing on internal resources.

During the mature stage of firm internationalization, the gap between the DMNEs and AMNEs in technology become narrower and the incremental learning slow down due to change in competitive situation. In the new internationalization stage, DMNEs start to depend on itself and might adopt the ILO model to further their internationalization. All changes reflect the change in competitive situation and the driving force of that are resources and capabilities that are sustainable, rare and difficult-to-copy. In the case of hi-tech industry, these strategic resources and capabilities are technology. The technology advancement is linked with international expansion because one of most important access to the strategic resources for DMNEs is internationalization. In the beginning, the born global companies adopt international strategy because international business capabilities and international market knowledge is the strategic resources for these companies. As these

companies adopt an international generalist strategy, they expand not only in the international dimension but also the technology dimension. This is one of the important routes for companies to grow into international generalist especially for hi-tech industries.

Practical contributions

The theoretical framework provides business owners and managers a practical tool to develop long term company strategy in face of globalization. As the globalization break the country border as nature resource partitioning, the internationalization of industry changes the competitive environment of the industry that firm depends on. With the international market as new and enlarged stage, the growth opportunities of firms are no long limited by local environment. All these make internationalization as a possible niche expansion strategy for firms to grow with the resources provided in the international stage. With the niche expansion-based view of firm internationalization, a new strategic matrix is created to provide good tool for decision maker for the analysis of firm internationalization strategy. The case study of precision optics manufacturing industry in China provides a clear description of the development of the industry over the history. This provides valuable information for decision makers to think in long term and to develop long term niche expansion strategy. The individual cases demonstrate that DMNEs' catch-up normally follows two different niche expansion strategies, i.e., international generalist and international specialist. With comparative analysis, we can how different strategic groups have different niche expansion pattern in the catch-up process and how companies from the same strategic group grow differently with different level of execution of niche expansion strategy. This provides good guidance to decision makers as how to analyze the organizational fundamental niches in both dimensions to develop a strategy accordingly and focus on the execution of strategy by realizing the actual niche space.

The theoretical framework and the case studies also provide important tool for policy makers to develop relevant policies when promoting trade and investment. With the integrated model of firm internationalization, the institutions including the local government and local industry association are important players of firm internationalization. The interaction among firms with different internationalization strategy (from international generalist to local specialist) provides the local government and local industry association with good understanding of how to promote the internationalization of local firms and industries. Possible promotion measures include more financial and non-financial support to the international generalist and international specialist in their international geographic expansion to promote the level of internationalization of the industry as a whole.

7. Limitations

This study can be interpreted as a small scale case study for a much more thorough and rigorous empirical testing of the niche expansion based view of firm internationalization to be confirmed. The idea of cross-allocation principle if relevant need possibly empirical testing across multiple populations. All these obviously go far beyond the possibilities of DBA research. Even within the scope of this DBA work, there is some limitations of this small scale case study. The lack of study of catalog precision optics manufacturers of and the AMNEs in China all requires further investigation. The institutional factor of export countries for DMNEs can be a good topic for further study. The dynamics of the different strategic groups with the precision optics manufacturing industry requires further study to develop more insight to the competitive analysis.

First of all, there is a lack of study on the study is focused on the non-OEM optics manufacturing companies. We have only modeled and analyzed the internationalization of six optics manufacturers in China and all six players are customs optics manufacturers. There is a lack of study on optics manufacturers who provide standard products (also called as catalog companies). To improve the validity of our result, we should observe the patterns in the catchup performance of catalog optics companies and the competitive dynamics of internationalization on them. There are a number of local catalog optics companies in the industry and some of them are also involved in foreign trade. However, none of these catalog optics companies has catch up n to a decent size due to strong competition from major international players such as Thorlabs and Edmond. The international catalog optics companies from advanced economies are dominating the global market and are successful also in China market. Although there is no successful international catalog company from China, the reason behind this is also worth investigating.

Secondly, there is also a lack of study on foreign invested precision optics manufacturing companies in China. Although most of these AMNEs set up the China production site to leverage the cost advantage of China and supply goods to the mother companies, some of them have developed independent strategy competing with Chinese precision optics manufacturers for the China local market. The Zeiss factory in Suzhou and R&D center in Shanghai is a good example of such successful international niche expansion. The Zeiss Suzhou factory manufactures the lower end microscopes and the R&D center in Shanghai is dedicated to develop products for the China local market. Other examples include Swiss Optics Wuhan which serves not only as production site but also sourcing center for the Swiss operation. Casix and Photo from Fuzhou founded by the same group of engineers who are formal CASTECH colleagues were also major players in non-consumer precision optics manufacturing. They were acquired by major international players Fabrinet and II-VI respectively and became important AMNEs in China. So, these foreign invested precision optics manufacturing companies not only help the home country mother companies to be more competitive in the international market but also directly compete with local Chinese players in the local market. The competitive implication of these companies on the internationalization of the China precision manufacturing can be an interesting topic for future study.

Thirdly, the institutional effect on the industry is not investigated. Unlike other industries in which successful international Chinese players enjoy a lot of government support, the global precision optics industry is a complete free market and the government support in China normally goes to the local state-owned generalist precision optics manufacturers for non-consumer applications such as aerospace and scientific research. Due to competition in the local market, a lot of former state-owned precision optics went out of business and the only ones that still survive either live on military jobs or adopt international expansion. However, the ones adopted international expansion might be in disadvantage competing against

private companies. With the same international generalist strategy, the state-owned Phenix cannot compete with the private-owned Sunny Optical. This also reflects that government support was not an important factor in our analysis of DMNEs catchup. At the same time, while the international market for consumer precision optics is a complete free market which provides good catch up opportunities for DMNEs in China, the non-consumer precision optics manufacturing is highly regulated by western countries including the US and Europe. China precision optics manufacturers are restricted from the military jobs in the US. And Europe and a lot of machinery are restricted to export to China. This can partly explain why the catchup of non-consumer precision optics manufacturers in China was not as successful as that of consumer precision optics manufacturers. The institutional factor of export countries for DMNEs can be a good topic for further study.

Finally, the relationship among different strategic groups in China precision optics industry remains an interest topic for further investigation. As the industry become more and more international in China, firms from different strategic groups develop different niche structure and form one of the four strategic standings, i.e. international generalist, international specialist, local generalist and local specialist. The competitive dynamics of the industry also changes. Although the relationship among players within the same strategic group is competitive, there are different kinds of relationships between different strategic groups. The different relationships between the firms among these different strategic groups determine the competitive dynamics of the industry. So, what are different relationships between the firms remains an interesting topic for the study of competitive implication of DMNE's niche expansion.

In summary, my current work only provides first findings of the influence of niche expansion to the internationalization and catchup in precision optics industry in China. The niche expansion-based view of firm internationalization need more theoretic and empirical studies not only from the same industry but also from other international industries that niche expansion played an important role in for firm internationalization and catchup.

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