International manufacturing networks—to develop global competitive capabilities

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Abstract

This paper seeks to extend existing manufacturing system concepts and develop new structured knowledge about international manufacturing networks by analysing the networks, classifying the configurations and identifying the capabilities. The design and operation of international manufacturing networks is an increasingly important issue for transnational corporations faced with rapid changes in global market opportunity, competition and new managerial mechanisms. Four international manufacturing networks in mechanical and process industries are analysed and a number of conclusions drawn: first, a novel configuration map is proposed; second, key strategic capability parameters are identified; third, networking trends and their implications for configuration are discussed. Finally, the paper explores strengths and weaknesses of the particular methodology adopted in this research. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: International manufacturing networks; Global manufacturing strategy; Manufacturing strategic capability

1. Introduction

Business globalisation is leading to widespread restructuring of international manufacturing systems in transnational corporations (TNCs) (UNCTAD, 1993). Little systematic research in manufacturing engineering or production/operations management (P/O M) has focused on these new manufacturing systems (Anderson et al., 1989; Lawrence and Rosenblatt, 1992; Miller and Roth, 1994; Shi and Gregory, 1995). Many critical issues, such as properties of international manufacturing network systems in terms of structural architecture, dynamic mechanisms, and related strategic capabilities and strategy processes, are poorly understood and are not covered by current manufacturing research agendas. In industry, lack of global vision and appropriate strategies during the internationalisation have become major barrier to the effective management of international operations (Klassen and Whybark, 1994).

Manufacturing engineering and P/O M are experiencing a rapid change in manufacturing system concepts from a factory focus towards a corporate international factory network (Ferdows, 1989). There are strong parallels with computer developments from centralised mainframe systems to distributed networks. Nowadays, in computing, nobody doubts the network is the computer and has more capabilities than standard machines alone. Similarly, the world-wide dispersed corporate factory network can be seen as the manufacturing system but with many different characteristics from the classic model. Networks, therefore, are not only a new type of manu-
manufacturing system deriving new strategic capabilities and requiring design tools but also posing new theoretical questions about systems and decision processes.

The paper is organised in five parts. The ‘background’ (Section 2) explains why international manufacturing needs more attention and what the main issues are. The ‘research design’ (Section 3) introduces the research approach and some conceptual models of the networks, and details the relationship between this paper’s results and a practical project. In Section 4, four international manufacturing networks from 15 studied cases in engineering and process industries are then analysed to demonstrate the most recent transformation of the networks. Following the cases, two revised conceptual models are presented in Section 5—strategic capability parameters and the configuration map and discusses some new findings from the main driving forces, trends of networks, to optimised configurations. The final part of the paper discusses the need for further research work about networks.

2. Background

2.1. The changing industrial environment

The international market is not only a sum of different national markets. Traditionally, international business strategy is based upon these individual markets and sets up objectives and policies separately to satisfy the specific requirements of different countries. This type of international development is an outcome of ‘multidomestic’ oriented strategy (Dicken, 1986; Porter, 1980). As international communication and exchanges extend, especially under the trends of political regionalisation and rapid economic growth in some developing countries, the global market—a new type of international market is emerging (Levitt, 1983; Yip, 1992). This global market is based on the shared and common demands of different countries. It integrates different national preferences into a core entity and presents this as a fundamental and nondifferentiable market requirement. To satisfy the growing global market, the traditional products and related development strategies are clearly not enough to satisfy companies’ internationalisation. TNCs are therefore keen to learn about and develop global or world products and to restructure their worldwide manufacturing systems.

Although domestic and regional markets will continue to exist, the reality of global competition is very clear. It means not only an increase in the number of competitors in the world but also a qualitative change in the nature of competitive advantage. Many TNCs have sought to achieve lower cost, higher quality, faster product introduction, greater flexibility, and shorter delivery time, all at the same time (Daniels and Daniels, 1993). This has become a necessary requirement of global competition. The ‘trade-offs’ principle of Skinner (1969) and the generic competitive strategy of Porter (1980) obviously are not enough to satisfy the global competitive requirements. Companies therefore need to pay more attention to their internal capability building and new patterns of manufacturing system searching to create a proactive competitive influence rather than a reactive responsiveness to the new industrial environment (Hayes et al., 1988).

The emergence of the global market and intensification of global competition is matched by major developments in technology. New generations of communication and transportation technologies are creating the possibility for TNCs to organise their worldwide operations more effectively and efficiently. There are also major changes in the way people think about manufacturing. New system technologies, for example, are guiding managers and engineers to have more integrated and dynamic vision about manufacturing systems. Indeed manufacturing systems are increasingly expected to fulfil new requirements for learning and adaptation (Leonard-Barton, 1992; Hayes and Pisano, 1994).

In general, these new driving forces—global market opportunity, new patterns of competition, and reorganising potential or possibility—require a new generation of networks beyond the classical pipeline of physical transformation. The networking characteristics of the new manufacturing system must involve a wide perspective covering geographic dispersion and interdependent coordination rather than the traditional focus on separated manufacturing sites. These new perspectives require new understandings of the nature of manufacturing systems and the ways in which the required performance can be achieved.
2.2. Literature review on international manufacturing networks

Over the last ten years, manufacturing has been taken increasingly seriously by both industry and academics. In contrast to studies at factory level, however, the research focusing on the international manufacturing networks is quite scarce. There seems to be a widespread belief that, if a company masters manufacturing strategy and factory design, the strategy can be applied no matter where the manufacturing is located or distributed. Sprague (1990) represented this principle as a series of decision grids by which the markets could be identified and served to construct a series of internationally distributed factories. International manufacturing network design is simplified into location decision and good factory design. Following similar assumptions, Dubois et al. (1993) studied the relationship between international manufacturing configurations (IMCs) and manufacturing strategy. They found four key manufacturing performance priorities (efficiency/cost, quality, dependability, and flexibility) which, in addition to three other key variables, market orientation, experience and product characteristics, play important roles in the development of IMC strategies.

However, international manufacturing networks are integrated rather than aggregated. Flaherty (1986) studied one pattern of IMCs and provided a sound basis for the observation and exploration about international manufacturing systems. Based on empirical research in microelectronic industry, she suggested that one type of IMC with particular patterns of geographic dispersed facilities and shared common infrastructure/mechanism could lead to a synergy advantage in the network. The work does not, however, address linkage to the corporate strategy or tackle comprehensively the range of possible IMCs and coordination to give companies more alternatives during their internationalisation.

Ferdows (1989) defines the international manufacturing system as a network of factories. Each factory plays different strategic roles in the network, e.g., off-shore, source, server, contributor, outpost and lead. “Using it for analysis of factory networks provides a fresh perspective and yields new insights.” So the focus of Ferdows is on the relation between network and its factories. He tries to link the strategic motivations to the role of each factory in a network and emphasises new opportunities for learning in the networks. This model perhaps put a little too much emphasis on strategic role of separate factories rather than functions of the integrated or coordinated network.

Cohen et al. (1989) consider the network including vendors, plants and markets. But their international manufacturing strategy is mainly driven by the international financial factors, such as fluctuations of currency exchange rate, global corporate taxes, tariffs and so on. These factors could influence the behaviours of TNCs but may be not the driving forces to the strategy.

The interdependent coordination in the networks is a determinant of network structure. Dicken, a British economic geographer, observing the tide of large-scale production geographic dispersion globally, generalises two patterns of production coordination strategy. He calls them horizontal expansion and vertical integration. “Each of these strategies has rather different implications for the internal relationships between the individual parts of the enterprise. In particular, units which are part of a vertically integrated operation tend to be locked into a much tighter network of internal interdependencies with other parts of enterprise” (Dicken, 1986, 1992). De Meyer and Vereecke (1994) recently also suggest two types of manufacturing network architecture—product focus and process focus, the former is same as Dicken’s horizontal expansion strategy and the latter is as vertical integration strategy. They mention “the choice between the process and product focus has strong implications for the range of tasks of the corporate manufacturing staff and the factory management. The factory in a process-focused company in general operates less autonomously than the factory in a product-focused company”.

These strategy patterns and network architecture at manufacturing level are the consequence of the globalised or multidomestic focused strategy of the corporation. Therefore, the coordination between future market requirements and corporate strategies influences not only the corporate organisation but also the manufacturing network and factory internal characteristics. The pattern choices of coordination must be made before the international manufacturing network is physically designed. The problem is that, even though
it is a very important parameter of the networks, the coordination dimension alone is not sufficient to present the whole picture of international manufacturing networks.

In summary, there still appears to be little serious research concerning integrated networks of factories as whole systems and little about the process of strategy development to build such networks. Even though reviewed research shows some people have started to observe the dispersed factories in an integrative and interdependent way and tried to put the factories into some kinds of configurations, the general industrial requirements in manufacturing internationalisation are far from satisfied. This represents another serious missing link in corporate strategy (Skinner, 1969).

2.3. New agenda for international manufacturing systems

A new concept of manufacturing systems needs to be developed as manufacturing business develops internationally. However, as TNCs’ internationalisation is a very complex process, it is not possible to identify one dominant pattern suitable for all future development. Even while many TNCs believe the main stream will be global integration or coordination, may others believe the multidomestic nation by nation to be more appropriate (Kanter, 1991; Fleenor, 1993).

Faced by contingency options for internationalisation, international manufacturing managers need knowledge about the options and network characteristics in their strategy analysis and network design. Work to develop the necessary new knowledge is difficult to justify within individual companies but is an appropriate subject for research aimed at new theory building and practical tool development. Research into the international manufacturing networks therefore should answer the following fundamental questions.

· What are the international manufacturing networks? Are existing manufacturing system concepts adequate and if not what constructs should be?

· What should the international manufacturing networks do? What strategic requirements and/or missions are expected from networks and strategic capabilities does this suggest?

· What could the international manufacturing networks do? How can different configurations of networks and the relationship between capabilities and configurations be understood, e.g., by classifying the networks, mapping their transformations, and profiling capabilities?

· How to match ‘should’ to ‘could’ to design a network? How might a strategy process be developed to guide the transformation of international manufacturing system towards global coordinated networks.

It is clear that such questions requires intensively theoretical and practical research. And it is also essential to design an integrated research approach to tackle these issues.

2.4. International manufacturing network research programme

Research adopted to tackle the above issues forms a wide research programme. The programme’s objectives are: (1) To develop new theoretical knowledge that better understands the international manufacturing networks in terms of their missions, configurations and capabilities. (2) To develop a practical process detailing the analysis and decision of the international manufacturing strategy and network transformation towards globally coordination.

The programme thus includes two basic parts—knowledge-based research work and application-based research work—shown as the core of Fig. 1.
The research programme extends manufacturing system concept from factory focus to international factory network, but at the same time is limited within the factory network boundary. This type of international factory network usually belongs to one strategic business unit (SBU) in a transnational corporation, which is consistent with the boundary of the manufacturing strategy (Skinner, 1969; Hayes and Wheelwright, 1984). As an international manufacturing system can be seen a factory network with matrix connections, in contrast to a more linear system of a factory, the linkages with the environment through sourcing, strategic alliances and R&D networking are of course important for the networks. But for this research work, the focus is just the international manufacturing factory network in which a TNC has direct investment, no matter how large or small percentage of the ownership, since this represents the activities over which the company has direct management control contrasting with other types of collaboration. Another reason for this focus is that it should be the bottom line for a company to first optimise or better manage its own resources.

The international manufacturing network research programme has been designed as three major stages— theoretical model building, workbook methodology piloting, and workbook testing through detailed case studies (Fig. 1). The programme in general seeks to combine theory construction and practical application through the ‘process research approach’ (Platts and Gregory, 1990). In its first and second stages, 15 case companies have been studied based on the conceptual models and pilot workbook. The second stage is a connection between theory construction and its application, transferring the new knowledge into a practical workbook assisting international manufacturing strategy formulation and network design. Currently the research programme is entering the third stage to test and apply the workbook entitled as ‘Global Manufacturing Strategy—Developing New Manufacturing Capability’.

2.5. The focus of this paper

This paper mainly introduces the knowledge-based research work in the research programme, by focusing on the first and second stages of the research programme in Fig. 1, although the background to the full programme is briefly introduced in the paper to provide context. Presenting four typical cases to demonstrate the emerging and transformation of international manufacturing network systems, the paper sets out to discuss typical options of the network configurations and their related strategic capabilities and managerial behaviours. However, as this knowledge-based research is only a part of the wider programme, it might be helpful to remind that the research strategy, model constructions and methodology choice are designed from the point of view of the whole programme rather than just for finding knowledge or building theory.

3. Research design

3.1. The knowledge-based research

Fig. 2 sets out the approach to the knowledge-based research work, starting from pilot industrial case studies and workshop discussions and related literature survey to the identification of key industrial issues and research agendas. Drawing on industrial requirements for tools and processes for international manufacturing decisions in the first phase of the research, conceptual models are developed to

![Fig. 2. The research procedure of the theory-building part in the knowledge-based research.](image-url)
guide field observation and underpin workbook in the second phase. In the third phase, supported with a pilot workbook application in companies, case studies serve to detail and test the conceptual models leading to modifications where necessary. They also provide an exploration of new issues not captured in the conceptual models and a vehicle for maintaining close links between research and practice.

Fifteen case companies (or strategic business units) have been studied (Fig. 2), covering the pharmaceutical, snack food and engineering industries. In each case, starting from access to its annual reports and/or Internet Web sites to find general vision, stage of internationalisation and proper people or department, several unstructured interviews are organised by introducing the collaborative project, searching configuration ‘data’, understanding evolution process and strategic intentions at each turning points, and discussing recent developing issues and cooperative requirements for research work.

3.2. Research methodology

The ‘process research approach’ was adopted in the knowledge-based research. The process approach enables firms to capture strategic and operational decision-making into a relatively standardised implementing procedure which is easier for firms to apply and control (DTI, 1988; Platts and Gregory, 1990; Platts, 1993; Maslen and Lewis, 1994). Platts and Gregory (1990) note:

The audit procedure has sought to ‘operationalise’ the existing strategy frameworks . . . and make them accessible to the management of operating companies. This has been done by using worksheets at each stage of the process to facilitate the recording and progressing of the procedure. The use of worksheets is most important as they require the users to interact formally with the process rather than simply reviewing a ‘checklist’. The worksheets also provide traceability: the logical and data of the analytical part of the process are recorded and can be revisited periodically to check that the bases for the strategy are still appreciate.

For applying the approach, rather than act as external ‘auditors’, we have sought to act as ‘facilitators’. Personnel within the company have been intimately involved in the process, our role being to provide the required structure, and to advise and assist when required. We have used multi-disciplinary workshops involving, in addition to manufacturing personnel, representatives from marketing, product engineering, finance, personnel etc. Generally speaking the representatives have been at director level and the workshops have been chaired by the Manager Director. We structure the workshops by using the worksheets as an outline agenda and use them as the basis for discussion aiming to reaching a consensus view at the completion of each stage. Between the main workshops there are data gathering activities and mini-workshops usually involving lower levels of management.

This approach in the knowledge-based research specifically integrated with the conceptual model development by interview, understanding the historical transformations of the manufacturing networks during the pilot workbook application. One of the major benefits of this research methodology is that the combination of theoretical exploration and practical process development (Fig. 1) allows researchers access to industry to observe in detail the latest strategic and operational practices. This provides network knowledge and, at the same time, provides managers more practical tools.

3.3. Overview of the conceptual models about the networks

As Fig. 2 details the research procedure, the conceptual models are basically developed through pilot case studies, literature review, and wide discussion with academics and managers. The purpose of constructing the following conceptual models is to better steer the case studies in very complex international manufacturing systems. Another reason for using the models, as mentioned before, is to stimulate managers to use them and ‘test’ them.

3.3.1. Construction of international manufacturing networks

An international manufacturing system may be seen a factory network with matrix connections, in contrast to the linear system of a factory. Table 1 lists some of the key system elements making up an international manufacturing factory network and
Table 1
Comparison of the construction of two types of manufacturing systems

<table>
<thead>
<tr>
<th>Characteristics of the system construction</th>
<th>Difference of two types of manufacturing systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factory manufacturing system*</td>
</tr>
<tr>
<td></td>
<td>International manufacturing network system</td>
</tr>
<tr>
<td><strong>Structural Elements:</strong></td>
<td></td>
</tr>
<tr>
<td>(static levers controlling the architectural configurations of corporate international manufacturing system)</td>
<td></td>
</tr>
<tr>
<td>(1) Capacity:</td>
<td>(1) Factory’s characteristics:</td>
</tr>
<tr>
<td>amount, timing, type.</td>
<td>(as whole left column).</td>
</tr>
<tr>
<td>(2) Facilities:</td>
<td>(2) Geographic dispersion:</td>
</tr>
<tr>
<td>size, location, specialisation.</td>
<td>distributed factory condition.</td>
</tr>
<tr>
<td>(3) Technology:</td>
<td>(3) Horizontal coordination:</td>
</tr>
<tr>
<td>equipment, automation, linkage.</td>
<td>coordinated mechanism.</td>
</tr>
<tr>
<td>(4) Vertical integration:</td>
<td>(4) Vertical coordination:</td>
</tr>
<tr>
<td>direction, extent, balance.</td>
<td>international dispersion of the corporate value-adding chains and their linkages.</td>
</tr>
<tr>
<td><strong>Infrastructure elements:</strong></td>
<td></td>
</tr>
<tr>
<td>(dynamic levers controlling the operational mechanism of corporate international manufacturing system)</td>
<td></td>
</tr>
<tr>
<td>(5) Workforce:</td>
<td>(5) Dynamic response mechanism:</td>
</tr>
<tr>
<td>skill level, wage policies, employment security.</td>
<td>opportunity identify, and manufacturing mobility.</td>
</tr>
<tr>
<td>(6) Quality:</td>
<td>(6) Product life cycle (PLC) and knowledge transfer in international manufacturing networks.</td>
</tr>
<tr>
<td>defect prevention, monitoring, intervention.</td>
<td></td>
</tr>
<tr>
<td>(7) Production planning/material control:</td>
<td>(7) Operational mechanisms:</td>
</tr>
<tr>
<td>sourcing policies, centralisation, decision rules.</td>
<td>network daily co-ordination, management information system.</td>
</tr>
<tr>
<td>(8) Organisation structure:</td>
<td>(8) Dynamic capability building and network evolution:</td>
</tr>
<tr>
<td>structure, control/reward system, role of staff groups.</td>
<td>learning by operations.</td>
</tr>
</tbody>
</table>

*Hayes and Wheelwright, 1984.
compares them with those for a single factory. The network elements chosen in Table 1 are partly based on existing research findings, such as the model of Porter (1980) and the observation of Flaherty (1986), and partly based on our pilot case studies and industry workshop at Cambridge, especially for those dynamic elements which make the network distinguished from factories.

As for the elements of factory system Hayes and Wheelwright, 1984 in Table 1, the levers controlling the network are interdependent but have different characteristics. The first four levers are system determinants settling the various patterns of structures, which have more radical and architectural influences on the network construction. The following four are dynamic controllers from daily operations and accumulative improvement, to product transfer, and network evolution during internationalisation. The structural elements determine the capabilities of the network and influence the patterns of infrastructure and dynamic mechanisms; but, it is also possible for the dynamic levers to act on the configuration in a long term and accumulative way.

3.3.2. Classification of the international manufacturing networks

Based on the principal dimensions from the model of Porter (1980), Table 2 sets out two key dimensions of the classification and presents seven typical configurations of international manufacturing networks and some of their characteristics.

Once a business has moved beyond a conventional single domestic operation it is obliged to establish coordination mechanisms. The multidomestic approach, a mode of weak coordination, involves the development of more or less autonomous manufacturing units geographically located close to target markets. In the most extreme case such units might have complete design and manufacturing authority with only financial performance reported to the centre. On the other hand, the globalised approach involves closely managed coordination of a dispersed manufacturing system and integration of both product design and development and production. The manufacturing system is seen as a unified whole with a mechanism of sharing knowledge, and/or with elements of the task being performed in the most advantageous areas.

Manufacturing dispersion covers the full range of options from domestic manufacture to worldwide manufacture. Domestic means that all production is carried out in a single country serving both home and export markets. Regional approaches set up factories and networks located in a particular geographical region, such as Europe, North America, Far East or South Pacific areas, sharing similar cultural value systems. Multinational approaches, with trans-regional dispersion, involve factories located in several economic sectors or countries. The geographic dispersion can cause large social and psychological differences. Worldwide, an extreme case of the geographic dispersed approach, involves the establishment of many manufacturing operations around the world.

3.3.3. Strategic capabilities of the international manufacturing network

In the international manufacturing networks, strategic capabilities derived from the system configuration can be categorised into resource accessibility, thriftiness ability, manufacturing mobility, and learning ability (Fig. 3) (Dunning, 1994; Ferdows, 1989; Yip, 1992). The capability of a firm is to renew, augment, and adapt its core competencies over time. Capabilities thus reflect the firm’s latent competencies (Teece et al., 1992). As each different configuration has a particular structure and consistent operational mechanisms, each configuration has different capabilities to satisfy the strategic requirements. Severe mismatch between configuration and requirements is likely to make strong performance difficult.

The resource accessibility of the network means the ability to establish and serve a ‘presence to the marketplace’ and to reach the other corporate strategic resources. The thriftiness ability is derived from coordination and/or integration of the network. It reflects the ability to develop more efficiency through networking. Combining accessibility and thriftiness, more competitiveness could be achieved from the whole network system through the optimised geographic dispersion of the corporate value-adding chain.

Unlike the above capabilities which could directly decide the network’s effectiveness of performance, mobility and learning represent longer-term capabilities of network restructuring. Manufacturing mobil-
### Classification of the international manufacturing networks

<table>
<thead>
<tr>
<th>The degree of plants dispersion</th>
<th>Coordination conditions in international manufacturing network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multinational</td>
<td>Multidomestic Orientation. Multidomestic-oriented strategies are characterised by manufacturing system tailoring to the local market and having autonomy. Therefore the coordination is weak in network and factories are independent.</td>
</tr>
<tr>
<td>Worldwide</td>
<td>MMC3: Glocalised Manufacturing Configuration. Glocalisation means global localisation, which is the maximum of multinationalisation. This strategy is strong market and local management resource oriented and autonomy focused. But, some Japanese companies, like Honda (Mair, 1994) and Mitsubishi (company file), are adopting this strategy. The competitive advantages could be generated from taking full advantage of local resources, especially, national characteristics to have real adaptability, in terms of quick responsiveness and special service, and network synergy, in terms of product R&amp;D, capability and culture fusion, from the autonomy.</td>
</tr>
<tr>
<td>Domestic</td>
<td>MMC1: Regional Uncoordinated Manufacturing Configuration. Its international manufacturing disperses centrally in only one region (Europe, Far East, Northern America...) and the plants are tailored to the local country or regional market. There is no coordination between the plants. As the culture is very similar in the region, there is no serious problem for manufacturing transfer.</td>
</tr>
<tr>
<td>Domestic</td>
<td>It does not belong to the international manufacturing networks because it has no transnational manufacturing operations.</td>
</tr>
<tr>
<td>Worldwide</td>
<td>GMC4: Global-Coordinated Manufacturing Configuration. Its manufacturing is dispersed worldwide with homogeneous strategy-separated facilities and shared product, technology and operation mechanism. Generally, the configuration includes global product and standardised process and managerial mechanisms. The network disperses its nodes globally to access the markets. McDonald and KFC could be good examples. Many automobile component firms also try to follow this path. When company focuses more on its core competence and adopts advanced manufacturing technology, the factory could be more integrated and easier to be distributed like KFC restaurants.</td>
</tr>
<tr>
<td>Domestic</td>
<td>GMC1: Home Exporting Manufacturing Configuration. It centralises manufacturing in home country but usually has a global logistic system. Its product lines could cover the global market. Boeing jet and Rolls-Royce car are examples.</td>
</tr>
</tbody>
</table>
ity leading to the system’s swift transfer and quick response of strategic dispersion could be directly determined by the international manufacturing configurations.

4. Case studies

4.1. Case 1—new vision of manufacturing systems

The company is one of the largest industrial and municipal boiler manufacturers in the world, which up to the 1980s adopted an export policy worldwide based on its Northern America manufacturing centre. Boiler production typically requires 500,000 to 600,000 manufacturing hours and so very expensive in labour. Since the middle of 1980s, the company has changed its policy to locate its manufacturing operations more in foreign countries, especially for bidding developing countries’ projects.

The company set up its first joint venture (JV) factories in Jakarta, Indonesia in 1984 and Beijing, China in 1986. After assessing the performances of the JVs, the company found the benefits from marketing, in terms of penetrating the national or regional markets and better service to local customers, to be much larger than the benefits from cost reduction. Especially, in China, the company’s JV soon took about 30% of Chinese market. The success in market area by manufacturing dispersion stimulated the company to establish more manufacturing bases in strategic regions in following years, including India in 1988, Turkey in 1989, and Egypt in 1994.

Such widely dispersed manufacturing systems and strong autonomy JVs transformed the company into a real multinational corporation with unique competitive position, especially in developing countries, and lead to very fast growth in the second half of 1980s. As a business manager mentioned, the company with such wider international operations has the following advantages.

- Competitively priced products, mainly by reducing transportation cost and time, and taking advantage of local labour and materials, but with the same quality assurance standards regardless of manufacturing location.
- Better local service in terms of quicker response time, knowledge of customers and their factories, and local supply of parts.
- Strong worldwide export product coverage including Canada, China, Cyprus, Egypt, Indonesia, Inner Mongolia, Philippines, Saudi Arabia, Syria, Thailand, United States.
- Enhanced eligibility for government funding with local manufacturing activities and localisation linkages.
- Flexibility to apply expertise and resources of various joint ventures to commit to customer’s deadline.

With the successful presence in the strategic regions and capacity growing in each joint venture factory, however, the company also faced serious duplication issues. Two years ago, therefore, the company started adapting its global manufacturing strategy by networking the JVs in different nations based on specialising its product lines and centralising key manufacturing processes. For example, its Chinese JV is playing more and more important role in the field of main components manufacturing, final
assembly, and engineering design service of industrial boilers, especially in high pressure sector, within the networks. Since 1986, the Beijing JV has developed its manufacturing capacity more than four times and upgraded its manufacturing capability to the 600 MW boiler from only 50 MW boiler.

JVs in the network now have more specialised product focus according to national strategic resources and existing or developing competencies, as well as undertaking routine manufacturing operations to optimise the manufacturing and transportation costs. Of course, operating such a network is much complex to design and coordinate, but the company believes this is the key success factor for its future survival.

In summary, the company has experienced three main transformation, from regional manufacturing (MMC1 in Table 2) to wider distributed and autonomised system (MMC2) and then towards global coordinated network (GMC3), during recent twelve years. The network structural elements in terms of geographic dispersion, horizontal and vertical coordination and factory characteristics determine the architectural pattern of the networks in the transformation. As the configurations were changed, the strategic capabilities were transformed from more accessibility domination towards more thriftiness, efficiency and resource integration focus.

4.2. Case 2—new motivation of development

The company has three business groups, household and toiletry, pharmaceutical, and food. Its pharmaceutical business is focused on ‘over the counter’ (OTC) sales. As the businesses had very close relation with local customers and national taste, traditionally the company adopted very sharp multidomestic strategy to pursue market growth through its manufacturing presence. Based on its aggressive foreign direct investment, mergers and acquisitions, the company positioned itself to be a truly worldwide player ‘at home in over 120 countries’ in the early 1990s.

‘‘The national market driven strategy made us very successful in foreign markets and a leading position in the industry,’’ an international manufacturing manager reflected. ‘‘At the same time, however, the duplication of our manufacturing operation cost us a lot. In some extreme cases, to penetrate a protected national market, we had to put some factories in the country first, even though we were not quite sure whether sufficient market existed. For example, several factories in South America never got chance to operate, simply because there were no actual customers.’’

The company decided to rationalise its worldwide manufacturing system from national based manufacturing towards global coordinated networks in 1995. What the company did in its most important business sector—household and toiletry—was the following.

· To restructure the world manufacturing operations into seven regions based on geographical and cultural characteristics.
· To centralise manufacturing sites based on the requirement of economies of scale to support whole regional market rather than traditionally national markets.
· At global manufacturing level, to standardise the manufacturing and managerial processes and share them within seven regions.
· At product development level, to promote the generalisation of regional products from national ones and further global products from regional ones; but all of them share the standardised manufacturing system.
· At group coordination level, to develop, introduce and implement sharable managerial processes like new product development and manufacturing operation benchmarking globally.

Such strategy is clearly different from the market-drive approach. And it is also distinct from traditional cost-cutting policy. As its group manufacturing manager emphasised, ‘‘Efficiency or cost reduction, of course, is a target. But, to foster new strategic capabilities perhaps is more important issue for the new manufacturing network design. This could include more responsiveness through our regionalised dispersion and intensive coordination between regions, learning mechanisms between regional factories through expertise sharing and internal competition. This might be basic difference between factory and factory network design.’’

Since early 1996, the regionalised global strategy has been transferred into its pharmaceutical sector. The company believes, if the global strategy can be successful in the household market, it should be
appropriate in pharmaceuticals—‘a truly global industry’ (Ballance et al., 1992). In the pharmaceutical sector, the company at first rationalised its European manufacturing sites from 16 into only three—one integrated and two specialised—bases. A very similar strategy was adopted to focus on core technology and standardise manufacturing and managerial processes. In the near future, there will be only 10 manufacturing sites serving seven regional markets.

As each manufacturing site has been standardised and focused on core technology and operations, the internal operations are much easier to manage and some learning mechanisms, such as knowledge sharing, problem solution, and various kinds of benchmarking, are adopted within the network. The emerging problem, however, is outsourcing to support this coordinated regional network. The company is facing new challenges dealing with interfirm networks. Another issue is to keep the original strength in the development of customer-tailored products and at the same time transfer them into regional or even global products effectively. It is not easy at factory level to produce different levels of products while simultaneously introducing new products.

The transformation of this company highlights effective response to current major changes in worldwide trade environment. Configuring its international manufacturing network into GMC4, the company integrated its regional products to global products, standardised the manufacturing processes and centralised the manufacturing sites based on its strategic regional markets. The company hopes that the global coordinated configuration can accelerate sharing of resources and knowledge and learning in the group to strengthen the economies of scope and scale and other capabilities for the future.

4.3. Case 3—new architecture of the network

A top pharmaceutical company in the world had manufacturing operations at 47 sites in 32 countries, utilising assets with a net value of £1.2 billion and employing 17,000 staff. Although its international manufacturing operations were more widely spread than many of its competitors, the company’s manufacturing systems were highly globally integrated along the value-adding chain. Its international manufacturing strategy embodied the following principles: (1) highly centralised strategic sites for global supply of bulk drug substances and new product development; (2) specialised and relatively widely dispersed regional sites for more complex formulations; (3) more widely dispersed and market driven local formulation/packaging sites for close relation with national or local markets.

In contrast with its other competitors’ strategies, such as the efficiency driven strategy of Merck and Eli Lilley, the dispersed packaging strategy of Astra, and the export base dependent strategy of most Japanese pharmaceutical companies, Case 3 company had a more optimised or balanced network to manufacture its products efficiently and cover its local market effectively.

ZTK is the company’s most important product accounting for more than 40% of its total sales in 1993/1994, and is also the most successful medicine in the world. ZTK’s international manufacturing network is a very good example of the company’s international manufacturing strategy and the network design principles.

ZTK’s bulk drug substances were manufactured mainly in the UK and Singapore. In fact, the Singapore factory supplied most of the regional formulation sites apart from the UK. The formulation processes for ZTK were dispersed to some of its 24 strategic and regional secondary sites, which covered every continent. As the manufacturing process of ZTK tablet is robust and relatively simple, the secondary sites generally integrated the final packaging process to supply local markets directly. Besides the strategic and regional secondary sites, more than 20 local formulation/packaging sites were used to access other local markets.

Before ZTK’s success, the company was a UK-based pharmaceutical manufacturer ranked number 25 in the world. Great global market opportunities from ZTK pushed it into being a global reach company. But it is worth noting that, unlike other market driven companies, ZTK’s manufacturing network, based on wider geographic dispersion, was also highly integrated rather than purely multidomestic. Experiencing fast geographic expansion in the 1980s, the company rationalised its world wide manufacturing operations since the early 1990s. It changed its loose linked sites into more integrated and better
coordinated networks especially along the value adding chains. For ZTK’s networks, more complex formulation processes were more centralised.

There were a few differences between the main product lines. For many newer products, they appear to have more centralised and closely coordinated networks, compared with ZTK’s networks. This was mainly because of the better international trade environment, especially in some free trade regions, but also partly because of the earlier product life cycle, and partly because they were more potent compounds requiring lower manufacturing volume. The main trends in the company, therefore, were to develop more integrated networks along the value adding chain based on its existing dispersed sites.

In summary, such balanced or optimised global integrated manufacturing networks, more GMC3 (Table 2) oriented, have clear advantages in higher efficiency, a high level of quality and supply control security, exploitation of both manufacturing sites and local market opportunities, and higher responsiveness to various kinds of changes. But on the other hand, some weaknesses include difficulty of minimising cost of production and supply, some underutilised bases and fragmented supply chains, diffused control of global manufacturing, and little immediate contribution to the competitive advantage from highly coordinated and complex network operations.

4.4. Case 4—new mechanisms of manufacturing system

The company is a leading manufacture of bakery food processing equipment. During the 1980s, through a merger with another liquid food processing machinery company and wide range of acquisition, the company grew very fast and developed a strong presence in different geographic markets. Two factories in the States serve the whole American continent, an Australian factory supplies the south Pacific region, and two factories in UK cover the markets of the rest of the world.

One of the main characteristics of the company’s products is its made to order, one off or very small batch, and ‘highly customer engineered content’, although there is a product catalogue guiding the order. The company has a large range of products, approaching more than 500, and has been trying to modularise its designs for a long time to balance customer’s featured requirements and internal manufacturing efficiency. Up till 1993 when the company identified new directions of market and product, little progress had been made.

The company has similar manufacturing facilities at its different locations around the world. This is largely because its products are tailored to the customers, its acquisition of similar companies, heavy weight and expensive transportation of the products, and different standards of product and engineering in the areas in which it operates. This multidomestic product strategy and manufacturing duplication historically helped it to access the different countries and compete effectively.

But many markets in traditional regions have seen sustained period of growth, with rising demand for higher quality products. On the other hand, for serving new growing markets, the company faced the problem of penetrating the developing countries’ markets where its products are quite price sensitive. In order to meet the new challenges the company was faced with a number of options: 1) to reinforce the current approach with more highly focused manufacturing and duplicated operations to satisfy the local market; or 2) to develop its competence to challenge the global market with dynamic capability without trade-offs between higher quality and lower cost; or 3) to diversify the business by merging or acquiring new business to develop a totally different new competence.

The company decided it would develop new capabilities to face the global competition. It adopted a set of new business global policies including developing global products, restructuring the business value-adding chain, and implementing the strategy through pilot testing.

The company has developed its first generation of world product through the coordination of the engineers in three continents, thanks to the modern communication technology. The development was never easy, the R&D cost of the new world product was 60% higher than the normal one. “But it is necessary learning fee.” Besides the world product, the company also set up a product module system to cope with global homogeneous demand and national specific demands. It developed the engineering plat-
form for new product development in the future by standardising the international and imperial technical standards.

Paralleling with the development of the world product, the company restructured its UK manufacturing factories as a pilot testing for the manufacturing globalisation. Before the change, the duplication of manufacturing not only happened in different countries but in the UK and USA. Based on their different manufacturing competence, the company centralises the manufacturing operations in different factories, one focuses on the two-dimensional components fabrication for tins and cans; another focuses on the metal process, control system and final equipment assembly. Such change, as a pilot test, wins more economies of scale without compromising quality and delivery. The company is currently transferring this mechanism to its factories in the States.

In the future, the company plans to set up a new factory in China to cover the Far East market, which means the company has a global product and relatively standardised manufacturing process shared by six factories in four continents, which configures its network more like GMC4 in Table 2. This will promote efficiency by coordination and learning. At the same time, it also increases the accessibility to the markets and different kinds of resources. The duplication of manufacturing operations based on similar systems in different continents, as mentioned by the managers, is largely because of the huge transportation costs, but it could increase the dynamic responsibility for the global change of the demands. Some more common parts, such as the control box, may be centralised further in the further future.

5. Findings and revised models

5.1. Driving forces towards globalisation

Globalisation of manufacturing has two clear characteristics—geographic dispersion and interdependent coordination between factories (Porter, 1980; Ferdows, 1989; Bartmess and Cerny, 1993). As the cases in Section 4 show, however, the driving forces behind the dispersion and coordination are complex and different. Understand of these forces is essential to the understanding the missions, capabilities and behaviours of manufacturing globalisation.

Geographic dispersion of the manufacturing networks is drawn by external forces, especially new market opportunities. Emerging global markets (Levitt, 1983; Yip, 1992) have fuelled development of global product and related strategies in classical global industries such as pharmaceuticals and electronics and also customer dominated industries such as household products and engineering, as demonstrated in the cases. Fast growth of some developing countries is another key engine of dispersion. Recent annual reports of UNCTAD (1992, 1993) show that the dominant countries getting foreign direct investment (FDI) are developing countries. Many manufacturing managers share the same opinion as Gomez of Thomson—"you do not choose to become global. The market chooses for you; it forces your hand" (McCormick and Stone, 1990). Besides market attractiveness and local presence strategy, global competition is another driving force dispersing manufacturing to access strategic resources along the value-adding chain (Porter, 1980). In our case studies, however, the global competition pressure appears to cause more concentration or integration of manufacturing rather than the dispersion to access the economies of scale. In general, however, dispersion of manufacturing networks is a very powerful, competitive weapon to access market and fuel company growth. When we study the restructuring of networks towards more integrated and specialised patterns, for example case 1 company was losing its Eastern European market to ABB, its main competitor in worldwide, simply because there was no manufacturing presence in the area.

Coordination between dispersed factories is another key characteristic of manufacturing networking in the case studies. Theoretically, the coordination is a more critical feature of globalisation than geographic dispersion (Fleenor, 1993). From the cases, regional free-trade and economic deregulation in FDI are clear drivers for Case 2 company to adopt its regionally based global strategy. For the other companies, global competition, especially the requirement for higher efficiency and lower cost without quality and service compromises, demands manufacturing coordination. Many studies have emphasised different coordination mechanisms to balance or op-
timise efficiency and tried to explore strategic motivations (Porter, 1980; Flaherty, 1986). The cases indicate that for many companies, strategic capability is much more important than the traditional drivers of responsiveness to local market requirements. Globalisation of manufacturing networks is typically the result of an internal push for extended capabilities rather than externally driver.

This kind of capability-building strategy such as the case 1 and 2 companies challenges the traditional manufacturing ‘trade-offs’ mindset. Some companies like case 3 and 2 did depend heavily on their optimised network architecture to provide competitive edge; but increasingly companies found that it is important to have a capability development process and learning mechanisms within the networks.

5.2. New strategic capabilities of manufacturing

What are the strategic capabilities that many global companies are pursuing and the networks are trying to generate? Fig. 3 suggested a framework from system structure and function aspects. Using this framework, managers in the case companies, from group manufacturing coordinators and business CEOs to project and factory managers, were interview. They identified and detailed the required strategic capabilities of international manufacturing networks from framework to a operational system design.

The new strategic capabilities of the networks can be categorised in Table 3. Like computer networks focused on communication instead of processing, the missions of the network are significantly different from those of a single factory. As a whole system, the nodes still play a transformation role in the network, but the total configuration can generate more additional functionality for both corporation and its factories.

In Table 3, accessibility and thriftiness are more directly determined by or derived from the architecture of the networks. Mobility and learning ability are dynamic, process oriented and more determined by operational stages rather than mainly design stages. While the former two have some trade-off relationship separated by the networks’ dispersion and coordination (Prahalad and Doz, 1987), the latter

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<td>Strategic capabilities of the international manufacturing networks</td>
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(1) Strategic targets accessibility. Mainly derived from dispersion of the network
- Strategic markets: beating trade barriers; closing to the customers; quick response.
- Production factors: labour; materials; energy; product and process technology etc. to tap national resources and advantages.
- Managerial skills: managerial knowledge, organisational skill, administration heritage, and corporate value and culture.
- More sensitive to global changes: understand wide range and different customer requirements; more sensitive to future trends, information, technology, competition.
- Other special benefits: nontax; policy benefits; partner’s business and social connections.

(2) Thriftiness ability. Mainly derived from coordination of the network
- Economy of scale: special for the dispersed value-added chain configuration;
- Economy of scope: wide product lines with shared R&D, engineering, manufacturing, marketing and distribution facilities . . .
- Reducing duplication of activities: for all business activities

(3) Manufacturing mobility. Mainly required and derived from dispersion of the network
- Product/process mobility: transferred technology and system for donors and receivers and robust process for such transfer.
- Managerial skill mobility: learning process for the skill, knowledge, culture, value . . .
- Factory manufacturing flexibility: wider product lines and economy of scope for global changes and competition; more flexible system for the product life cycle.
- Network manufacturing flexibility: network is more flexible for change its location, node linkages, value-chain relationship.

(4) Learning ability. Mainly required and derived from coordination of the network
- Special learning opportunity: wider internal and external comparison, exchange, and benchmarking.
- National capability integration: culture fusion, learning and tapping the special national strengths.
- Global product integration: learn from the worldwide market demands and abstract core requirements for development of world product.
two capabilities have strong synergistic power and suggest integration or optimisation.

From the cases, the indications are that the four strategic capabilities can be built up by developing the global products, dispersing and coordinating between factories. Fig. 4 tries to generalise the new missions of manufacturing systems from the cases and link them to required strategic capabilities of international manufacturing networks. It illustrates that manufacturing network systems need new structures and mechanisms to deliver the capabilities and satisfy the missions.

5.3. International manufacturing network configurations

Lack of systematic support to strategy formulation severely limits the effectiveness and efficiency of the system design. Configuration provides a better way of concisely representing an complex organisation and an approach forming an integrated view. The issues of the network design, such as geographic dispersion, horizontal and vertical coordination and the various dynamic operational mechanisms, can not be picked and chosen independently in the way ‘a shopper picks vegetables at the market’. Rather, these and other elements of the network design should logically configure into internally consistent groupings (Mintzberg, 1979; Miller, 1993).

The configurations of international manufacturing networks not only represent the structural groupings in terms of dispersion and coordination but also, more importantly, demonstrate capability patterns derived from the structures. The configuration therefore can bridge very effectively and efficiently between the strategic requirements from corporate or business level and the network capabilities during the system design. It is essential to develop a systematic way to present the networks, to provide a concise visualisation to the complex network systems of international business.

Fig. 5 presents a map for international manufacturing network configurations which groups seven configurations into four blocks, in terms of Regional Focused Networks, Global Exporting Networks, Multidomestic Autonomy Networks, and Global Coordination Networks, along vertical/dispersion and horizontal/coordination dimensions. It is populated with examples from other literature references (Flaherty, 1986; Mair, 1994; McCormick and Stone, 1990; Taylor, 1991; Maruca, 1994) and our own case work. This map shows the relationship between the configurations and characteristics of the networks and their transformation. There is quite clear trend in a number of companies towards more global configurations generating global competitive capabilities from Fig. 5.

In the global coordinated networks (top-right block in the map), there are two typical global network configurations.

- The geographically dispersed and vertical integrated value-adding chain (GMC3) reflects a drive to access the most favourable resources through appropriate location of nodes (Porter, 1980), because of each node of its VAC can access most favourable resources. Case 1 Company provides an good example of this configuration trying. Practically, pure GMC3s are quite rare. Very like the global exporting networks (bottom-right block) losing their global-covering power, GMC3 is also challenged by its limited presence and sensors in local markets.
Geographically dispersed and horizontal coordinated factories (GMC4) provides the ability to replicate and deliver a synergy advantage from a shared common infrastructure/mechanism in the network (Flaherty, 1986). Currently favoured by service industries such as McDonald’s and KFC, MacCormack et al. (1994) argue that this model will proliferate and help companies focus more on competence. The Case 2 shows this trend but the problem of increased duplication of manufacturing facilities and potential to damage efficiency remains.

Case 3 Company combines advantages from GMC3 and GMC4 by centralising and/or specialising upstream manufacturing operations (bulk of medicine and special formulation processes) and localising or tailoring down-stream operation (packaging) based on local market demands. It is a balance or optimisation between higher efficiency, control security, market accessibility, and higher responsiveness to various kinds of changes.

Besides optimising the structure of the networks, most companies in the case study are more keen on fostering a dynamic mechanism to promote learning and sharing between networking factories. This can provide unique and protectable future competitiveness. But such system may be much more difficult to manage.

In summary, the configuration map provides a practical tool underpinning the workbook for international manufacturing strategy formulation (Shi and Gregory, 1996), because it provides a better way of concisely representing an complex organisation and forming an integrated view. The issues of the network design, such as geographic dispersion, horizontal and vertical coordination and the various dynamic operational mechanisms, can be logically configured.
into internally consistent groupings. More importantly, the configuration map can bridge effectively and efficiently between the typical configurations and the network capabilities. It can be used to best advantage in the early stage of network design such as developing global vision for new global capabilities, self-assessing the network performance, configuration selecting and outside requirement matching.

6. Trends and methods of international manufacturing research

6.1. Globalisation: different perspectives and prescriptions

The term globalisation is used rather freely and there are no widely accepted definitions (Fleenor, 1993). Marketing people argue about reality of the market globalisation (Levitt, 1983; Yip et al., 1988; Baden-Fuller and Stopford, 1991). Strategists identify emerging trends in global competition and changing rules of business (Hout et al., 1982; Hamel and Prahalad, 1985; Daniels and Daniels, 1993). Manufacturing staffs tend to pursue global sourcing, seeding factories close to markets and then networking ( Ferdows, 1989; DuBois et al., 1993; MacCormack et al., 1994). As there is a lack of common language and shared vision about globalisation among these people, “their prescription on how to manage globally have also been very different, and often contradictory” (Ghoshal, 1987).

Based on the case studies presented here, manufacturing globalisation might be defined as the process of moving from an independently managed businesses serving local markets to networks of businesses serving the businesses’ chosen markets in a coordinated and optimised way. Manufacturing networks are the main outcome of globalisation and capability development is one of the key motivations of the process. Just as global strategy cannot be really operated without manufacturing networking, the manufacturing system and whole business require globalised coordination and cooperation.

In the future, the term globalisation might be lost, but manufacturing networking with vertical integration or horizontal coordination or other synergy mechanisms between factories will last in long term. From this perspective, the manufacturing competitiveness will heavily depend upon network construction and mechanisms rather than separated factory nodes. The definition of a manufacturing system therefore needs to be extended beyond the scope of factory towards the network, just as in the early years of this century manufacturing people extended their scope from separate machine towards a product manufacturing line.

6.2. Research focus: international manufacturing networks

Manufacturing globalisation, in our definition, is one kind of internationalisation involving internal coordination and external cooperation in manufacturing networks. This emphasis on globalisation seeks to overcome some of the limitations of international manufacturing strategy research.

At the highest level it is clearly important for a strategist to select the appropriate configuration to match its corporate strategic goals. However, the successful implementation of the desired international manufacturing configuration requires a great deal of detailed input, selection between options, and the process of matching and transforming. Configuration models can give some support to the decision. They can never be definitive. Managers still need some craft process and tools to make effective decisions for the network design even though the configuration could help the efficient decision-making. Besides intra-network relations emphasised in this paper, the inter-network relationship, especially with strategic alliances and other functional departments, is becoming more and more important in internationalisation. Therefore, surrounding the networks, the following issues need to be tackled in the future: (1) To develop transform strategy processes between configurations to facilitate adopting an international strategy. (2) To understand more about international strategic alliances based on manufacturing networks. (3) To explore wider network relations with other function departments, especially for global product development and capability building. (4) To explore the detailed relationship between network capabilities and factory capabilities to understand the contribution of a network to each of its nodes. (5) To identify the detailed distinctive capabilities of each
network configuration to make international strategic decision more efficiently.

6.3. Research methodology tackling the network issues

The research methodology adopted in this research project is quite unique, rather engineering oriented than social science oriented. The major reason for using the process approach is to balance both equally important issues—develop new network knowledge and design the network system. Traditional academic observation methodology can be very efficient to explore the network knowledge but not sufficient for practical design. On the other hand, the classical system engineering approach can satisfy customer requirements more efficiently but inhibits new exploration. From the cases presented, the process approach can combine both facets and integrate them in the research process. The knowledge based research part in the project can heavily involve various kinds of practitioners and generalised knowledge can be tested and modified in a relatively short cycle. This is difficult for any other research methodology.

It is clear that this methodology is not all-purpose, even though it can combine several approaches together in a process. Alternative approaches include large scale questionnaire surveys which are high efficient in developing new knowledge and illustrating mega trends. But there is a concern that the reliability of knowledge generalisation from such methodology may be inhibited by low feedback rate. Pure observation has the fundamental weakness of developing no constructive relation with business world. From this perspective, the process methodology pursuing tangible benefits to companies makes it easier to engage companies in a productive way.

A mutual trust and benefit relationship is extremely critical in the process methodology. The relationship is of course not easy to set up based on single research project. It depends on long-term cooperation and network building.

7. Conclusions

In summary, manufacturing businesses are increasingly faced with decisions involving global considerations and capability development. The literature of manufacturing strategy and of international business are reasonably well developed but the links between them are weak. The research set out in this paper suggests the following.

- Manufacturing globalisation, based on internal coordination or rationalisation rather than pure geographic expansion, clearly dominates current manufacturing business internationalisation (Fig. 5).
- International manufacturing networks are new manufacturing systems in terms of mission, structure, infrastructure, capability, and design process, which needs more detailed observation and theory building.
- A classification of manufacturing configurations based on geographic reach and differentiating between multidomestic and global orientations can provide a useful characterisation of international manufacturing systems.
- The particular capabilities which international manufacturing systems can provide to a network include accessibility and thriftiness ability, but the success of the network depends upon the mobility and learning ability in the networks (Table 3).
- Businesses need tools and techniques both to identify appropriate manufacturing configurations and to navigate between them; configuration ‘map’ (Fig. 5) can provide complementary support to international decision-making.
- Further study should focus on both internal and external network issues, and the process of global manufacturing strategy formulation.

References