Interlinkages and paths of German factories' manufacturing and R&D strategies in China

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Abstract

Purpose – As a consequence of the sluggish growth in Europe caused by the Euro-crisis, many German companies are currently expanding their manufacturing and innovation activities in fast-growing China – or intend to do so. The paper aims to provide new practical and theoretical insights on how German manufacturing companies are readjusting and further developing their production and innovation strategies in China and which future paths they plan to follow to make the most out of their foreign factories in this market.

Design/methodology/approach – Based on in-depth interviews with the top management of 18 German manufacturing companies in China, this paper analyzes the present state, interlinkages and future development paths of their local manufacturing and innovation strategies, employing Ferdows' framework of foreign factory roles.

Findings – The authors find that up to now most of the surveyed factories represent an additional type of an advanced server factory, characterized by a "Chinese gap" in new product development (NPD) and basic innovations. Based on that the authors propose five guiding principles on how foreign factories in China can cope with the upcoming challenges in China and make the most of their local strategies.

Originality/value – The research provides unexpected insights of a high strategic relevance for practitioners currently engaged in optimising their global production and innovation footprint. It challenges established frameworks on foreign production and innovation modes by comparing them to the established practice of frontrunner companies from key sectors of the German manufacturing industry.

Keywords China, Foreign factories, German manufacturing industry, Innovation gap, International manufacturing strategy, Manufacturing – R&D interface

Paper type Research paper

1. Introduction

The allocation and relocation of production activities in the fast-growing emerging countries in Asia has become more and more important in recent years for firms of all sizes (Barba-Navaretti and Falzoni, 2004; Pennings and Sleuwaegen, 2000). The global economic crisis and the current Euro crisis raise the question, whether recent patterns

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and trends in the internationalisation of value-added activities are going to continue in the future or have significantly changed. In the absence of significant mid-term growth potential in Europe, this is of immediate relevance for European manufacturing companies. Many managers dedicate their attention even more than before to the market potential beckoning in the emerging economies – and thus have to tailor their competitive strategies to the changing environment accordingly (Gunasekaran and Ngai, 2012).

It is in particular China that stands out in this context. In the last decade, the country developed into the second-largest economy, the leading export nation, and largest recipient of foreign direct investment (FDI). China's large market and the dynamic market growth in many segments that belong to the German industry's core sectors are particularly attractive: China has meanwhile become the world's largest automotive market and top export partner of the German industrial sector with respect to manufacturing facilities, machines, devices, mechanical equipment, and electronic/electrical products (German Federal Statistical Office, 2011). Moreover, China already belongs to the major research and innovation locations. China ranks second behind the USA and clearly before Japan with regard to the number of researchers, although these figures must be considered in proper perspective to the population size. Of particular importance are the high increases in research and development expenses (ca. 20 percent per annum since 2005) and the rapidly increasing Chinese publications and patent applications (Frietsch and Schueller, 2010).

These dynamic location developments led to large-scale FDI in China by German industrial companies. Even in 2009, when the global economic crisis led to a severe reduction in global FDI flows, FDI of German companies to China increased by 11 percent compared to 2008 and even by 44 percent compared to 2007 (Deutsche Bundesbank, 2011). In 2009, German FDI stocks in China exceeded €20 billion (Deutsche Bundesbank, 2011). About 1,300 German companies with approximately 400,000 employees generated strongly increasing sales of €75 billion.

In the past, the China strategy of many manufacturing companies focused on the quest for cost reduction opportunities in addition to the tapping of new market potential (Kinkel and Maloca, 2010; Nassimbeni and Sartor, 2007). In the German case for instance, fewer industrial companies transferred parts of their manufacturing activities abroad during the onset of the economic crisis in 2007-2009 than in the period before the crisis from 2004 to 2006 (9 percent vs 15 percent). Nonetheless, China developed into the most attractive relocation destination, meanwhile accounting for 27 percent of the companies' relocation activities (Kinkel and Maloca, 2010). It is remarkable that China has not only become an attractive relocation destination for large companies, but equally for small- and medium-sized companies (SME).

However, in particular cost-driven relocation strategies are not free from risk of failing (van Eenemaam and Brouthers, 1996; Robb and Xie, 2001). According to a recent study in the German manufacturing industry (Kinkel, 2012), every third German company that relocated its production activities abroad is now matched by one company that moved parts of its production activities back to Germany. For the first time in 2009, a significant portion of these backshoring activities (16 percent) came from China. In particular quality problems, and deficiencies in the supply chain with respect to flexibility and the ability to deliver, play an important role in this context (Kinkel and Maloca, 2009). Furthermore, recruiting of highly qualified

staff becomes more and more challenging, not only in terms of availability, but also as a significant cost factor (Mao *et al.*, 2009).

To summarise, given the sluggish growth of their home markets, European manufacturing companies are all but forced to seek their future growth potentials in emerging economies such as China – and empirical evidence actually shows that they do so. However, there is also empirical evidence that a growing number of companies obviously fails to achieve a sustained success when having (parts of) their production and innovation activities allocated in emerging markets – which usually requires them to relocate activities back to their home countries or to change their internationalisation strategy in the long run. From a practitioner's point of view, both lead to the question of what are the key success factors when picking up production and innovation activities in countries such as China, i.e. which strategies they actually have to deploy in order to be successful. From a theoretical point of view, both raise the question on how the success and failure of European companies in emerging markets can be explained with established internationalisation theory and models.

Thus, the objective of this paper is to provide new practical and theoretical insights on how German manufacturing companies are readjusting and further developing their production and innovation strategies in China after the global economic crisis and which future paths they plan to follow to make the most out of their foreign factories in this rapidly growing market. It challenges established frameworks on foreign production and innovation modes by comparing them to the established practice of frontrunner companies from key sectors of the German manufacturing industry. However, as this will require an in-depth analysis of their specific competences and strategies, we have chosen a qualitative and explorative empirical research setting to be able to yield the necessary insight. Our approach is actually based on case studies and has a specific focus on China. The case studies were compiled from in-depth interviews conducted with the top management of 18 German manufacturing companies on-site in China and were then reflected against theory.

This paper is structured as follows: first we will review the literature on production and innovation strategies in the next section in order to come up with a conceptual framework and appropriate research questions. Section 3 will then outline the methodology applied to conduct and evaluate the case studies. Section 4 will present and discuss the results, and Section 5 will summarize the implications of our findings and conclude with further prospects for research and business.

2. Literature review on foreign production and innovation strategies

2.1 Foreign production strategy

Different theories and analytical frameworks try to explain why firms produce internationally. Internalisation theory (Buckley and Casson, 1976; Caves, 1982), international product cycle theory (Vernon, 1966, 1979), and the eclectic paradigm of Dunning (1980, 1988), are well-established core frameworks for explaining the motivations of foreign production strategies in international business (IB) literature. Empirical studies examined different push and pull factors as the main drivers of international production activities. Reduction of labour costs for efficiency improvement, access to new markets and proximity to customers, and access to new knowledge and key resources are among the most important motives (Dunning, 1980, 1988; Ferdows, 1997; Kinkel *et al.*, 2007; MacCarthy and Atthirawong, 2003; Vereecke and Van Dierdonck, 2002).

According to co-evolutionary approaches (Hutzschenreuter *et al.*, 2007; Manning *et al.*, 2008), institutional and environmental factors and particularly external shocks like a worldwide economic crisis or a Euro crisis, are affecting companies' FDI and relocation strategies significantly. The 2009 World Investment Report has shown that the global economic crisis led to a severe reduction in global FDI flows (UNCTAD, 2009). However, the setback of FDI inflows hit most emerging economies, e.g. China, later and not that hard than most developed countries. Thus, it is not clear whether the economic crisis affected international production activities of MNCs in emerging economies negatively or not. However, in an economically challenging environment it can be assumed that local labour cost advantages are becoming more important for international production location decisions, as cost control is crucial. For China as a production location of foreign companies, the search for lower labour costs has played an important role for a long time, too, but today market seeking motives have become more important (Roland Berger Strategy Consultants, 2011; Kinkel and Kleine, 2013).

On the other hand we can also find arguments for a reduction and re-concentration of international production in times of high economic uncertainty. The economic crisis was causing German companies to maintain their production and utilize their capacities at existing locations rather than look for further cost saving potentials in low-wage countries (Kinkel, 2012). Long physical and "mental" distances from the German headquarters to the factory in China can make it very costly to enforce all necessary coordination activities. This includes efforts for quality insurance, technical support and management supervision, which can very fast render a low-cost-location with rising wages uneconomically (Kinkel and Maloca, 2009).

Since the emerging BRIC economies (Brazil, Russia, India and China) do not only provide new market opportunities, but have also increased competition, Western companies today face the challenge of deciding on which of the traditional competitive strategies still fit to the upcoming challenges (Gunasekaran and Ngai, 2012). Especially when foreign manufacturing companies engage in offshore activities in one of these countries with the explicit purpose of serving the local market, which is one, if not the main focus of German companies in China, it is important to know which strategies the local competitors employ. Robb and Xie (2001) found that local Chinese manufacturing companies still appear to focus on quality, reliability and costs. In contrast, foreign invested companies (FIC) have already recognized the necessity of focussing on customer value in terms of due dates, delivery performance and reliability when serving the local market, yielding them a significant competitive advantage. This is interesting since it shows that some FIC appear to have recognized the changing nature of China from a foreign workbench to a fully developed market of its own, even before their local counterparts. From the point of view of German manufacturers, these findings are even more important when they are related to their specific goals of their engagements in China: German companies are particularly interested in:

(1) The size of the market and its very dynamic growth in many of their core industries, which enables them to substitute the limited market development in the European core market.

(2) Local labour cost advantages are an important driver for production allocation in an economically challenging environment, as cost control becomes all the more important.

(3) China is already one of the most important R&D locations worldwide, measured by the number of scientists, by increasing R&D investments and fast growing publications and patent applications (Frietsch and Schueller, 2010).

To be able to characterize the strategic roles and future paths of German factories in China, we apply Ferdows' (1997) typology of foreign factories. In this seminal work, he distinguishes between the following six roles of foreign factory sites (Ferdows, 1997, pp. 76-77): an offshore factory is established "to produce specific items at a low cost, which are then exported either for further work or for sale". The primary purpose of a source factory is also low-cost production, "but its strategic role is broader than that of an offshore factory, as its managers have greater authority over procurement, including the selection of suppliers [. . .]". A server factory "supplies specific national or regional markets" and "it typically provides a way to overcome tariff barriers and to reduce taxes, logistics costs, or exposure to foreign-exchange fluctuations. A contributor factory " also serves a specific national or regional market, but its responsibilities extend to product and process engineering [. . .]" and it "competes with the company's home plants to be the testing ground for new process technologies [. . .] and products". The primary role of an outpost factory is "to collect information". A lead factory "creates new processes, products, and technologies for the entire company" and "taps into local skills and technological resources [. . .] to transform the knowledge that it gathers into useful products and processes". In Ferdows' matrix, the strategic motivation for setting up the plant is entered on the horizontal *x*-axis. In this context a distinction is made between:

- access to low-cost production;
- access to skills and knowledge; and
- proximity to market.

On the vertical *y*-axis, we operationalized the descriptive charting of his plant roles and transferred it into a set of concrete factory competences (Kim *et al.*, 2001; Vereecke and Van Dierdonck, 2002). We differentiate between the following plant competences: mere collection of information, production, technical maintenance, local logistics, product and process improvement recommendations, product customization and redesign, production planning and process changes, procurement, choice and development of suppliers, product and process development (no basic innovation), testing ground for new (basic) process technologies and products, supply of global markets and global hub role for product and/or process knowledge. Based on the competence levels that build on each other in a hierarchy and which are derived from the above, Ferdows' (1997) six strategic plant roles as well as the specific roles of German production sites in China can be graphically characterised (Figure 2).

2.2 Foreign innovation strategy

Analogue to the typology of Ferdows, it is possible to analyze the developmental paths for the localization of R&D tasks by their strategic goals. The three main motives for localizing R&D offshore, knowledge exploitation, knowledge augmentation and efficiency seeking are closely linked to the main motives of Ferdows' typology, namely proximity to market, access to skills and knowledge, and access to low-cost production. The localization of R&D is thus facilitated by knowledge accumulated in other

business operating areas (Rilla and Squicciarini, 2011), in particular production activities. These interlinkages will be described in the following.

The strategic goal of knowledge exploitation (Kuemmerle, 1997, 1999; Le Bas and Sierra, 2002; Niosi, 1999; Rilla and Squicciarini, 2011) aims to capitalize on the existing knowledge of the parent company about products and their production process. This knowledge is transferred mostly by expatriates from lead factories in the home country to local server or contributor factories in the offshore country. Further capabilities are built up in the offshore site to adapt the products and production processes to the local conditions. This includes capacities for product adaptation from simple changes in the appearance to advanced changes in the functionality. The production process needs to be adapted to the competencies of the local employees.

Another strategic reason to localize R&D offshore is knowledge augmentation (Kuemmerle, 1997, 1999; Le Bas and Sierra, 2002; Niosi, 1999). The knowledge gathered in the offshore country embodied in the local staff or in product or process innovations is used for the whole company. This starts by activities like monitoring local markets and technology scouting, which could be done by an outpost factory. Beside these activities, networking with research institutes or specialized suppliers is important to be informed about emerging clusters early on. An advanced usage of local knowledge allows for product innovations. Some companies use the local knowledge base in emerging markets for developing new low cost products (Schanz *et al.*, 2011) based on so-called cost innovation (Williamson, 2011). Advanced R&D tasks could be realized by separate business units or directly connected to an existing production site (Schanz *et al.*, 2011).

In recent years, also cost savings have become relevant for R&D offshoring decisions (Couto *et al.*, 2006; Sachwald, 2008), leading to a rising attractiveness of low-cost locations in emerging countries, particularly in Asia. Nowadays, such strategies of efficiency seeking increasingly affect the offshoring of knowledge intense tasks (Dunning, 1988; Murtha *et al.*, 2001). In this context, the global search for highly-qualified workers and lower-cost personnel in developing countries is to become one of the major drivers (Ambos, 2005; Couto *et al.*, 2006; Lewin and Peeters, 2006; Lewin *et al.*, 2009). Most cited examples for this strategy are the offshore branches or external business partners of IT enterprises in India (Boes and Kaempf, 2011; Tate *et al.*, 2009). The focus on low wages and a big supply of knowledge workers implicates an analogue status to the extended workbench or offshore factory: tasks like testing, engineering or improvement of existing products could be done on an "extended drawing board". A more advanced R&D centre would be able to develop products or production processes autonomously or even undertake basic research.

Regarding the impact of the global economic and the euro crisis on innovation strategies of Western companies in emerging economies, research and empirical evidence is rather scarce. Case studies of French MNCs have shown that these firms tended to rationalize their R&D expenses, to accentuate their open innovation strategies, to develop a strategic use of IPRs and to implement new innovation paths, oriented toward the exploitation (product adaptations) and the accumulation (new technologies) of their knowledge-capital and parallel (Laperche *et al.*, 2011). A study based on Innobarometer 2009 and European Innovation Scoreboard 2008 data shows that around two-thirds of the firms have kept their innovation investment unchanged in spite of the crisis (Filippetti and Archibugi, 2011), confirming the importance of accumulation and

persistency of innovative activities over time (Patel and Pavitt, 1997; Geroski *et al.*, 1997; Cefis and Orsenigo, 2001). On the other hand, they also observe a relevant share of pro-cyclical innovation strategies across firms, particularly in large firms with a high innovation intensity and a high export intensity, as firms' internationalization and innovation activities go hand in hand (Filippetti *et al.*, 2009). Pro-cyclical innovation activities mean that firms globally followed the rhythm of the economic activity, with increasing innovation investments in growth periods and decreasing investments in periods of recession (Harfi and Mathieu, 2009). The most important factor for braking the reduction of firms' innovation expenditures in times of a crisis is the availability of human resources, as firms are very reluctant to fire qualified workers even when facing a drop in their demand (Filippetti and Archibugi, 2011).

Recently, a new form of globalization of R&D called "reverse innovation" is emerging. This strategy says that "companies must learn reverse innovation: developing products in countries like China and India and then distribute them globally" (Immelt *et al.*, 2009). Some major companies are changing their strategy towards reverse innovation, for example general electric:

> For decades, GE has sold modified Western Products to emerging markets. Now to preempt the emerging giants, it's trying to reverse. [. . .] If GE doesn't master reverse innovation, the emerging giants could destroy the company (Immelt *et al.*, 2009).

In this context, collaborative research is an essential component of crisis and reverse strategies, as it is fully consistent with the imperative of profitability. Firms collaborate with academic research, with customers and suppliers at all stages of the innovation process. All these co-operations in innovation activities aim at the access to new skills and knowledge and the increase of the interactivity of the innovation process, saving time and improve the return on investment in R&D and innovation (Laperche *et al.*, 2011).

The strategic motives for the localization of R&D could be analyzed analogue to Ferdows (1997). Efficiency seeking aims for cost savings ("access to low-cost production") by re-importing knowledge intense inputs to countries with higher wages for qualified employees. A close link to the local production in the offshore country is not necessary. On the contrary, localizing R&D tasks for knowledge exploitation aims for the support of the local production ("proximity to market"), for instance by improving local selling by the adaption of the products to the local requirements. In cases where markets and manufacturing location are tightly coupled, for instance in automobile bodies, firms may need to put even more emphasis on understanding the impact of local production differences on technology competitiveness as on understanding local markets (Fuchs *et al.*, 2011). Strategies of knowledge augmentation are used to arrange the flow of knowledge from regional networks and clusters in the offshore country to the parent company ("access to skills and knowledge"). Higher competencies could lead to a regional centre that undertakes R&D tasks as part of a local lead factory or for other production sites.

So far, there is only very limited evidence how Western companies adapted their production and innovation strategies in emerging economies, particularly in China, to the changing conditions resulting from the global economic and the Euro crisis, and what their strategy for the midterm future will be. Are they primarily going for cost reductions through low-wage production and innovation as cost control became even more important? Or are they consequently focusing on the market and growth

potentials in China, giving their factories more and more process and product innovation competences for supplying their local customers to complete satisfaction? Based on the understanding of the different motives for international production and innovation and our operationalization of Ferdows' (1997) typology outlined above, we search answers to the following research questions:

RQ1. Do production and sourcing strategies of German manufacturing companies in China evolve from simple strategies of on-site-assembly ("server factory") and low-cost-production ("offshore factory") to more advanced approaches where more complex products are produced with a higher local supplier integration for Chinese and export markets ("contributor" or "lead factory")?

RQ2. Do innovation strategies of German manufacturing companies in China evolve from mere collection of information ("outpost factory") or adaption of products for the Chinese markets ("server factory") to global development centers which are responsible for R&D of products and processes of a specific line/division ("lead factory")?

3. Methodology and firm cases

The qualitative design of our research approach is both indicated by the theoretical framework as well as by the available empirical data. To evaluate the strategic role of the manufacturing plants in China based on Ferdows (1997), the competences in procurement, production technology, human resource and research and development need to be analyzed in depth. Therefore, the qualitative approach sheds light on the causal interlinkages of the different fields and allows for an in depth assessment of the respective competence level in the manufacturing plants.

Given the explorative character of our research questions, the qualitative approach also allows for refining the theoretical approach and checking for unexpected insights from the experts in China to guide future research.

To be able to do so, it was highly important not to restrict the data to closed questions and fixed scales of measurement. Thus, the interview guideline heavily relied on open questions in order to allow for new and unexpected insights from the experts in China. With that qualitative approach it was possible to identify causal interlinkages (George and Bennett, 2005) in the development of the manufacturing plants. The interview guide covered the fields of human resource, procurement, production, research and development and the strategic orientation of the plant. Open questions regarding the different fields of activities in the plants encouraged the experts to describe the current situation from their point of view, and thus helped to avoid too much bias from existing models and concepts. More detailed sub-questions went deeper into the different dimensions of our research questions. For the operationalisation of academic concepts such as knowledge exploitation and knowledge augmentation, questions about the operational management and activities conducted in the plant were asked for.

Although it was not possible for us to apply a sampling method that would have led to a sample of cases meeting all dimensions of interest relevant to our research questions (Breckenridge and Jones, 2009), the firm cases actually chosen still cover a broad range of variance within the field. Among the firms represented by the interviewed experts were both firms with a long presence in china but also latecomers, which started their transplants in China only within the last years. We talked to

representatives of big multinational enterprises as well as medium-sized companies. The position in the value chain within the industrial sector was from the production of basic materials (such as chemical products) over manufacturing and assembly processes up to full solution providers. The products and thereby production technologies varied from simple metal products to specialty chemicals. The regional scope of the case study was limited to facilities of the Beijing area, including Tianjin, and Shanghai, including Nanjing.

The firm cases comprise five companies in the automotive and supplier industry, four companies in the mechanical and plant engineering and propulsion technology sectors, four companies in the electrical engineering, automation technology and measuring equipment sectors, three companies in the chemical industry and one company each operating in the white goods and engineering service segment. Five companies had a staff level of less than 1,000 employees in their subsidies, three had a staff level ranging between 1,000 and 2,000 employees and ten had more than 2,000 employees worldwide. Five of the eight companies thus belong to the "typical German medium-sized companies". In all, the surveyed companies employ approximately 115,000 people in China, which corresponds to around 30 percent of the total employment of all German companies in China. They also account for around 45 percent of all local sales of all German companies in China. Therefore, the selected sample provides a very informative picture of the production and innovation strategies of German companies in China.

In total, 18 expert interviews with local senior managers or board members of German manufacturing plants in China were conducted in the period from May to June 2011 in order to provide the input for the case study – each lasting between 2 and 3 h followed by an inspection of the facilities. The interviews were recorded and then transcribed in order to allow for a textual and computer based processing of the results. The transcribed and processed interviews were then systematically condensed into structured firm cases to allow for a cross-company comparison and in particular to allow for a test of our theoretical model. The results of this process are presented in the following section by reflecting the structure of the compiled case studies.

4. Results and discussion

4.1 Production and sourcing strategy

The surveyed industrial companies indicate that the opening up of markets is the main reason for establishing value-creation activities in China. With one exception, the majority of Chinese plants serve solely the Chinese or Asian market. The production strategies are geared to the pattern "in the market for the market". The main reasoning behind this strategy is closer customer proximity: "Our local strategy is mainly driven by delivery periods and costs of transportation to local customers as well as market proximity as a pre-requisite for product adjustments" (quote taken from a company in the electrical engineering industry). Local content requirements and import limitations act as catalysts for this strategy, but are usually not the driving factors.

Even though companies seek to export their goods from the Chinese location to other Asian countries, this does rarely occur in practice. This is attributable to the fact that the expansion of own capacities at mid-sized companies in particular can hardly keep pace with the rapidly increasing market demand from China. Consequently, all products manufactured locally are delivered to Chinese customers. "This might be easy

business, but also constitutes a challenge given the strategically desired diversification of our country portfolio" (quote taken from a supplier for the automotive industry).

In contrast, the cost reduction strategy aiming at low local wages is becoming less important as a production ratio. Occasionally there are re-imports of selected products or components to Germany, but they play no major role in the strategic alignment of the production site – with only one exception where the Chinese plant acts as an "offshore factory/extended workbench" for the German plant. The surveyed managers consistently assume that "China's production cost advantages over Germany are becoming less and less important" (quote taken from a company in the mechanical engineering industry). This is attributable to the high wage dynamics in China. Wage increases are massive, ranging from 10 to 15 percent per year, and from 20 to 25 percent in case of specific qualifications. This is in line with the calculations provided by Barclays Bank, according to which the wages in China presently increase by about 20 percent annually. In addition, there is a high employee fluctuation rate, which ranges from 5 to 10 percent at very good companies. Some companies even report an employee fluctuation rate of 20 percent and more. This further pushes up the local wages as well as the personnel recruitment and qualification costs.

In this context, the experts interviewed also report on a "Go West" trend within China for tapping further cost reduction potential in the heartland. This leads to improved living conditions also in the heartland and probably to rapidly increasing wages. Consequently, less people will migrate from rural areas to the cities. The demographic change in China adds to this trend. The resulting shortage in labour supply will then also put further pressure on wages in the industrial coastal belt. However, on the upside, the increasing purchasing power translates into more local customers with respect to German premium products, in particular motor vehicles and consumer goods (Roland Berger Strategy Consultants, 2011). Thus, none of the surveyed companies has moved into the heartland so far or plans to do so in the near future, since the advantages of good infrastructure and lower transportation costs are deemed to be of greater value than the temporarily achievable wage cost reductions.

With respect to the technology and automation levels, the surveyed companies mainly apply global standards. "The production technologies employed locally largely correspond to the global corporate standards" (quote taken from a company in the chemical industry). This provides the advantage that the same product quality can be achieved with virtually the same quality assurance processes and management concepts, irrespective of the location of the respective plant. Another advantage is that production capacities can be easily exchanged within the network of various company sites in order to flexibly offset capacity fluctuations. Against this background, local technical process innovations play no role. In most cases, there is a strict "copying and pasting" of the manufacturing technologies of primary plants outside of Asia. Locally, processes are adapted to the local circumstances (climate, suppliers, raw materials, qualification level of local staff) to a relatively limited extent. In most cases, the standards required by customers or that are applied internally, only permit a very limited implementation of lower local automation levels for exploiting existing wage advantages.

In their outlook for the future, the surveyed experts expect that the opening up of markets will continue to be the main motive behind the local production strategy. China will not only increasingly develop into the Asian market hub, but may even

provide some Asian headquarter functionality for German industrial companies. Overhead functions will then also be established and concentrated in China. In view of sharply rising wage costs in China's industrial coastal belt, the surveyed experts predict that further automation at local Chinese production sites and companies will become necessary for maintaining their competiveness in the future. This, in turn, may offer further growth opportunities to German suppliers of manufacturing equipment and automation technology.

The sourcing strategy of the surveyed companies usually aims at higher localisation. Consequently, a high local sourcing share remains a major goal in all cases, in particular with respect to simple products or pre-products that must be available at all times or that are difficult to transport. In terms of quantities, the already achieved, relatively high local sourcing shares of up to 90 percent in some cases, clearly indicate that this is feasible with local Chinese suppliers – at least for the less complex parts. However, the share of local sourcing in terms of value is usually significantly lower, since particularly complex, and thus expensive, components continue to be imported from highly specialised suppliers, often from Germany.

The performance of the local suppliers is largely considered positive:

> Especially on the supplier side, we observe that China is increasingly developing from an "extended workbench" to an industry of its own, which is able to also deliver more complex products at a decent quality (quote taken from a company in the electrical engineering industry).

However, the development of high-performing local suppliers also comes at the cost of effort and time. For instance, it took the surveyed companies about 10-15 years before they were able to achieve a local sourcing share of 80 percent (volume share). In addition, there are still high support-related expenses even in the case of well-established supplier partnerships. On the one hand, Chinese suppliers usually display greater flexibility than, for example, German suppliers when it comes to volume flexibility, i.e. the provision of higher volumes requirements in the short term. On the other hand, Chinese suppliers are hardly able to maintain the agreed quality standards or to ensure process stability in case of product changes (variant flexibility), unless they receive considerable outside support. The interviewed experts report that German supplier networks are still by far more superior in this respect. As a consequence, local suppliers might not necessarily be the most cost-efficient when total costs are considered:

> The lacking competence of some local suppliers [in variant flexibility] is part of the problem. This has to be secured consistently – and may sometimes even render existing cost advantages of local procurement over imports obsolete in the long run (quote taken from a company in the measuring equipment sector).

However, the learning capacity of local suppliers should not be underestimated.

In the future, the prompt establishment and maintaining of local supplier structures will continue to be one of the major challenges to competitive production activities in China. Early coordination with Chinese suppliers and corresponding support on the basis of development programs are especially required with regard to innovations and changing product programs ("variant flexibility"). Due to the considerable expenses involved in the establishment of sustainable supplier structures, medium-sized companies might also have to promote joint activities and co-operations with

competing companies in the future, as it can be observed in single cases already today. The high growth rates of successful Chinese suppliers might also turn into a problem, in particular for medium-sized companies. Some of the suppliers developed for a specific purpose have meanwhile become larger than their original German customer. As a result, the German company may become increasingly less attractive to the suppliers, now as "B" or "C" customer. In some cases, there might even arise the risk of forward integration and of being taken over by those cash-rich suppliers.

Regarding the German companies' production strategies in China, we observe the movement from combined low-cost and market seeking strategies, serving the local Chinese market as well as export markets, towards a more pronounced customer serving and satisfaction strategy with a clear focus on the requirements of local customers. Looking at sourcing strategies this includes the consequent development of local suppliers, with current limitations in a quick adaptation of supplier parts to changing customer needs. Thinking in Ferdows' (1997) factory roles this implies development paths from offshore factories to source factories and on the way to contributor factories and from server factories on the way to contributor factories. However, the whole picture cannot be drawn before the local innovation strategies are analyzed, which is outlined in the following part.

4.2 Innovation strategy

The pervasive strategy of opening up local markets also defines the prevailing patterns concerning the innovation strategy. In most cases, the companies' organisational units designated as "R&D departments" are to ensure that the products are adapted to the Chinese markets on the basis of "application engineering". However, it became evident that manufacturers of industrial and consumer goods take different approaches to this subject. With respect to industrial goods manufacturers, products that were ultimately "localised" from scratch and thus exclusively designed for the Chinese market, are still the exception. In the industrial goods industry it is the high technological competence and performance of German products that is usually demanded, and clients are so far still willing to pay for the "premium price level". This allows the companies to set up development units for only minor product adjustments, which fits the locally available competence level and staffing. "In the mechanics segment, we reached a competence level that is on par with Germany's. However, local competences in the electronics, mechatronics and automation segment still lag behind considerably" (quote taken from a company in the electrical engineering sector). In contrast, major product adjustments that have to consider cultural aspects are usually required in the case of consumer goods. Some examples of such localized products are stoves with only two burners and a wok ring, exhaust hoods for higher temperatures and fat components, cosmetics with whitening instead of tanning effect, as well as strongly perfumed bath liquids, shower gels and shampoos to compensate for the culturally founded non-usage of deodorants.

Cost-driven relocations of R&D capacities aiming at lower local costs for R&D salaries hardly play a role. Strategies focusing on acquiring know-how by establishing plants in relevant cluster regions or networks are being pursued rather cautiously to date. Collaborations with universities are mainly entered with the purpose of recruiting highly qualified staff or to set up technology scouting programs. Those scouting and screening activities aim at getting access to a vision of the advances of science and technology. They are usually focused on segments in which Chinese universities have

a high level of academic reputation, based on the frequency at which their work (papers) appear in high impact journals and the quality of their papers, measured in citations and academic journals. Some examples for this are the areas of chemistry, materials research and nanomaterials.

Engineering strategies to adjust the costs of products to the purchasing power of Chinese customers are also increasingly required with respect to consumer goods and industrial goods. Up to now, the production and development capacities of German companies have often focussed on supplying their products to the solvent Chinese upper class or to financially sound Chinese companies, which where willingly paying the premium prices for the higher-quality products and technologies. In the future, the greatest market growth is, however, expected to stem from the growing middle class and companies that need to increase their automation level and have to watch out for cost efficiency in process and product adaptations. With respect to rather simple consumer goods such as cosmetic products, this requirement can be met through local production and sourcing at Chinese prices and through the efficient design of production processes. It becomes more difficult with respect to complex consumer and industrial products that must be fundamentally "downgraded" in terms of technology and reduced to their basic functions in order to be able to compete in cost-driven Chinese market segments. But when they downgrade too much, some German manufacturers are in the peril of losing their brand identity. However, there are also success stories to report in this context. One example is the computer tomograph (CT) of a medical engineering company, which was fundamentally re-designed to fit the Chinese price level while strictly focussing on the necessary functionality for the customer. In fact, this engineering activity was so successful that in the meantime, the CT is also very successfully exported to other Asian and overseas markets. But still, this only relates to a systematic, functional re-engineering. The basic technological innovations and the major design concepts are originally defined and developed at the German lead plant of the company.

Overall, if all conducted interviews are taken into account, the study reveals some kind of a "Chinese gap" in the area of fundamental new developments and basic innovations (Figure 1). The scope of responsibility of the local R&D units is often limited in the ways described above, to less complex product adjustments, further development of existing products and the improvement of the products' suitability for Chinese customers (which are depicted in the two easternmost segments in Figure 1). In addition, some companies pursue targeted activities in the technology

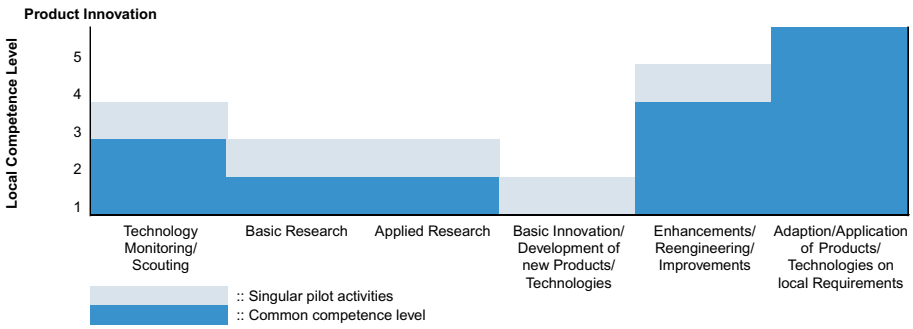

Figure 1.
"Chinese gap" concerning the competence level for product innovations

scouting and monitoring area in collaboration with Chinese research facilities and, in exceptional cases, also with other companies (which are depicted in the westernmost segment in Figure 1). Turning to the intermediate segments (second to fourth segment in Figure 1), from basic research through applied research to the new product development (NPD) and basic innovation of technologies, in particular, the surveyed companies have been very cautious so far – and only very few of them plan to get actively involved in the basic innovations segment in the future.

Moreover, the local R&D departments are usually managed relatively strictly from the head office in Germany. "Despite the high local development capacity, 80 percent of the research topics are defined by our parent company" (quote taken from a company in the plant engineering sector). The example of a company in the chemical industry vividly illustrates this: all eight product and development platforms in the adhesives technology segment are located at the Chinese site, which is a unique accumulation worldwide. However, the Chinese plant does not hold the primary responsibility for any of those segments. The central control function concerning seven of the eight segments is exercised by the head office in Germany.

Regarding future innovation strategies, the surveyed experts expect that China will develop into an important research location with regard to some selected technological segments. This concerns focal points of the Chinese governmental research strategy in the following areas: basic chemicals, nanotechnology and energy storage technologies, among others. In addition, high activity is also to be expected in the future-oriented segments, such as the electro-mobility segment, that are stressed under the Chinese five-year planning.

The creativity of Chinese staff and the innovation culture of the Chinese sites remain key challenges. Largely related to their socialisation, graduates from Chinese universities are hardly able to work independently and creatively right from the start. This is attributable to the academic educational system, which is very school-like and primarily provides answers, but rarely encourages students to find own solutions. The German companies are thus forced to first provide on-the-job trainings – which last between two and three years – to the young academics before they can expect to receive independent and creative contributions from them. Trying to hire academics with professional, international or management experience is just as difficult. Such personnel is hard to find and even more difficult to retain. Since practically "all Chinese academics want to become managers" (quote taken from a company in the chemical industry), it is almost obligatory to present differentiated personnel development concepts with systematic career and development paths to this group, along with competitive salaries. This must be accompanied by socialising activities in order to ensure their long-term commitment to the company. As for the wages, it is reported that experienced academics may well demand 75-100 percent of the salary level in Germany, while the salaries of university graduates correspond to approximately 35-50 percent of the salaries paid in Germany. This situation is aggravated by the fact that China is already experiencing a lack of experienced academics, which is reflected in a virtual "fight for talents" (quote taken from a company in the electrical engineering sector). In the past, foreign multinational companies were the most attractive employers. Today, "Chinese companies are becoming increasingly more attractive. The current ranking of the Top five most attractive employers in China consists exclusively of national companies" (quote taken from a company in the measuring

equipment sector). This is in particular accountable to the fact that Chinese academics, focusing on management careers, have the prospect to attain any position in Chinese companies, including the top management, while especially the latter is virtually closed at German companies to Chinese employees. This clear perspective for heading "all the way to the top" leads to increasing competition by local companies on the labour market.

Overall, from the perspective of the local innovation strategy, most factories of German manufacturing companies in China are so far no testing ground for new process technologies and products, which is a necessary pre-condition for a contributor factory in Ferdows' (1997) typology. In the view of the identified "Chinese gap" in basic innovations for products and processes, they seem to represent a factory role which is positioned in between the server factory and the contributor factory as described by Ferdows. We will describe this modified role model in the conclusions part of our paper.

5. Recommendations and conclusions

Based on the outlined results above, we will conclude this paper by:

- recommending five guiding principles when planning and enhancing the future development of Chinese plants' production and innovation strategy in order to help practitioners in sustaining their business success in China (Table I: "five guiding principles"); and
- by summarising the conclusions for theory that follow from our findings.

5.1 Recommendations for practice

Production and sourcing strategy.

(1) In recent years, the local expansion of capacities at most of the companies – with the exception of individual companies in the chemical and automotive industries – lagged behind the surging market demand. In the future, the objective will be to promote a pro-active expansion of capacities in those growth areas in which China is expected to expand strongly in the future or in which it can achieve a leading global market position. At the same time, attention must also be directed towards other Asian markets that can be serviced from China as a "bridgehead". For the sake of minimising risks concerning the expansion of capacities, attention should be in particular paid on ensuring high flexibility between the diverse product segments and manufacturing locations so that capacity peaks and lows can be absorbed internally. The fixed costs incurred by temporary, strategic excess capacities must always remain manageable and should not exceed 15 percent of total costs.

(2) Up to the present date, local plants focused strongly on exploiting local wage cost advantages. Due to strongly rising wages, the focus in the future will have to be much more on cost efficiency by increasing productivity through higher local value added and automation. In this context, it makes sense to implement global technical standards instead of local standards wherever possible. It will become necessary for Chinese production sites to start focussing on process innovations more systematically than in today's practice – even if technological process innovations will still be pushed by other lead plants. Also, the staff concerned

Table I. How can companies further develop Chinese plants? Five guiding principles and their limitations

Subject area	From	To	Limitations
Production and sourcing strategy	Reactive capacity expansion (managing demand opportunities)	Pro-active expansion of capacities in selective growth areas – also with a focus on other Asian markets Secure manufacturing flexibility between product segments and locations/sites	Fixed costs incurred due to strategic excess capacities must remain manageable Reference value: fixed costs < 15 percent of total costs
	Cost orientation with focus on low wages	Product orientation with focus on value-creation and automation	Automation only when total factor productivity can be increased significantly
	Process innovations: "copy and paste" of foreign lead plants	Process innovations: take into account the requirements (qualification, capabilities, materials) of Chinese plants	Training of staff before the implementation of new technology
	Selective supplier development, often as single source approach	Systematic development of local suppliers for strategic components in a dual source approach Taking advantage of joint activities and co-operations with other – possibly also competing – companies	Supplier development takes time: operational partnerships take months and strategic partnerships even years to develop! Not for commodity parts (where a simple change of supplier is possible) and components which often require adjustments Changeover of suppliers due to price reasons only where Chinese suppliers have significant cost advantages (>20 percent)
Innovation strategy	Product adjustments to specific requirements and operating conditions; partly technology scouting	Products are systematically geared to functionality and clear customer benefit Possibly bottom-up design (in some cases "downgrading") of solutions focusing on functions and costs Systematic research co-operations with technical universities in focal areas	No local basic innovations of technological principles if the retention of the competence edge and protection of know-how are not secured Research co-operations focussing on areas in which local universities demonstrate excellence on a global scale
	Curb employee fluctuation	Establish systematic personnel development concepts and career paths to find and retain good employees Special focus on key positions, including successor strategies	Owing to competition and demographic change, actually without any alternative Critical analysis of the location/site when personnel costs (including staff training, HR overhead) threaten local profitability

should not only be trained in line with the specific requirements, but also in due time before or in parallel to the implementation of technology. However, automation must not be implemented simply because of technical feasibility, but only when total factor productivity can be increased significantly.

(3) Up to the present date, the Chinese plants of German industrial companies pursued a very selective supplier development strategy, which was often aligned to a single source approach, especially at medium-sized companies. In the future, the objective will be to promote a systematic development of local suppliers – at least at a dual source approach – for strategic components that can be procured locally. In order to optimise the necessary resources, it is worthwhile to verify where strategic co-operations could be entered with other – possibly also competing – companies. However, companies should always note that the development of suppliers in China takes time; operational partnerships take months, and reliable strategic partnerships even years to develop! With regard to these efforts and involved expenses, strategic partnerships should not be aimed at with respect to commodity parts – where a simple change of supplier would be possible – nor with regard to components which often require adjustments ("variant flexibility"), as this has not (yet) emerged as a specific strengths of Chinese suppliers. If a change of suppliers is planned due to price reasons, local suppliers should offer significant procurement cost advantages (of at least 20 percent or more) in order to be able to achieve sustainable overall savings and to account for the expenses involved in their management.

Innovation strategy

(4) So far, only product adjustments and continuative developments for specific local requirements and operating conditions were systematically pushed under the local innovation strategy. Some cutting-edge companies in the chemical industry and the plant engineering sector successfully experiment with technology scouting approaches. In the future, it will become much more important to ensure products that are systematically geared to functionality and total costs of ownership (TCO), and thus exhibit a clear customer benefit to the strongly growing middle class and to more efficiency-oriented local companies. This might require fundamental, bottom-up re-designs, which may in some cases involve a systematic "downgrading" of the utilised technology base for adequate solutions in terms of functionality and costs. However, basic innovations of technological principles should only be promoted locally when the protection of know-how and the retention of competence edge can be sufficiently secured through technical and organisational measures. With respect to technology scouting, it is mandatory that systematic research co-operations are entered with technical universities in those areas in which Chinese universities are world class or which are promoted as "lead markets" under the Chinese governmental research strategy (e.g. some areas of chemicals, nano-materials, energy storage).

(5) With regard to the HR strategy, the focus was hitherto primarily on curbing employee fluctuation. Competition with local companies and the demographic change now force all companies to be even more systematic about implementing personnel development concepts and career paths than before – not only in

order to find good employees, but even more importantly to be able to retain them on a long-term basis. Early development and successor strategies are recommended with respect to staff in key positions. A critical review of the personnel strategies at the site is necessary when the personnel costs of highly qualified personnel, including costs relating to staff training and HR overheads, threaten local profitability.

5.2 Conclusion

According to our analysis, most of the surveyed plants have ample local competences in the following areas: production, technical maintenance, local logistics, product customization and redesign, production planning and process changes, procurement, and choice and development of suppliers. Usually, some local competences in product development were also set up. However, the competences do not encompass basic innovations and NPD. Most plants are thus no test or application plants for new products, let alone for new process technologies, which – as described before – are almost exclusively attained by a "copy and paste" strategy from plants outside of Asia (usually from the German lead plant) at which they had already been tested. Consequently, they do not fully meet the necessary requirements specified for a contributor factory in Ferdows' (1997) seminal work and in concrete operationalizations of the relevant factory competences in empirical studies using his framework (Kim *et al.*, 2001; Vereecke and Van Dierdonck, 2002). Thus, the German factories in China with their local competences represent yet another type, which can be classified as advanced server factory (Figure 2). This is in accordance with the "Chinese gap" in basic innovations for products and processes, but accounts for the strengths and capabilities of the local plants in product adjustment and re-engineering activities.

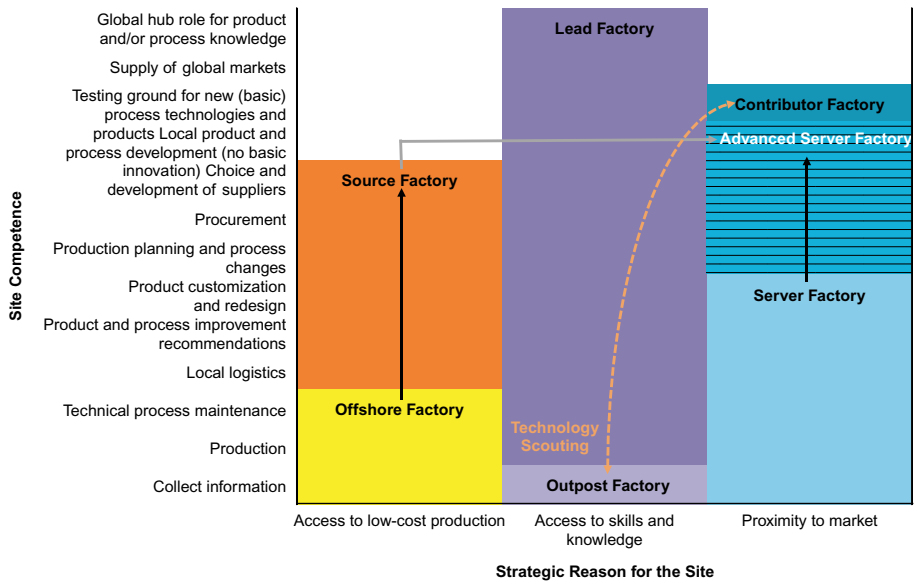

Figure 2.
Plant location roles and development paths of German plants in China

The typical development paths (black arrows) that have been pursued to date particularly include the path from the local server factory to the advanced server factory and, less frequently, the path from the offshore factory to the source factory. In isolated cases, there were also developments from a primary cost-oriented source factory to a market- and customer-oriented advanced server factory (gray arrow). In both cases, simple on-site assembly and component manufacturing strategies in order to circumvent import and local content barriers (server factory) or to benefit from cost advantages with regard to the wages for exporting products to established market (offshore factory), were developed into advanced production strategies. Those advanced production strategies are characterized by the local production of more complex products for the Chinese market with a greater vertical integration of manufacturing and a higher localisation share of suppliers.

Coming back to our research questions, we can partly affirm *RQ1* has the local factories of German manufacturing companies in China are gradually developing towards the strategic role of a contributor factory, but have not achieved this stage yet. In the future, if they follow the primary guiding principles for overcoming the identified challenges (Table I: "five guiding principles"), they will increasingly develop into a plant role of a contributor factory with specific outpost factory functions concerning technology scouting in selective focal areas (orange dotted line). On the other hand, the great majority of companies are still far from – and not intending to plan – establishing lead factories in China with global responsibility as excellence centres for new products, processes and technologies for a specific corporate segment or the entire company. This stance is due to strategic reasons relating to the retention of competitive edge and the protection of know-how. The relating "Chinese gap" in basic innovations will prevent them from developing lead factories in China also in a midterm perspective, thus negating *RQ2*.

To summarize, our qualitative and explorative research design provided unexpected insights of a high strategic relevance for practitioners currently engaged in optimising their global production and innovation footprint. Although the results are conducted based on a rather small case study with focus and China, we believe that they will still basically hold true even in a more generalised context. Our research design in particular enabled us to analyse the situation and strategies of the local manufacturing plants for a large share of German enterprises currently engaged in China. Further, the results also allowed for a test of established theoretical models in this regards and – at least to some extent – provided directions for their refinement. For practitioners and teaching it is important to know that up to date most of the surveyed factories represent a type of an "advanced server factory" with its local site competences as described above. For academics and future research it is interesting to see and discuss the emerging role of a contributor factory with specific outpost functions in the area of technology scouting that the pioneering manufacturers in this study are likely to take up in the near future.

However, we also recommend to keep the restrictions of our research approach in mind when applying and extending our findings in future research. In this regards it might be necessary to conduct further interviews with more representatives or even start longitudinal study. Interviews with firm representatives from the head quarter would help to assess the position of the plant within the transnational value chain further.

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