The role of economic clusters in improving urban planning support

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The role of economic clusters in improving urban planning support

Economische clusters en een betere ondersteuning van de stedelijke planning

(met een samenvatting in het Nederlands)

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Chapter 1 Economic clusters: concept and instrument for improving urban planning support

Urban planning is often criticised for its poor ability to accommodate economic dynamics. The consequences of this defect are ineffective planning decisions and tensions between spatial and economic development (Friedmann 2005). In recent decades, economic clusters (ECs) have been introduced into urban and regional policy agendas as a strategy for creating and strengthening local competitiveness and performance in the globalised economy (Porter 1996, 1998a, 2000). However, applications of ECs for spatial planning or spatial policies are relatively rare. As a spatial-economic phenomenon, ECs may be a very useful concept and instrument to better support urban planning in coping with contemporary urban economic development. Research in this area will both require and generate innovative knowledge and methods, with theoretical as well as practical relevance to inform and guide policy making. This chapter opens the discussion on the potential of ECs, as a concept and instrument, to improve urban planning support by integrating spatial (physical) and economic developments.

1.1 Planning support: approaches and systems

Planning is thought of as a process for determining appropriate future action through a sequence of choices (Davidoff and Reiner 1962). It is assumed that urban planners can analyse, predict and prescribe for urban and regional development issues, which results in valuable recommendations for policy decisions. To that end, the process of planning needs to be supported with a large amount of data and information, which requires a range of operational theories and methods. With the increasing complexity of the world and the fast growth in availability of data, knowledge and information sources, improving supporting facilities based on science and technology becomes more important in urban planning.

Like society, urban planning is becoming more complex too. Urban planners are challenged to address management and development issues from several dimensions, including socio-cultural, economic and environmental, which together and in interaction contribute to sustainable development. In any given situation, it is a matter of balancing these concerns but also of setting priorities. This trend is notable in North America, but already evident in European countries like Britain, The Netherlands and Italy, where planners are being trained to work across all four dimensions of urban development:

spatial (physical), environmental, socio-cultural, and economic (Allmendinger and Tewdwr-Jones 1997; Friedmann 2005). Such an orientation is also important for developing countries which are undergoing fast socio-economic change and spatial restructuring. In addition to the multi-dimensionality issue, the complexity of urban planning stems from the fact that current urban and regional development becomes ever more interwoven with globalisation, in particular the globalising economy. In this perspective, urban planning has to deal explicitly with exogenous growth, and with balancing it with internal developments. Examples include the mobility of capital and talent versus the structure of the local labour force, local area development versus interregional cooperation, and main infrastructure investment versus promoting regional economic growth. Such complexities make urban planning more dependent on information and on scientific and technological knowledge, but also on methods to generate and process the data and information.

Urban planning support is an instrument to improve the work of planners and to better facilitate political decision making. It may emanate mainly from professionals, but should also be developed with active participation of citizens and various professional stakeholders. One of the major approaches to realise adequate urban planning support is to develop and innovate dedicated tools, information, and knowledge for understanding planning issues for facilitating the interaction between and cooperation of relevant groups like planners, designers, engineers, politicians and the public, and for helping to create a dedicated and supportive institutional environment for urban planning (Geertman 2006).

Recently, the integration of theories, technology and planning tools has seen the emergence of Planning Support Systems (PSS). As a precursor, Harris (1989) coined the term and defined PSS as ’appropriate computer-based models and methods that can support urban planning‘ (Brail 2008). Later, the view of PSS was broadened. PSS is now seen as a framework which comprises of three sets of ideas and functions: (1) supporting the planning process by various models or conceptions of the system of interest and the problems which planning aims to resolve; (2) informing the participants in the planning process by employing system models to analyse, predict and prescribe; (3) transforming basic data into information, which in turn provides the driving force for modelling and design (Harris and Batty 2001a, p37; Geertman and Stillwell 2002, p6). Intelligence, knowledge, technology and various tools are integrated to improve the ability and capacity of PPS. This, however, leaves the question open on how to integrate modern, advanced tools with theoretical rationalities.

The inception of PSS is largely attributed to the rapid development of computer and information technology (Harris 1965; Klosterman and Landis 1988; Harris 1989; Brail and Klosterman 2001). Accordingly, a series of automated systems have been developed. For example, the METROPOLIUS system models household and job location based on the model of Ira Lowry (Putman and Chan 2001); TRANUS integrates land use and transport choices based the discrete choice theory (Barra 2001); FLOWMAP is developed based on transportation models (Geertman, Jong, and Wessels 2002). More complex models are INDEX, which can monitor, evaluate and explore scenarios based on ranking and weighting of indicators (Allen 2001), URBANSIM, considering land markets and demand-supply interactions in a dynamic city development (Waddell 2001), and COMMUNITY VIZ, which can generate two- and three-dimensional visions of the (future) spatial reality for citizens and communities (Michael and Bernard 2001).

The development of this type of computer programs can improve the efficiency of the work of planners. It facilitates the automation of recording, retrieving and analysing data, and highly improves the ability to organise and manage information, alleviating planners and researchers from onerous data related tasks (Harris 1989). And more importantly, the possible consequences of initiatives and proposals can be explored (computed and visualised) (Brail and Klosterman 2001), or policy choices can be directly linked with other indicators to predict future changes, for instance to answer *what-if?* questions *(*Klosterman 2001*)*.

A pronounced feature of PSS is that these systems are developed in a Geographical Information System (GIS) environment, taking advantage of GIS technology in modelling, representing, visualising, monitoring, processing and communicating (Holmberg 1994). Refering to urban planning, Webster (1993) categorises the value of GIS as: managing and processing data, facilitating the building of accurate, speedy, and sophisticated problem-oriented systems, providing methods of system analysis and cost-benefit analysis, and providing information required by planners through descriptive, predictive and prescriptive analyses. Using GIS, planners can project demographic, land use and economic changes in cities or communities and estimate effects and impacts (Hopkins 1999; Harris and Batty 2001b). Planning initiatives and policy choices can be visualised, which may be the most impressive ability to improve communication between planners and policy makers (Holmberg 1994; Alshuwaikhat and Nkwenti 2002). Moreover, the combination of GIS and web technologies encourages the participation of the public in the planning process. This facilitates the transition of the

planning tradition from *who plans for* to *who plans with* (Geertman and Stillwell 2002). In this way, the adoption of GIS-based or -oriented technologies supports a participatory, collaborative and/or interactive approach in urban planning (Alshuwaikhat and Nkwenti 2002; Geertman 2002).

It is however widely recognised that most PSS are technology oriented (Brömmelstroet 2009) rather than planning oriented and that these systems meet bottlenecks in widespread application in the planning practice (Vonk, Geertman, and Schot 2005). Strong voices, even from PSS experts, point out that the function of GIS in supporting urban planning remains far from optimal (Stillwell, Geertman, and Openshaw 1999). GIS-based tools still only play a limited role in planning specific tasks such as storytelling, forecasting, analysis, sketching (rapid and partial description of alternatives) and evaluation (Klosterman 1997). The computer-based or GIS-based support tools are criticised for being far too generic and complex, inflexible and incompatible with most planning tasks (Klosterman and Landis 1988; Harris and Batty 1993; Geertman and Stillwell 2002; Vonk, Geertman, and Schot 2005). There is a serious need for a more explicit focus on the planning and support aspects of PSS instead of, as is often the case, on their system aspects (Geertman and Stillwell 2002).

Although technological tools can support the planning process, the right understanding of relevant concepts developed for urban and regional development still play a decisive role in the success of the process. It is important to note that geographically referenced information and spatial analysis techniques alone cannot adequately support all necessary planning activities (Harris and Batty 1993; Klosterman 1999). Planning processes are function-led, rather than technology-oriented (Geertman and Stillwell 2002). The planning support systems must be designed based on their application value and not on a particular technology and should include only tools appropriate for serving particular needs of planning (Hopkins 1999).

Urban planning support, though being better facilitated with the advancement of computer-based technologies, may need to be further developed so as to better fit the complex dynamics of the real-world planning context (Geertman 2008). Planning itself can be facilitated but cannot be automated in a computerised way following standard procedures (Harris 1989). Although planning tools quite often can be transferred from one planning case to another, planning processes themselves are seldom replicated(Geertman and Stillwell 2002). Basically, they are interactive processes between planning notions, ideas, concepts, decision-making trajectories and GIS oriented information technologies (Batty 2008, p11).

To strengthen planning support, the multi-dimensionality of current urban and regional development should be carefully considered as well as the information demands from policy making. Practical ideas and approaches need to be explored. As Healy (1997, p8) states: “planning is a continual effort to interrelate conceptions of the qualities and social dynamics of places with notions of social practices of shaping places through the articulation and implementation of policies”. Physical planning is a subset, aimed at guiding physical shape and form, the morphology and spatial organisation of an urban region. Urban planning support can therefore be decomposed into two interacting lines of information processing: one dealing with physical development and the other with spatially relevant non physical development. Both are linked to public decision making in an institutional context (Figure 1.1).

The physical framework for planning support deals with physical-spatial attributes of urban development such as allocation, urban form and spatial organisation, which more or less corresponds to many current GIS-based planning support systems. The non-physical, framework deals with socioeconomic and environmental aspects of urban development that is relevant for physical urban planning. As Harris and Batty (2001b) claim, a predictive system is needed to deal with future trends in population growth, age composition, migration and economic development. The process of decision making is embedded in an, often region specific, institutional context in which planning style, political context, and the legal and organisational regulation of plan and decision making are major elements (Geertman 2008).

The main components of each line of planning support are: intelligence, theoretical and practical knowledge, technology and methods and tools/instruments. These components are present in both the physical and the non-physical line of planning support. But each line requires specific disciplinary expertise. Data and methods based on geo-information science and technology are dominant in the physical line. Social and economic sciences play a major role in the knowledge and methods in the non-physical line.

In order to better support the urban planning process, the physical and non-physical line should interact. A straightforward reason is that most urban change has physical and non-physical characteristics. For instance, population growth and household formation is directly related to changes in quantitative housing demand. Changes in household income level and lifestyle influence qualitative housing demand. One of the major concerns is that urban planning is poorly linked to economic dynamics (Friedmann 2005). Lack of socioeconomic concerns weakens the probability that urban (master)

plans and programmes can be realised in practice. This leads to ineffective planning decisions or even creates tensions between spatial and economic development.

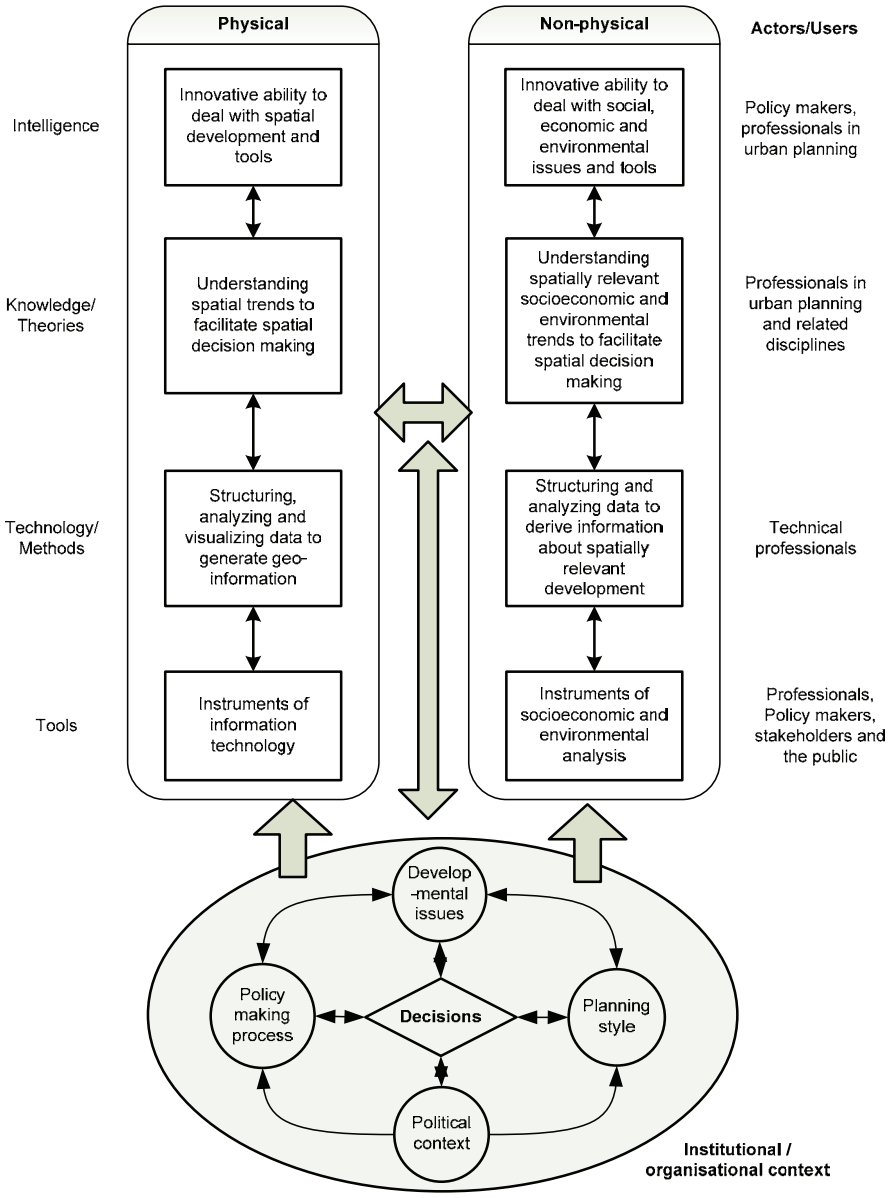

Figure 1.1 Support for urban planning: physical and non-physical information support lines and institutional context

To better support urban planning, support systems should have the ability to accommodate new issues and come up with new ideas. As

planning is essentially oriented to the future, the knowledge about new issues plays a crucial role in improving urban planning support. To a large extent, urban planning support should pay attention to long-range problems and strategic issues (Geertman and Stillwell 2002). It can be ascertained that in improving the ability of urban planning support, intelligence and knowledge play an important role, probably more so than technology and tools.

Intelligence, knowledge and information from both physical and non-physical domains should contribute to a well-designed plan or programme. Communication of perspectives and plans, both physical and non-physical, can highly improve the insights into planning issues. Stakeholders and the general public (citizens, visitors) should be involved. This may give rise to innovative or new ways of looking at problems and solutions and should be incorporated into PSS.

Improving the intelligence of PSS is quite often directed at strategic issues. They usually exert wide and long-range influences for urban and regional development. The recent development of ECs is a prominent example. As a both economic and spatial concept and reality, the EC has become a topical issue in urban economic policy. But it is not yet sufficiently elaborated as an element of urban spatial policy. This study will explore the instrumental roles of ECs in improving the ability of urban and regional PPS to effectively integrate spatial and economic concerns.

1.2 Economic clusters: potential roles in supporting urban planning

ECs are a topical issue in urban and regional development. As an economic-spatial entity, the idea of ECs has both scientific and practical significance for economic and spatial domains. It regularly appears in contemporary discourses on urban economic development policies. Application of ECs in spatial policies is rare. It requires a combination of spatial and non-spatial knowledge, theories and methods. However, ECs potentially provide a concrete and important concept to analyse complex urban dynamics and an instrument to improve planning support.

1.2.1 Economic clusters: an exploratory scientific concept

ECs refer to a relatively geographically bounded group of similar, related or complementary enterprises which are functionally interconnected and share a common local infrastructure and institutional environment. It is a concept describing both an economic

and spatial phenomenon in urban structure and development. It captures the close relationship between firms in economic operation and sectoral interactions. It also acknowledges that such a relationship/interaction can give rise to and in turn be strengthened by the spatial convergence of economic activities at a certain geographical scale.

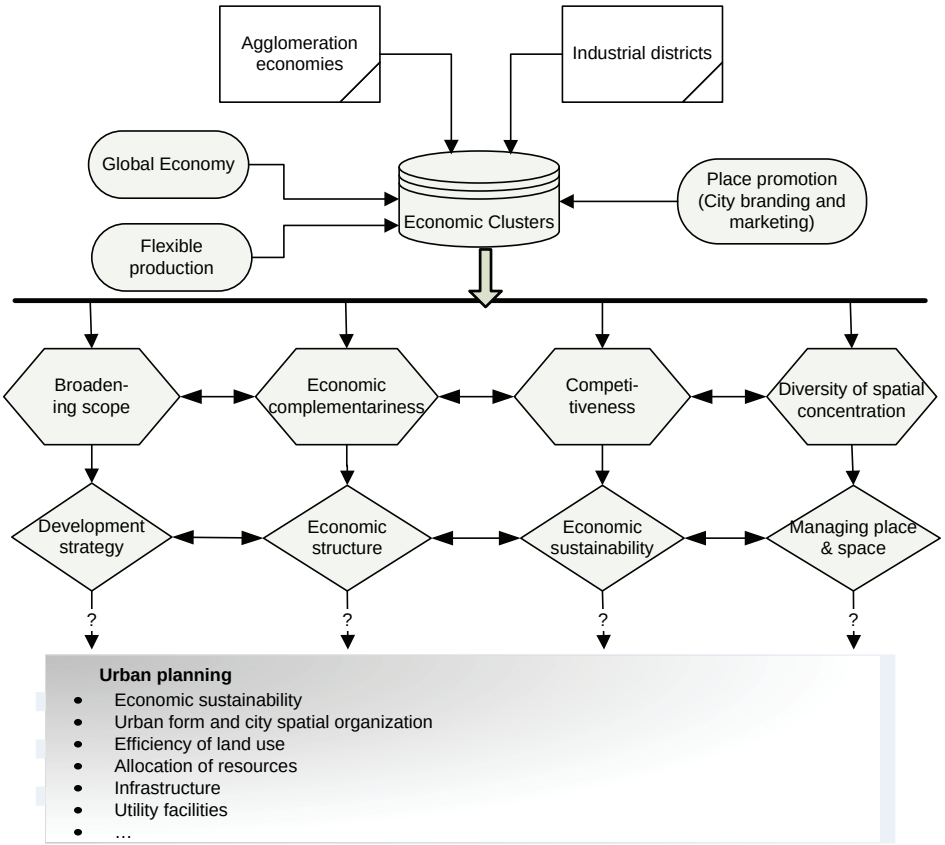

Figure 1.2 Economic clusters and their role in urban planning

The concept of the EC provides a scientific field to theoretically explore economic and spatial phenomena (Figure 1.2). It draws the interests of economists in addressing *agglomeration economies* and geographers in determining *industrial districts, both* with the aim to explore the reason and impact of spatial concentration of economic activities. In addition, current concerns regarding the globalising economy and flexible production systems add values to the notion of ECs (Hutton 2000, 2006). Related changes in economic organisation and the significance of localised economies are used to promote city

growth. At the same time, local initiatives for enhancing economic performance have emerged as a reaction to the growing competition of cities, largely induced by the globalisation of markets (Mihalis Kavaratzis 2005; Gospodini 2006). Place promotion or city marketing is acknowledged as an important aspect of urban policy (Young and Lever 1997; Mihalis Kavaratzis 2005). It is closely linked to development goals and implemented by trying to create and establish (more) identity or a (better) image via architectural aesthetics and social and cultural uniqueness. The established images of places can then be used as a strategy to market or advertise a city.

ECs can be related to a number of characteristics of contemporary urban and regional development (Figure 1.2). Starting with manufacturing, ECs gradually expanded to cover the entire scale of economic activities, such as agriculture, business services and consumer services (Rosenfeld 1995; Rosenfeld 2000; Keeble and Nachum 2002). This trend gives ECs the potential to become part of new spatial development strategies. Needed is a transformation of policy thinking, from individual industrial establishments to a group of related businesses or firms. Urban and regional policies can be 'upgraded' with the concept of ECs which will improve the traditional sector-based policies. This upgrade involves the transformation of economic structures as a response to the increasing importance of the role of demand in the contemporary economy. This is quite different from the working of agglomeration economies in most applications of the last century, when the main focus was cost-saving. The current cluster concept is interested in knowledge innovation, which is based on interactions between similar and complementary firms and industries (Porter 1998b; Lorenzen 2005).

As the EC notion proliferates, competitiveness becomes the most prominent issue. It brings together the phenomenon of industrial localisation and regional development strategies (Porter 1990). Stemming from the growth of clusters, competitiveness can benefit the region in attracting and retaining firms, capital and talent so as to realise economic sustainability. This belief also stimulates place promotion programs in many cities and places such as city marketing and branding.

In Porter's ideas, the role of the geographical level is however somewhat obscured. It seems that Porter and other business strategy thinkers take the geographical proximity of firms by default (Martin and Sunley 2003). Actually, some observers have pointed out that contemporary clusters have a 'distanced' character and may concentrate at several locations in large city regions (Scott 1982; Mills 1992; Porter 1998b; Maskell and Lorenzen 2004; Sturgeon, Van Biesebroeck, and Gereffi 2008). The elasticity and diversity of the

spatial concentration of economic activities is a new issue in urban and regional spatial-economic development.

Exploring theses ideas of ECs helps us understand the complexity and multidimensionality of the urban development process. An EC based analysis focuses the policy making process on targeting linkages among industries and firms, and the linkage between economic and spatial development, so that the effect of policy arrangements can be leveraged. This knowledge can be applied to support the current and future urban and regional planning practice. To that end, knowledge, theory, technology and tools are required to integrate the economic and spatial domains. On the spatial side, these explorations will generate insightful perspectives and suggestions on planning issues such as incorporating economic sustainability, reshaping the spatial organisation of cities, improving land use efficiency and managing industrial allocation, infrastructure and utility facilities.

1.2.2 Economic clusters: a policy tool

During the last two decades, ECs have become a reality in urban and regional development. Important clusters have developed in North-American, European, and East-Asian countries (Audirac 2003; Hallencreutz and Lundequist 2003; Rosenfeld 2003; Hospers 2005; Cortright 2006). The types vary from industrial (manufacturing) clusters, business (office) clusters to knowledge and creative clusters (Porter 1990; Rosenfeld 1996; Bergman and Feser 1999; Wu 2005; Maskell and Malmberg 2007). According to a survey in 2003, at least 500 clusters were identified at different levels by the Organisation for Economic Co-operation and Development (OECD), World Bank, national governments (such as the United Kingdom, France, Germany, the Netherlands, Portugal, and New Zealand), and by local and city governments (US states) (Sölvell, Lindqvist, and Ketels 2003)[i].

In the global economy, cities and regions are the main arena for organising economic activities and for coping with exogenous developments (Krugman 1991). The performance and competitiveness of cities does correlate with the growth of ECs (Porter 1990, 1996), which generate spatial convergence and diffusion of resources, capital and talents. Given their intrinsic spatial and economic relations, ECs provide a possibility for integrating spatial and economic planning processes for urban and regional development (Figure 1.3).

Policy intervention, so far, is mainly initiated through economic policy agendas. Important economic incentives include taxes, the availability of specialised labour and the size of markets to create

strong economic clusters that can realise increasing returns to boost economic development. In order to achieve such a situation, various forms of collaboration need to be established, such as the synergy between universities, research institutes and firms to carry out joint labour training programs, joint innovation projects and regionally synchronised industrial policies. Such collaborative mechanisms will create a vibrant economic environment, especially for facilitating the development and transfer of technology towards real production. It makes it possible to avoid the trap of decreasing economies of scale and scope.

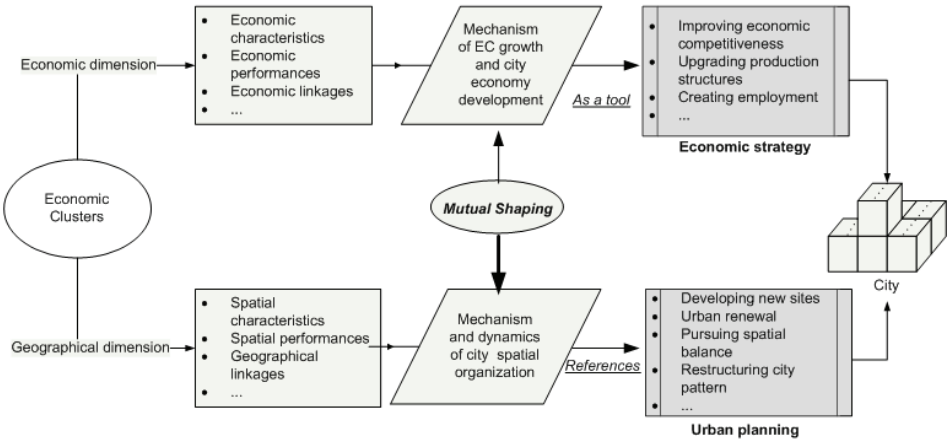

Figure 1.3 Economic clusters: a 'sum' strategy for urban development

Taking advantage of ECs, economic policy goals can be achieved such as improving local economic competitiveness by promoting and supporting high-tech and high-end business clusters, upgrading production structures by introducing new technologies and by raising levels of education and training and creating more jobs (Figure 1.3). To pursue these aims, a series of templates are devised and suggested (Bergman and Feser 1999; Atherton 2003; Ketels 2003; Rosenfeld 2003). It is fairly common now that regional economic strategies are based on a particular group of firms with the aim to benefit the local economy and to provide an access to the global economy.

Economic and spatial developments are often interrelated. This is particularly evident in ECs. Convergence of firms, investments and business in a particular geographical area creates the formation and growth of ECs. The development of ECs gives spaces and places specific economic and social characteristics. Many places and spaces have their own identity, a localised environment with a particular lay-out and architecture, traffic system and life and work styles

(Gospodini 2006). To some degree, economic clusters can attribute to the image of cities and regions, influencing their attractiveness for visitors and investors.

Many ECs are anchored by establishments of large multinational companies. In the global economy, multinational companies play a dominant role and greatly affect local economies. These companies relatively autonomously manage their business, capital transactions, production organisation and allocation of personnel. Quite often, their frequent global reorganisations directly impact local production system, such as introducing new suppliers or distributors and changing number and type of employees. The multinational company is a focal point for introducing new information and technology into the local production environment. Other ECs may primarily be a constellation of medium and small sized enterprises, which are deeply embedded in local production, service and capital networks. The developments of ECs are also closely related to local or regional social environments, for instance through networks of persons (within and outside the business community) and information transfer. Hence, behind the visible geographical clustering, there are many invisible linkages that tie the developments of ECs and the city and region together.

These linkages can change the spatial organisation of a city. Especially, economic linkages play a dominant role. For example, the changes in vertical industrial linkages have altered the traditional location pattern of enterprises in southern California (Allen Scott, 1988, cited by Anas, Arnott, and Small 1998). The disintegration of vertical production chains shaped the geographical structure of a number of industries, including: electronics, animated films, and women's clothes. Recently, the forming of ECs is more based on complementary and cooperative relations. Examples are the concentration of firms with similar activities in one place to share business information, and the cooperation between firms and research institutes. This change shows that ECs are not developing in a hierarchical way but as networks with a comparable spatial footprint. If the EC is successful, it brings more economic activities and an increase of employment in a particular area. This in turn results in a higher demand for infrastructure and utility facilities. But employment, residential and traffic patterns are also likely to change.

The increased competition for mobile capital and labour creates a so-called 'economic war' between communities. Both employers and workers can 'vote with their feet'. Municipalities and regions seek to create environments that are attractive to industry, residents and capital investment (Morgan 2004). The effect of ECs on economic, social and spatial structures of a city can quickly take shape.

Therefore, the study of the spatial performance and geographic linkages of ECs is both from a scientific and a policy point of view important. If the interrelated drivers of the spatial development of ECs can be disclosed, especially focussing on the economic mechanisms at work, knowledge about ECs has a high potential of improving support for urban planning and decision making. This is relevant for various planning issues, like new areal development, urban renewal and spatial restructuring of city regions (Figure 1.3).

1.2.3 Economic clusters in urban planning practice

In practice, ECs are quite different from their theoretical prototypes; moreover they vary greatly in different socioeconomic contexts. ECs are usually known as various types of industrial zones, office parks, logistic nodes and special business streets and districts. The industrial zone concept was developed in the United Kingdom and later as 'enterprise zones' disseminated to the United States (Oakley and Tsao 2007). When the knowledge economy took shape, in particular the new information and communication technology, Silicon Valley developed as a regional EC and became an example to be followed. Thus, high tech industrial and service parks became the most popular type of policy initiated economic clusters and they can be found in America, Europe, China and India. Politicians use geographically targeted tax incentives and relaxation of regulations as instruments to encourage job creation, business activity and to improve the environment (McCarthy 1998). The development of ECs is a typical place-based investment and local authorities are aware of the importance of this type of investments.

With the development of ECs, many macro and micro level planning issues emerge (Figure 1.4). On the micro level, a local project should be developed in consensus between private and public interests. For instance, the London Docklands Redevelopment Scheme is developed with a consortium of British, Dutch and American developers (Brindley, Rydin, and Stoker 1996, p113), and the Beacons for a Brighter Future Partnership in Manchester is formed for regenerating the legacy of a heavy industrial past over a 30 year period[ii]. Other recent cases include the Greater Toronto Marketing Alliance[iii]. Many stakeholders active in economic cooperation are also key players in urban planning. The private sector can play an important role in spatial planning with respect to location preferences and choices and regarding the optimal size of the EC. Being involved in ECs, the private sector can be relatively easily encouraged to also participate in spatial planning processes. Public and private partnerships help establish mutual understanding of interests, perspectives and actions with respect to EC development. Co-financing and budgeting

mechanisms in public private cooperation can be built up, which relieves budget limitations met by local authorities on spatial projects and improves the economic efficiency of public investments in infrastructure.

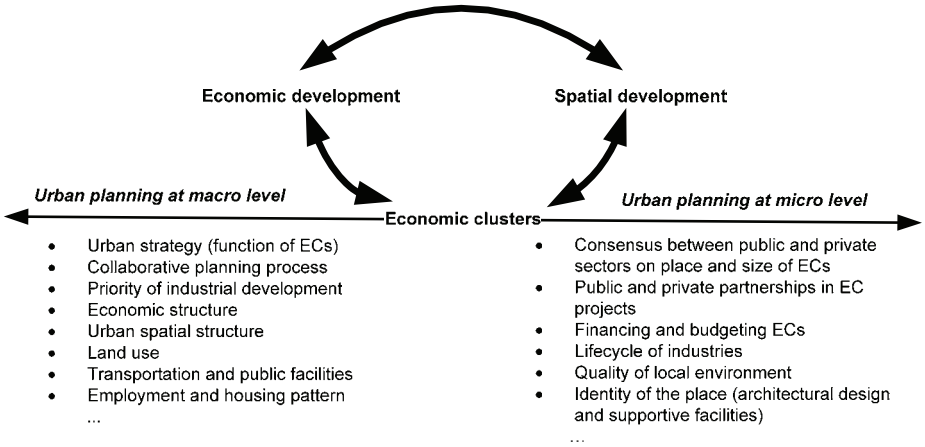

Figure 1.4 Economic clusters and related urban planning issues

The lifecycle of industries and the stage of ECs are crucial for economic performance, which is directly related to market conditions but also associated with the business environment. Among others, improving the identity of places is an important planning task to create a proper environment to attract and accommodate firms. This may include various aspects, from the layout of functional areas to architectural styles and from the provision of public facilities to micro transportation systems within the site of ECs.

The development of ECs is also relevant for planning issues at the macro or city (region) level. It is a major aspect for many urban strategies aiming at economic sustainability. Improving economic competitiveness and designing proper spatial development schemes are important action points in this respect. In dealing with these issues, a more integrated analysis of urban patterns is needed, which can be based on case studies of individual behaviour in an urban setting (Batty 2000; Alfasi and Portugali 2007). ECs provide a good object of study as they are an example of various interrelated urban development processes. This object includes the evolvement of actors, activities, flows and facilities so that planning can be directed to the substance of decisions and the impact on cities (Hopkins 1999; Alfasi and Portugali 2007). Such a redirection is urgently needed to complement an approach that stresses procedural planning processes.

By focusing on ECs, a collaborative planning process is encouraged involving cross-disciplinary scholars and cross-department policy makers to communicate and share different perspectives on planning issues. Spatial development planning should include a full understanding of economic dynamics and urban spatial structure should be regarded as the composite result of both economic development and the created physical infrastructure. Addressing issues such as quality of living, the sustainability of the environment and economic efficiency of urban land use and transportation systems will benefit from integrated approaches with positive implications for urban planning.

1.3 Research framework

1.3.1 Objective and Research Questions

The aim of this PhD research is to **explore the roles of ECs in strengthening the analytical and monitoring ability of urban planning through better accommodating urban economic dynamics**. Towards this end, the research, including an empirical study of Beijing, examines the evolution of ECs in both economic and geographic space. We refer to *functional clusters* as the representation in economic space and use the term *spatial clusters* to describe the geographic pattern of functionally related activities.

Related to the main aim, the three research questions are:

(1) How to conceptually incorporate ECs into models of urban planning processes in order to improve the latter's capacity to deal with economic development?

(2) How to practically implement the idea of ECs in urban planning analysis with a case study of Beijing?

This question can be subdivided into two parts:

- How to identify functional clusters and spatial clusters with up-to-date dedicated cluster analysis techniques?

There are several shifts both in economic and geographical discourses about ECs. This sub-question deals with how to employ functional clusters to support economic strategy and how to connect them with spatial clusters.

- What can be the role of spatial-economic clusters in improving current urban spatial planning?

Following the study of the spatial manifestation of ECs, this question analyses associated implications for urban planning.

(3) How can ECs form an instrument to improve urban planning support?

The answer to this question will highlight the value of incorporating ECs in planning analysis for improving policy decision making processes. Further, the theoretical and technical aspects of applying ECs in urban planning support systems will be discussed.

1.3.2 Outline of the thesis

After this introductory chapter, chapter 2 conceptually explores the notion of cluster evolution and the rationality of incorporating this concept into urban planning. Chapter 3 introduces the geographical context of Beijing. Chapter 4 identifies Beijing's functional clusters by means of input-output table analysis for the periods 1983-87, 1988-92, 1993-97 and 1998-2002. Correspondingly, chapter 5 examines spatial clusters for each period. Based on identified functional and spatial clusters, chapter 6 analyses and discusses the urban economic-spatial dynamics and the mechanisms of EC development. A reflection will also be given on the current urban economic and spatial policies. Chapter 7 concludes the thesis by summarising the major findings and outlining a ECs-based framework for future development of planning support systems.

Endnotes:

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[i] The "Global Cluster Initiate Survey", in 2003, was organized by VINNOVA, ISA, NUTEK, TCI, CIND (Uppsala University) etc. Based on this survey, one report, Cluster initiative Green Book, has published, Sölvell, Lindqvist et al. 2003.

[ii] The Beacons for a Brighter Future Partnership, available online: http://www.eastmanchesterndc.com. Last accessed 12th December 2007.

[iii] The Greater Toronto Marketing Alliance, a partnership of GTA local governments, the governments of Ontario and Canada, and private firms, serves as a key point of contact for businesses exploring investment opportunities in the GTA. About the GTMA, available online: http://www.greatertoronto.org. Last accessed 12th December 2007.

Chapter 2 Economic clusters: linking economic and spatial policies

This chapter explores the rationality of Economic Clusters (ECs) as an instrument for effectively integrating urban planning with economic policies. The EC is an evolutionary concept in urban and regional research and practice with, until now, only limited applications for spatial-economic development. An integrated economic-geographic approach is desirable to improve both cluster studies and urban strategies. The evolution of cluster concepts is examined, highlighting their associated value for policy application. Next, according to the reprehensive cases of ECs in the world, a generic illustration is made to show how ECs organise urban spatial economic activities. At a macro-level, evolutionary and neo-classical economies provide a framework for the analysis of the growth of ECs and its roles with urban development, in which major players are governments, globalisation and market economy. The theoretical and practical explorations cast light on some perspectives on the application of ECs for urban economic and spatial policies. The chapter mainly addresses strategic issues and focus on the instrumental role of ECs in improving urban planning support. Based on literature study, a model is developed for empirical cluster research that aims at sustainable urban development.

2.1 The evolution of cluster concepts

2.1.1 Define economic clusters: dimensions and levels

The term cluster describes a phenomenon that firms are not randomly distributed over space, but tend to be concentrated in a particular area (Chakravorty, Koo, and Lall 2003). The concentrated area is in turn often occupied by a particular group of industries. For instance, a Central Business District (CBD) is a district for stock exchanges, banks, related business services and high-end shopping malls. Firms are geographically proximate, benefiting from lower transaction costs and easy information communication. This situation enhances their economic returns. With the success of firms, the area becomes a magnet that continuously attracts more firms and businesses. ECs are therefore basically a two-dimensional concept: *economic and geographic*. One more dimension, *time*, is important when the evolution of ECs is examined.

Clusters also represent themselves at two levels. On the *firm level,* it is more intuitively clear that the number and size of firms increase in a particular area. The amount of goods and services going to and

from those firms increases as well. Entrepreneurs accordingly adjust their business for their target markets and try to reduce production cost by economies of scale and introducing new technologies. After time, the area is dominated by several related economic activities and firms are specialised in a particular segment of industrial chains, including related services. Under the stimulus of economic returns, the specialisation process, and associated adjustment of production processes, all firms in one sector or in a set of interrelated industries are expect to become interrelated (Chakravorty, Koo, and Lall 2005). Clusters are thus also phenomena *on* the *sectoral level*. This level is the outcome of the fact that firms are competing for resources and markets and have the ability to utilise technologies to upgrade their production process. It usually also indicates a structural change in economy.

In this study, the term EC refers to an economic-spatial phenomenon. Quite similar to the idea of Porter (1998b, p199) who addresses cluster in perspective of development strategy, in this research, the EC is defined as 'a relatively geographically bounded group of similar, related or complementary enterprises or industries which are economically interconnected and share a common local infrastructure and institutional environment'. In order to be able to look separately at the spatial and economic properties, the term *functional clusters* is used to address a group of economically functionally interrelated industries, and *spatial clusters* refer to the geographic concentration of functional related economic activities and their associated pattern in geographic space.

2.1.2 Evolution of the cluster concept

The concept of clusters is a popular term in urban and regional research and practice. In particular, their relation to topical issues like 'city competitiveness', 'dynamic increasing returns' and 'local innovative systems', make clusters a focus for many policy programs and are they heatedly debated in academia. Economists and geographers have co-fertilised the concept and explored fields for policy application under various labels of clusters. Clusters are therefore associated with different approaches and perspectives. They are supposed to be able to absorb in their meaning knowledge innovation and changes in firms, industries, institutions and labour markets.

Although rarely explicitly specified, most scholars examine clusters either as an economic or a spatial way of organisation. This understanding goes back to two closely related concepts from the mid of the 19th century: *industrial clusters* and *industrial complexes*. The industrial cluster, at that time, defined the economic agglomeration of

industries by acknowledging functional interdependency (Bergsman, Greenston, and Healy 1975; 1979; Loviscek 1982). As a counterpart, the industrial complex considers economic agglomeration as a set of activities at a specific location. Although not neglecting the input-out relations, it more addresses certain technical and production interrelations in a given place (Isard, Schooler, and Vietorisz 1959).

After many years, the progress in knowledge and understanding leads to a redefined cluster concept that is now common in research and practice. New theoretical notions about the behaviour of firms and institutions give rise to a new type of cluster studies. In particular, Michael Porter ascertains that clusters are of importance to local competitiveness. This provides a new perspective for development strategies from the viewpoint of business management (1990; 1996; 1998a). Subsequently, many new ideas and concepts about clusters are put forward such as creative clusters (Wu 2005). Keeble and Nachum (2002) extend Porter's industrial cluster from manufacturing to service activities. The Porter-type or *Porterian cluster* is the one that is able to achieve a critical mass of interrelated firms and institutions in one place, from suppliers to universities to government agencies, so as to enjoy competitive success in a particular field (Porter 1998a). The major contribution of the Porterian cluster is the elaboration it brought of the cluster concept from a spatial concentration of firms to being an essential part of a strategy for economic development.

On the other hand, Krugman (1991a; 1991c) stresses the need of scrutinising the relationship between cluster development and economics of scale and regional lock-in effects. This consideration stimulates applying the cluster concept to regional policy, because much development is imbalanced in space and 'blocs' exist in global trade and investment (Poon, Thompson, and Kelly 2000). In this sense, *regional clusters* help to understand regional economic conditions and trends that affect economic growth and change (Enright 1996). Differentiation in economic conditions, such as specialisation in metropolitan areas, the ability of access to financial and market resources and the availability of knowledge and labour, encourages the geographical concentration of the same or closely related industries in several cities and regions (Krugman 1993; Bergman and Feser 1999).

Within the tradition of cluster concepts, the new cluster idea proliferates. In analogy to what happened to the industrial complex concept, s*ocial networks* are put forward to describe the cooperative mechanisms between the clustering of firms and the roles of institutions in a given geographical place (Gordon and McCann 2000; Pallares-Barbera, Tulla, and Vera 2004).

For example Amin and Thrift (1996) speak of 'institutional thickness' to describe a web of supporting organisations for clusters, which comprises of financial institutions, chambers of commerce, trade associations, training organisations, local authorities, and marketing and business support agencies. Interest in social networks is related to the Porterian cluster concept. In both the social network and the Porterian cluster the importance of social conditions for ECs is addressed and found important for institutions and firms. The work on social networks however involves more in-depth analyses of the role of institutional and social environments for the clustering of firms.

Similar to the regional cluster, the ideas of *regional milieu* (Keeble et al. 1999; Gordon and McCann 2005) and *regional innovation systems* (Asheim and Isaksen 1997; Cooke, Uranga, and Etxebarria 1998) are applied to improve regional economic performance. They aim at providing necessary institutional and technological support to cope with potential competitors. Compared to the work in social network analysis for clusters, they accentuate formulating supportive polices by looking at particular types of industries or sectors.

Italian economic geographers contribute much to the discourse of clusters. *The Third Italy* sets up a prototype of an industrial district to analyse the benefits of co-location to businesses and the production in the area (Schmitz 1990). The model was quite similar to the industrial complex approach, taking firms as analytical units but well adapted to be able to provide a theoretical paradigm to focus on the technical-productive processes (Harrison 2007). It also argues for the importance of trust in creating and sustaining collaboration between economic actors within districts and for local embeddedness (Lorenz 1992; Newlands 2003). A new study of Italian districts takes Neo-Marshallian external economies as a driving force for framing the industrial district as a place to integrate infrastructure, social and economic resources to enhance its competitiveness. In this transformation, territory is regarded as a versatile integrator of firms, sectors and society. The place of the industrial district does no longer exist in isolation (Sforzi 2002).

The concept of clusters is therefore not the product of a single line of reasoning, but a set of multiple perspectives in dialogue (Benneworth and Henry 2004). The scope of clusters encompasses input-output or buyer-supplier linkages, geographical co-location, shared business-related local institutions, and informal co-operative competition (Feser and Sweeney 2000). Martin and Sunley (2003) recap the key dimensions of clusters as geographical and economic aspects. Combined with the analytical levels used – firms, industries, and

regions – various perspectives and approaches have been developed and affected mutually.

2.1.3 The roles of cluster concepts in policy making

In most cases, the perspectives of cluster studies are complementary to each other; they took different angles to examine the same economic-spatial phenomenon. For example, the former industrial cluster and industrial complex are a twin concept respectively focusing on the economic and spatial organisation. Porterian clusters emphasise the local economic competitiveness, implicitly acknowledging what regional clusters claim of the territorial imbalance of economic development. Innovation systems and institutional building are a focus for regional clusters to improve the capacity of regional policies but more detailed information about knowledge spillovers and social relations that are provided by social network analyses of clusters. The resulting information about cooperation between firms and local sportive institutions is a core part of Porterian clusters.

Table 2.1 Roles of main cluster concepts in policy making

Type	Research approach	Policy interest
Industrial cluster	Sectoral analysis	Economic structure
Industrial complex	Firm analysis	Spatial heterogeneity, growth pole, industrial localization
Porterian cluster	Firm analysis*	Competitiveness, combination of firms and institutions
Regional cluster	Sectoral analysis, social analysis including labour, culture and knowledge	Imbalance of territorial development
Social network	Entrepreneurs, trust, supportive roles of institutions for firms	Innovation system, regional production division and cooperation
Italian industrial district	Firm analysis	Localization economies and growth pole
New Italian industrial district	Take a place as a local system	Competitiveness of places

*Note: * Sometimes researchers use sectoral analysis, for instance Porter (1990) takes the location quotient of industries to map clusters on a large geographical scale such as nations. In this case, it is closely related to regional clusters. The policy interest is however still in interrelated firms and institutions.*

Different types of clusters produce different guidelines for policy applications. Table 2.1 summarises their main contributions (argument). In the 1960-70s, the focus of industrial clusters was on the economic composition of a city or region, while the concept of industrial complexes took a 'place' as an analytical unit to explore the reasons for the agglomeration of firms. The concept of the industrial cluster provided references to economic structure for industrial policy. The industrial complex promoted growth poles as a key for regional

economic development by linking linkage effects and spatial polarisation (Darwent 1969; Casetti, King, and Odland 1971; Chapman 2005). Followers of Porterian clusters argue that their competitive strength relies on the performance of a group of related firms, believing that the clustering of firms can be transferred into economic prosperity. They therefore propose a supportive framework to achieve the full potentials of clusters (Porter 1990). Regional clusters are engaged in territorial developmental issues, such as labour and economic division, productivity and regional cohesion by rationally arranging economic activities embodied by sectoral relations (Enright 1996; Bergman and Feser 1999; Oosterhaven, Eding, and Stelder 2001; Chapman, MacKinnon, and Cumbers 2004; Hospers 2005).

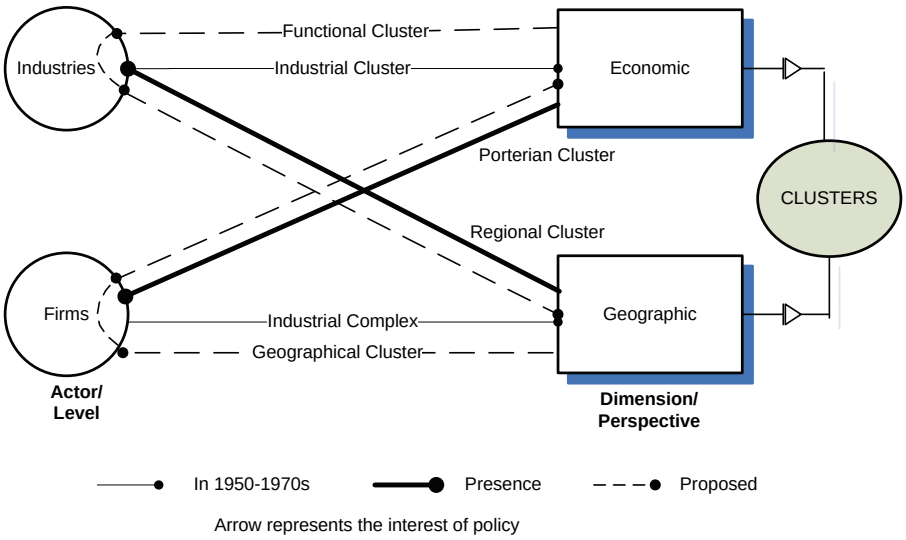


Figure 2.1 Analytical and policy shifts in clusters concepts: past, present and proposed in this study

These different discourses reflect analytical and policy shifts in the cluster application (Figure 2.1). In them, the key to understand the cluster application and approaches is the dimensions (economic and geographical) and the levels (firms and industries) of analyses. With the cluster evolution over time, two major shifts are observed.

One is the research focus shifting from the dimension to the level (actor). In the mid-nineteenth century, economic researchers paid most attention to the specialisation in economic space and geographers were interested in the place where firms concentrated as a special geographical location. The main purpose of politicians was

to leverage taxes and subsidies to influence industrial specialisation and employ specific measures (infrastructure investments) to promote place-based growth. As a result, fragmentation was purposely created in both economic and geographical spaces. Currently, more emphasis is on clustering behaviour of firms or industries. Research interest is to develop specific firm-based clusters by exploring the roles of knowledge, innovation and social relations in cluster's growing. Or, it is to study the performance of industry-based clusters and their roles in promoting regional development. The result of this shift is therefore not to create fragmentation. Instead, acknowledging the difference of clustering economy with others, it aims to seek a strategy for economic development based on firms and for geographical (territorial) development based on industries.

The other shift is to take the angle of firms' developments to examine economic space and take industrial performances to understand geographical development. Previously, economic policy mostly considered from the demand at the industrial level such as taxes and subsidies. It now pays more attention on promoting micro-business environment. On the other hand, firms are often inappropriate as an analytical unit for urban spatial economic policy as cities are as whole in the cooperation and competition with others. Representing aggregated information, industries are a useful object to analyse regional imbalances and developmental strengths.

These two shifts parallel changes in governance and management styles. In the 1950s, nations were independent after the World War II. The priority of the policy programs was to reconstruct and rehabilitate their economy. The concept of industrial clusters was used to understand the national economic structure and industrial complexes became an appropriate tool for centralised planning, especially in counties like the Soviet Union and China. Since the 1990s, globalisation has become an influential trend and local governments have become more powerful because of decentralisation processes and the dominance of the market economy. In coping with the globalising market economy, the concept of clusters is adopted as a strategy to strengthen local competitiveness and performance. Not only interested in understanding urban economic and geographical spaces, the new generation of cluster concepts is rather establishing a channel to link internal to external development contexts for policy making. Consequently, planning and policy making processes concern more firms and industries: the clustering factors and in turn the role in urban and regional development.

The Italian school forms an exception to these shifts. It always takes firms as a basic analytical unit, often based on the model of industrial districts, to examine the externalities of business operations,

innovation and knowledge spillovers. The difference is that the perspective of the classic industrial district model is changing from being place bound to being space bound, by examining its roles in city space (Sforzi 2002).

Paradoxically, almost all cluster concepts mainly have a limited scope, either the economic or the geographical. For example, industrial clusters were defined as industries related through formal production linkages regardless of geographical proximity. Industrial complexes underline the geographical concentration of firms engaged in same or similar activities. Such divergence can also be found in subsequent cluster concepts. In the analysis of Porterian clusters, analysts and policy makers almost take the geographical dimension by default. The same is true for regional clusters in coping with the economic dimension. The regional cluster aims at improving the performance of the entire region, for example by regional innovation programmes (Cooke, Uranga, and Etxebarria 1998; Gordon and McCann 2005). It often overlooks micro-business operations of firms and sometimes of the interrelation of industries.

The conceptual diversities, and sometimes confusion, leads to a dilemma for cluster studies and policy applications. The case-oriented approach, often adopted in firm-based analysis, suffers from the problem of hardly testable logic and representation (Lorenzen 2005) and arbitrary place of analysis. Owing to various limitations, the case study approach can usually not generate all necessary information, even for a type of functional cluster in the city. This situation undermines the value of Porterian clusters when they are applied for urban strategies. Despite an interesting point on economic policy arena, Martin and Sunley (2003) question the rationality and validity of Porter's notion of 'clusters' if it largely ignores the issues and relations of industrial localisation, spatial agglomeration of economic activity and the growing salience of regions in the global economy. On the other hand, industrial / sectoral analysis usually generates the whole picture of clusters but the coarse information is insufficient to support detailed policy making especially on the micro-level.

There is a need to carefully consider the theoretical underpinning of the versatile concepts and recheck the validity of methodologies so as to elaborate an integrative view on space and economy. The integrative view is imperative, given current urban and regional development, where 'thinking globally and acting locally' has become an accepted guideline for politicians. Despite Porter's attempts to base national or regional developmental strategy on firms' competitiveness, it is still not straightforward. Besides, individual successful experiences may not work for all. The geographical proximity in his concept is too vague to implement for urban planning

practitioners. Hence, place choice and spatial organisation achieve insufficient attention. Local policy makers are often little aware of these until the effect of localisation economies achieves a critical mass and local cluster developments become noticeable. This hindsight may hamper a policy of strategically initiating clusters. Although providing little detailed information for the management of individual firms, sectoral analysis shows the structural changes in urban and regional economies. It therefore potentially provides a (partial) solution for the question of how to achieve better informed urban strategies for geographically concentrated economic activities.

An integrative approach is suggested in this study. This approach links the economic and geographical dimensions and considers the mutual interests of firms and industries (sectors) in cluster analysis (Figure 2.1). Given that economic development is a dominant factor in economic-geographical space and also given the importance of integrating the external environment and internal management, this approach starts from the economic dimension to identify groups of interrelated industries with (potential) strengths for cities or regions. This process forms *functional clusters.* Those clusters should be selected based on their roles in strengthening the economic competitiveness and performance of the city. According to functional relations, the spatial arrangement of ECs in the city is then examined at a fine scale, for example postcodes or wards, to identify the area with prominent geographical concentration of given type of economic activities. These are then *spatial clusters*. A spatial cluster is comparable to industrial complexes or districts, but with clearly defined boundaries, pertinent to the geographic scale of analysis.

Following this approach, cluster views can shift from the industrial level, often chosen in the regional economic sciences, to the firm level which is central in economic geography and business management. Within relatively rigorously defined areas, researchers can perform firm-based case studies to scrutinise location and agglomeration economies including both economic and geographic considerations. The result can provide policy makers either a retrospective view or one seeking future local developmental strength. This approach also links strategic and action levels. But, more importantly, by empirically coping with the relationship between the economy and geography, local and regional policy makers can broaden their scopes, connecting economic policy with spatial planning.

2.2 Urban and regional spatial-economic dynamics

ECs are a dynamic element in urban and regional development. In recent decades, they have proliferated to virtually all sectors of the

economy. The phenomenon of ECs gained renewed interest when they developed in dynamic, knowledge based industries, such as Information and Communication Technology (ICT), biochemistry, and high-tech car manufacturing, electronics, and pharmaceuticals. Particularly, the Silicon Valley example in California has evoked a widespread initiative to create ICT clusters elsewhere. They are introduced in Europe (Hospers 2005) and developing countries including India (Parthasarathy 2004) and China (Zhou 2005; Tan 2006). This new business localisation trend later spread to other sectors like financial and retail services (Keeble and Nachum 2002), and also to traditional sectors such as textile, leather, ceramic and furniture industries (Chakravorty, Koo, and Lall 2005). It is also noticeable in other industries like recreation, culture, media (Hutton 2004; Mommaas 2004; Scott 2004) and e-business (Boasson and MacPherson 2001).

ECs are important drivers for both economic development and changes in urban spatial organisation and structure. Table 2.2 summarises the main characteristics of important ECs illustrating how these clusters are embedded in the spatial economy. A similar description can be found in the recent work of Gospodini (2006), who however mainly addresses landscape issues. In our scheme, ECs are a symbiotic economic-spatial organiser for modern cities and regions due to various agglomeration factors and intrinsic economic and spatial interrelations.

For example, financial clusters, including banks, insurance companies, stock exchanges and accounting-firms, are clustered owing to the volatility of capital across regions. This extra-regional competition distinguishes them as business or services clusters, which are agglomerated for benefiting from comparative advantages of various advanced services such as management, consulting, advertisement and legal services. The developments of the clusters in financial and other advanced business services are often interrelated, because capital flows are proportional to business exchanges. Both of them are based on a high quality business environment, where mutual trust and exchange of tacit knowledge can take place with face-to-face contacts. To a large extent, such requirements result in geographical concentration of many business service activities (Figure 2-2). Prosperity of local business will attract more outer-region capital. Finance and business clusters usually dominate in the CBD-part of a city centre often with overspills to major sub-centres.

Table 2.2 Spatial-economic characteristics of main economic clusters

	Financial clusters	Business services clusters	Knowledge clusters	Entertainment /Recreation clusters	Manufacturing clusters	Agricultural clusters	Logistic clusters
Major Agg-lomeration factors	Volatility of capital, face-to-face contacts, prestigious location	Business competit-ion, face-to-face contacts, vibrant and high level business and services environment	Knowledge spill-overs, face-to-face contacts	Social factors, incl. life style & culture, pleasant/unique environnent	Industrial traditions and resource advantages, global trade and labour division, industrial specialization	Efficiency of agricultural production, scarcity of land	Accessibility and quality of infrastructure
Main economic activities	Banks, insurance companies, financial markets, accounting services	Management, professional, particularly IT services, consulting, advertisement and media industries	A synergy of universities and industries, or creative services related to culture & knowledge	Hotels , restaurants, cafes, theatres, street- and nightlife, recreational shopping	Large scale production with suppliers and supporting agencies located in the region	An agricultural complex with farming, agricultural services, food production and tourism	Multimodal transport and distribution centres of regional or national importance
Location	City centre	City centre or sub-centres	Inner city, edge city or peri-urban	Inner city, edge city or peri-urban	Urban fringe, transport corridor	Peri-urban or exurban	Transportation nodes (air, sea, road, rail)
Embedded linkages with cities	Financial system	Business environment, cooperation of firms	Supportive institutes and talented workers	Convergence of culture and (upper-) middle class	Partly dependent on the other clusters	Partly dependent on the other clusters	Logistic systems
Spatial signatures	City landmarks	Large office parks/districts with shops and services	Co-location with universities or institutes, with high quality ambience	Stylish, fashionable or picturesque environment	Industrial parks	Probably loosely distributed	Huge transport infrastructure
Typical Examples	City of London, Down- and Midtown Manhattan	Manhattan, Central London	Silicon Valley, Route 128, IT clusters in Bangalore and Beijing	Orlando in USA, and La Rambla Avenue in Barcelona	Petro-chemical complexes (Houston, Singapore), automobile manufacturing in Detroit	Horticulture in the Netherlands	Schiphol Airport, Rotterdam Seaport

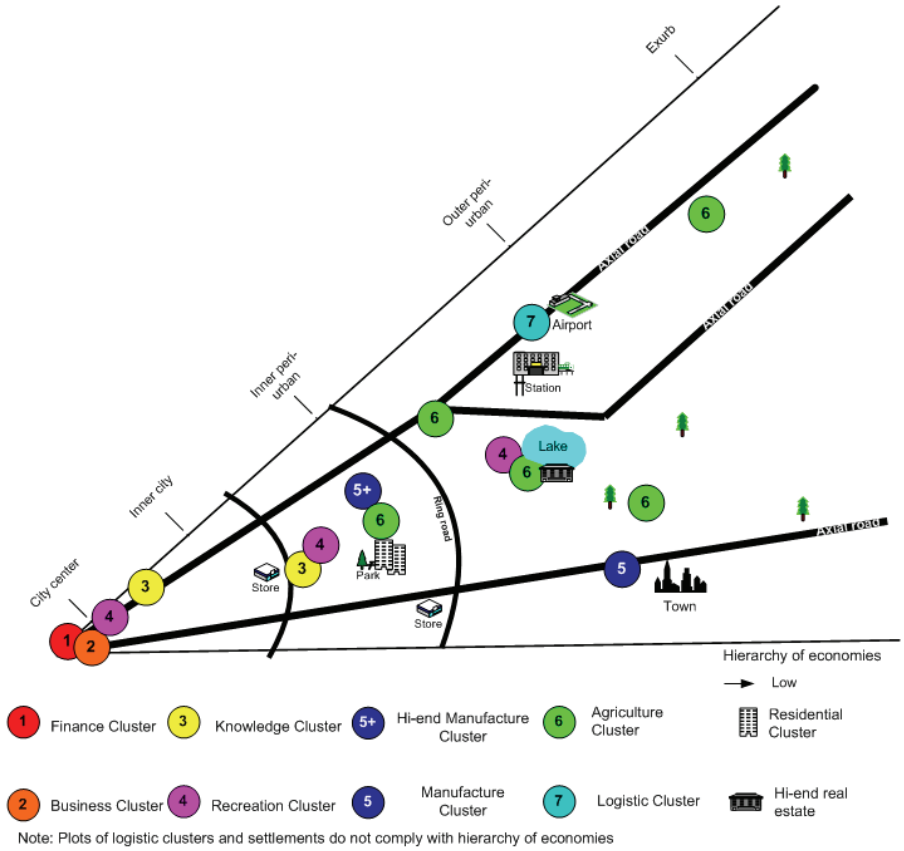


Figure 2.2 Model of economic clusters in a city

Knowledge clusters are perhaps the most typical activity in the modern economy. They are growing at the convergence of cultural activities and urban development, signifying the increasing significance of innovation in value-added production, and the competitive advantage of inner city environments for creative industries (Hutton 2004). The value-added production occurs in dynamic manufacturing economies including IT, biochemistry and pharmaceuticals. Their clustering process often involves professional services like information services and knowledge creation. This creates vibrant areas within certain parts of the city. The development of creative or knowledge intensive industries usually benefits from the synergy between universities and high-end industries (Hall 1997b; Smith *et al.* 2001). Examples are Silicon Valley ICT cluster in the United States, and in Cambridge and Oxford in the United Kingdom.

Traditional industries also follow cluster-based spatial organisation principles. The competitiveness of manufacturing is consolidated based on resources or traditional advantages, like the oil industry in Texas and automobile manufacturing in Detroit. Modern manufacturing production can also be highly concentrated. For example, in Switzerland, high-end watch processing is located in the Geneva region, and low-end processing in the Jura region[iv]. The current development of manufacturing is often the result of restructuring and relocating from old inner city sites to peri-urban locations or to new growth areas in nearby towns and regions. That is particularly true for developing countries, which take over a large share of industrial production from developed countries due to increasing global trade and division of labour. Meanwhile, for developing countries, establishing manufacturing clusters becomes an important strategy to revitalise their local economies and develop new urban land. For instance, TAECO, located in Xiamen in China, is proposed to become the largest production centre for parts of the aviation industry and for airplane maintenance in Asia. Except for manufacturing, agricultural activities also reveal clustering tendencies owing to the increasing inputs of technology and investments, and the shortage of land resources. These clusters build on and encourage inter-industrial linkages among traditional farming, food processing and agricultural tourism, to provide fresh local produce as well as recreational services to a growing urban market (Donald and Blay-Palmer 2006). Agricultural clusters are however likely to be pushed towards the fringes of urbanised areas.

The development of various types of ECs is often interrelated. Business, finance and knowledge clusters are developed within an innovative and attractive milieu. They in return generate an influx of new, affluent middle class, with a busy time budget, but also with high demand for high-level housing, culture, leisure, experiences, and novelty (Chatterton and Hollands 2002; Hollands and Chatterton 2003; Beriatos and Gospodini 2004; Mommaas 2004; James 2005). This life style contributes to the development of entertainment and recreation clusters. Recreation clusters are cultural products (Scott 2000; Scott 2004), but at the same time, reflect commercial behaviour like fun shopping, exhibitions and conventions. They are often developed around traditional tourism resources, or in the vicinity of finance, business and knowledge clusters and are signified by highly stylistic architecture for buildings such as museums, theatres, galleries, and luxury and picturesque hotels. Examples are the amusement and theme park clusters (resorts) in Orlando in Florida and Disneyland in Paris, but also the Potsdammer Platz in Berlin and the La Rambla Avenue in Barcelona.

ECs can cooperate to more easily obtain competitive advantages. Through the alliance of Rabo Bank and the logistical advantage of Schiphol Airport, the Netherlands has established a successful cluster with flower trade and distribution. In Oregon, the wood production cluster is supported by the anchoring role of Credit Enhancement Fund of Oregon Wood Product Competitiveness Corporation (Rosenfeld 1995). Logistic clusters can also co-develop with manufacturing ones. This has occurred in Seattle in conjunction with aircraft production and similar linkages with manufacturing are also evident in Chengdu in China.

It should be noted that, although the clustering of economic activities is a tendency of modern, future oriented cities and regions, not all cities will contain all types of ECs. However, ECs do have major economic and spatial impacts and are very noticeable in the urban landscape. Examples such as the Potsdammer Platz project in Berlin, the Milan Fair Area, and the Dublin Docklands demonstrate how important large, key revitalisation projects can be (Moore 2002).

Through their economic externalities and spatial spillovers, cluster developments can radically transform land use, traffic flows, property values and even the city's environment and image. Such transformative power is evident in the inner London neighbourhood of Barnsbury and the Brooklyn Heights neighbourhood of New York City, where a super-gentrification process is interwoven with the clustering of finance and business services (Lees 2003; Butler and Lees 2006). The transformative role is also due to a self-reinforcing process between ECs and city growth, which is accompanied by accumulation of capital and elites, but also by policy initiatives.

We should also be aware that the scheme of Figure 2.2 just illustrates the basic skeleton of spatial organisation of ECs according to the spatial-economic hierarchy and regularity in a mono-centric city region. In reality, many variants can be found, especially because productive elements such as knowledge, labour and capital play increasing roles in current economic and cluster development and are not place bound.

2.3 Mechanisms of economic cluster development

The approaches of neoclassical economics and evolutionary economics explain the operation of current economic development, the role of market demand and supply, institutional mechanisms, technological innovation and the response of economic agents. They supplement each other in providing a general framework to explain EC development (Nelson and Winter 1974; Boschma and Frenken

2006). This framework can support policy making in actively and effectively intervening in cluster growth.

2.3.1 Neoclassical economics

Since the 1990s, the rapid growth of the global economy has created a new reality in many urban and regional economies (Johnston, Taylor, and Watts 2002; Scott 2008). It intensified worldwide relations, which link distant localities in such a way that what happens locally is shaped by events occurring many miles away and vice versa (Giddens 1990). Trade and investment flows, cultural and technological exchanges are facilitated among regions, which are seeking cooperation even as they are facing competition of 'time and space compression' (Harvey 1989).

In the globalised economy, the world increasingly becomes a network system with its nodes specialised in one or several economic activities (Krugman and Venables 1995; Knox 1997; Poon, Thompson, and Kelly 2000). Urban and regional development has to seek for the most appropriate anchor points where it can leverage its strength to defend itself or to break into investment and trade blocks (Nachum 2000; Porter 2000; Zhao and Zhang 2007). Improving their market vitality becomes a major mission for many cities and regions.

One essential consideration of neoclassical economics is how economic agents deal with competitive situations. Firms or other economic agents are seen as an actor who has alternatives regarding inputs and outputs and rationally procure and produce based on the marginal effect determined by demand and supply (Nelson and Winter 1974). In business management, this viewpoint is taken over by Porter in his diamond theory. He advocates the role of rival strategy and competitive pressure in encouraging excellence in industrial and economic development (Porter 1998b, 2000).

Neoclassical economics explains the role of markets in determining the value of products on the basis of demand relationships. By contrast to classical economics, it stresses maximizing utility or the satisfaction associated with the consumption of goods and services. What makes neoclassical economics attractive is that it treats agents, households and firms as rational actors who can optimize their outcomes.

Within neo-classical economics, neo-modern theory has particularly caught the interest of economists in explaining geographical issues (Helpman and Krugman 1985). The interest is on the role played by increasing returns to scale and market structures in determining spatial investment patterns (Krugman 1991c; Venables 1995). Krugman (1991c) uses a neoclassical approach to explain trade,

specialisation and agglomeration under imperfect market competition. He describes the existence and persistence of urban agglomerations in terms of rational decisions of economic agents. Under a market regime, the clustering of economic elements is formed, which is accompanied by the forming of trading blocs (Poon, Thompson, and Kelly 2000) and spatial disparities (Venables 2005). Fujita *et al.* (2008) adopts a neoclassic economics approach to argue that under globalisation, East Asia is undergoing a process of agglomeration and dispersion of industries. Economic globalisation presses most countries to take the role of the market seriously, especially for the New Economies including Brazil, Russia, India and China.

The approach of neoclassical economics provides a general theoretical framework in which the clustering of economic activities happens. Particularly for economies in transition such as China, the market is increasingly replacing the state, as a dominant player in economic development. The basic routine of economic policy is changing from supply-dominated to market-orientation. Within this context, the proposition of neoclassical economics with respect to market rationality is of value to explain current urban development and the forming of ECs. However, the main critique of neo-classical economics is its lack of consideration of institutions in economic development (Nelson and Winter 1974; Gordon and McCann 2000).

2.3.2 Evolutionary economics

Evolutionary economics, which is usually directly linked to the path dependence concept, offers another view to examine economic development. It is a general theory of change which can empirically examine specific processes in time and space (Frenken and Boschma 2007).

Path dependence is evident in economic evolution and spatial structuring (Martin and Sunley 2006). It is therefore useful to consider spatial development as an integral part of economic development (Massey 1992). Place-based development is particularly path dependent because it follows the sorts of externalities and social infrastructures featured by its specialised areal environment and physical infrastructure (Cox 1996). As an approach to investigate urban and regional evolution, institutions and technologies usually act as carriers for the path (Martin and Sunley 2006).

Path dependence provides a powerful perspective to understand the mechanisms used to study the growth of ECs by looking at functional relationships, knowledge systems and social and cultural environments in path-dependent trajectories (Bell and Albu 1999;

Kenney and von Burg 1999; Pinch and Henry 1999; Maskell and Malmberg 2007).

Most ECs do not emerge from scratch. Path dependence plays a role at the micro, place and based firm level as well as at the macro, structural and socio-economic contextual level. Krugman (1991b) ascertains 'the long shadow cast by history over location is apparent at all scales, from the smallest to the largest – from the cluster of costume jewellery firms in Providence to the concentration of 60 million people in the Northeast Corridor'. New firms entering a place or region may be subject to similar locational preferences as earlier ones, such as favourite infrastructure and specialised services. What choices that firms make is not purely rationally following an optimal decision-making process. They often just follow the decision of similar businesses. This partially explains the clustering of vertically disintegrated firms specialised in a particular techno-industrial field in several regions in Europe (e.g., the Third Italy) and the United States (e.g., Silicon Valley) (Boschma and Lambooy 1999).

Path dependence is both a cause and an effect in the economic and geographical landscape. It stresses pre-existing socio-economic structures, the legacy of actions undertaken in the past, and the environment in which current activities occur (Pinch and Henry 1999; Martin and Sunley 2006). New activities can be attributed to historical developments (Krugman 1991a; Massey 1992; Arthur 1994). Path dependence can (partly) disclose the evolution of ECs and urban economic-spatial dynamics.

Accounts for path dependence cast a light on how government can actively participate in cluster development. Arthur (1994) boils the influences of path dependence for economic development down into four features: (1) fixed costs, learning effects, coordination effects and adaptive expectations to consider and balance the unit cost for products, (2) the proliferation process of knowledge and experiences, (3) managerial costs and (4) the cost for alternatives. Although this conclusion is based on the analysis of technology, it is very relevant for economic policy agendas for considering the social context to generate increasing returns for agglomeration economies. In simple words, the probability of further steps along the same path increases with each move down that path, because the relative benefits of the current activity compared with other possible options increase over time (Pierson 2000). One should however not deny any attempts of policy makers to innovate towards new economic activities, but these initiatives perhaps need more deliberations and the possible resulting path should be carefully considered.

Since the evolution of ECs strongly relates to urban economic-spatial dynamics, a better insight into this relationship could improve the use of ECs as an instrument for urban policies. The evolutionary approach places the emphasis on cluster emergences, booms, declines and shifts. It is a way to better know the role of institutions in economic development.

2.3.3 A framework of explaining economic cluster development

Boschma and Frenken (2006) compare the approaches of neo-classical and evolutionary economics applied in economic geography on key behavioural assumptions, units of analysis, treatment of time and their conceptualisation of agglomeration economies. The new model of growth, trade and economic geography has been placed on the assumption of increasing returns to scale and imperfect competition. Based on this neoclassical assumption, however, these models mostly acknowledge the possibility of multiple equilibrium, path dependence, irreversibility of outcomes leading to lock-in and sub-optimal outcomes.

The differences of these approaches in explaining ECs and economic development can be summarised in four aspects. First, neoclassical models assume a given market structure while evolutionary models take into account entry, exit and innovation, and let market structure evolve endogenously. Second, neoclassical models address the spatial economy at the macro-level in terms of location decisions of agents (firms and consumers). By contrast, evolutionary approaches explain the spatial evolution of industries and networks at the meso- or macro-level by exploring structural change. Third, most neoclassical models interpret the formation of agglomerations based on static analysis. Evolutionary models take agglomeration as temporary convergence and search for various causes behind it. Last, the neoclassical approach explains agglomerations on pecuniary rents (increasing returns to scale internal to the firm); evolutionary approaches, instead, are more interested in agglomeration economies arising from knowledge externalities. The approaches of neoclassical evolutionary economics therefore constitute a complementary framework to explain the evolution of ECs. In this framework, the roles of markets, governments (or institution) and globalisation are three core elements.

2.5 New perspectives for economic and spatial policies

The practical and theoretical advances both show the EC is pertinent to current urban strategy. While application of ECs into policy is not new, it needs new perspectives according to the demands from urban economic policy and planning to deal with the complexity of society and improve the coherence of policy making and actions.

2.5.1 Implications for current urban strategy

The EC represents an urban strategy afoot. Facing the globalisation process, cities and regions are the fundamental locus of contemporary development (Krugman 1991a). In many places, both in the developed and the developing world, political power shifts from national programs to regional decision making on economic, financial and infrastructure arrangements. Competitiveness and performance become important parameters guiding developmental policy (Thrift and Olds 1996). Under this circumstance, EC policy becomes an important and sensitive issue for urban and regional development.

In a broad scene, cluster policy is a framework which comprises of business management, social capital and inter-organisational networks, and of the integration of competition into a comprehensive model of regional economic development (Porter 1998a). It involves a wide discussion of economic, social, institutional and political issues. This openness often results in a huge task for cluster analyses and for policy making processes.

Policymakers are therefore moving from the traditional conceptualisation of a policy process as a largely linear phenomenon towards a process that emphasises more fluid relational processes that favour association, interaction and collaboration between individuals, institutions, firms and other concerned groups (Burfitt and Macneill 2008). This process *per se* seeks a cooperative mechanism to better respond to exogenous growth factors and translate this mechanism into internal managerial ability. Relevant policy inventions take place in different fields, different dimensions and across different levels of government. They usually involve discussion and negotiation such as for the selection of policy incentives, type of clusters and prioritised places for cluster development (Burfitt and Macneill 2008).

In order to leverage the advantage of ECs in contemporary urban and regional development, it is necessary to set up a collaborative structure and process among different policy fields. Since geographical proximity and economic relationships are connected, the

concept can improve the connection between urban (spatial) planning and economic policy.

2.5.2 Perspectives for economic policy

The developing of ECs is very dependent on socio-economic context. Policy goals and institutional arrangements vary from place to place. In developing countries ECs are an instrument to stimulate backward regions while in developed countries ECs are pioneers in innovative economies. In India and China, ECs are emerging as a new spatial form for production, intertwined with dramatic economic restructuring and an environment of institutional reform (Yu and Tong 2003; Parthasarathy 2004). Cluster policy is not a 'one-size-fit-all' approach (Cortright 2006). Although sometimes best practices, such as the Silicon Valley, are indicative, good practice is largely based on adaptation to local conditions.

A basic agreement is that ECs represent a synergised action rather than zero-sum economic policies (Doeringer and Terkla, 1995). A good EC policy will network various supportive agencies, suppliers, institutions and universities to meet the requirement of a group of firms or industries.

This procedure includes multi-level actions and involves various levels of government. At the micro level, local governments usually use a cluster policy to address a group of firms with a supportive institutional network and collaborative innovation systems. The key is to establish or shape a favourable business environment. Much policy research has been devoted to this aspect. By contrast, less concern is given to the strategic level, which should be backed by municipal or provincial governments. Although there is nothing wrong with the emphasis on the business environment, local economic structure, conditions and future trends are largely ignored. The claim of developing ECs to foster regional development could be either plausible and unrealistic (Palazuelos 2005).

In economic policy, a fundamental issue is to identify clusters. The identification could be to counteract the challenge of structural decline such as with the automobile cluster in the British West Midlands (Burfitt and Macneill 2008). Or more usually, cluster initiatives are based on existing clustering potentials or strengths (Cortright 2006). Clusters may arise as a result of both challenges (such as a shortage of natural resources or labour) and opportunities (for example an abundance of particular input factor) (Porter 1990). EC selection should be based on local socio-economic context and if it is driven by challenges, many critical efforts can be anticipated to override existing barriers.

Economy policy seldom deals explicitly with geographical issues. Nevertheless, the EC is clearly a place-specific phenomenon. Increasing returns happen in the spatial location of production (Krugman 1991b; Arthur 1994: 49-67). The initial centres of economic activity may act as a magnet and influence the locational decisions of other firms and investment. With the development of ECs, it is both a chance and a challenge for economic policy to cope with geographical space.

2.5.3 Perspectives for urban planning

Unlike economic policy, urban planning explicitly addresses the physical development of a city. It focuses on physical aspects of ECs such as infrastructure, public facilities and the broader location of a cluster in the city space. Being a powerful economic organisation, the EC is also a strong shaper and organiser of the city space. The integration of ECs into urban planning could provoke many new ideas to improving current place making processes. Consistent with the aims of this study, this is considered at strategic level of urban planning.

2.5.3.1 Improving the ability to cope with economic development

The economic dimension of urban dynamics is a prime component of urban planning. This is particularly so with the macro-trend of globalisation and ensuing economic restructuring worldwide. In response, local governments actively attract new industries to their jurisdictions by offering competitive packages of land and financial incentives (Fainstein 1991). This spurs on new planning initiatives particularly for strengthening the adaptability to market changes.

The inadequacy of urban planning in dealing with rapid economic development is due to a verity of reasons. It arises from imbalance between the volatility of economic elements and the relative stability of spatial components. While an urban economy could be restructured within 5 years, spatial infrastructure revision may require 10 years and, and moreover, it will have a lifespan of 20 years or more. Fairly speaking, urban infrastructure and facilities are provided more often for a group of firms than for individuals; however, a few firms are always active and playing a leading role in urban economy. The inadequacy is also rooted in the fragmentation of urban policies. As Friedmann (2005) points out, in most developing counties, city or urban planning systems are limited to physical concerns. Urban planners only consider the physical dimension of cities, while other professionals – economists, sociologists and so on – take

responsibility for social, environmental and economic aspects, often with only limited attention for spatial dimensions. This fragmentation contributes in many developing countries to problems like an unbalanced spatial-economic structure, social imbalances, pollution, traffic congestion, landscape degradation and land abuse, creating difficult challenges for future urban development.

Nowadays several countries, such as China, India and Brazil, are on the path of rapid economic transition and growth and, as a result economic dynamics are dictating urban planning. It is though increasingly widely recognised that urban planning and economic development should be coordinated interactively. But ignorance of the workings of market-led developments can lead to inadequate spatial planning with a permanent or long-lasting burden of suboptimal decisions, due to lock-in or premature commitment to wrong solutions (Harris 1996).

Being an economic-spatial concept, ECs can be introduced into urban (spatial) planning and implementation programmes as it is also a policy vehicle to unlock development potentials (Hull 1998). To a large extent, the shaping of competition should not only be realised through economic incentives. It would be incomplete without measures that determine the quality of local and regional physical environments.

ECs therefore are potentially a common object that both urban planners and economic policy makers can work with. They recognise the most active actors in economic development as groups of industries and firms rather than individual ones. Rationally, urban planning can therefore more actively participate in economic development.

With the common object, a bridge is established over urban planning and economic policies. It facilitates communication and cooperation between economic analysts and urban planners. Good communication can better inform urban planners about material resources and problems and interests of private actors with an aim to realise consensus and robust commitments among stakeholders, thus making master plans more realistic and implementable.

In practice, the process of forming and managing ECs autonomously stimulates the fast changing economic context. Quite often, this is facilitated by a public-private-partnership (PPP). In the Netherlands, the national legislature authorised PPP to facilitate large scale infrastructure projects, such as the Rotterdam Central Station redevelopment (Friedmann 2005). The PPP approach is also practised in the urban renewal in France (Dormois, Pinson, and Reignier 2005), in the regeneration of localities in the UK (Gore 1991), and in the

large Pudong project in Shanghai (Olds 1997). The formed PPPs create their own organisational framework with varying degrees of autonomy, and might also increase transparency as well as accountability (Friedmann 2005). If PPPs can be well integrated in and managed together with political institutions, urban planning may improve its effectiveness of predicating demands and facilitating implementation.

Besides these actions, more important is that it creates a niche within which urban planning can improve its strategic ability to enhance the competitiveness and performance of a region. To a large extent, this will supplement urban planning's usual focus on the long-term with a more active role in regional development. The development of ECs implicitly means a move to create developmental synergies between urban planning and economic policies.

There are however many uncertainties associated with private developers, local economic restructuring and the response of social movements. The integration of ECs in urban planning is therefore suggested to adopt an adaptive planning style, rather than the traditional static blueprint style. By this, urban planning can adapt itself to the underlying external and internal economic dynamics. This requires strategic thinking and nimble action which are to be combined with the flexibility to respond quickly to unexpected changes in development forces as ECs reveal themselves.

The strategic property of ECs for urban planning is to accentuate the interaction between economic growth and spatial development so that long-term spatial planning goals are matched and interwoven with the vision of local economic development. In order to accomplish that, cities and regions should strengthen local competitive advantages. If ECs are policy initiated, their realisation largely depends on finding competitive locations. Coincidence between the spatial concentration of industries and regional specialisation is fundamental to link economic policy and urban planning. Urban planning should commit to create this coincidence by allocating land, transport and public facilities in the right place at the right time and with the right quality and quantity. As to spontaneous clustering processes, urban planning should consolidate this if practical, rather than deny it or (carefully) create new rivals in space.

In addition, land, transport and public facilities should be provided according to the desired linkages between economic interactions and geographical proximity. Land use-transportation systems are a determinant to the productive and business environment. Particularly, the linkage between employment and housing areas is of utmost importance, as it affects the perceptions and attractiveness of a place

for human capital. Both contribute to generating and improving the level of amenity, as a requirement for dynamic and sustainable growth of ECs in geographical space.

Not all ECs are however successful; they may not prosper and they may relocate as well. At a strategic level, there is a need for a monitoring process to evaluate the performance of the ECs related to the urban economy, the efficiency of land use, and the urban accessibility (transportation). The anticipated major impacts and actual performance of cluster projects are of great value as references for the development of urban planning as an adaptative learning process. This measurement should improve the implementation aspect of strategic planning.

2.5.3.2 Understanding and optimising urban structure

Urban planning has a long tradition in observing and analysing spatial patterns of cities and regions, and applying established and emerging changes as signals for development or remedying schemes. Among various testable spatial arrangements, the spatial pattern of economic activities is of a particular interest for urban researchers and planners. Not only do ECs mirror the underlying industrial organisation, they also reflect the spatial drivers of urbanisation and trigger the demand for public facilities and housing at successful areas or show unused potentials and challenges in declining areas.

ECs provide a field to understand current urban structure. Previous understanding is largely based on the classical bid rent curve (O'Sullivan 2000), which assumes a mono-centric configuration of city space. Correspondingly, a distance-decay model is employed to measure movements in place and space. Such Euclidian understandings are however insufficient to comprehend the increasing complexity of current city regions. City regions may have several places with peak or sub-peak land prices. These prosperous area are usually are where ECs stay.

The locale of ECs is however not a point but a place in space. The clustering niche usually exist as a packaged urban environment, for example, the complexes of London's Broadgate and New York's Battery Park. In these cases, state-of-the-art work spaces, upscale housing, retailing, schools, fitness centres, skating rinks and car parks are provided with dedicated links to rail networks (Graham and Marvin 2001).

Hence, successful clusters create an identity of locale, representing the image of space or place. The cluster place is often personalised with high level financial services, technology-intensive firms and knowledge-based institutions, constituting 'signifying epicentres'

introducing a ‘glocalised’ landscape of built heritage and innovative design of buildings and public open spaces (Gospodini 2006). Such new urban landscapes are a product of local responses to globalisation. With novel or exotic outlooks, they can easily be recognised by city visitors and stay in their minds.

Besides, ECs are the center of producing and reproducing new economic and social fashions and relationships (Graham and Marvin 2001; Campbell and Fainstein 2003). Business centres, shopping malls and mixed use industrial and office parks can influence city development in a variety of visible and invisible ways. These relationships are particularly what Healey (1997) argues that should be understandable and reflected in urban physical structure.

The biggest challenge for incorporating the cluster in urban planning could be the issue of the geographical proximity. In Porter’s idea, the concentration of economic activities seems ‘free of geographical scale’ (Martin and Sunley 2003). Although he has his right considering the mobility of growing and productive factors (Maskell and Lorenzen 2004; Lorenzen 2005), geographic proximity still matters especially for formal and informal social ties and trust, and knowledge transfer process (Audirac 2003; Benner 2003; Mota and de Castro 2004; Phelps 2004). In contemporary cities, more and more research observes a tendency of several localities of one cluster or the ‘distanced’ character of economic activities (Scott 1982; Mills 1992; Porter 1998b; Maskell and Lorenzen 2004; Sturgeon, Van Biesebroeck, and Gereffi 2008). Drawing on the literature, so far we can conclude that the geographical scale is not free, but elastic. This geographical elasticity calls for innovations in empirical research.

An obvious goal of applying ECs in urban planning is to leverage the creation of a polycentric urban spatial form. In contrast to a mono-centric urban structure, polycentricity is an ideal spatial form and is advocated as one of the defining characteristics of the urban landscape in advanced economies (Robert and Sako 2001) that is expected to dominate city space in the future, in particular for mega-city regions (Hall 1997a). Typically, there are two polycentric configurations in the world. One is a poly-nucleated metropolitan region, which consists of a number of cities (Dieleman and Faludi 1998). Randstad may be the earliest well-acknowledged polycentric region (Hall 1984). The concept was used to emphasise the internal interdependence of the cities in the area with respect to physical and environmental planning, but also later on given consideration of economic functionality. The other main type refers to the ‘free standing’ metropolitan area, or a ‘city’ in the broad sense including suburbs and commuting hinterland. This has been most fully articulated in North America, with various employment and service

sub-centres developed that rival the CBD in size (Anas and Kim 1996; Champion 2001). In either polycentric form, economic functions are at stake.

The integration of ECs into urban structures is related to three major planning goals. The first is to enable or balance local developments, calibrating the function of places. Since existing places enjoy better facilities and infrastructures for similar economic activities, they are also a means to prepare candidate places for new investments and spatial projects. As Webber (1963) contends, urban space associated with the economies of localisation and agglomeration is a peculiar resource. Urban planners should take advantage of this resource. The second is to control or build up proper densities and improve accessibilities to the clustering places, therefore directing to compact development to reduce the amount of land use and facilitate the commuting between work and home places. Compactedness reduces the physical costs for economic development and urban growth. Last, to develop ECs in the right place to drive a polycentric city region to create spatial-economic sustainability for the region, making the whole network of the city more than the sum of its parts (Meijers 2005). This role also helps realising the physical goals such as creating sub-centres but also rehabilitating mono-functional dormitory towns and districts.

2.6 An Empirical Model

To recapitulate the theoretical explorations, the role of ECs in economic policy and the potential for linking economic and spatial policies are:

ECs are an inherently spatial and economic phenomenon and this phenomenon spreads out to nearly all producing sectors, which makes it feasible to (partly) deal with a broad and complex urban spatial economy;

The contemporary notion of ECs advances (localised) agglomeration economies as a (globalised) competition strategy, which challenges policy programmes to address internal management with external environment;

The perspective of government and business management moves towards a group of industries and firms, rather than individual ones;

The development of ECs is a multi-scale framework of synergising activities, from firms to industries and from the very local to the global scale, including supportive agencies and institutions;

The growth of ECs is closely related to the city as a whole; urbanisation economies are at least as significant as localisation

economies and a diversified economic structure is necessary to maintain healthy ECs and city growth;

Non-spatial, mobile agglomerating factors including knowledge, information exchange, capital flows and talents increasingly play crucial roles;

The elasticity of geographic scales is basically true for ECs; geographical proximity matters for information exchange, knowledge innovation and face-to-face business contracts.

Therefore,

Urban planning has a great potential to incorporate ECs as an instrument to improve its ability of coping with fast economic change;

To understand ECs spatially, an essential appreciation of physical elements as well as a relational perspective of economic and social manifestation on space is needed;

Firms with close functional relationships could be concentrated in several areas in a city;

The locale of ECs is not a point, but a 'packed-up' place in space; the quality of space is important.

The elasticity of the geographic scale gives a certain amount of freedom for urban planners to deal with location, but, in turn, urban form becomes crucial, which significantly affects human behaviour (transportation, residential preferences), environmental quality and energy consumption.

Given these concerns, a top-down approach is proposed for integrating ECs in urban planning (Figure 2.3). We configure functional clusters based on their core relationships – input-output relations in economic space - to capture a group of similar, related or complementary industries which are economically interconnected.

Quite different from classic industrial complex studies in geography, we reformulate spatial clusters according to current urban spatial dynamics. Relying on industrial complex/districts, polices usually focused on industrial locational choice (Weber 1965) are used to realise a converging and diffusing process in a territory (Isard, Schooler, and Vietorisz 1959; Isard 1975). The elasticity of geographic scale and the spatial-economic relationships however make the location-fixed model outdated for many cities and regions. We use spatial clusters to to explore the place of the geographical concentration and pattern of functional related economic activities. They cast light on a locale of functional clusters and basic spatial process of economic relations. The major places and patterns of spatial clusters to a large extent constitute the urban spatial-economic structure.

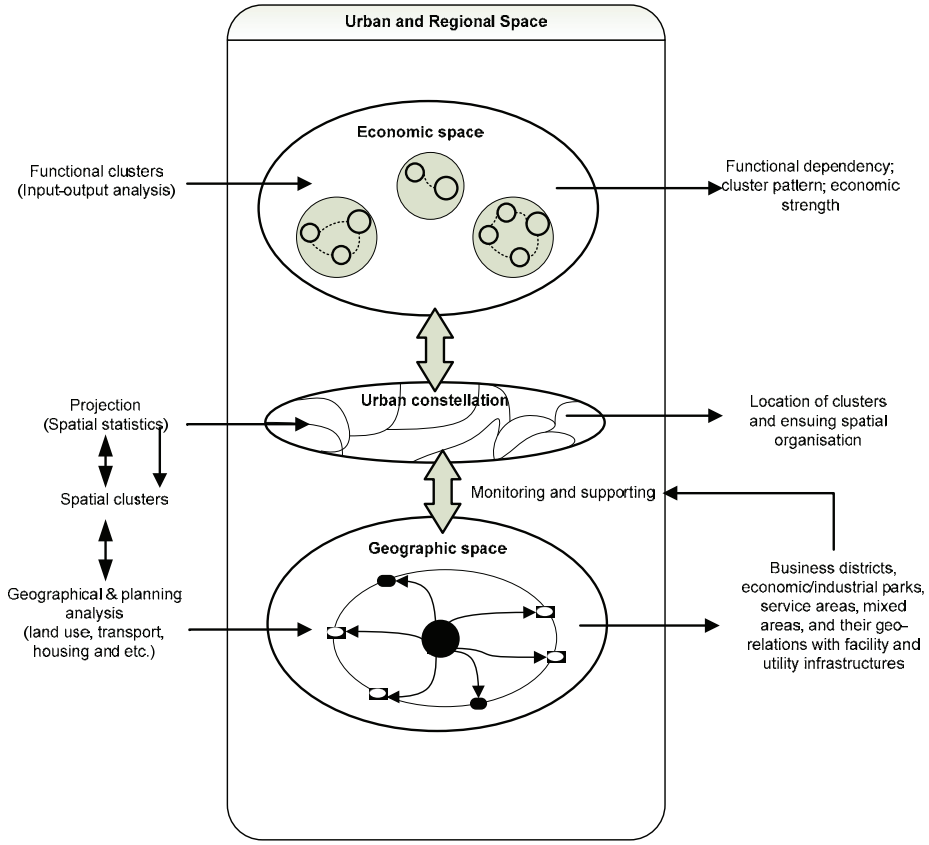


Figure 2.3 The empirical framework of the research

Based on functional and spatial clusters, geographic analyses and planning studies can be performed to gain knowledge about the actual development on the ground of business centres, industrial and office parks, and service centres. Their spatial characteristics and geographic relations can be explored. In this research, we focus on the developmental issues related to spatial organisation such as the roles of ECs in urbanisation and urban structure. The study area is Beijing, which is experiencing rapid economic growth and urban structure change.

Endnotes

[iv] The Institute of Strategy and Competitiveness of Harvard University establishes a large database 'Cluster Profile' covering a wide range of economic activities and regions, available at http://data.isc.hbs.edu/cp/index.jsp. European Cluster Observatory can be found at http://www.clusterobservatory.eu/, which covers EU-27 countries. Last access on Jan 16, 2009.

Chapter 3 Beijing: economic spatial development and cluster initiatives

Beijing is a suitable city for studying economic and spatial restructuring and their associated policy implications. As the capital of China, Beijing is one of the largest cities in China. In the early 1980s, Beijing started the transition process from a planned to a market economy, with major consequences for its economic structure and for construction. Economic cluster initiatives have gradually been incorporated into the city's policy agendas and have become an important component of development. This chapter gives an overview of Beijing urban development and its cluster initiatives.

3.1 Beijing overview

Beijing is well known for its historical and cultural richness. It is the capital of China and was so for over 3000 years' civilisation (Hou 1962). Such a long history created plentiful cultural and architectural heritages, many of which, for instance the Forbidden City at the right urban centre, deeply affect the contemporary city development. Beijing is also home to contemporary Chinese culture. It has the largest number of universities, academic institutes and college students of any city in China. Some universities and academic institutes are leading in the world, which makes Beijing a source of knowledge in China and a connection to the world. It is therefore not surprising that Beijing plays a pivotal role in Chinese politics and culture.

The city profile of Beijing is however not just one of historical and cultural richness. It is the 2nd largest city in China (Figure 3.1). Together with Shanghai, it ranks in the 1st tier of Chinese cities in terms of economic development and urban construction. Although the municipal government is an autonomous entity in management, the national government plays a crucial role in the development. Owing to its capital status Beijing is often a prioritised area for national policy programs, and in turn, its developmental experience may have a demonstrative value for other Chinese cities.

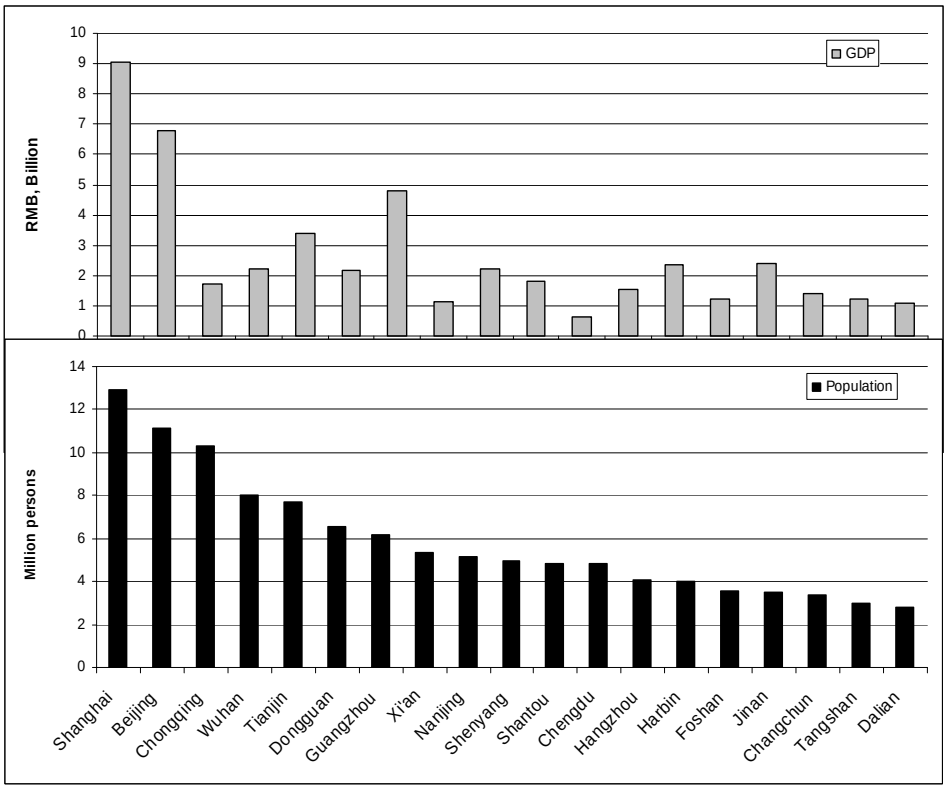


Figure 3.1 Largest 20 Chinese cities, 2006 (urban prefecture)

Data of source: China City Statistics 2007

The municipality covers 16,809 km^2 and is composed of 16 urban districts and 2 counties (Figure 3.2). The basic structure is determined by motorways: starting from the 2nd ring road that borders the Forbidden City and expanding to the 6th ring road that connects the town seats of ex-urban districts. Area located within the 4th ring road is generally regarded as the urban centre of Beijing, comprising 4 traditional inner urban districts and parts of 4 inner urban districts. Although some farmlands and orchards remain in the inner urban districts, economic activities, landscape and lifestyle are similar within the 4th ring road. At present the 4th ring road acts as a virtual boundary between urban and rural areas.

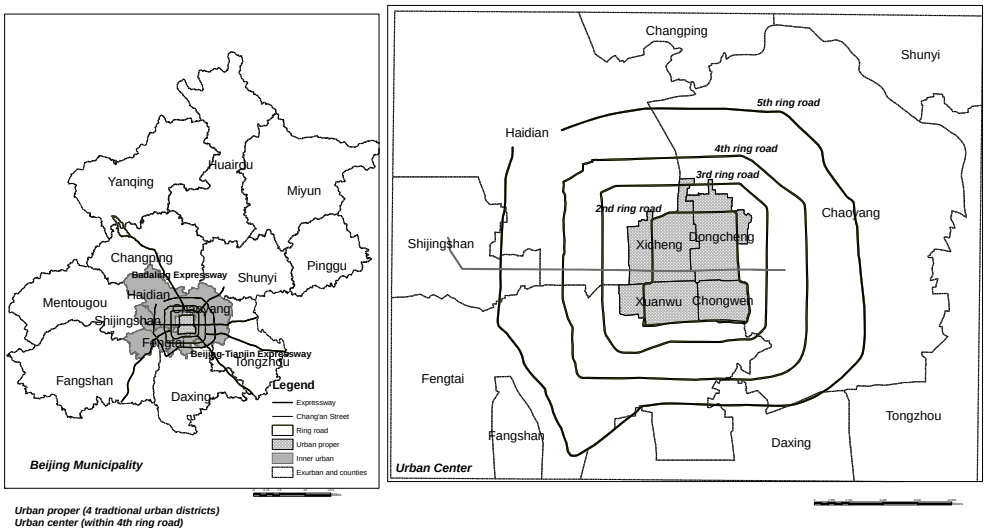


Figure 3.2 Basic spatial structure of Beijing

The total municipal population increases from 9 million in 1980 to 16.3 million in 2007, of which 15.3 million are living in the urban districts. Owing to the special status of the city, the urbanisation level is very high and by the Census 2000 was 78%. Beijing is also a city of migrants with 4 million migrants looking for economic opportunities and social welfare. The high urbanisation rate and a large number of migrants propel economic and spatial developments but create many challenges for urban policy.

In a wider geographical extent, Beijing is located in an emerging Extended Metropolitan Region (EMR). The urban system is composed of two core cities: Beijing and Tianjin, and several other main cities in Hebei Province, including Langfang, Baoding, Shijiazhuang Qinghuangtao and Cangzhou along the Bohai Rim (see Figure 3.3). With a hinterland of 40 million people and 185,000 km^2 the Beijing-Tianjin-Hebei (BTH) EMR is the third largest extended metropolitan region in China, behind the Yangze River Delta (YRD, Shanghai-Nanjing-Hangzhou) EMR and Pearl River Delta (PRD, Guangzhou-Shenzhen) EMR. Like Shenzhen and Shanghai, Beijing acts as a connection between the Chinese and the global economies.

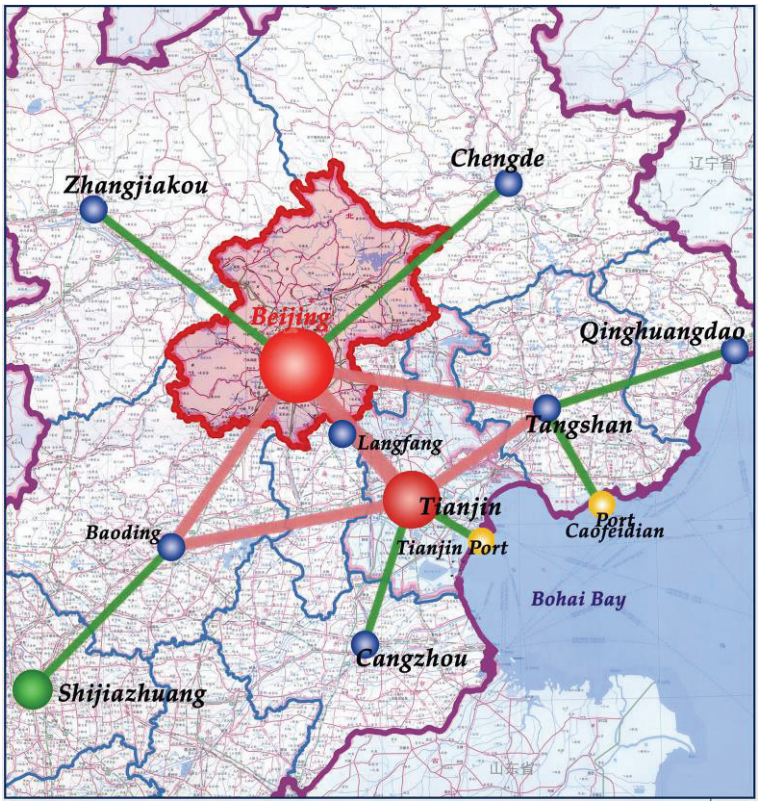


Figure 3.3 Beijing-Tianjin-Hebei (BTH) extended metropolitan region

Source: Beijing master urban plan 2006-2020

3.2 Institutional context

The fast development of Beijing and its a pivotal role in this BTH EMR have been accompanied with and to an extent made possible by a series of institutional reforms. The key aspects are discussed below.

3.2.1 Pre-reform

The socialist ideology, established in 1949, had a great impact on Beijing's development. With regard to the economy, the socialist state proclaimed its vantage in achieving fast economic growth. In the immediate aftermath of World War II and the subsequent Communist Revolution this was reflected and realised by means of a planned economy with a major focus on industrialisation. Accordingly Beijing started a massive industrialisation campaign as a part of the drive to transform its function from a 'consumer' to 'producer' of goods.

As the capital of China, Beijing obtained a strong support for its industrialisation from the central government. In contrast to other cities such as Shanghai, Jiangsu, Liaoning and Tianjin which remitted over 50-80% of local tax revenue to the central government, nearly half the fixed investment for Beijing came from the central government during that period until 1982 (Gu et al. 2006). Besides construction, investments concentrated on heavy industries including textiles, machinery, construction materials, and later on electronics, automobiles and high-tech industries. During the planned era, some (super-) large enterprises were established. Several State-Owned Enterprises (SOEs) with national significance, for instance the Capital Iron and Steel Enterprise (*Shougang*) and Yanshan Petrochemical Company each had over 10 thousand employees. As a result, Beijing became a new production base for energy (such as coal, oil and hydroelectric power), raw and semi-refined materials and low-end manufacturing. The city's gross industrial output increased 18 times during 1952-78, contributing greatly to the share of manufacturing in GDP that increased from 34% to 65% (Beijing Statistical Bureau 1998). Beijing became one of the most important industrial bases in China.

Population and migration controls were also an important aspect of national development strategies. A household Registration System (HRS), the unique system of China, was adopted to regulate both rural-urban migration and inter-city migration and control urban population (Lu 2003). The HRS strongly and effectively affected population dynamics in urban China between 1958 and 1985 (Gu et al. 2006). It was implemented as a means to ensure economic recovery and to realise industrialisation at the expense of rural and agricultural consumption. Under the system, administrative approvals were required for the movements of any individuals. Registration and approval was required for a rural household to become registered as an urban household and also for inter-city migration. Such migration permits were usually granted when people were engaged by state-owned enterprises. The growth of urban population was therefore closely related to industrialisation and strictly controlled. Registration of work and residence was part of the central plan and was administered by the Public Security Bureau at different administrative hierarchies (Gu et al. 2006). As household registration was a prerequisite to 'an individual receiving education, finding employment, obtaining supplies of food and daily necessities and even getting married and rearing children' (Chan, 1995), it was by and large an effective instrument for controlling the urban population, especially for big cities. It virtually impeded the mobility of labour and the associated diffusion of knowledge and technology between different parts of China and even within the city.

The socialist ideology was also embodied in the spatial organisation at city level. Tiananmen Square at the historic centre of Beijing symbolised the power of the socialist state. Beside the historic architecture of the Ming and Qing Dynasties in the Forbidden City, there are numerous central government and municipal official buildings, occupying almost all of the area within the 2nd ring road, in the vicinity of Tiananmen Square. While the north-south axis maintained the traditional imperial skyline, the newer east-west axis, Chang'an Street, was a contrasting landscape to symbolise the strength and power of the new socialist country.

Soviet planning models, in particular the idea of *production territorial systems*, were adopted as main regulations for spatial organisation. The model of work units *(danwei)* put this idea into practice, based on the principle that similar and complementary industries should be located together and that working and living places should be adjacent one another (Gu et al. 2006). In this manner a spatially self-sufficient system was formed at the neighbourhood level, not only for working and residence but also for education, health care and shopping (Gaubatz 1999). As enterprises were state-owned, the land for plants was provided by the government and they were entitled to build up plants as well as dormitories or apartments for their employees. Land and housing property markets were therefore entirely absent in planning and policy regulations.

The municipality was structured by a zoning method with an urban centre and numerous peripheral and remote centres (Figure 3.4). Remote centres are town seats of exurban districts and counties; the urban centre and peripheral centres have changed over time. In 1950s, the urban centre was the 4 traditional urban districts, and peripheral centres comprised of 6 planned key residential-industrial complexes. For instance, steel manufacturing was in Shijingshan (West); automobile manufacturing was in Fengtai (Southwest); cotton and machinery manufacturing was along Tonghui River (East); electronics was in the Jiuxian Bridge (Northeast); chemicals were in the southeast suburban; textile and communication equipments were in north part of the suburban (Liang and Chu 2005).

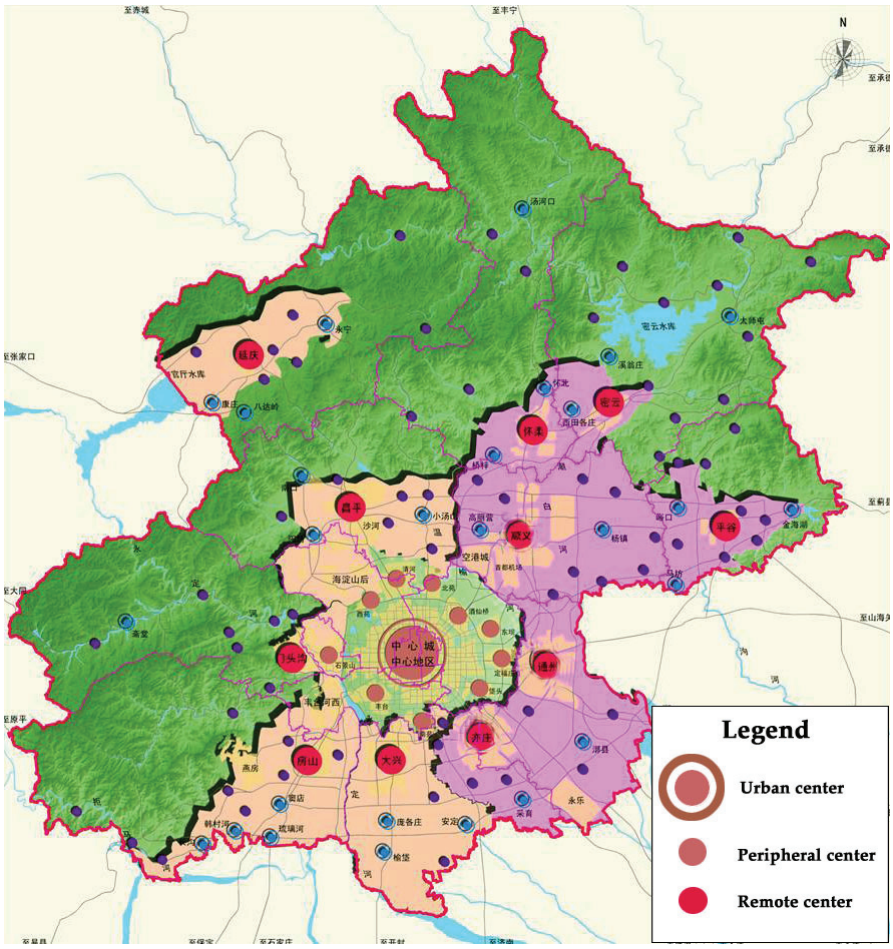


Figure 3.4 Spatial distribution of urban centres

Sources: (a) revised based on the pre-studies for Beijing master land use plan 2006-2020 (Institute of Beijing Urban Planning and Design, 2006)

Main residential and industrial areas were established adjacent to the ancient city. Until 1962, 70% of new houses were constructed in the inner urban areas (Liu 2004). Accordingly, most transport and utility facilities were located in the inner urban area. Industrialisation and increasing of residential areas dramatically promoted the development of the inner urban areas. These land uses gradually replaced the farmlands, orchards and green spaces typically in the urban fringe. By contrast, nearly half of projects intended for the key towns were not carried out [5]. As a result, the purpose of developing manufacturing and residential areas in remote areas was not realised. The zoning pattern was modified slightly in different planning periods, but there were no big changes until the middle of 1980s (Committee

of Beijing City Planning, Research Institute of Beijing City Planning, and Association of Beijing City Planning 2007).

The spatial organisation was mainly based on the allocation and reallocation of heavy industries. In the 1970s, many heavy industries expanded, including the machinery industries, petrochemical and textiles. In the early 1980s, 61% of manufacturing, providing 75% of Beijing's employment, is concentrated in the inner urban areas (Liu 2004). The developments of heavy industries and existing housing and facilities established the basis for the current mono-centric spatial pattern.

In the planned era, the institutional mechanism for Beijing's urban development can be summarised as: (1) political ideology dominated the city development, which resonates with the fast growth of manufacturing and mono-centric city spatial pattern; (2) the industrial-residential complex was the main mechanism regulated by the danwei system within inner urban areas; (3) key towns in the exurban and countryside were initiated with the purpose of relieving the pressure of the urban centre on residence and industrial development as well as promoting urban and rural integration, which were however not realised.

3.2.2 Transformation forces

Since the *economic reform* and *open-door* policy in the early 1980s, the institutional environment has dramatically changed by introducing market mechanisms in economic operations. This process involved reforming large, state-owned enterprises replacing state-responsibility by enterprise-responsibility in business operation (Wei and Yu 2006). It practically entailed the adjustment of the city's industrial structure from heavy to light and high tech industries

The first generation of modern enterprises was established in the early 1990s. The market economy created a powerful private sector that required strong but flexible public policies and regulations. Decision making processes were therefore decentralised: giving local governments more freedom and incentives to generate revenue for their own benefit in an entrepreneurial way (Lin 2002). Public investment and pricing policy no longer play a determinative role in economic development. This role has been taken over by market competition and cooperation. As a result, the government's role gradually shifted to monitoring economic development and attracting private capital and investments. The challenge for the government is to find a good balance between market forces and policy regulations in promoting and guiding city development.

The reform of the HRS plays fundamental roles in city spatial restructuring (Gu et al. 2006). The change of the HRS lags behind the reform of the rural economic system, which is based on collective property with the purpose to improve agricultural productivity. Higher agricultural productivity results in a large number of surplus rural labours, many of whom break through the household registration regulations by seeking a job in cities. On the other hand, college graduates and technicians are more likely to change their household registration by altering their residences to be closer to economic opportunities. As a response, the HRS is gradually more flexibly applied. Large scale inter-city and rural-urban migration has become a fundamental feature in Chinese urbanisation dramatically stimulating the growth of cities, especially for big cities[6]. More importantly, the relaxation of the HRS virtually encourages the free mobility of labour and capital (Gu et al. 2006).

An urban land market, as the second policy, was established in the early 1980s in order to change the situation that land use was entirely operated, invested and managed by governments. The 1989 Provisional Act of Land Use Taxation on State-Owned Urban Land was the first of several acts dictating land use taxation, mostly in the secondary land market. In 1991, taxation on land use became a top national priority via concrete legal guidance for land use rights with the objective to reform the land use system, rationalise land development, enhance land management, promote urban construction and spur on economic development. Nowadays all land should be traded in a bidding process in the land market[7]. The function of parcels is however under the control of urban planning acts and regulations.

The property market is the third driver of the transformation of a market-oriented urban planning. Successive changes in housing policy stimulate the commercialisation process of housing and the public's perception of housing provision (Wang and Murie 1996). During the 1990s Beijing experienced an unprecedented boom in residential construction in all segments from luxury villas and high-rise condos to public housing. The development of a property market was accompanied by residential reforms, including some related to employment in state-owned enterprises. Work-units no longer provide housing and services. This reform generated a huge demand on property, which encouraged domestic as well as foreign developers to participate in the housing market. Real estate development became an important driver for both fiscal revenue and GDP growth.

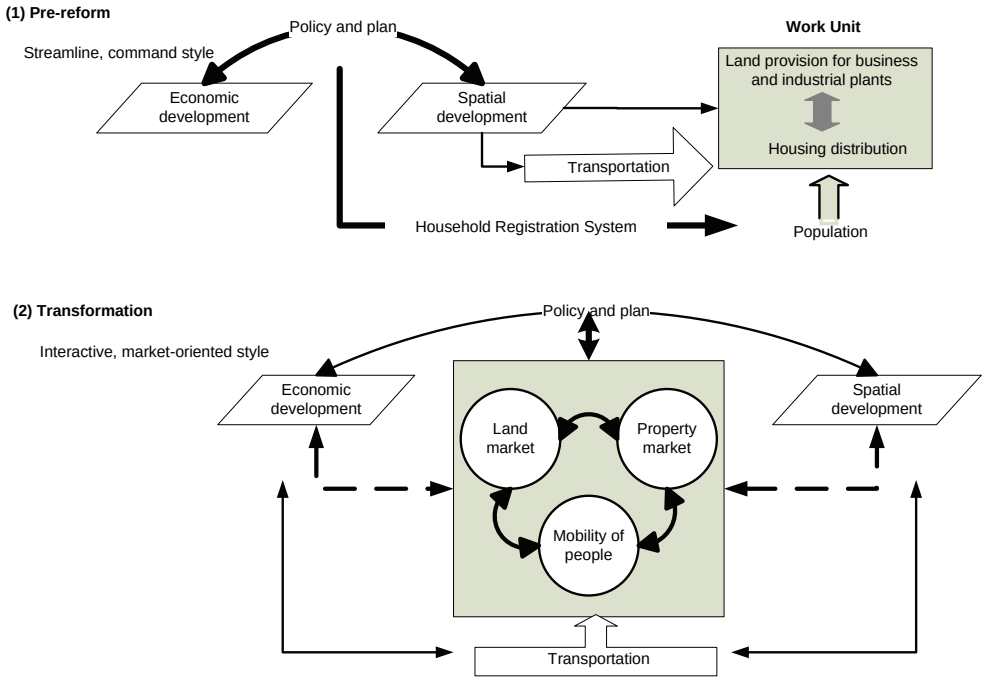


Figure 3.5 Institutional transformation for urban development

Figure 3.5 shows the transformation schematically. The pre-reform phase was a liner process. Economic and spatial developments were separate parts of the policy guidelines. In addition, the HRS, directly controlled by policies, influenced the size and characteristics of population, who set parameters for residence and working places in the framework of the working-unit as a major regulatory mechanism to realise spatial plan.

In the transformation phase, the increasing mobility as result of the relaxation of the HRS and the establishments of property and land markets directly contribute to the growth of the market economy. Governments however still play an important role in land provision, resource allocation and regulation of each specific project (Ma 2002). Therefore, interplay of government and market roles exists in the city development. This mechanism replaces the work unit as the main form of the city space.

As the market economy creates tremendous developmental opportunities for enterprises; it also stimulates local bureaucrats to seek profits. The consequence of this is that many developments may not be prescribed in the plan. This situation leads to uncertainty and complexity compared to the planed era and therefore requires consistent urban spatial and economic planning. For example transportation should be planned with considering the developments

of both sides to meet the demand from market-based development as well as be a way to distribute development0 potentials over space.

3.3 Urban economic and spatial dynamics

In the transformation of institutional context, the urban spatial characteristics and trends of Beijing are changed and reshaped. In this section, these dynamics are examined in detail.

3.3.1 Economic dynamics

3.3.1.1 Economic growth and structure

Beijing has undergone an exceptional development process since the establishment of a market economy. Gross Domestic Product (GDP) reached RMB 935 billion in 2007, an average annual growth of 17.8%, while GDP per capita increased 35 times (Figure 3.6). GDP per capita exceeded US$ 3,000 in 2000 and quickly breached US$ 5,000 in 2005, an important indicator of middle-income urban status.

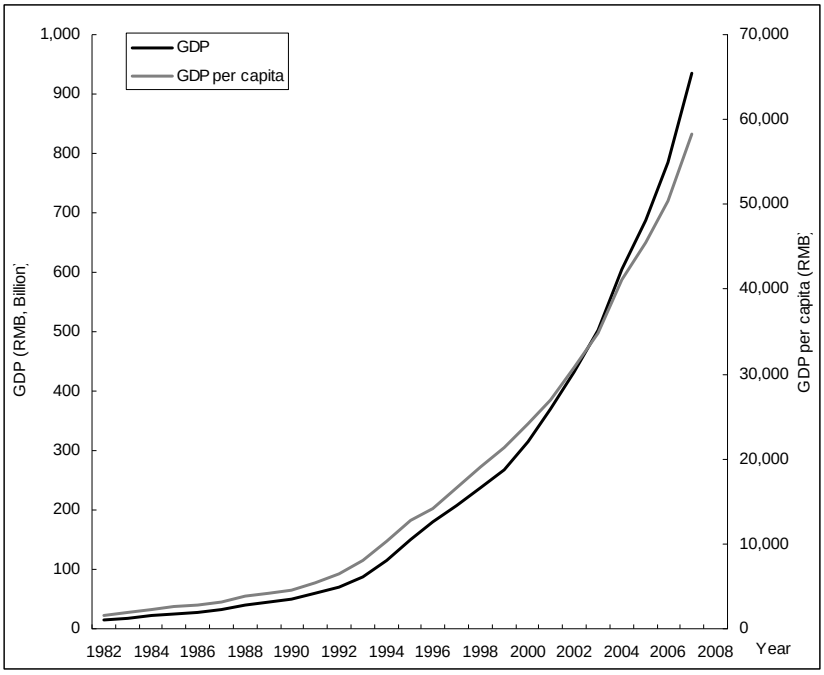
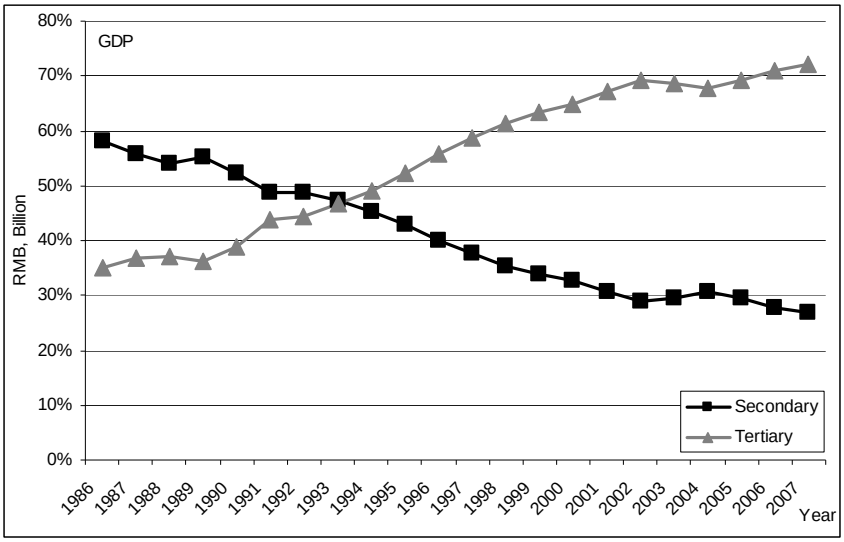


Figure 3.6 GDP and GDP per capita, Beijing

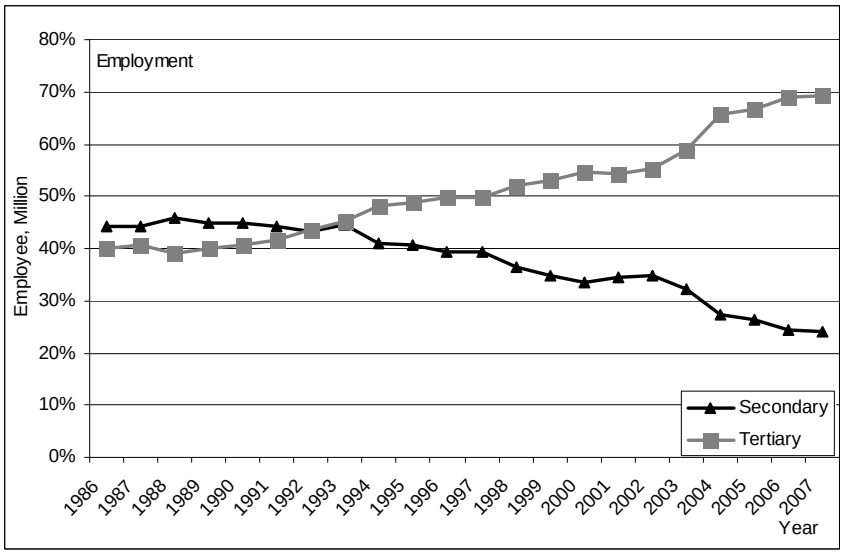
Data source: Beijing Statistic Year Book, 2008

Note: the GDP per capita is calculated for permanent residents

The economy was initially driven by manufacturing which accounted for over half the GDP or RMB 16.6 billion including construction in 1987. This situation was not changed until the middle of 1990s when the service economy gradually emerged as a dominant force both in outputs and employment (see Figure 3.7).



(a) GDP



(b) Employment

Figure 3.7 Relative share of GDP and employment of manufacturing and services in Beijing, 1986-2007

Data source: Beijing Statistic Year Book, 2008

Figure 3.8 shows that all major service sectors increase in importance, especially during 2002-07. The most significant growth was technology services with 51% annual growth during 2002-07 accounting for 15% of GDP in 2007. Other dramatically growing industries were financial and business (22%), real estate (32%), wholesale, retail and catering (34%), and hygiene, sports and entertainment (24%). Manufacturing also increased by 19% yearly during 2002-07 but its share of total GDP dropped considerably to only 22% from 33% in 1997.

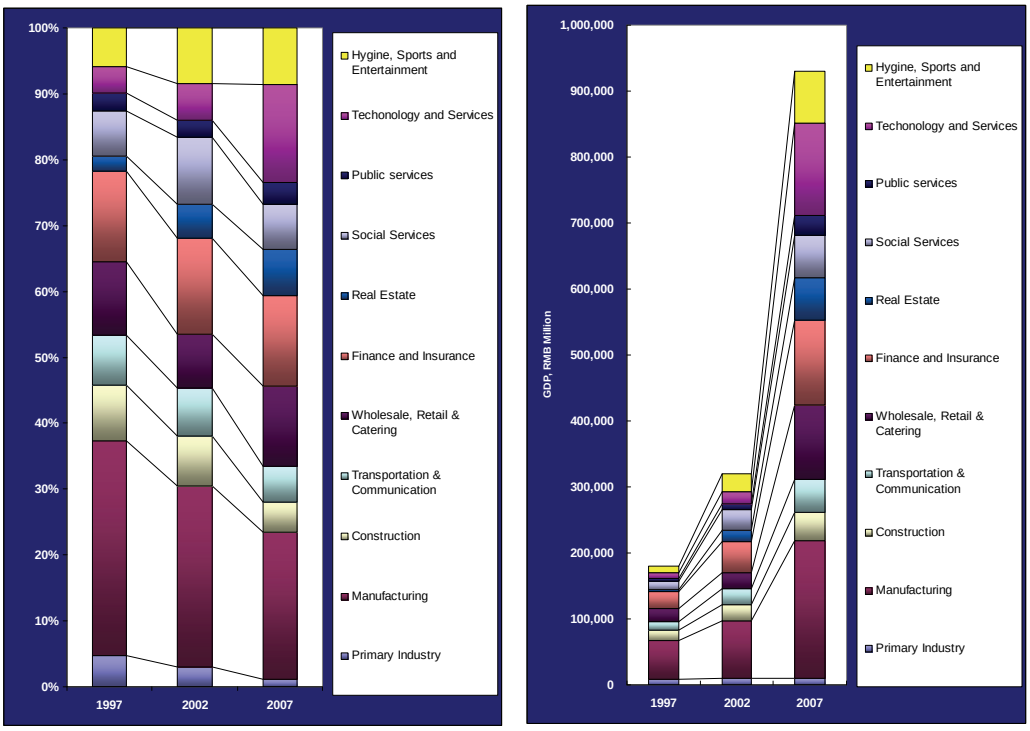


Figure 3.8 GDP structure of Beijing in 1992, 1997, 2002 and 2007

Data source: Beijing Statistic Year Book, 1998 2003 and 2008

Indicated by the Location Quotients (LQs), which measure the relative geographic concentration, Beijing has comparative strengths relative to other major Chinese cities in science, information, culture and arts, business, real estate, trading, accommodation and catering, and personal and household services (Table 3.1). The city's status as the capital city likely contributes to its leading role in many industries. In terms of manufacturing Beijing is below the national average and its counterpart provincial cities. Health care, education and finance are also generally lower. For example Beijing's LQ of finance is only just higher than Chongqing. This would however

probably be very different if high-end financial services and educational services are compared. This demonstrates the effect of the statistical classification used in calculating LQs.

Table 3.1 Location quotients in employment of main sectors in Beijing compared with other provincial cities*, 2005

		Beijing		Tianjin		Shanghai		Chongqing		Avg. Level of the Four Cities		Beijing's Perfor-mance ***
	Measuring level **	City	Nation	City	Nation	City	Nation	City	Nation	City	Nation	
	Health Care	0.5	0.8	0.9	0.9	0.9	1.1	1.0	0.7	0.8	0.9	3
	Personal and Household Services	6.0	4.6	2.4	3.0	3.3	2.4	0.3	0.5	3.0	2.6	1
	Logistics & Transport	1.4	1.4	1.2	1.2	1.7	1.8	1.3	1.0	1.4	1.3	2
ESCI	Education	0.4	0.6	0.7	0.7	0.5	0.7	1.2	0.9	0.7	0.7	3
	Sciences	1.9	3.0	1.4	1.4	1.6	2.3	1.2	0.9	1.5	1.9	1
	Culture & Arts	2.5	2.6	0.8	0.8	1.0	1.2	0.7	0.6	1.3	1.3	1
	Information Services	2.4	3.6	1.0	1.2	1.2	1.2	0.9	0.8	1.4	1.7	1
FIRE	Finance	0.6	0.9	0.9	0.8	1.2	1.9	1.1	0.7	0.9	1.1	3
	Business	3.9	5.2	1.5	1.4	2.8	2.3	0.4	0.4	2.1	2.3	1
	Real Estate	2.6	3.6	0.9	0.8	1.8	1.4	1.1	0.9	1.6	1.7	1
	Trading	2.4	1.6	1.0	1.1	2.5	1.3	0.7	0.7	1.6	1.2	1
	Accommodation & Catering	3.2	3.0	0.9	0.8	1.3	1.1	0.8	0.7	1.5	1.4	1
	Manufacturing	0.6	0.8	1.4	1.5	1.1	1.3	0.9	0.7	1.0	1.1	3
	Construction	0.9	1.0	0.6	0.6	0.6	0.5	1.9	1.6	1.0	0.9	2

Data source: Chinese City Statistic Yearbook 2006, and China Statistic Yearbook, 2006

*Notes: * There are four provincial cities: Beijing, Shanghai, Tianjin and Chongqing, which are different from other cities in geographical scales, institutional and fiscal systems; the location quotients are measured by*

$$LQ_{ij} = \frac{E_{ij} / \sum_j E_{ij}}{\sum_i E_{ij} / \sum_i \sum_j E_{ij}},$$

where E_{ij} *denotes the number of employees of industry* i *in area* j *.*

***As Beijing is a provincial city, the comparison is based on the 287 cities excluding rural areas, and on China's national sector structure.*

****This is compared with the average performance of the four cities, category '1': absolute concentration, '2': moderate concentration, '3': less concentration.*

3.3.1.2 Private economy

With the establishment of the market economy, the private sector now plays crucial roles in urban development indicated by employment (Figure 3.9). The percentage of employment in state-owned enterprises sharply decreased from 56% in 1997 to 35% in 2007. By contrast, during the same period the proportion of total employment by private companies increased from 16% to 44%. Although creating 85,000 new jobs, the relative importance of foreign companies fell in 1997-2002. More recently its share of employment has again risen.

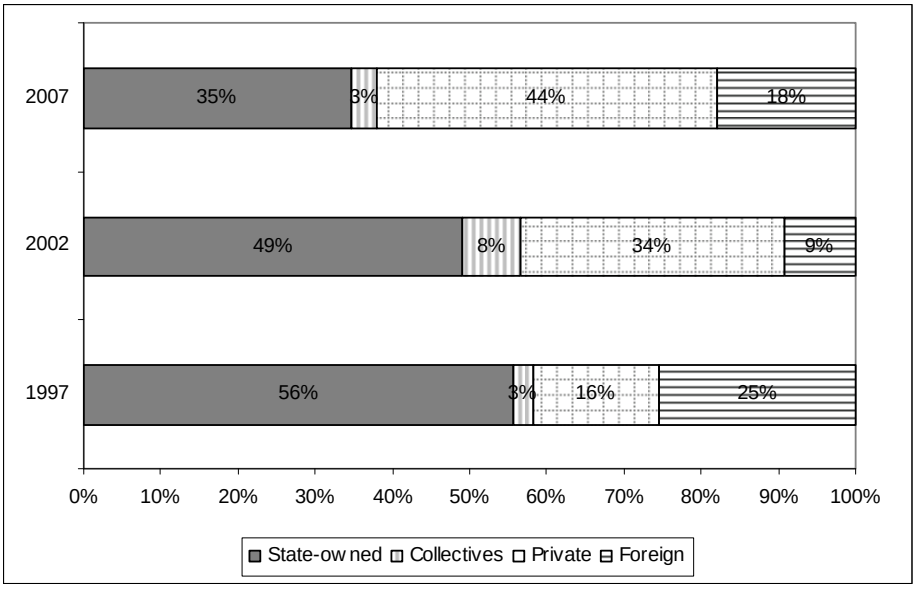


Figure 3.9 Employment structure by ownership

Data sources: Beijing Statistic Year Book, 1998, 2003 and 2008

Table 3.2 shows the transformation of investment in fixed assets during 1978-2007. Remarkably, more than half of the total investments of the last 30 years have been acquired in the last 5 years (2003-2007). Moreover, it is the first time that private investment in fixed assets exceeds public investment. The emergence of a stronger role of private investors implies that public policy makers have to think carefully about how to encourage public and private cooperation in urban construction and economic development. Not only this, more and more is there a need to think of how to encourage investments of the public sector in a strategic manner towards achieving public goals.

Table 3.2 Public and private investments in fixed assets

	Total (RMB, Billion)	Public (RMB, Billion)	Private (RMB, Billion)	Public share (%)	Private share (%)
1978-1982	16	16	0	100%	0
1983-1987	45	32	13	71%	29%
1988-1992	94	90	4	96%	4%
1993-1997	374	277	96	74%	26%
1998-2002	697	400	297	57%	43%
2003-2007	1485	530	955	36%	64%

Data source: Beijing Statistic Year Book, 1998, 2003 and 2008; Beijing 50 years: 1949-1998

Fiscal revenue is an important source for public financing. Its relationship with GDP indicates the ability of governments sharing and controlling social and pubic resources. As indicated by Table 3.3, the fiscal revenue more than doubled in 2003-07 compared to the previous period, and its growth is higher than that of GDP (i.e. the elasticity coefficient is great than 1) after 1993. This implies that unit economic output brings with more fiscal revenues. With the increase of economic outputs, local government would be better able to invest in public goods and services such as education health care, and infrastructure. Public investment can therefore still play a strong role in urban development.

Table 3.3 Increment of fiscal revenue

	Fiscal revenue (RMB, Billion)	% of GDP	Elastic coefficients*
1978-1982	24.6	37%	0.66
1983-1987	26.2	21%	0.89
1988-1992	37.0	14%	0.68
1993-1997	66.0	9%	1.07
1998-2002	209.3	13%	1.24
2003-2007	562.1	16%	1.52

Data source: Beijing Statistic Year Book, 1998, 2003 and 2008; Beijing 50 years: 1949-1998

** Elasticity coefficients equal the relative growth rate of fiscal revenue compared to GDP.*

Data sources: Beijing Statistic Year Book, 1998- 2008; Beijing 50 years: 1949-1998

3.3.1.3 Foreign direct investment

Foreign Direct Investment (FDI) has a strong role for local economies in establishing and enhancing linkages with the world economy. It

brings capital, technology, know-how, jobs and exports (Geiger 2002). Beijing is no exception. Beijing started oversees trade in the period of 1980-87, when only 6 FDI-based projects were approved. After a somewhat cautious start, perhaps attributable to concerns about socio-political stability after 1989, FDI is growing rapidly at 23% p.a. in 2003-2007 and now exceeds US$ 5 billion p.a. The recent fall in 2000-2003 was due to the economic restructuring in the South Asian Counties after the Asian Financial Crisis in 1997, which did divert FDI away from China. It is also likely that the global recession of 2008-2009 will reveal itself through substantial impacts on FDI.

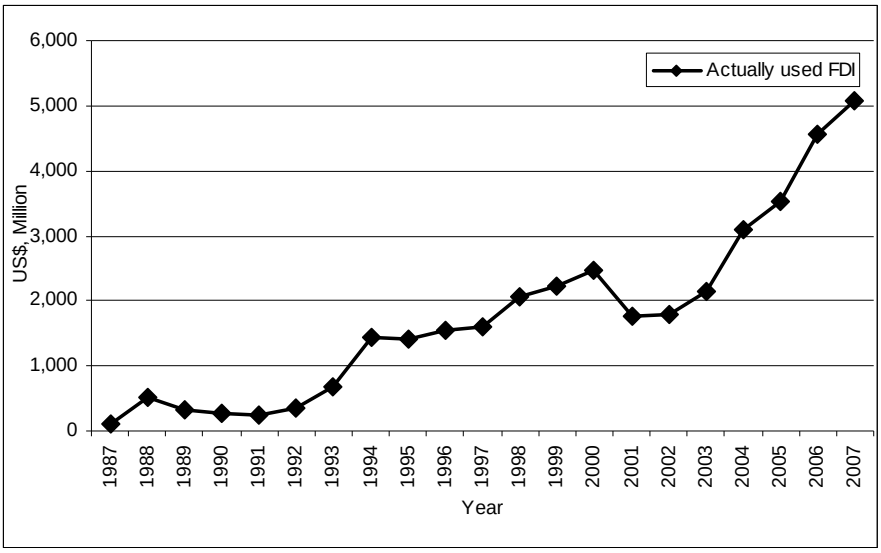


Figure 3.10 FDI in Beijing

Data source: Beijing Statistic Year Book 2008

FDI accelerates Beijing's economy in a variety of ways. It dramatically stimulates the real estate, business services, and information and communication industries. In 2007, the share of the total FDI for these industries was respectively 24%, 19% and 16%, increasing by 264%, 80% and 360% compared to 2003. In addition, manufacturing attracts 18% of FDI and increases by 24% (Figure 3.11). Besides these main interested sectors, FDI dramatically increased in (sales) wholesale, retail and catering. It however shows less interest in construction and accommodation and catering.

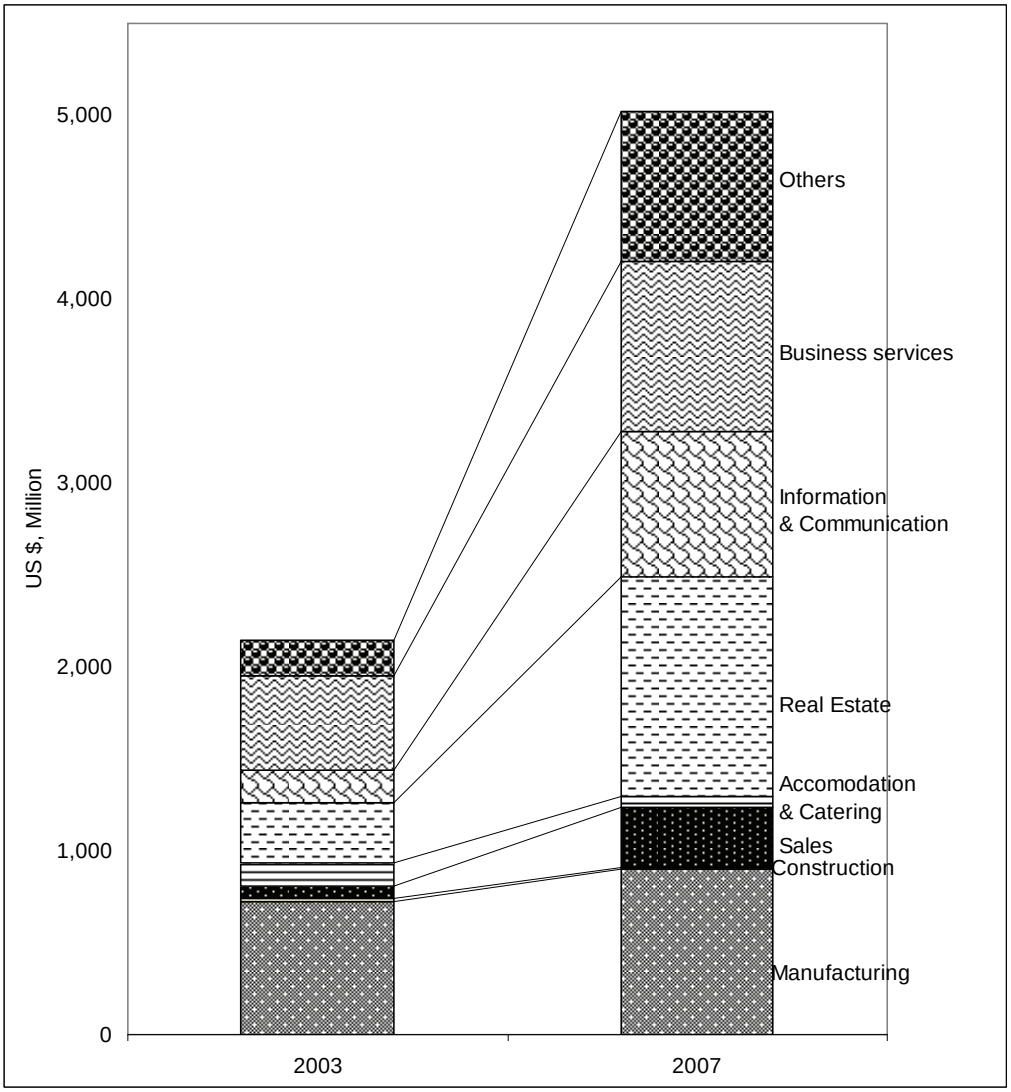


Figure 3.11 Composition of FDI by sector in 2002 and 2007

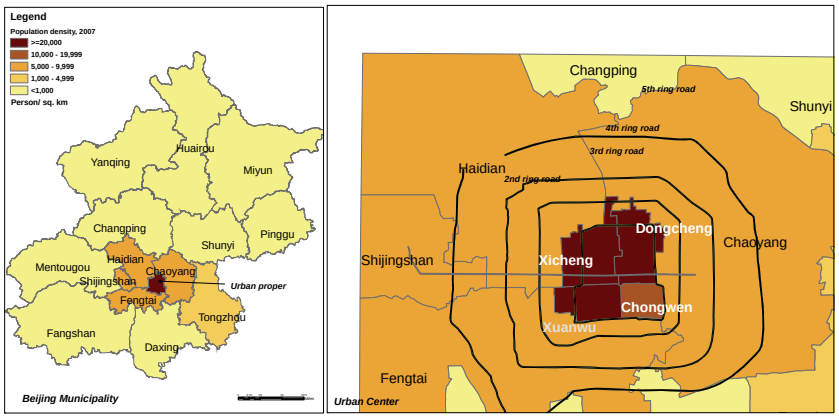
Data source: Beijing Statistic Year Book 2004, 2008

3.3.2 Spatial dynamics

3.3.2.1 Urban population distribution

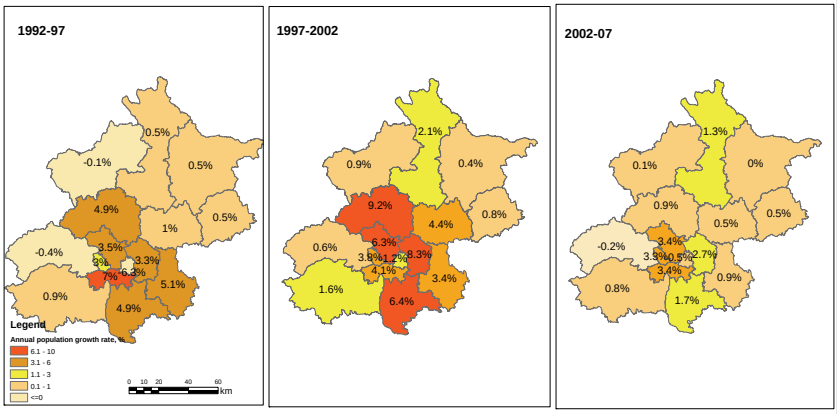
There were over 16.3 million residents living in the municipality in 2007, of which nearly half in the inner urban areas. This situation contributes to a densely populated urban core with over 20,000 persons / km^2 (Figure 3.12). By contrast, the density for the whole

inner urban area sharply decreases to 6,300 persons / km^2. The differences in density (core/inner urban) reduced from 7 times in 1992-97 to less than 4 times in 2002-07. The lowest population density is in the rural counties, only 174 persons / km^2.



Population density (person/sq.km in 2007: urban proper=22,394, inner urban districts=6,312, exurban districts=506, counties=174, and mucnipality average=995.

(a) Population density, 2007

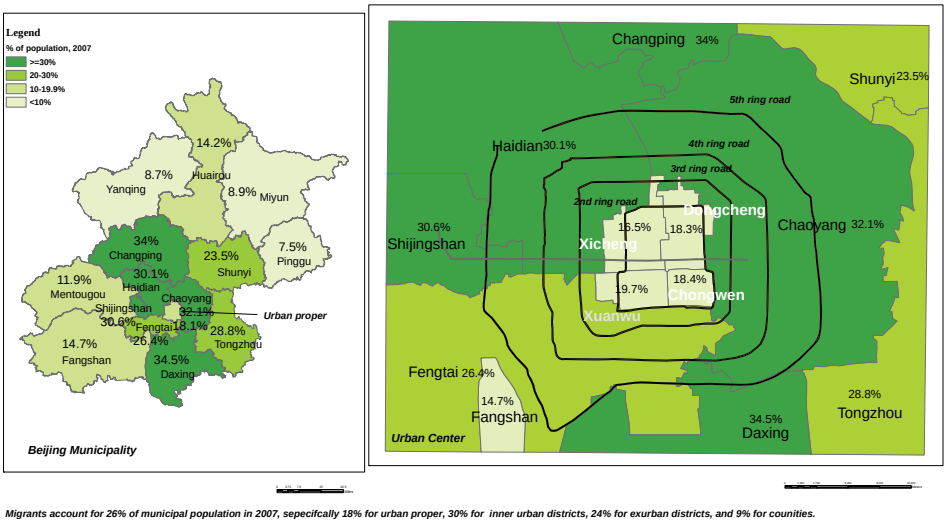


(b) Population growth, 1992-2007

Figure 3.12 Population density and growth by prefecture, Beijing

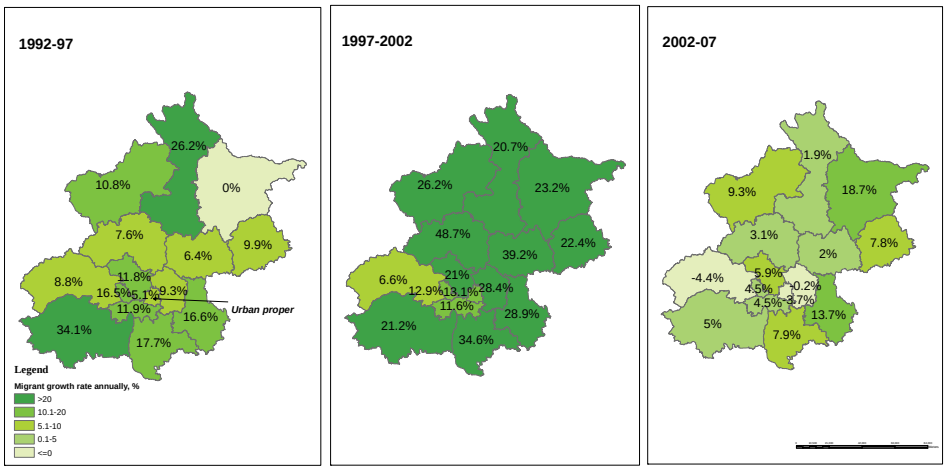
Data source: Beijing Statistic Year Book, 1998, 2003 and 2008

Since 1992, the inner urban area has become a major place for population growth. With growth rates of 3.1% p.a, 6.4% p.a. and 4.1% p.a. in the periods of 1992-97, 1998-2002 and 2002-07, the population growth of the inner urban area is far higher than the traditional urban core, the exurban area and counties. The traditional urban core is now losing population (Figure 3.12).



Migrants account for 26% of municipal population in 2007, sepecifcally 18% for urban proper, 30% for inner urban districts, 24% for exurban districts, and 9% for counities.

(a) Migration distribution, 2007



(2) Migration growth, 1992-2007

Figure 3.13 Migrants distribution and growth by prefecture, Beijing

Data sources : Beijing Statistic Year Book, 1998, 2003 and 2008

According to 2007 statistics, migrants accounted for 26% of the city's total population, 4.2 million persons. Most migrants live in the inner urban area especially in Haidian and Chaoyang. In the exurban districts, Changping and Fengtai have also become main places for migrants (Figure 3.13). Although for the municipality the migration rate in 1998-2002 was as high as 22.3%, recent figures of 2002-2007 show an annual growth rate only at 3.2%. In particular, the migrant population starts to decrease in the urban core. Clearly, migration is still a growth factor, but its scale and nature has substantially changed. With urban construction slowing down and a

shift to high-tech industrial development both quantitative and qualitative changes in migration occurred.

Population distribution is now following a mono-centric pattern, with population density gradually decreasing from the centre to periphery. The dynamics however show that the urban core is losing urban population to the inner urban area. The inner urban area also becomes a major place for migrant influx. Consequently, a huge population core is formed with a stronger axis of northwest-southeast orientation indicated by the concentration of migrants (Figure 3.13). In terms of social class and lifestyle, Beijing's population distribution is gradually becoming more heterogeneous socially and spatially with different groups tending to cluster in different parts of the city (Feng, Wu, and Logan 2008).

3.3.2.2 Transportation

Inner-city

The ring road system plays a crucial role in Beijing's transportation. Construction of the 2nd ring road circling the traditional urban core started in 1987 and completed by 1992. Based on 10 flyovers that date back from 1974, the ring was constructed to alleviate the transportation pressure in the urban core. It is the first real motor freeway in China. In the following years several new rings were added: the 3rd ring road was finished in 1994, connecting the inner urban districts (Zhang 2001). The 4th ring road, was completed in 2001 and was intended to become the border between the urban and rural areas in the region. The 5th ring road was open in 2003 to connect the key towns in the inner urban area. Most recently, the 6th ring road was added to link the town seats of the exurban districts (Figure 3.14).

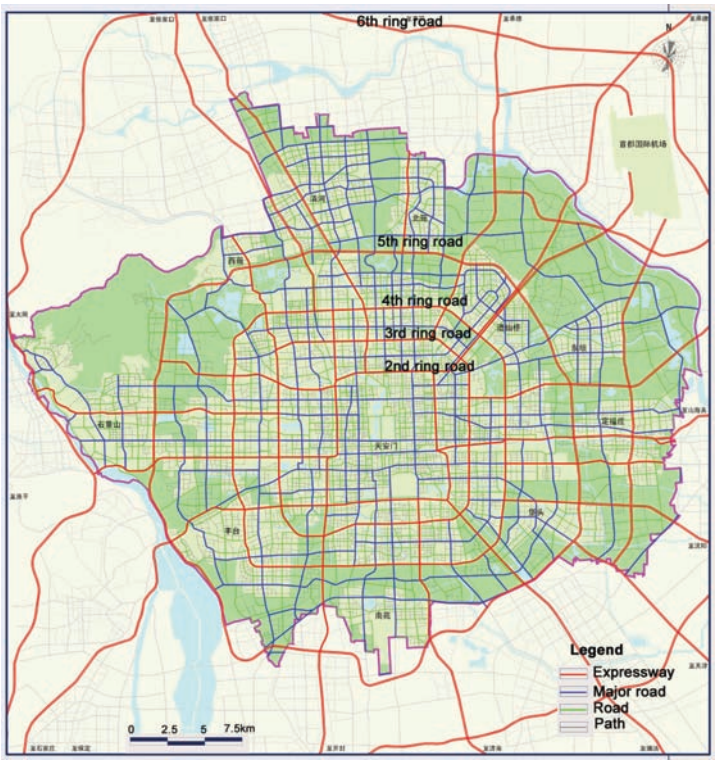


Figure 3.14 Road system inner Beijing

Source: Beijing master urban plan, 2004-2020

Besides the ring road system, the metro system is an important element of intra-city transportation. Beijing started its metro system in 1965, when Metro 1, along the Chang'an Street, was constructed and opened in 1969 with 23.6 km at that moment. Metro 2 opened in 1984 almost overlapping the 2nd ring road. In the later years until 2007, the metro system extended slowly with in total 42 km or 1.3 km built per year. Particularly during 1987-97, only 1.8 km was opened for the Metro 1, from Fuxingmen to Xidan (Zhang 2001). New metros were opened in the 1997-2003 period when Metro 13 and part of Metro 6 were completed. Metro 13, part of which is a light rail line (LRT), links the two main transport nodes Dongzhimen and Xizhimen with Huilongguan, the new densely built residential area, and Wangjing, the new huge complex of business districts and residential quarters. In 2005, the metro system's length was 114 km[8].

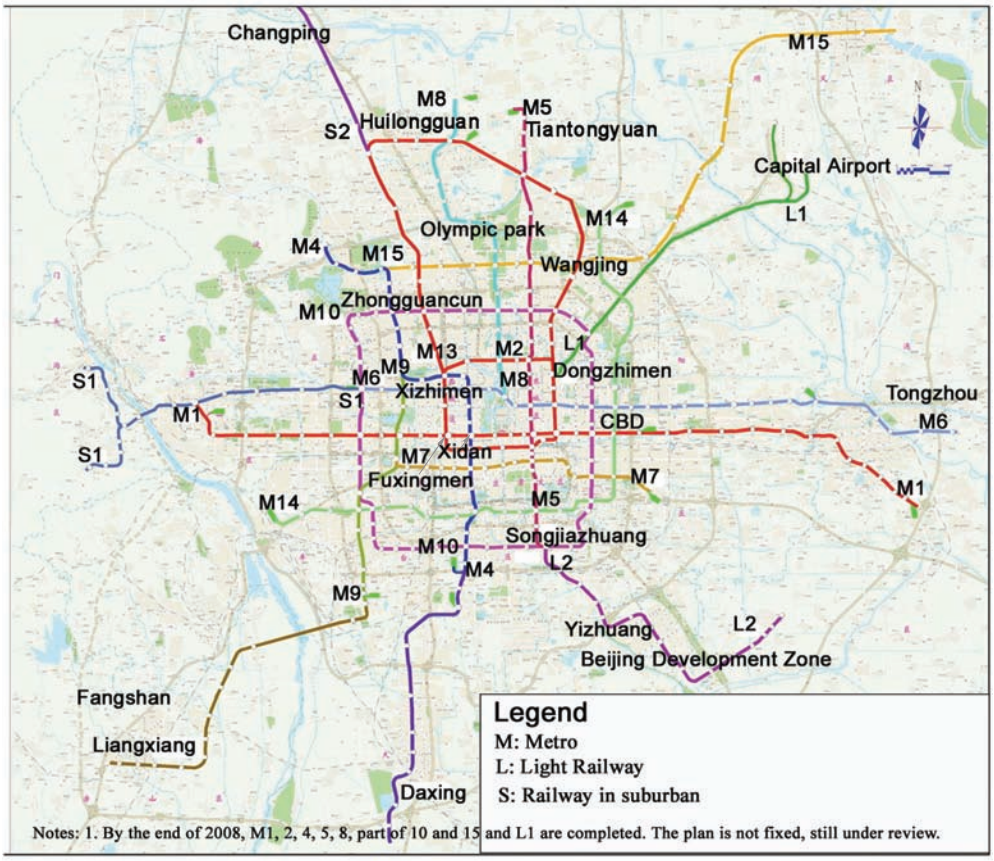


Figure 3.15 Metro system in Beijing, planned for 2015

Data source: Beijing Subway http://www.bjsubway.com/cns/dtfz/index.html, last accessed on 25 Feb 2009

The 2008 Olympic Games provided an impetus for the construction of 3 new lines: Metros 5, 10 and 8 (Figure 3.15). Metro 8 links the main stadium of the Olympic Games to the network. Metro 10 plays a role in reducing traffic on the 3rd ring road. Metro 5 connects the existing and proposed big residential areas: Tiantongyuan and Songjiazhuang, each with over 500,000 residents. In addition, the Capital Airport was connected by the light rail line L1 (LRT) to Dongzhimen, a transport node for the eastern part of the inner city. In 2008, the total length of the metro system (including LRT) amounts to 220 km, carrying around 1.3 billion passengers in 2008, with a daily peak of 4 million passenger-trips[9]. An indication of the demand is that within its first 27 hours of operation Metro 5 carried 706,000 passenger-trips[10].

New metro lines are still under construction. According to the plan, by the end of 2012, Metro 4, 6, 7, 8, 9, 10, 14, 15 and suburban railway

1 (phase 2) will be completed, which will extend the system to 407 km, covering key areas within the 5th ring road and some key towns in exurban districts: Yizhuang, Daxing and Liangxiang. The next step is to extend the metro system into the exurban areas giving it a length of 561 km. This plan is however not yet decided on as some aspects are under review for financial, technical and implementation feasibility.

Inter-city

In addition to the vast development of local transportation, Beijing is the national centre for railway and air transport. It has five railway stations, among which, two major stations, East and West Railway Station are located within the 3 ring road and along Chang'an Street. The Capital Airport that connects 84 domestic cities and 59 foreign cities in 41 countries by 208 routes, handled 410 million passengers in 2005[11]. In addition, 8 major inter-city or regional transportation lines radiate from the city centre crossing the 4th ring road. Inter-region passenger and cargo traffic increase the pressure on the local transport networks.

A large inter-city transport system closely links Beijing with the surrounding cities (Figure 3.16), reflecting the forming of the Greater Beijing or BTH EMR. With 3 expressways, the connection between Beijing and Tianjin is perhaps the most important. In addition to the expressways, the inter-city rapid railway dramatically shortens the distance between Beijing and Tianjin only to 39 minutes. A possible site for the 2nd Capital Airport is located along the Beijing-Tianjin highway. The geographical distance is 'shortened', through the creation of high speed links, which promote regional integration and strengthens the function of each city. For example, Tianjin can play a complementary role as a sea port for Beijing. The biggest iron company, Shougang to Caofeidian, in Beijing will relocate in a port city near Hebei Province.

Figure 3.16 Inter-city expressway system of Beijing

Data source: Beijing master urban plan, 2004-2020

3.3.3 Challenges of urban economic and spatial developments

Beijing continues to grow fast. However, a vibrant city is not without challenges. In particular, the city is under a fundamental change from a low-end manufacturing-led economy to a modern service-oriented economy. To successfully realise such fundamental change is not an easy task, particularly under the relatively new phenomenon of external cooperation and competition. As indicated by the LQs (Table 3.1), some of Beijing's comparative advantages, such as in education and health care, are not realised. Some research points out that the number of patents granted to Beijing's high-tech industrial development is only half of the country's average (Zhao and Wu 2006). With regard to high-end services, the LQ of employment for the finance sector is rather low, which is perhaps attributable to the

competition of two competing business/financial areas (Zhou 1998). Besides, despite the fast economic growth, there is no guarantee that the welfare of the citizens will also improved over time. To preserve and promote the function and leading role of the city in national and global city networks, a more careful policy guidance, supported by modern information systems, is needed.

Given the economic transformation, the relationship between private and public activities becomes important. The private economy has gradually replaced the public management of business development and employment creation. To a large extent, the facility and infrastructure construction cannot be implemented without acknowledging the role of the private sector. Nevertheless, public investments still play an important role especially through the special support from the National Government for the capital city. The growing importance of the private sector has the potential to draw public investments and policy away from their main focus of ensuring public welfare. A critical point is how to find a fair balance between public investment and private profits in city development.

The growth of FDI shows that Beijing is likely to be an increasingly important player within the global economy. The fluctuation of the FDI trend however does show over-reliance on export-orientation. Such a FDI-based economy is not without risk. To sustain economic momentum, the city must consolidate its economic competitiveness as well as transform external factors into local internal strengths. Continuous attention for strategies and innovative ways to improve current economic policies will be required.

With economic development, additions to and reconstructions in the city's urban area were rapidly constructed following a largely mono-centric model. Comparing figures 3.17 and 3.4 show this structure basically followed a mono-centric model till 1992, and the urban expansion encroaches on green space and agricultural land. The dramatic growth of the main urban centre absorbed 6 planned peripheral centres from the early 1990s. Although city planners were aware that a polycentric pattern, with strong multi-functional centres, is a better option for Beijing's spatial organisation[12], the situation was beyond their expectations and control (Committee of Beijing City Planning, Research Institute of Beijing City Planning, and Association of Beijing City Planning 2007).

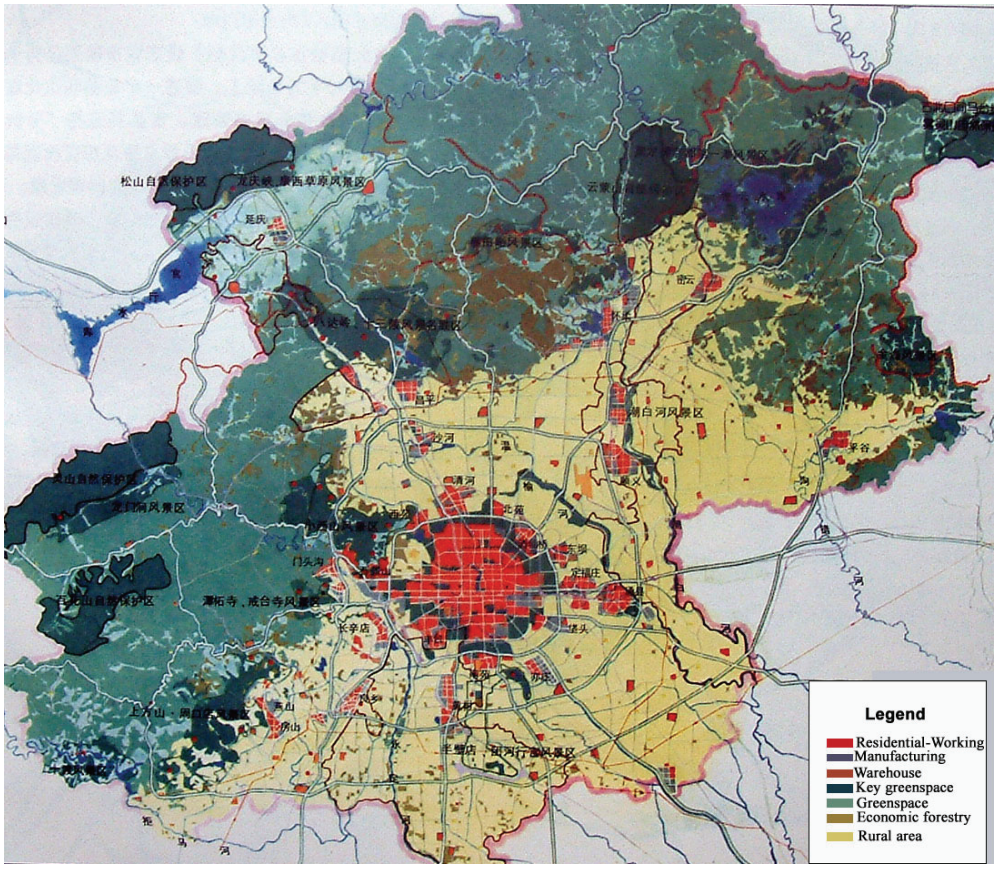


Figure 3.17 Beijing 1992 urban master plan

Source: Beijing Urban Planning Committee, Association of Beijing City Planning, and Institute of Beijing Urban Planning and Design (2006). Beijing City Planning, 1949-2005.

If the mono-centric trend continues, the municipality will be faced with major pressures in the fields of traffic, housing and ecological sustainability (Committee of Beijing City Planning 2005). For example, according to the carrying capacity of the water resources and green spaces, urban population should be contained to 18 million by 2020 (Committee of Beijing City Planning 2005). Currently most people live in the urban centre. They cannot enjoy sufficient green spaces, their living environment is deteriorating and for residents of the core and inner districts, access to peripheral green areas becomes increasingly difficult.

With the economic development and population growth, the number of motorised vehicles increases dramatically, most of which are private cars. In 2007, about 3.1 million cars and buses drove on Beijing's roads, 2.3 times the number in 2000. The surge of vehicles

and frequent use of private cars exerts a big pressure on the road network. For instance, in 2005 the traffic volume on the north and west parts of the 4th ring road was over 160,000 vehicles per hour at peak time (Beijing Transportation Research Center 2005, p42). Within the 4th ring road, the average vehicle speed is limited 20-40 km/h at the morning peak and 20-35 km/h at the evening peak (Beijing Transportation Research Center 2004, 52). By 2004, the road transportation system in the urban centre was nearly saturated with average traffic load of 0.88 and 9% of all urban roads were over saturated during peak hours (Beijing Transportation Research Center 2004).

The severe traffic congestion is in part due to the transport system. Within the 2nd ring road, the road system is based on a grid pattern following the pattern of the Forbidden City. A ring road system has been constructed, but less attention has been given to the radial road system that connects the rings. Between 2nd and 3rd ring roads and between 4th and 5th ring roads there is a lack of nodes which can effectively divert traffic or provide alternative routes. As a result, 50% of trips occur within the 3rd ring road (Beijing Transportation Committee and Beijing Transportation Research Center 2005). Congestion is particularly problematic at the entry/exit points to and from the city centre along the 3rd ring road, especially during peak hours.

The traffic problem is partly attributable to the spatial organisation of the city. With the urban renewal, many residents were relocated from of the centrally located, traditional urban districts to peripheral areas. Services and business however became even more heavily concentrated in the city centre. Following the concept of key towns during 1970s-90s, some new dormitory suburbs such as Tiantongyuan and Huilongguan, each with over 200,000-300,000 residents, were constructed in the peripheral area. Another peripheral town, Wangjing was also destined to be a dormitory suburb. Although a plan was made to include a new business area it actually has about 300,000 residents but only provides 20,000 jobs. On the other hand, Wangjing is with a distance of 5 km to the main transport node (Dongzhimen) and the Central Business District (CBD). This situation undermines its attractiveness for business investment. The end result is massive, long distance daily commuting and congestion.

Beijing's traffic problems are particularly due to the imbalance between specialised work and residence locations in the land-use pattern (Zhang and Gao 2008). If the spatial imbalance between work and residence continues, the traffic problem will become more severe. This is substantiated by a recent transport survey. In 2005, 31.9% of private cars were driven for daily commuting between work

and residential places and 30.6% of car owners had to drive for their daily work (Beijing Transportation Research Center 2006, p36). Most users of private cars are now paying for the city's imperfect spatial organisation.

Reducing the traffic problem apparently requires the integration of two considerations: one is the traffic system and the other is the spatial organisation that is determined by the major economic areas and residential districts. With the expansion of the metro lines, the share of public transport such as bus and metro transports has dramatically increased in 2008. It is expected that the metro system will contribute to the alleviation of transport congestion. As several metro lines are spatially related to ring roads, they can draw some road users into the public transport service, but they also reinforce the ring roads as a shaper for the current mono-centric urban pattern. Adjusting the current form will require investments to be made that promote poly-centric development based on strong, multi-functional urban districts that provide housing, employment and services.

3.4 Economic and urban planning policies

These new urban dynamics require the adjustments of economic and urban planning to adapt to the development trends and meanwhile overcome or avoid existing, potential and possible problems in the growth of the city. This section discusses the new characteristics of and introduces some issues in recent economic and urban planning.

3.4.1 New characteristics of economic and urban planning

With the transformation of the institutional environment in China to a market-based system, both the economic and the urban planning policies are gradually changing. Economic policy making is affected by the decentralisation of the fiscal system, the opening up to the world economy and the establishment of land and property markets. Local economic policy thus actively participates in local economic construction, financial budgeting, and setting up its development goals. Accordingly, urban space is becoming less centrally controlled and is substantially influenced by the mobility of productive and economic elements and external influences. Also, adjustments to urban planning policies have been required. Rather than acting as an auxiliary measure to realise city's industrialisation (Xie and Costa 1993), urban planning is gradually developing and exercising power to intervene in construction projects, especially after 1984 when economic reforms were introduced into urban areas (Gar-on Yeh and

Wu 1999). The enactment of the 1989 City Planning Act was a milestone that established and formalised a new style of urban planning in the transitional economy (Gar-on Yeh and Wu 1999). Consequently, new planning methods, foci and styles were developed to embed the urban planning making within a market economy framework.

Economic policy at the municipal level is a type of development planning. It comprehensively analyses the current situation of economic development from the viewpoint of resources, conditions, advantages and challenges so as to predict and prescribe the future economy. The economic planning broadly repositions the city development for the subsequent 5 years and, according to given aims, details and formulates policy regulations sector by sector. It is therefore very much a master-plan type i.e. a sector-oriented blueprint plan following a hierarchical political process, replicating the economic policy model of the Central Government with local considerations. Sector policies are usually developed for key industries, listing main sub-industries and prescribing supportive measures. However, this description and prescription gives few considerations to cooperation among business sectors and focuses on competition from the external environment.

The new market-oriented urban planning is accommodating some issues which did not exist in the pre-reform era. With the abolition of the HRS and work-units, urban planning has to deal with a far higher pace of change of in both the economic and the social domains and in mobility within and between cities. Moreover, the growth of private sector influence in land and real estate development has to be facilitated.

Currently, urban planning seems incapable of responding adequately to the demands of economic development. Urban master plans often lag behind reforms and have to be revised constantly in order to follow the new directives. As a result, much development and new construction lacks proper planning guidance (Wei 2005).

One of the causes of poor guidance is the inconsistency between sectoral economic policy and physical urban development, which is often visible at district level. Strictly speaking, urban districts have their own rights to design and operate their district's economy, but in doing so they need to negotiate with the municipal government. The municipal sectoral policy should provide guidance for this but given the scale of the opportunities at hand, urban districts may not confine themselves to the municipal development guidelines. Also, many new economic opportunities and urban projects were simply not foreseen at the time of plan development. Spatial development policy

therefore conveys many of the uncertainties in economic development policy into urban planning and design. Whenever and wherever new opportunities for investment arise, conflicts and deviations from approved development plans are likely to occur.

3.4.2 Current economic plan

In the latest 11th five-year plan (2006-2010), the main goal of economic development is to promote Beijing as a global city. Together with Shanghai, Beijing is regarded by the central government as having the potential to achieve such a status[13]. Both cities are seen leading cities to drive the Chinese economy into globalisation. To that end, high-end service economies are prioritised including finance, business, information and communication, and knowledge industries. Individual industrial plans are also made. The plan for the service sector argues for culture, logistic, exhibition, wholesale/retail, education, tourism, real estate, household and personal services and health care. The manufacturing plan emphasises information and communication manufacturing, electronics, pharmacy and related equipments, professional machinery, automobiles, clothes, food and printing (Beijing Development and Reform Commission 2006; Beijing Industrial Development Bureau 2006, 2007).

These sector-based plans are blueprints that build upon identified strengths, challenges and opportunities for the Beijing economy that particularly rely on several industries including information, automobile, finance and business industries. The rationality of such choices is not fully elucidated. Any large change in the external environment or from the market could challenge the rationality of these choices. Since they were selected without considering the complementary relationships between industries, it may be too limited and rigid to capture the incubated economic opportunities and fully recognise the role and function of each sector. A good cooperation between the public and private economies is lacking in current economic planning. As a result, many pressures and uncertainties arise such as for the aim of being/becoming a global city.

3.4.3 Current urban planning

Economic forecasts are important for urban planning but the city, and especially a global city, is more than a concentration of businesses. A big step forward in the latest urban plan (2004-2020) is the change from purely supporting economic development to transforming current urban space so as to create a more friendly place for residents and visitors. The main goals of the latest urban plan are to

(re)build Beijing as a global city and liveable city besides its unchallenged status as the political and cultural centre of the nation (Committee of Beijing City Planning 2005). The liveable city addresses environmental and spatial aspects by considering land and water resources for sustainable development, the natural ecological quality for living and physical conditions including transport and facility services for people working and residing in de city.

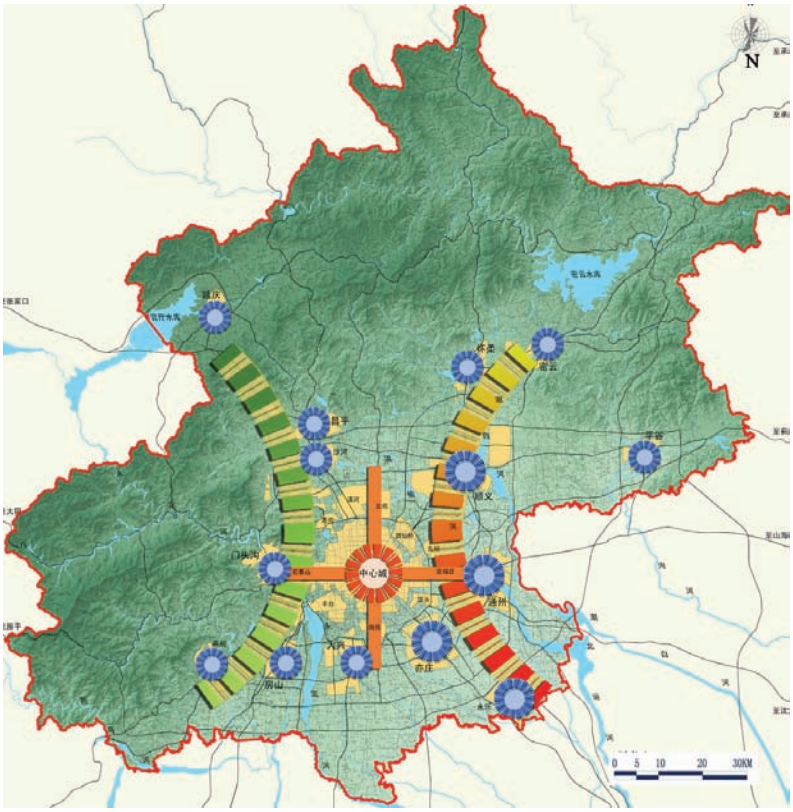


Figure 3.18 Strategy of 'two-axes-two belts' of Beijing

Source: Beijing master urban plan, 2004-2020

In attempting to balance economic development and spatial concerns, urban planners came up with the concept of 'two axes, two belts and multi-centres'. As Figure 3.18 illustrates, one axis is along the Chang'an Street, which is the time-honoured ceremonial axis. The other one, in the north-south direction, is the real and new development axis, which has been formed and underlined since the 1978's plan. The two axes conceptualise the structure of the urban centre. 'Two belts' are the concept of configuring spatial organisation at the municipal level, comprising of the eastern belt on basis of economic function and the western on environmental protection.

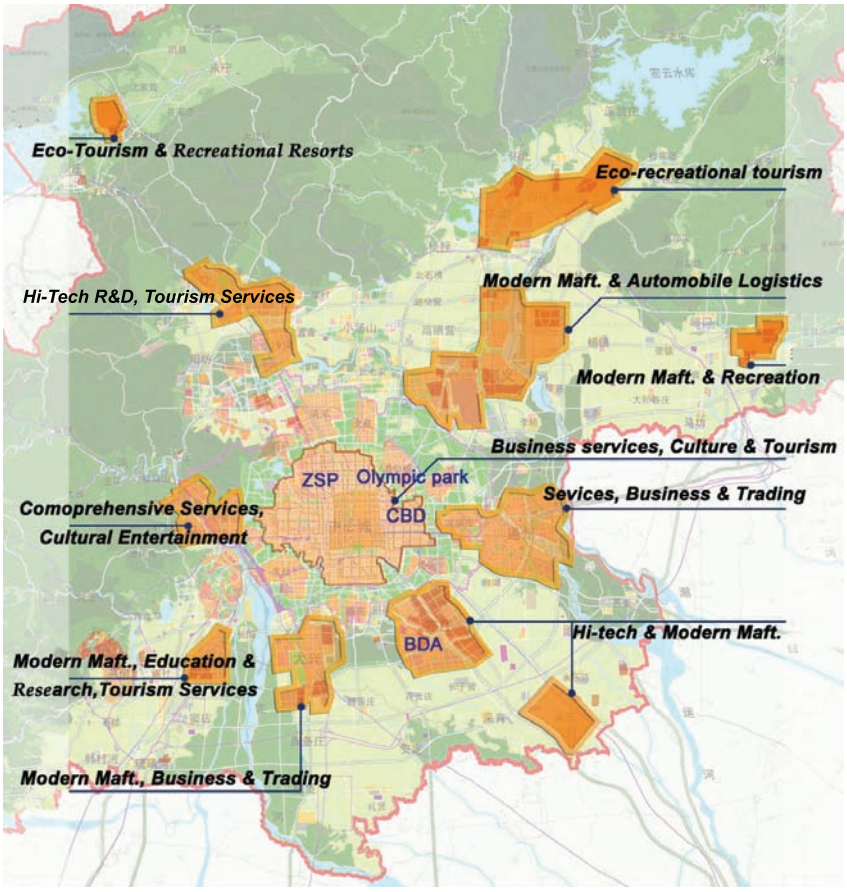


Figure 3.19 Conception of 'multi-centres' of Beijing

Source: Beijing master urban plan, 2004-2020

To realise this concept, 'multi-centres' are designated in the developmental axes and developmental belts. These centres include existing and emerging economic areas, such as Zhongguancun, the CBD and services concentrations such as the Asian Games Village and the Olympic Park. But this element also includes many new proposed, uncompleted, or not fully fledged centres, see Figure 3.19.

The main idea of this scheme is to change the current mono-centric form to a polycentric pattern. As indicated above, quite similar planning ideas like key towns, sub-centres originating from the 1950s and 1980s were only partly realised for a variety of reasons. A lesson at hand is that the nodes in such a polycentric form must be functional to provide a diverse and large number of jobs. Monitoring of the economic activities and developments in these new clusters is therefore particularly important if they are to have more success than their 'paper' predecessors.

3.5 Clusters initiatives and presences

3.5.1 Cluster initiatives and urban development

ECs now form a major aspect of Beijing's development. The following ECs are particularly important in terms of Beijing's global city status: Zhongguancun Science Park (ZSP) in high-tech industries; the CBD and financial street in high-end business and finance; the cultural and green space of the Olympic Park (Wei and Yu 2006). Public policy is strongly supporting developments in each of these fields. The development of these industries requires cooperation between firms and universities/institutes, and a friendly policy environment.

To date the EC concept has often been applied in spatial policy in the form of different business and industrial parks (Figure 3.20). Comparing Figures 3.18 and 3.19, planning initiated sub-centres that overlap with the industrial and business parks to a large extent. It is worthwhile to explore how these parks are shaping the spatial structure of the city.

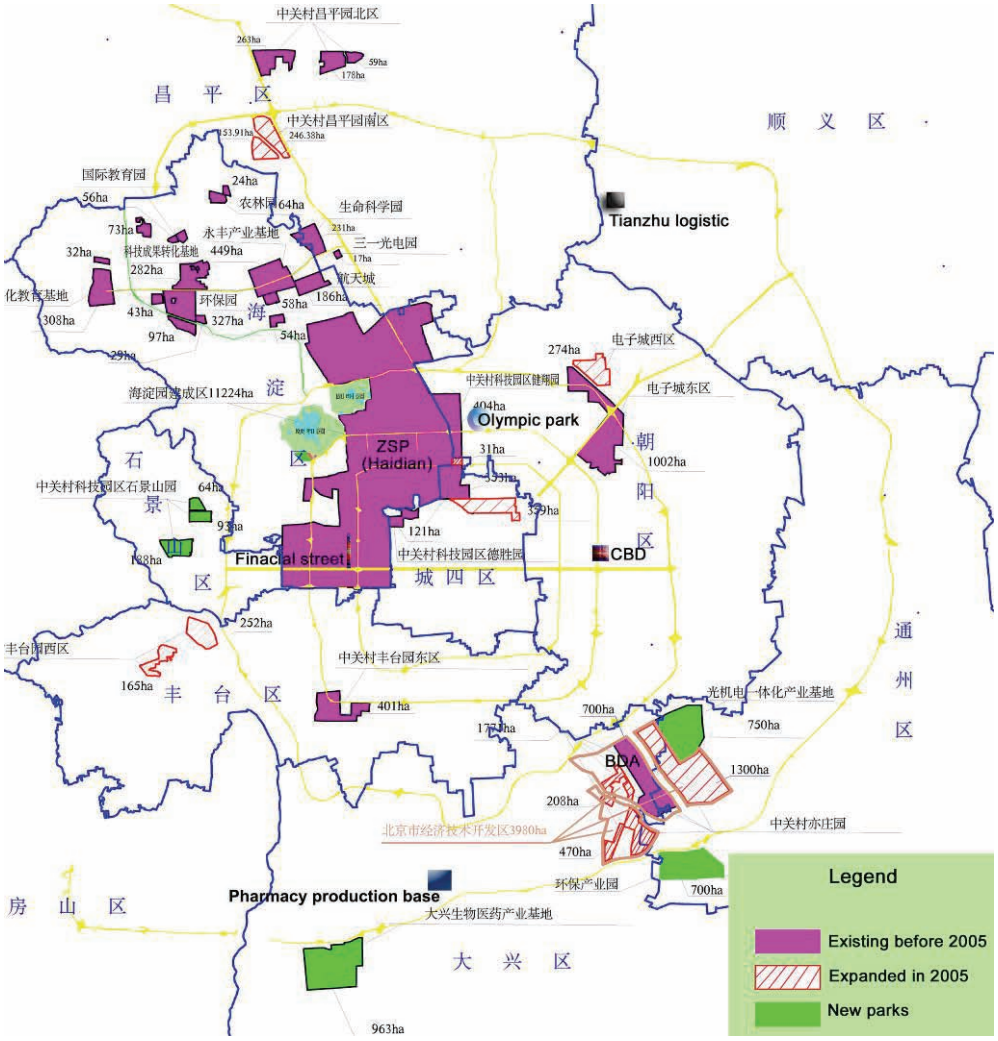


Figure 3.20 Industrial and business parks

Note: The map is based on the plan of industrial parks of ZSP, provided by the ZSP Administration (retrievable at http://www.zgc.gov.cn/fwpt/trzfw/hgjj/). To date the ZSP has become an overarching idea of organising and managing industrial park's development and includes all industrial parks in Beijing except minor ones in exurban areas. In this research, we specifically refer to the ZSP main park in Haidian, which is the earliest and core part, if not mentioned specially. This map shows the industrial parks. In addition, the map also shows the location of the most significant business parks, including the financial street/district and CBD, the Tianzhu logistic park and the Olympic park.

3.5.2 Connections and differences of cluster initiatives in economic and spatial plans

In current economic and spatial plans, there are some connections as well as differences with respect to cluster initiatives (Figure 3.21). In economic policy, the cluster idea is virtually sector-based. A key sector is screened by its outputs or employment and is labelled as a 'pillar industry', expected to be a leader of the entire economy. Then, a hierarchical system is built up from pillar industries to common industries by deciphering the main industrial chains for the pillar industries. The cluster initiative is thus for a specific industrial sector and many of its relations are overlooked. The economic policy also treats the cluster as a location or a place. Economic policy makers seem to be just interested in where economic activities are, which is usually indicated by the allocation plan, rather than considering a broader examination of the spatial implications of their economic ties.

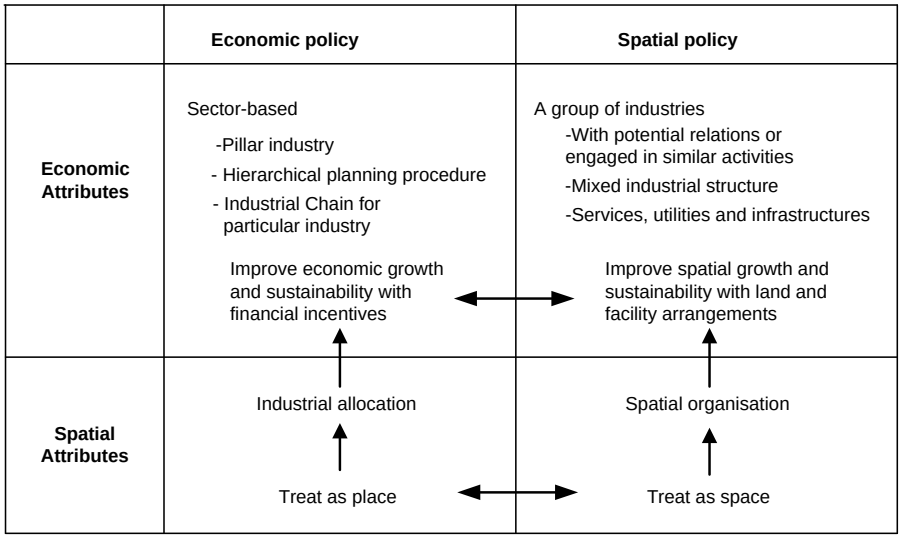


Figure: 3.21 Connections and differences of cluster initiatives in economic and spatial plans

The spatial plan, on the other hand, concentrates more on the geographical distribution of economic activities over space and the characteristics of the places that are created. Spatial planners therefore look at the EC as a group of industries, or a mix of several groups. For example the ZSP includes various high-tech activities: information technology, bio-pharmacy and electronics. In addition, spatial planners also consider spatial relationships with other activities such as housing and residential services.

Strong connections between economic and spatial policy interests can be established via ECs. Economic policy would like to see more vibrant economic activities and wants to attract investments. The cost of business development depends much on the location and surrounding environment in the city, which is determined by spatial policy. Land is a basic economic resource in spatial development. Leveraging land price, spatial policy can attract investors in order to realise spatial development. Co-efforts of spatial and economic policies can therefore facilitate the realising the development goals of both policy sectors.

3.5.3 Presence of economic parks

Various economic parks play a dominant role in Beijing's economic space. Particularly after the success of Zhongguancun Science Park, several more parks of varying size sprung up across the city. By 2003 they numbered 470, including several municipality operated parks. The central government's response was control and regulation. The number of industrial parks is now 19, of which 3 parks have national status including ZSP (high-tech), Beijing Development Area (BDA, manufacturing-led) and Tianzhu (logistics and automobile manufacturing). ZSP comprises of 7 sub-parks and is often referred to as Haidian Park, the name given to the main and earliest of the sub-parks (see Figure 3.20). Besides these manufacturing parks, there are two important high-end service areas: one is the Financial Street/District besides the 2nd west ring road dominated by banks and financial agencies, and the other is the CBD opposite to the 3rd east ring road. The CBD is new compared to the Financial Street but it grows very fast as a major concentration of high-end services and businesses.

The industrial parks play a leading role in the Beijing economy (Table 3.4). In 2007, investments in projects have reached RMB 640 billion. The annual increase was RMB 81 billion during the 2004-07 period. The investment on fixed assets in parks grew at 5.6% p.a., accounting for 30-40% of all investment in the municipality. The combined output value of all industrial parks amounts to RMB 526 billion, and it increased at annual growth rate of 24.7% during the 2004-07 period. This was much higher than the annual municipal GDP growth rate of 15.6% in the same period. For ZSP, the industrial output increased 28.1% per year. The park contributed 12.6 % to the municipal GDP in 2004 and 17.1% in 2007. Total revenue amounts to RMB 1145.9 billion at a growth rate of 26.3% p.a. The industrial parks generate 36% of the municipal tax, which doubled over the last three years. Half the municipal employment in the secondary sector is located in the park. In 2004-2007, municipal employment in

manufacturing decreased, while employment in the industrial parks increased by 26%. The industrial parks have become a main area for FDI, absorbing 27% of the total.

Table 3.4 Basic facts of industrial parks in Beijing, 2004, 2007

	2004			2007			Annual increase rate
	Industrial parks	The municipality	As % of the municipality	Industrial parks	The municipality		
Accumulated project investment (RMB, Billion)	397.4	NA	NA	640.3	NA	NA	Avg. 81billion per year
Incremental fixed assets investment (RMB, Billion)	103.4	252.8	41%	132.6	396.7	33%	5.6%
Accumulated FDI (US$, billion)	6.8	27.9	24%	11.0	41.0	27%	17.8%
Industrial output value (RMB, Billion)	270.8	595.2	45%	526.1	993.6	53%	24.7%
Added industrial value of ZSP (RMB, billion)	76.1	606	12.6%	160	935.3	17.1%	28.1%
Revenue	570.3	NA	NA	1149.5	NA	NA	26.3%
Tax	22.6	72.7	31%	52.2	143.7	36%	32.2%
Employment (,000 persons)	834.0	2328	36%	1051.0*	2254*	47%	26%

*Note: *Employment in the secondary sector and the figure is for 2006*

Data source: 1. Duan, Hongwei. (2008). Analysis of economic performance of ZSP in 2007. Department of industrial promotion of ZSP administration. (Presentation). 24 Jan 2008.（科技园区2007年经济形势分析，中关村管委会产业发展促进处　段宏伟，2008，1月-24）2. Beijing Statistic Year Book 2005, 2008. 3. website of ZSP administration, http://www.zgc.gov.cn/

Business parks also show a strong momentum. Table 3.5 illustrates that the total assets of the CBD and Financial Street accumulate to RMB 8747.4 billion in 2006, two times that of two years earlier. The development of the CBD and the Financial Street created 31% more employment in 2006 compared to 2004, and their share of the total employment in the tertiary sector grew from 14% to 17%. Also, revenues develop very positively.

Table 3.5 Basic facts of main business parks in Beijing, 2004, 2006

	2004			2006			Increase		
	CBD	Financial Street	Total	CBD	Financial Street	Total	CBD	Financial Street	Total
Assets (RMB, billion)	254.8	2611.7	2866.4	415.7	8331.68	8747.4	63%	219%	205%
Revenue (RMB, billion)	84.3	114.0	198.3	103.3	98.3	201.6	23%	-14%	2%
Employment (persons)	42305	50123	92428	91610	29603	121213	117%	-41%	31%
% of the municipal tertiary employment	6%	8%	14%	13%	4%	17%			

Data source: Beijing Regional Statistics, 2005 and 2007

The industrial parks are also major drivers of spatial development. An area of 326.7 km^2 is planned for the industrial parks in 2007, an increase of 59.7% compared to 2005. The actual developed area amounts to 107.4 km^2, with an increase of 21.3%. On top of this amount, the planned area for the CBD is 399 ha and 103 ha for the Financial Street. Vast areas of land have already been claimed for industrial and business developments, mainly in the form of parks.

Table 3.6 Spatial developments of industrial parks

	2005	2007	Increase
Planned area (sq. km)	204.5	326.7	59.7%
Reclaimed area (sq. km)	108.7	139.1	28.0%
of the planned area	53%	42.6%	
Actually completed development (sq. km)	88.5	107.4	21.3%
of the reclaimed area	81%	77.2%	

Data source: Beijing Regional Statistics, 2006 and 2008

The spatial development of the industrial parks is becoming a critical issue for spatial urban planning, not only because of land use, but also due to their potential for reshaping the spatial structure of Beijing. Integrating economic and spatial developmental mechanisms via ECs will bring with new insights for improving the performance of urban planning. For Beijing two issues are outstanding: monitoring the development and performance of ECs, and evaluating their roles in organising urban space.

3.6 Summary

This chapter analyses the economic and spatial developments in Beijing and the development of economic clusters in the city. In economic development, Beijing is moving from a planned to a market economy. In this process, the private sector, especially through FDI, has gradually become a force propelling spectacular economic growth as well as contributing to Beijing's integration into the global economy. Towards that end, innovative policy design is necessary, for instance the idea that ECs can be a mechanism for Beijing to identify its economic strength and establish a durable competitive advantage.

The introduction of market mechanisms exerts far-reaching influences on urban planning. Several legal regulations have been altered, adjusted or created corresponding to the markets' requirements. One of the most important is the relaxation of the HRS, which liberates labour and capital to move more freely over space. The ensuing rural-urban migration has had a major and direct impact on urban growth. Another significant change was the establishments of a land market and a property market, by which land becomes normal and tradable commodity. The impact of these changes on urban planning and the

importance of seeking a closer integration between economic and spatial planning should not be underestimated.

Generally, spatial development patterns do not respond as quickly to external changes as economic patterns, particularly when the planning system is still primarily rooted in a mode of production based upon government control. It is therefore hardly surprising that Beijing has struggled to adjust its spatial form from a mono-centric model to a poly-centric model. Nevertheless, poly-centric development is now seen as the way forward. The latest urban plan has targeted to build Beijing into a world class and liveable city. The success of this goal is likely to depend much on the city's ability to realise a network of urban centres each with a mix of economic and social functions. From a spatial perspective, the hearts of these urban centres are embodied in the form of industrial and business parks. In this sense, ECs are an important means to reshape Beijing's current spatial organisation.

EC initiatives are not very new in economic and spatial developments. Some ECs have already made great contributions to economic growth and spatial development. Their developments are however not without problems, especially for spatial issues including land use, traffic congestion. ECs as a central concept and an instrument therefore has the potential to further improve the integration of economic and spatial policies and the quality of urban space. It very desirable for urban planners to be able to monitor the development performance of ECs with both economic and spatial indicators and to devise a method to evaluate their roles in (re)organising urban space.

Endnotes:

[5] This is partially because of the later Cultural Revolution.

[6] Their number of migrants increases from less than 30 million in the 1980s, to between 70 to 80 million in the mid-1990s, 100 to 140 million in the late 1990s, and is about 150 million in 2005. Over half of them relocate to large cities.

[7] In 2006, land for industrial use was also officially obtained via a bidding process in the market.

[8] Beijing Subway, available at http://www.bjsubway.com/cns/index.html, last accessed on 3 April 2009.

[9] This figure was survey on 15 Aug 2008, see http://www.china.com.cn/info/txt/2008-08/17/content_16248941.htm

[10] This was survey was during 14-23hour on 7 October 2007 and 5-23hour on 8 October 2007, see http://news.xinhuanet.com/newscenter/2007-10/10/content_6855037.htm

[11] Beijing Port Office, http://bjkab.gov.cn/docc/news.asp?sortid=60&listid=84&newsid=264

[12] In the 1990s, a major planning commission is to realise the polycentric or multiple-centric spatial configuration for Beijing.

[13] So far, Hong Kong is the only global city in China, a status it achieved prior to the transfer of sovereignty from the UK to China in 1997.

Chapter 4 Identifying functional clusters for city development

Economic Clusters (ECs) are expressions of urban and regional development in the globalising economy. Documented experiences come mostly from case studies or informal knowledge of local experts on a particular aspect of the EC development. Although these understandings may bring about detailed information, there is a need for an approach that can help policy makers have a snapshot of a local cluster pattern for understanding the entire local economy. Equally important is that more objective information is required to supplement or amend informal local experiences so as to avoid bias in apprehending economic potentials. These requirements are crucial for incorporating ECs into urban planning.

This chapter illustrates a sectoral approach to objectively and comprehensively judge a functional cluster pattern according to the current and recent economic situations. The next sections examine how and what type of sectoral/functional relationships can fit this purpose and explores appropriate methods to derive the local cluster patterns. With the case study of Beijing, the successive functional cluster patterns for the 1983-2002 period are presented and discussed.

4.1 From urban strategy to functional clusters

4.1.1 Functional relationship in cluster analysis

As explained in chapters 1 and 2, the EC is an appropriate notion to understand local developmental strength, which can be elaborated to an urban-economic strategy. Such a strategy should effectively incorporate local resources including policy, finance, knowledge and labour market to improve performance and create chances for a local economy in globalised market (Porter 1998a). The competitiveness-led strategy is based on a synergy of institutions and economic operation, and a group of firms and industries (Doeringer and Terkla 1995; Porter 1998a; Lorenzen 2005). Policy interventions are therefore encouraged in developing ECs for facilitating public policies and maximally reaping the fruit from market operation.

Cities or regions are a fundamental dimension for the development of ECs and relevant policy applications. Initiating and managing of ECs is usually on the scale of cities and regions, because they have become the primary scale to organise economic activities (Burfitt and Macneill 2008). In the context of the globalisation, the convergence and diffusion of social and economic elements are much salient on

the city or regional level (Krugman 1991). Urban or regional policies will have direct influence on the developing of ECs , and in turn the growth of ECs will affect not only the incipient place, but the entire city or region.

Among other formative relations of ECs including geographic proximity, social, innovation and knowledge exchange (Feser and Bergman 2000; Gordon and McCann 2000), Input-Output (I-O) relations are probably the most robust one. Arguably, the forming and outcomes of ECs are ultimately owed to their tied economic relations and associated benefits for local economy. Various studies claim that agglomeration is more common and persistent in sectors that are sustained by economies of scale, as identified by Midelfart-Knarvik et al. (2002) for European regions, and Rigby and Essletzbichler (2002) for American cities. In the *new economic geography* is it also argued that the evolution of the economic landscape is mainly driven by pecuniary externalities created by the mechanism of I-O structures (Krugman and Venables 1995; Ottaviano and Thisse 2004). Hence, based on I-O relations, *Functional Clusters* (FCs) facilitate a cluster-based urban strategy.

In cluster related analysis, FCs have some virtues. The functional relationship discloses the agglomeration economies not from a specific industry, but from the economy of an entire city or region (Chakravorty, Koo, and Lall 2003; O'Donoghue and Gleave 2004; Phelps 2004). The robust functional relations materialise the forming of ECs as the first step to identify ECs, which provides a clue to linking economic and geographic spaces for urban planning. The changes of functional relationship provide a way to recognise the evolution of ECs so that relevant policy programmes can be calibrated.

4.1.2 Functional relationships and cluster representation

The representation of FCs depends on inter-industrial relations and dedicated analytical techniques. For a specific sector, industrial linkages can be classified as demand or backward linkages, and supply or forward linkages (Streit 1969; Roepke, Adams, and Wiseman 1974). The two types of industrial linkages reflect the dependence of one industry on others, as determinants of production and of technical progress of a region (Midmore, Munday, and Roberts 2006).

The configuration of the demand and supply relations produces different types of functional relations (Figure 4.1). A vertical linkage, from supply to demand, models the relationship between suppliers, producers and consumers (Hoover and Giarratani 1999). It forms

value-chain clusters with the aim of pursuing a deep supply network for technological and product upgrading (Enright 1996). A horizontal linkage simulates clusters with similar demand or supply. It stresses the sharing of markets and resources and competition, which compels innovation (Hoover and Giarratani 1999). For instance, with the same demand on the outputs of sectors 1 and 2, sectors A and B form a competing relationship on the market. Complementary linkages are a mutually attractive structure among industries. Outputs of one industry may provide inputs to the other or vise versa. As complemented industries also demand inputs from or supply outputs to other industries, complementary linkages are very often interwoven with horizontal relationships (Hertog, Bergman, and Remoe 2001; Fingleton, Igliori, and Moore 2004).

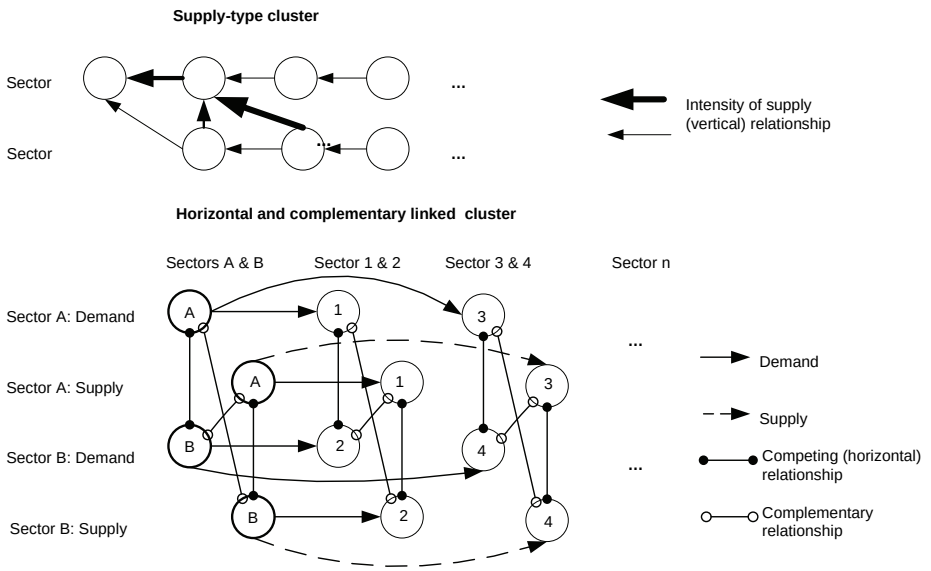


Figure 4.1 Functional relationships and the resulting clusters

Complementariness is a complex relationship: an increase of one activity can cause the growth of its complementary activity, although less when transaction costs are taken into consideration (Hoover and Giarratani 1999). It therefore brings extra opportunities for attracting new suppliers or buyers. The extending of complementary linkages is a process of completing the economy for an entire region. Externalities can be transferred from the production network to the labour market. This market crosses between very different sectors for instance the increasingly close relationship between manufacturing and services. Although the industries produce different goods and services, complementariness stimulates innovative networks due to sharing similar technologies in the value chain (Hertog, Bergman, and

Remoe 2001). The interaction of economic activities is a main source for realising dynamic external economies (Malizia and Feser 1999).

Owing to the importance of suppliers in the industrial organisation, some regional analysts are keen on the intensity of industrial linkages and argue for techniques of this type to derive clusters (e.g. Oosterhaven, Eding, and Stelder 2001). However, supply-chains and the intensity of industrial linkages are volatile in the present global economy featured by a high mobility of capital, talent and frequent restructuring of business cooperation. Weak intermediate linkages between cluster sectors do not necessarily imply a weak cluster in its performance (Learmonth, Munro, and Swales 2003). Identifying FCs should therefore preferably be based on the horizontal and complementary linkages, which are closer related to innovations and the same demand or supply.

An I-O table usually shows an industrial structure and trading pattern of a city, region or nation according to standard industrial classifications. The classifications are based on similarity of products or processes (Bergsman, Greenston, and Healy 1975). In particular the transaction matrix discloses I-O relations or buyer-seller linkages by means of monetary flows of goods and services. To a lager extent it resembles the diffusion pattern of innovations (DeBresson 1996) and the forming of technological externalities (Forni and Paba 2001). It provides a good source for FC related analysis.

In identifying diversity-underlined FCs, with functional complementariness, Principle Component Analysis (PCA) enjoys a preferred status for a long time (Streit 1969; Czamanski 1971; Roepke, Adams, and Wiseman 1974). PCA is a statistical method to reveal hidden dimensions underlying a raw dataset. The triangulation of industry flows suffers from the loss of considerable information, such as insufficient ability of identifying smaller clusters and the lack of recognisability of some of the large clusters. In contrast, component analysis is more sensitive to actual volumes of flows (Roepke, Adams, and Wiseman 1974). Czamanski (1971) and Roepke *et al.* (1974) have developed a procedure for processing I-O technical coefficients and applying them in a PCA for detecting clusters. By comparing to other techniques, O hUallachain (1984) confirms the value of the PCA in detecting complementary and horizontal relationships, tracing the network of interactions and revealing many critical links in industrial subsystems. The method provides a relative persistent and uniform means of revealing buyer-seller linkages and technological structures, where formal and informal channels meet fostering the cluster's evolution (Feser and Bergman 2000). Although only the trade information is measured, the other important factors,

like social relations, can only be implicitly reflected (Funderburg and Boarnet 2008).

The representation of FCs of this type has several advantages. Across these FCs, a diversified urban economy is exposed. As a counterpart for specialisation, a diversified economic structure also contributes to the forming of ECs (Rosenthal and Strange 2004). Particularly, diversity may help insure against the vulnerability of the economic system with a downturn of key activities (Siegel and Johnson 1995; Chapman, MacKinnon, and Cumbers 2004). In order to spur on creating innovation and economic opportunities, current clustering potentials exist in a group of industries with commonalities or complementariness (Porter 1998b, p. 199).

More importantly, as the method discloses a group of industries sharing the same or complementary demand or supply, the cluster pattern represents potential strengths, underlying weaknesses, latent threats and new opportunities (Feser 2001). It is therefore pertinent for strategic thinking, such as for connecting buyer-supplier relationships, common technologies, and buyers or distribution channels (Bergman and Feser 1999). The change of these circumstances indicates how clusters evolve. Such a structural change is more meaningful than sheer indicators of turnover, Gross Domestic Product (GDP) or employment rates for evaluating economic situations (Lorenzen 2005).

Given those advantages, the method of PCA has gained a resurging interest in recent years, but the application suffers from several limitations especially for policy making. First, although service or business clusters are reported very often and are increasingly important (Rosenfeld 1997; OECD 2000), almost all research predominantly focuses on manufacturing. For instance, Feser and Bergman's (2000) derived 23 manufacturing clusters on 2-digt Standard Industrial Classification (SIC); Funderburg and Boanet (2008) reported on 20 manufacturing clusters out of 30 components for Southern California on 3-digit SIC. Although some researchers following Czamanski (1979) integrated service industries into the derived manufacturing clusters after the PCA process (Liang, He, and Zhang 2005), manufacturing clusters still dominate the analyses. To our knowledge, so far there is no research based on this method fully including service clusters. This situation is inappropriate for current policy design.

Second, the work of this type usually derives a rather large number of clusters, as noticed above, which may be annoying policy analysts and limit understanding the main outcomes of the analyses. Policy makers, especially for strategic policies, have difficulty in handling

more than 20 factors or components. Although the number of derived components are contingent with SIC details, they needs to be limited or generalised to produce a manageable representation of the local economy.

Third, much research is based on a single period of time. This ex-ante analysis may be problematic for policy application owing to its static nature. This can be redressed by a multi-periodic analysis.

Taking the above mentioned points into considerations, a modified PCA method is introduced for an empirical analysis of the Beijing economy.

4.2 Methodology

4.2.1 Data description

The research used the complete I-O accounts of Beijing for the years 1987, 1992, 1997 and 2002 from Beijing Statistical Bureau. The industrial classification is comparable to the 2- or 3-digit industrial classification used in the International Standard Industrial Classification (ISIC) of the United Nations (more details see Appendix I.1). These accounts represent in value the transactions of goods and services among each category of economic activities. The recording system is consistent over time in categorising most manufacturing activities, (there are some alterations related to industrial structural changes in Beijing), but becomes more and more detailed over time for the classification of service activities. In the process, the industries with no flows of goods and services were omitted from the table since those economic activities do not affect others. This guaranteed the effectiveness of deriving linkages among industries as well as avoided a mathematically undefined problem in data processing. Consequently, there were 79 manufacturing classes used for all years and 26, 22, 31 and 40 service classes in the years 1987, 1992, 1997 and 2002 respectively.

4.2.2 General method of principle component analysis

The method applied followed the techniques of Czamanski (1971) and the work of Feser and Bergman (2000) in measuring industrial relationships. It involved three steps (Appendix I provides more detailed information).

Step 1: technical coefficients

$$p_{ij} = \frac{a_{ij}}{\sum_j a_{ij}}, \quad s_{ij} = \frac{b_{ij}}{\sum_j b_{ij}}$$

where a_{ij} represented purchase value of goods and services of sector j from i; b_{ij} denoted sale value by industry j to i. Intermediary purchase and sale coefficients p_{ij} and s_{ij} reflected the dependence of industry i on j for demand and supply or the strength of backward and forward linkages.

Step 2: structural similarity of industries

The technical coefficients indicate the structure of demand and supply for an industry represented by column vectors P and S. The structural similarity of each pair industries l and k can be assessed by correlation analysis of vectors P_l, P_k, S_l and S_k. Then four types of structural similarity between industries l and k can be computed: purchase similarity r_{PP}, sale similarity r_{SS}, purchase-sale similarity r_{PS} and sale-purchase similarity r_{SP}. The purchase and sale similarities formed the competing relationship, and the purchase-sale and sale-purchase similarities approached the complementariness.

The maximum value of these four structural similarities was obtained: $m_{lk} = \max\{r_{PP}(P_l, P_k), r_{PS}(P_l, S_k), r_{SS}(S_l, S_k), r_{SP}(S_l, P_k)\}$, which measured the most important relationship of each pair of industries. It comprised of a symmetric matrix M: $m_{kl} = m_{lk} < 1,\ \text{if } l \neq k;\ m_{kl} = m_{lk} = 1,\ \text{if } l = k$, used as the variables for the PCA. In that matrix, each column indicates a pattern of the structural similarity for a given industry related to other industries. This calculation process identified industries that were similar in economic space, not only due to sharing the same inputs or outputs, but also owing to complementariness between purchase and sale. The most important relationship is adopted for the calculation. The processes of calculating technical coefficients and preparing the structural similarity matrix have been computed in Matlab.

Step 3: generating clusters by means of PCA

The PCA was performed avail of the matrix M, using SPSS 15. Components were extracted for the each period consistently by the Kaiser's criterion of an eigenvalue no less than 1. The derived components revealed underlying patterns of common or complementary demand and supply relations in the local economy. If industries more likely shared a common component, they were more similar to a pattern. The extracted variance of components was used to measure their relative importance as it directly represented the amount of explained information of the variables. The components

were rotated by the Varimax method for facilitating interpretation. Referring to other work (Roepke, Adams, and Wiseman 1974; Feser and Bergman 2000; Liang, He, and Zhang 2005; Akgungor 2006), the variables with factor loadings not less than 0.4 were selected for interpreting components.

4.2.3 Modifications

The PCA was firstly performed for all industries, but almost all the service industries were excluded in the component matrix owing to their low factor loadings (<0.4). This problem was also encountered in previous studies; it was treated by either only deriving manufacturing clusters (Feser and Bergman 2000; Akgungor 2006; Funderburg and Boarnet 2008, for the recent research) or following Czamanski (1979) assigning service industries to derived manufacturing clusters based on linkages indicated by technical coefficients (Liang, He, and Zhang 2005). In consequence, manufacturing clusters predominated in the local cluster templates.

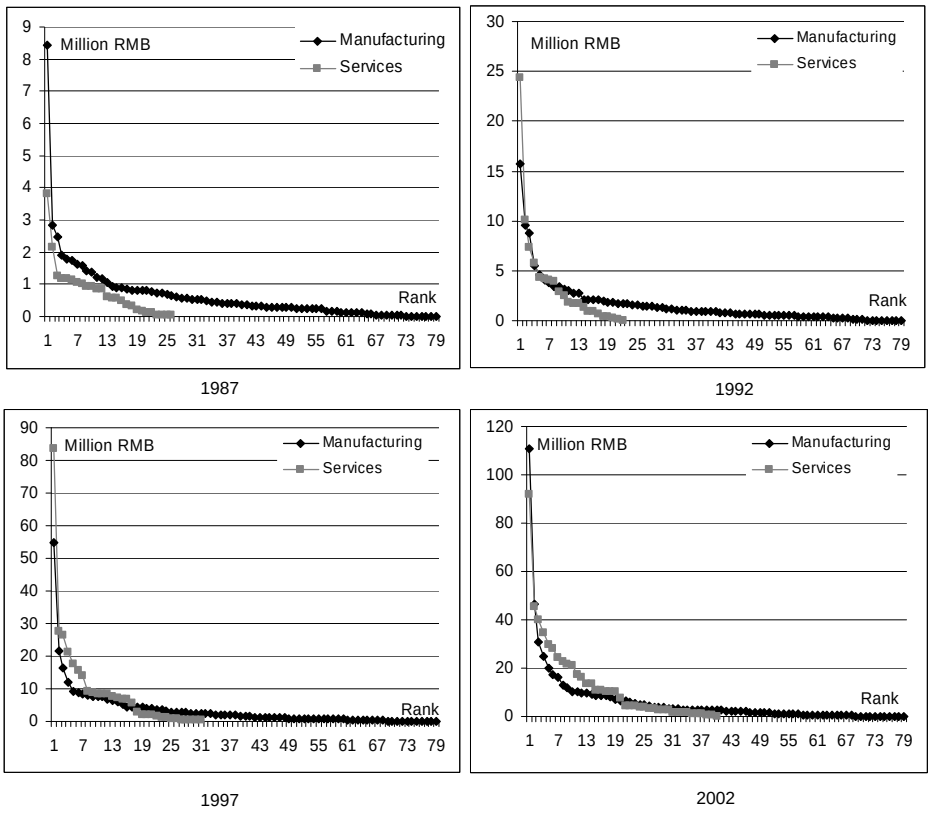


Figure 4.2 Rank of manufacturing and service industries by their outputs

The service economies are growing very fast and playing an increasingly important role in the urban economy. As indicated by Figure 4.2, most of service industries are larger in output than the manufacturing industries. During 1988-97, the service sector maintains a 31% annual increase rate, much more than the manufacturing sector with a 19% annual growth. In the subsequent period, 1998-2002, these increase rates for service and manufacturing sector are both 12% yearly. The average size of the service industries, in terms of outputs, is twice that of the manufacturing industries. The number of manufacturing classes is however much larger than that of the services classes, which leads to the imbalance between manufacturing and service industries, because the PCA weights all cases equally. When all classes are included in the PCA, the service industries are underestimated or ignored. If combining all manufacturing and serviced industries, the process may skew an analysis for some indistinct groups (Feser and Bergman 2000). In order to resolve this problem, two adaptations to the general PCA model were introduced.

Adaptation 1: Separate cluster template for manufacturing and services

The PCA was computed separately the manufacturing and the service industries. For each year a manufacturing and a services cluster template was derived in order to be able to investigate the composition of the clusters in detail.

Adaptation 2: Aggregate manufacturing-service cluster templates

The ranking plot (Figure 4.2) shows that the bulk of information, in terms of output, is concentrated in a few industries. Porter (1990) also argues that developmental strength is often present in a limited number of industrial classes. Therefore, a more generalised and transparent local cluster pattern can be derived by revealing the relationship among key industries. The key industries can be selected based on their economic significance, through comparing their output with the average output per class. Take x_i as the output value for industry i, x_T as the average total output value, x_M and x_S as the average output of all manufacturing and service industries. Industries can be categorised in three groups according to their outputs:

- Largest industries (M1 classes): if $x_i > x_T$ for manufacturing industries, or $x_i > x_S$ for services industries;

- Large industries (M2 classes): if $x_i > x_M$ for manufacturing industries, or $x_i > x_T$ for services industries;
- Small industries (M3 classes): the output value is less than the average of the manufacture and service sectors and of the whole economy.

This configuration weights the importance of industries relative to their manufacturing or service sectors and to the local economy as a whole. Because the average performance of manufacturing economy is lower than that of the service economy ($x_M < x_T < x_S$), the membership of industries was cross assigned for the larger industries (M2). In this way, all key manufacturing and service industries could be selected to generate aggregate cluster templates.

4.3 Results and interpretation

4.3.1 Results and comparison

Table 4.1 summarizes the results of the PCA for the two modifications. The separate templates were composed of 14-19 manufacturing clusters and 5-7 service clusters respectively in 1987 1992, 1997 and 2002. The total variances explained were at least 84% for the manufacturing economy and above 89% for the service economy.

The aggregate templates were composed of 9 to 11 clusters and explain around 90% of the variance for each year. If only key sectors were selected for the process, the numbers of manufacturing and service sectors were quite equivalent. Although the number of manufacturing classes was still much larger than the number of service classes in the early two periods, Beijing was making the transition from being a manufacturing to becoming a services dominated economy. For the statistical process of generating components of the economic structure it meant that the weight of the service industries has increased. Table 4.2 shows that the economic output was concentrated in the key industries. Roughly 30% of the manufacturing industries accounted for 75% of the manufacturing output; 50% of the service industries contributed to 85% of service output. The aggregate templates therefore capture the main structure of and changes in the Beijing economy.

The component matrix (factor loadings) was comparable between the two adaptations and therefore quite similar substantial interpretations of the clusters can be derived. The component matrixes for 2002 are listed in the Appendix I (AI.5-7) for reference. The finance, business

and real estate related classes had high factor loadings on the first component in the separate service cluster template; these components also kept high values on the first component in the aggregate analysis. However, the former consisted of transportation, warehousing, and rental and leasing industries, which made the cluster composition more detail. The latter related to some manufacturing industries for example wearing apparel, steel processing and energy supplying.

Table 4.1 Summary of the PCA analyses and extracted clusters of the separate and aggregate templates

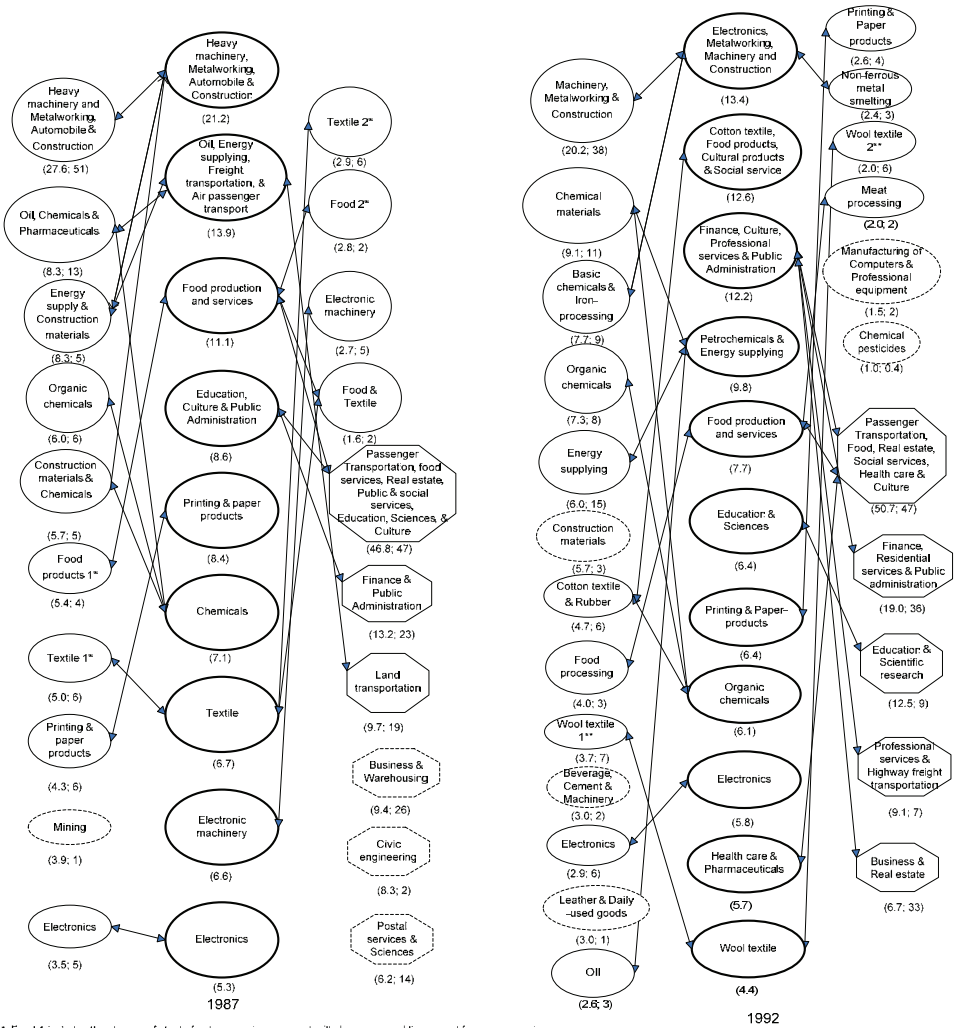
	1987	1992	1997	2002
Separate template				
Manufacturing				
No. of manufacturing classes	79	79	79	79
No. of derived clusters	14	19	19	17
Total explained variances in PCA	87.9%	91.3%	89.0%	84.4%
Services				
No. of service classes	26	22	31	40
No. of derived clusters	6	5	5	7
Total explained variances in PCA	93.6%	98.0%	91.1%	89.6%
Aggregate template				
No. of key manufacturing classes	25	22	21	21
% of key manufacturing classes	32%	28%	27%	27%
Account for manufacturing output	74%	73%	75%	79%
No. of key service classes	12	10	17	19
% of key service classes	46%	45%	55%	48%
Account for service output	82%	87%	95%	84%
No. of derived clusters	9	11	10	9
Total explained variances in PCA	89.2%	90.6%	91.5%	90.9%

Regarding the clusters representations (factor loadings) and the information extracted from the industries (communalities of variables), the results of these two adaptive analyses can related to each other. Figure 4.3 illustrates the relationship between the results of these two iterations. The linkages between the two types of clusters are drawn for their key industries.

In terms of the communality, which measures the total explained information of one variable (industry) (Field 2005), the information explained by these two approaches was comparable. The aggregate approach effectively however improves the statistical explanation of the information of key industries over the separate approach (Appendix AI.8). In 2002, the communalities for the software and professional technical services increased to 0.89 and 0.98 from 0.66 and 0.67 respectively. The other communalities improved included education, health care, oil and pharmaceutical products. Only the motor vehicles-related industry and the manufacturing of other electric machinery and equipment were significantly less ‘explained’

in the aggregate approach. This is related to the industrial change at that time, the growth of the automobile industry and other structural changes in manufacturing.

The aggregate approach provides a concise aggregated insight into the main economic dynamics by combining clusters in the separate outcomes. For instance in 1987 the Textile and Food cluster only appeared once in the aggregate template. The same is true for the Wool textile and Organic chemicals in 1992. However, these clusters were repeated in the separate templates.



* Food 1 includes the classes of staple food processing, egg and milk, beverage and liquor, and forage processing;
Food 1 includes the classes of sugar, other food process and other beverage processing;
Textile 1 includes the classes of wool, cotton, spinning, knitting, and sewing;
Textile 2 includes the classes of cotton, other textiles and sewing.

** Wool textile 1 includes the classes of wool, spinning, knitting, and other textiles;
Wool textile 2 includes the classes of wool, silk, and sewing

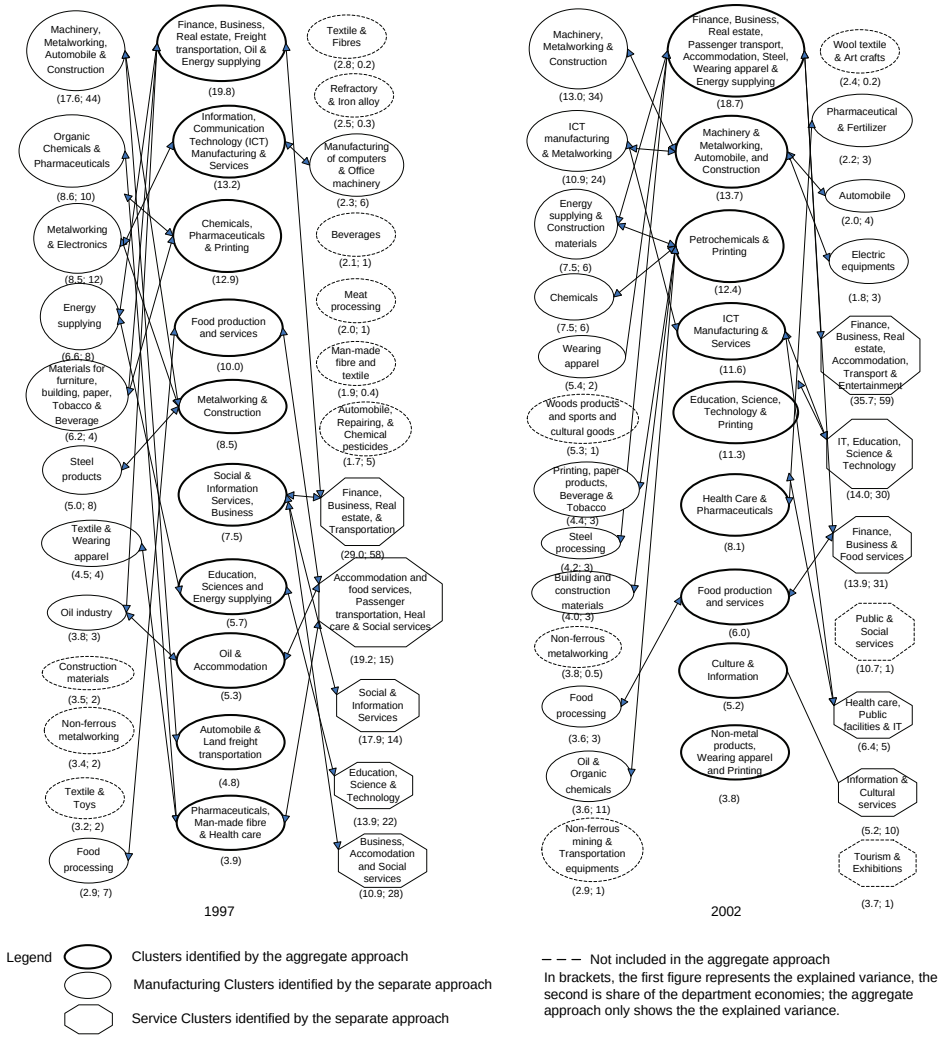


Figure 4.3 Relations between derived clusters in the separate and aggregate approaches

The aggregate approach rectified most of the problems of unrealistic, un-statistically derived clusters in the separate approaches. In 1987, 6 service clusters were extracted in the separate approach, but this was not the case for the 1980s when service economies were not fully developed. On the aggregate template of 1987, actually only one service cluster, Education, Culture & Public administration, was extracted. Many other service clusters can be related to manufacturing-dominated clusters, for instance the cluster of Land transportation was attached to the cluster of Oil, Energy-supplying, Freight transportation and Air passenger transport. This situation reflects the manufacturing-dominated situation at that time. And the

extraction of cluster of Education, Culture & Public administration reflects the capital function of Beijing.

Some clusters derived from the separate approach did not show up in the aggregate because they had no key industries with factor loadings higher than the threshold of 0.4. Checking all component matrices shows that all key industries passed the selection criteria for participating in the statistical analysis, which partially verifies that key industries substantially contribute to the cluster extraction. The clusters that do not show up can be categorised as: (1) the group of dwindling activities, such as mining in 1987, the groups of construction material-related activities in 1992 and 1997, the meat processing and the non-ferrous mining & transportation equipment in 2002; (2) the potential but not yet occurring as clusters according to the city economy such as the groups of business and warehousing, civic engineering, and postal services & science in 1987; (3) the potential and promising clusters including Sports and entertainment products (related to 'other textile') clusters in 1997 and 2002, and Tourism and Exhibitions in 2002. They were clustered and emerging with new industries; variants in development made them hard to tell; (4) the group hard to interpret, like the groups of beverages, cement, and machinery for daily-use electronic appliances in 1992, automobile-related industry, machinery-repairing and farm chemicals in 1997. The aggregate approach therefore masked some less important clusters. However, ignore some clusters consisting of only small industries but increasing fast like the Tourism and Exhibition cluster in 2002 were excluded.

In the aggregate cluster template, manufacturing and service industries were both represented. For instance, the food and catering, and the health care and pharmaceuticals were never separated in the aggregate template. The other typical case is the cluster of the Information and Communication Technology (ICT) manufacturing and services. Some clusters were changing their manufacturing and service components like the financial, business related clusters.

It is evident that the aggregate templates allow for a more transparent and concise interpretation. As some classes are excluded from the aggregate templates, the separate templates should be inspected to reveal detailed information about cluster composition and changes.

4.3.2 Detailed cluster pattern and cluster composition

The separate cluster templates provide a way for a more detailed understanding of the structure of the derived clusters and of the cluster evolution. First, the role of the factor loadings need further

clarified. In a PCA, a factor loading is the Person correlation coefficient between a variable and a component (factor). The squared value represents the substantive importance of a particular variable to a component (Field 2005). In a PCA of I-O tables, the variables used are the structural similarities of industries, rather than the linkages. It is therefore problematic to consider factor loadings to indicate the linkage strength between sectors and a given cluster (Feser, 2001). Instead, the approach of PCA in this research, derived clusters by statistically simulating the cluster pattern from the structural similarities rather than by grouping I-O data. So, theoretically not linkage intensity is addressed, but sectors with similar or complementary demand or supply structures are identified. The factor loading here is thus more properly understood as the similarity of an industry to a cluster pattern.

This similarity indicates to what extent an industry belongs to a given cluster pattern, or in other words, it represents the likelihood that an industry interacts with the others based on the same or complementary demand or supply. More interactions imply more odds of innovation and new economic opportunities that the industry can benefited from the 'belonging' to a cluster. It also means the industries share the weakness or threats of the cluster. In this sense, factor loadings can be seen as a proxy to measure a degree that helps an industry either to gain clustering strength for enjoying external economic effects and stimulating innovation creation or run the risk of negative cluster development.

There is no consensus on the cut-off value for factor loadings in PCA. The relevant research selects as lowest value ranges 0.35-0.6 (Roepke, Adams, and Wiseman 1974; Loviscek 1982; Feser and Bergman 2000; Liang, He, and Zhang 2005; Akgungor 2006). In statistics, it normally takes a loading with an absolute value of no less than 0.4, accounting for 16% importance of the factor/component (Field 2005). Allowing for the variable's importance to a component S can be obtained by squared the factor loading f as $S = f^2$, the degree of the similarity of industries belonging to a cluster is set as follows:

- High degree (C1): $0.9 < f \leq 1$, as an industry has over 80% similarity to a cluster;
- Middle level (C2): $0.7 < f \leq 0.9$, with 50-80% similarity of an industry to a cluster;
- Basic similarity with a cluster (C3): $0.4 < f \leq 0.7$, 16-49% information was explained for the cluster.

The similarity degree can help diagnose the role of an industry in a cluster together with its economic presence. The economic presence largely reflects the status of industries in the local economy. Larger outputs imply a larger proportion of economic activities and trades for the local economy. Therefore, industries with large outputs relatively highly affect the cluster. This consideration complements the nature of the PCA of equally weights of variables (industries). The role of an industry in the FC can be formulated as follows:

Very important: an industry with significant presence (M1 & M2) shares a high degree of structural similarity (C1) with the given cluster for gaining full potentials or running high risks in the cluster development;

Important: an industry with a middle level of the structural similarity (C2) is significant to local economy (M1 & M2), which may achieve a critical mass for the interaction with other industries or equally run risks;

Potential: an industry does not demonstrate significant presence in local economy (M3) but much resembles the cluster (C1 & C2) , which may play a supportive role in the cluster;

Relevant: industries are with significant presence (M1 & M2) but only share a basic similarity (C3) with a cluster.

Figure 4.4 illustrates the roles of industries in the economic structure as can be derived from PCA-based cluster analysis. Industries at the left-bottom corner have a high probability of being coincidently grouped as a cluster. Such clusters are hard to interpret, for example the grouping of automobile repairing and chemical pesticides in 1997 (Figure 4.3). Since the economic significance and structural similarity are both low, the industries at this corner are less important to local economy. Obviously the aggregate approach cannot recognise industries in the M3 field. Given that, the separate approach is recommended for further investigating into the cluster compositions and their changes.

Changes of the industries and their roles provide a means to structurally examine the cluster evolution. They imply a subtle alteration for a cluster pattern, which indicates the changing or upgrading of technological or economic structures. Figure 4.5 illustrates the evolution process of motor vehicles, ICT and Manufacture of Machinery and Metalworking (MMM) related clusters. Figure 4.6 shows the forming of Finance, Business, Real Estate and Insurance (FIRE)-related clusters. On the evolutionary map, it is clearly seen that industries play different roles at different cluster stages in different periods. For instance during the first three periods,

the metalworking acted as very important industry influencing the pattern of the machinery-manufacturing related clusters, but not as strong as the industry of special machinery-manufacturing in the last period. In the FIRE-related clusters, the industries of finance and business alter their status in different periods.

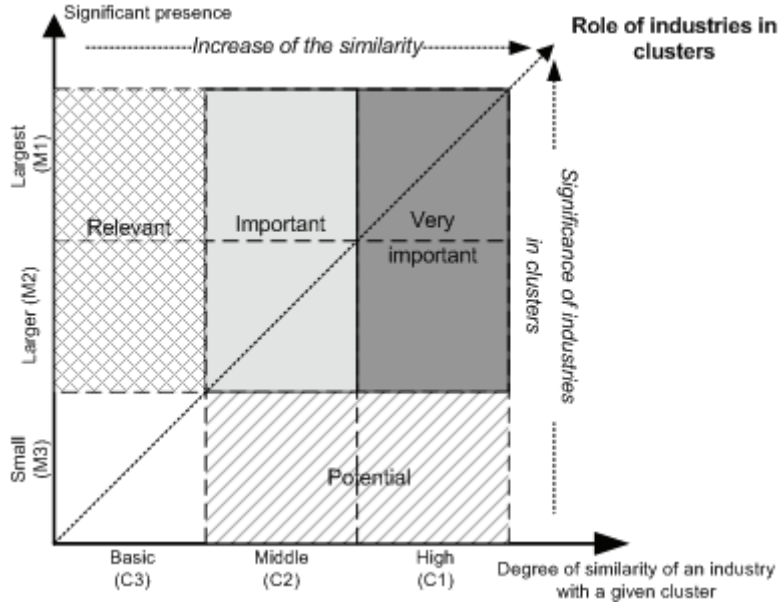


Figure 4.4 Roles of an industry in a cluster

These cluster maps are helpful for understanding the trajectory of cluster developments. Figure 4.5 indicates that the MMM cluster was inherited from the previous and finally anchored with the industries of metalworking, electric equipments and manufacturing of special-purpose machinery. As the cluster became smaller new clusters emerged that are much more specialized. For example in 1987, the cluster pattern was largely affected by turbine and engine manufacturing, metalworking, machinery-manufacturing and electronic equipments. In 2002, three specialised small clusters appeared: steel processing, manufacture of machinery & metalworking and automobile. The ICT cluster has been experiencing a process of continual composing and upgrading. It eventually became a very large cluster, formed by the joining of the clusters of computer-making and consumer & communication electronics in 2002. The change over time of the ICT cluster corresponds to the development of the Zhongguancun ICT cluster, described in policy documents and relevant literature (Wang and Wang 1998; Beijing ZSP Administration 2006).

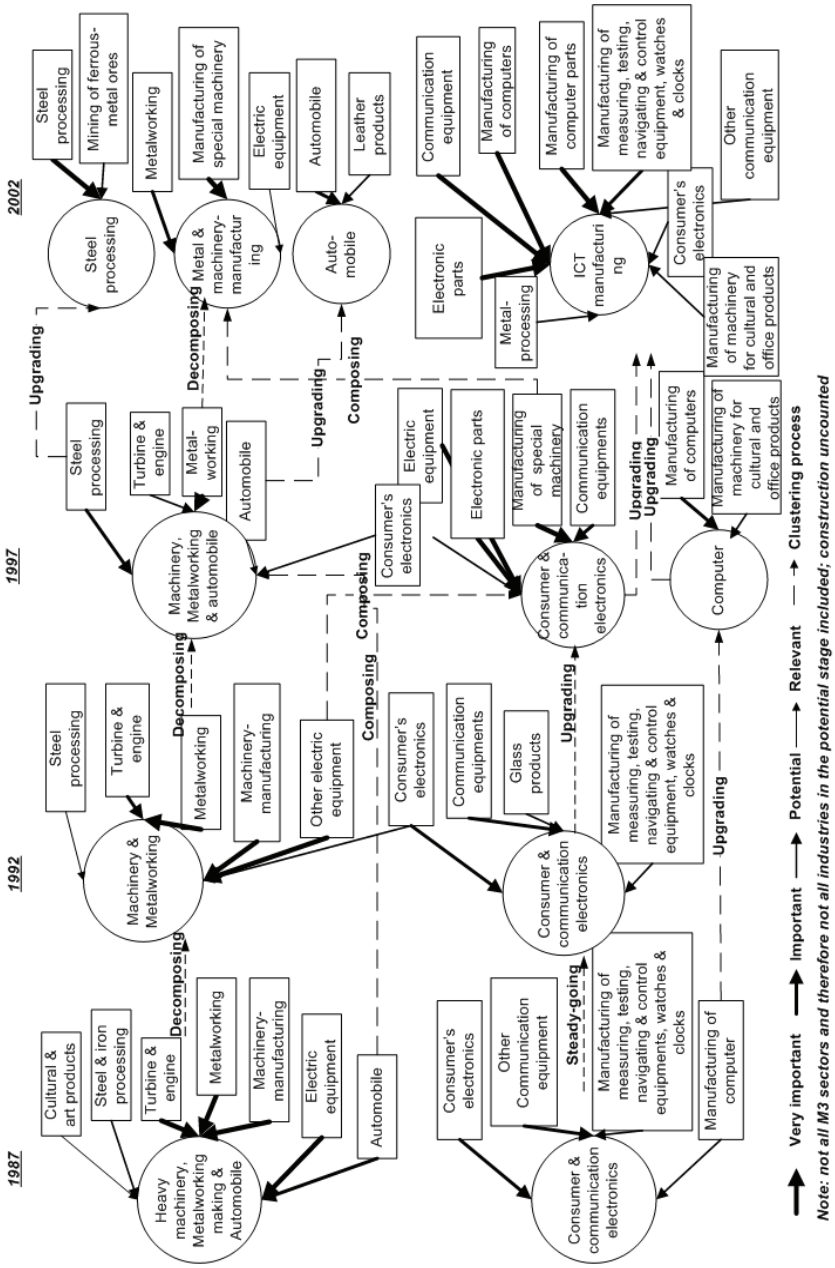


Figure 4.5 Functional evolution of motor vehicles, ICT and MMM clusters

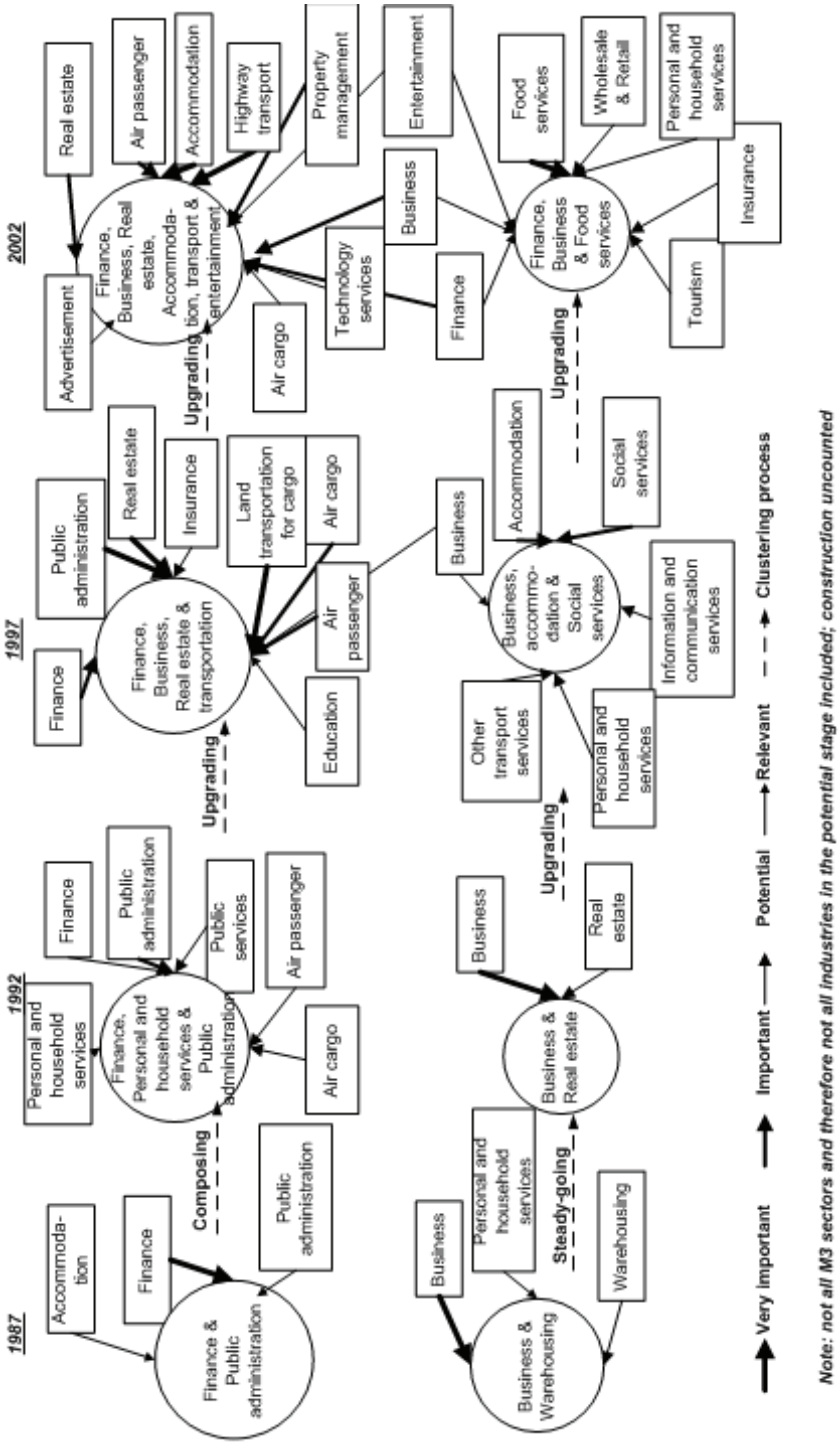


Figure 4.6 Functional evolution of FIRE-related cluster

Figure 4.6 depicts an expanding process of the FIRE cluster involving more industries and some of them are in the existing or emerging stages. Given the special status of Beijing as capital of China, it is interesting to note that the public administration appeared in the 1987-1997 period, but disappeared in 2002. It is also interesting that in 2002, the first finance and business cluster worked on the high-end market as it related to air transport and advertisement, and the second one may focus on the mid-range level since the food services, whole sale and retail played very important and potential roles.

Table 4.2 Functional clusters in 2002

2002	Explained information	% of manufacturing /service	% of total economy
Machinery, metalworking and construction	13.0%	34.1%	16.2%
Of which Machinery and metalworking		22.3%	10.6%
ICT manufacturing	10.9%	24.3%	11.5%
Oil industry	3.6%	11.4%	5.4%
Chemicals	7.5%	5.7%	2.7%
Energy-supplying and construction materials	7.5%	5.6%	2.7%
Automobile	2.0%	3.6%	1.7%
Steel processing	4.2%	3.4%	1.6%
Food processing	3.6%	3.3%	1.6%
Printing, paper products, beverage & tobacco	4.4%	3.3%	1.6%
Pharmaceutical & fertilizer	2.2%	2.9%	1.4%
Electric equipment	1.8%	2.7%	1.3%
Building and construction materials	4.0%	2.5%	1.2%
Wearing apparel	5.4%	2.0%	1.0%
Wood products, sports and & cultural goods	5.3%	1.0%	0.5%
Non-ferrous metal manufacturing	3.8%	0.5%	0.2%
Non-ferrous metal mining and transportation equipment	2.9%	1.0%	0.5%
Wood textile and art crafts	2.4%	2.0%	0.9%
Finance, business, real estate, accommodation, transportation and entertainment	35.7%	58.9%	29.6%
Finance, business services	13.9%	30.7%	15.4%
IT, education, sciences and technology	14.0%	30.3%	15.2%
Information & cultural services	5.2%	9.8%	4.9%
Health care, public facilities and IT	6.4%	5.0%	2.5%
Public & social services	10.7%	5.0%	2.5%
Tourism and exhibitions	3.7%	1.0%	0.5%

The clusters derived in this research actually resemble common or complementary patterns. It is possible that not all industries in the clusters are growing. We checked the change in the outputs for the industries in the period of 1997-2002[14]. With only two industries slightly declining[15], the service classes performed better than

manufacturing industries with 39 out of 70 industries decreasing their output. Likewise, most manufacturing clusters contain industries in downturn, except the clusters of Computer Manufacturing, Beverage and Flax textile, which have no decreasing industrial classes, and the clusters of Metalworking and Electronic manufacturing, Non-metalworking, and Steel processing with only one industry declining. When most of manufacturing classes are shrinking, it can be expected that the cluster pattern is not stable, because these industries either are weakening or change their functions. For example 7 out of 20 industries decline in the machinery-manufacturing cluster, in particular the important classes of steel-processing and metal-working decline. As a result, this cluster is decomposed into three new specialised clusters (Figure 4.6).

Table 4.2 presents a summary of the clusters in 2002. Since the PCA measures the demand and supply structures, the explained variance provides the information that represents the importance of the cluster for the structure of the local economy. Combining the explained variance and the weight of the output value, the most important clusters are: MMM, ICT, Oil and Chemicals related manufacturing clusters, and FIRE, Information and Education related service clusters. Besides, some other industries are important because they grow fast in output, such as Pharmaceuticals (24% growth annually 1997-2002), and Entertainment (31%).

4.3.3 Concise pattern of city economic dynamics

The aggregate cluster pattern is more concise and therefore more suitable to understand the developments of clusters and city economic dynamics. Table 4.3 gives an overview of the PCA-generated clusters, their names and their contributing classes of economic activity. To make the pattern easier to understand, Figure 4.7 is designed. The derived clusters from key industries were projected along a time line with the number of key industries reflecting the size of clusters. The clusters were also positioned along a vertical axis with the commonly used subdivision of the economy. Industries contributing to different clusters were considered (partly) sharing the same cluster pattern and this relationship is shown by drawing connection lines between the clusters (Figure 4.7). This generates a view of conceptualised clusters. These conceptualised clusters are not the computed clusters, but constructed clusters for the purpose of better understanding by planners and policy makers. They are likely to have more interest in what are the clusters than how they are composed. The conceptualised clusters, when given a uniform and easily comprehensible label, can be used for periodical monitoring of urban economic change.

Table 4.3 List of considered industries for each conceptualised cluster

Type	Conceptualised clusters	Industries
Services	Finance, Insurance, Real Estate & Business (FIRE)	Finance, Business, Real Estate, Property management, Transport related sectors*, energy supply related classes*
	Culture & Information (EI)	Culture, arts & broadcast, Advertisement, Information communication services, Telecommunications, Technology communication and services
	Education & Sciences (ES)	Education, Scientific research & development, Professional services, Technical services
	Public Services	Public services, Other social activities services, Personal and household activities
	Public Administration	Public administration
Manufacturing-Services	Information & Communication Technology (ICT)	Manufacturing of computer, Manufacturing of computer parts, Manufacturing of measuring, testing, navigating and control equipment; Watches and clocks, Manufacturing of electric equipments & devices, Manufacturing of other electric machinery and equipment, Manufacturing of communication equipment, Manufacturing of electronic components, Manufacturing of consumer's electronics, Other electronic & communication products, Information communication & service, Computer related services, Software
	Health Care & Pharmaceuticals (HCP)	Pharmaceuticals, Health care, Professional services
	Food and Accommodation	Food products or processing, Food and beverage services, Manufacturing of maple food & forage, Manufacturing of alcohol & beverages, Butcher & meat processing, Accommodation
	Petrochemical	Oil industry, Basic chemical materials, Chemosynthetic materials, Other non-metallic mineral products, Manufacturing of petroleum products, Manufacturing of organic chemical products, Manufacturing of plastic products,
	Printing & Paper-products	Printing and reproduction of recorded media, Manufacturing of paper products
	Textile & Wearing apparel	Wearing apparel, Cotton textiles, Woolen textiles, Sewing
Manufacturing	Automobile & Logistics (AVL)*	Car industries
	Manufacturing of Machinery & Metalworking (MMM)	Metalworking, Manufacturing of (other) special machinery, Manufacturing of (other) general equipments, Manufacturing of other electric machinery & equipment, Steel processing, Electricity supplying, Manufacturing of boiler, engines & turbine, Manufacturing of other machinery products, Steel and iron related industries, Manufacturing of industrial equipment
	Construction	Construction, Construction materials
Other*		Air passengers Air cargos, Land transportation for passengers and freight, Energy supplying (including electricity, steam, gas and air conditioning supply)

*Note: * Transport-related industries were considered as the cluster of Automobile & Logistics if associated with the Manufacturing of automobile, otherwise as members in other cluster in our case. Energy supplying was contingent on it major host cluster which can be FIRE, Manufacturing of Machinery & Metalworking or Petrochemicals.*

Connections among the conceptual clusters were considered according to the membership and the factor loadings of industries. Owing that the key industries were measured for conceptualising the cluster pattern, a little stricter structural similarity was taken to judge the existence of cluster and its connection. Industries with factor

loadings ≥ 0.8 decided the existence of clusters and the member cluster should have factor loadings on less than 0.5. Provided the industries are unlike to be in one cluster (according to Table 3), the combing relationship was assigned among the clusters with their industries' factor loadings no less than 0.8, or otherwise a dependent relationship is drawn from the non-extent cluster (all industries' loadings less than 0.8) to the core cluster. For example, in the aggregate template of 2002, the cluster FIRE has 7 key financial and business sectors with 5 sectors' factor loadings >0.8; yet in the same component, accommodation (factor loading = 0.83) is combined with the FIRE and wearing apparel (factor loading=0.52) and steel smelting (factor loading = 0.63) show a dependent relationship (one-way arrow). With very few cases, the industries with their factor loadings greater than 0.4 were considered as cluster members. Eventually a conceptualised cluster template was derived.

Figure 4.7 illustrates the changes of the cluster pattern in the Beijing economy. In 1987 the city economy is clearly dominated by manufacturing, in particular two clusters engaged in MMM: the bigger one is in Metalworking and Heavy machinery and the other is Non-ferrous metal processing and Electronic machinery. Besides, this cluster relates to the Automobile & Logistics (AL) cluster. Petrochemicals also form a big cluster comprising 6 major industries. The other important clusters include Food & Accommodation, Textile & Wearing apparel, and Printing & paper-products. At that time, financial, business and other activities were at a very preliminary stage, having a weak relationship with the cultural, information and education industries.

By 1992 some changes appear. Although manufacturing clusters remain dominant, there is an evidence of the forming and growth of services and manufacturing-service clusters. In the manufacturing, the cluster of Textile & Wearing apparel grows dramatically and forms two separate clusters that also show various relations with business and manufacturing activities, public services and food services.

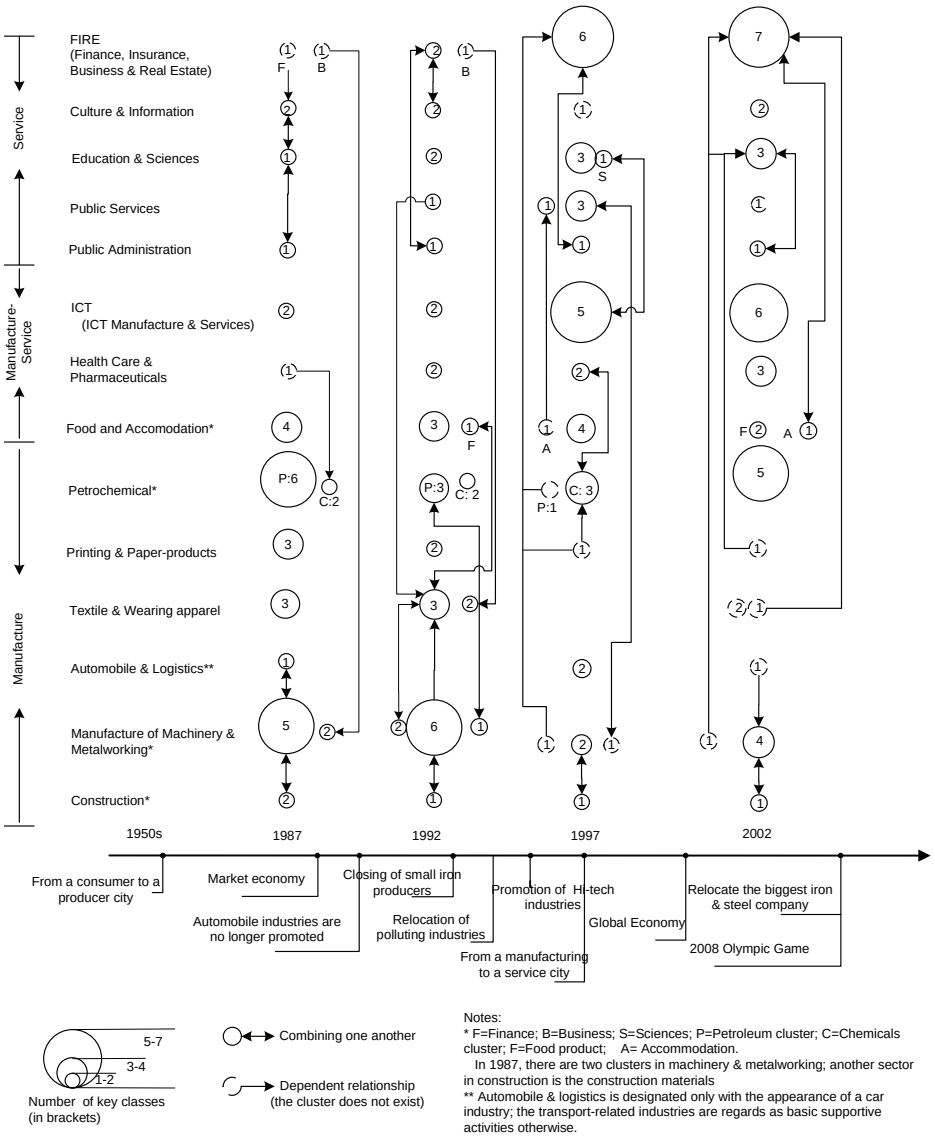


Figure 4.7 Evolution and interpretation of the functional cluster pattern of the Beijing economy

The cluster pattern of 1997 demonstrates a big transformation dominated by service clusters. This change corresponds to the phase of Beijing becoming a service city. The most striking development is the emergence of the ICT cluster combining 5 key industries, and the FIRE cluster with 6 important industries. The FIRE cluster also establishes a wide range of relations with other major economic activities, including public administration, printing and reproduction of recorded media, petroleum, and steel processing.

Most manufacturing clusters are dwindling at this time, like Textile & Wearing apparel and Printing & paper-products.

This trend extends to 2002, when only 3 out of 6 manufacturing clusters remain: petrochemical, MMM and construction. Service clusters become larger and larger. Other than the ICT and FIRE clusters, other emerging clusters include Education and Sciences (ES) Health Care & Pharmaceuticals (HCP). At this period, the Petrochemical cluster is revitalised involving 5 key industries

This conceptual pattern also helps to understand the interweaving of the manufacturing and service economies. The mixed structures can inspire meaningful deduction. For instance in 1997, accommodation shows a dependent relationship with public services. In the same year, energy supplying was combined with the FIRE and ES. That reflects an important change whereby the service economy, identified by business and science, is surging and consumes a large amount of energy. In 2002, the steel and wearing apparel have a connection with the FIRE, which implies outsourcing transactions caused by the upgrading of the wearing apparel industry and import and export transactions for resources and iron products. The growing interrelations between the manufacturing and service industries reflect the complementary of these economic sectors. The changes of in such relations are helpful to investigate the processes of technological upgrading and innovation.

4.4 Functional clusters and urban dynamics

4.4.1 The role of principle component analysis in identifying functional clusters

The analysis discussed in this chapter employed a sectoral approach to identify and monitor functional clusters in order to generate information support for urban planning. Given the fact that the functional relationships of complementariness and commonness are a seedbed for technological innovation and economic opportunities, the PCA is selected as the best method to reveal the local cluster pattern. Compared with previous research, two adaptations are employed to improve the effectiveness of this method. The separate approach provides detailed information about cluster composition and the aggregate one offers a glance at the development of clusters and city economic dynamics. Both of these adaptations allow for investigating aspects of urban economic dynamics.

The PCA approach is a preliminary, but integrated and fast assessment about the local cluster pattern, providing a tool to better understand piecemeal informal knowledge from individual cases or

local experiences. The generated functional clusters are based on demand and supply structures of industries, which can be used as an appropriate instrument for urban planning to cope with economic development. Compared to the previous emphasis in planning on vertical supply chains, the pattern-view produces more comprehensive, flexible and practical urban planning relevant information.

4.4.2 Functional clusters and urban dynamics

The analyses in this chapter indicate that the city economy can be represented by several groups of functionally related industries. Functional clusters can hence aid urban economic policy in gaining a better understanding of linkages among industries, rather than focussing on individual firms or industrial classes. Since public resources, for financial incentives and infrastructure investments, are becoming scarcer, policy actions need to become more efficient. Policy efficiency could be enhanced when policy actions can fulfil common requirements of several related industries. Coping with a volatile market economy, ECs represent common demands and supplies and complementary relations, which can help to better target policy interventions in economic development.

The evolution of the cluster patterns over the four periods vividly depict the city economy of Beijing changing from a manufacturing-based to a service-led economy. Generally, the manufacturing clusters became leading dominant in the periods 1982 and 1987 but the service clusters took the place in 1997 and 2002. In particular, service clusters are booming, including the FIRE, EC, HCP, Culture and Information (CI), and the mixed cluster of ICT, while manufacturing clusters are shrinking especially the clusters of Textile & Wearing apparel, Printing & paper-products and Food & Catering. This shift corresponds to the dynamics of the Beijing economy as shown by the changes of gross domestic product and employment. This trend is also reflected by the share foreign direct investment, with 57.4% for finance, business, real estate sectors and 17.7% for manufacturing sectors in 2007 (see Chapter 3).

Compared to these growth indicators, however, functional clusters are much more meaningful at disclosing structural changes of economy based on connections and interactions among industries. They are more suitable for gaining a deeper understanding of the economic functions of the city. In addition, the functional relationships give a clue for investigating the associated location preferences and spatial patterns of economic activities. It is particularly worthwhile to explore the spatial manifestation of the dominant clusters: FIRE, ICT, ES, MMM, Oil and Chemicals. The

exploration of the spatial evolution of these clusters would result in useful information for urban spatial policy.

Endnotes:

[14] These industries of these two periods are much comparable. 70 manufacturing and 30 services classes are compared.

[15] The two services are air cargo annually decreasing at 5% and hotel at 7%.

Chapter 5 Exploring spatial clusters for urban structure

The Economic Cluster (EC) is a fundamental driver for shaping urban growth and urban structure. It creates economic momentum and meanwhile shapes spatial structures (The World Bank 2008), especially in those cities with fast economic growth. However, the integration of economic and geographical dimensions is not explicit in both academic and planning fields. Little is known about the spatial organisation of functionally related firms or industries. That in turn undermines the comprehension of the associated urban spatial-economic structure.

This chapter presents an approach to explore spatial clusters, the locale of their concentration and the associated spatial pattern. Following the key functional clusters identified in the previous chapter, the clusters of Finance, Insurance, Business and Real Estate (FIRE), Information and Communication Technology (ICT), Education and Sciences (ES), Manufacture of Machinery and Metalworking (MMM), Petroleum and Chemicals are used as cases. The existence of the corresponding spatial clusters are explored by means of Exploratory Spatial Data Analysis (ESDA), and specifically Local Indicator of Spatial Autocorrelations (LISA), for the periods of 1983-87, 1988-92, 1993-97 and 1998-2002 using firm data at the postcode level in Beijing.

5.1 From urban function to spatial clusters

5.1.1 Spatial relations in cluster analysis

The growth of ECs influences urban structure and form. The concentration of firms, plants and business activities in certain places stimulates chances of spin-offs and generates demands on transportation and public facilities that are also place bound. Duranton and Puga (2005) argue that cities have moved from being sectorally specialized to becoming functionally specialized. Many ECs are also important functional areas in a city, such as the Central Business Area (CBD) and economic parks. Positioning and ensuring the efficient functioning of such places and spaces thus becomes a critical task for contemporary city development.

However, the understanding of ECs' spatial effects is mostly from subjective judgment or experiences based on case studies and the model of industrial districts. A systemic approach is lacking in geographically examining a functional-related group of industries citywide. Martin and Sunley (2003) argue that empirical studies

investigating the two core dimensions of the functional relationships and geographical proximity together are lacking. This lack of evidence in turn undermines an objective comprehension of the presence and potential of places. In addition, the classic model of industrial districts usually adopts spatial clusters as individual areas, geographically isolated from cities and regions. It overlooks the related urban structure (SuarezVilla and Walrod 1997). In a contemporary economy that is characterised by knowledge exchange and capital investment much diversified in space, even firms with strong functional linkages may not be located contiguously in space.

The elasticity of geographical proximity drives the understanding of spatial effects of ECs on two aspects. First, the place of ECs is a special space. As Webber (1963) contends, urban space associated with the economies of localization and agglomeration, is a peculiar resource. Second, firms' internal structures are closely related to urban structure by their production process and location behaviour (Rossi-Hansberg, Sarte, and Owens 2009). The associated spatial pattern of ECs therefore might reflect the spatial construct of underlying economic and social relations, which profoundly affect urban structure (Healey 1997; Ward 2002; Healey 2006). The locale and associated spatial pattern of firms therefore imply an increasingly important relationship between spatial clusters and urban structure.

Prior to this research only few studies incorporated functional relations in examining spatial effects of ECs. Ellison and Glaeser (1997) illustrate that the level of agglomeration varies considerably across industries, and contend that there is a tendency of an industry to co-agglomerate with other industries in space. The research of Feser and Sweeney (2000) verifies the existence of certain relationship in functional (input-output relations) and spatial relations of ECs. The association between economic linkages and geographical clustering however varies much for industries; it may be strong for knowledge-based clusters and loose for others.

For exploring spatial clusters, a central challenge is to make explicit the geographical proximity that facilitates economic cooperation and competition (Porter 1996, 1998a; Martin and Sunley 2003). In dealing with this issue, Input-Output (I-O) information could play a fundamental role in generating a reasonable link for the economic and spatial identifications of ECs.

In this research, we will simulate complementary and horizontal relationships in geographical space. This is because supply chains are firm or plant specific. At a strategic level, vertical relationships between firms are hard to capture or keep consistent. The complementary and horizontal relationships actually offer certain

flexibility for policy making, by which policy makers and planners can be informed about the concentration of specific economic activities in particular places. Since innovation and economic potentials are largely incubated within complementary and horizontal interactions (Porter 1998b), the identified place (EC) is also of interest for indicating the area with developmental opportunities. Vertical relationships depend much on the market and government plays a lesser role. Hence, the spatial cluster in this research reflects a particular area concentrated by a group of firms with common and complementary economic linkages to share common facilities and supportive agencies.

5.1.2 Review of methods for spatial clusters

Spatial clusters are often studied by means of measuring industrial or geographical concentrations. Indices of industrial concentration include the Herfindahl index, Herschman-Herfindahl index, Entropy, Gini and Locational Quotients (LQs) (Empirical work see: Garrison and Paulson 1973; Fan and Scott 2003; O'Donoghue and Gleave 2004; Tohmo, Littunen, and Tanninen 2006). Such measures indicate the overall condition of the industrial concentration in a city or region by comparing it to others, without accounting for the characteristics of firms such as their sizes. These indices roughly link industrial linkages with geographical concentration.

Industrial concentration is however not neutral when it comes to geographical concentration (Ellison and Glaeser 1997; Bertinelli and Decrop 2005; Duranton and Overman 2005). For instance a higher index of industrial concentration could be attributed to a highly concentrated sector but with few plants concentrated in space (Bertinelli and Decrop 2005). Acknowledging this problem, Ellison and Glaeser develop the EG index to distinguish geographical concentration from industrial concentration by controlling for differences in the size distribution of plants and for difference in the size of the geographical areas (Ellison and Glaeser 1997). Taking similar approaches or alternative indices, other researchers investigate the geographical concentration and agglomeration of economic activities (Maurel and Sédillot 1999; Devereux, Griffith, and Simpson 2004; Bertinelli and Decrop 2005). These endeavours improve the measurement of geographical clustering of business activities.

A new method of measuring the geographical concentration stems from spatial statistics. Based on the distance, K and D functions calculate the geographical concentration of firms against the null hypothesis that business establishments should be randomly distributed without agglomerating factors (Ripley 1981; Marcon and

Puech 2003; Duranton and Overman 2005; Arbia, Espa, and Quah 2008). These functions provide an apparatus to investigate actual plant sites and deducts whether industries of a given type are geographically concentrated. However, the methods of industrial concentration and geographical concentration both overlook the spatial dependence of economic activities.

Compared to the conventional approaches of measuring industrial concentration and geographical concentration, spatial associations provide a particular way to investigate spatial clusters. They address the feature that events in geographical space are dependent on each other. There is a propensity for nearby locations to influence each other and to possess similar attributes (Goodchild 1992, p33). The event of one location is partially affected by ones at other locations through the interaction, exchange and transfer processes for example population diffusion and economic growth. Some elements may be unobservable, for instance the knowledge and information exchange, but may greatly influence spillover effects in a spatial process. This spatial process is evident in the outcome data, such as employment increase, in the form of spatial association, which provides a way to investigate spatially-conditioned urban structure and growth (Páez and Scott 2004).

Based on the principle of spatial dependence, the Exploratory Spatial Data Analysis (ESDA) developed rapidly in recent years (Goodchild, Haining, and Wise 1992; Unwin 1996; Fotheringham 1998, 1999; O'Sullivan and Unwin 2002). ESDA discloses spatial relationships based on the structure within geodatasets. It requires little prior knowledge but contributes to objectively identifying the spatial pattern of a particular socioeconomic phenomenon. ESDA casts light on broader aspects of regional disparities which are not formalised within mainstream economic theoretical frameworks and on the issue of spatial heterogeneity in urban analysis (Páez and Scott 2004; Boots and Okabe 2007; Getis 2007; Bivand 2008; Yamamoto 2008). Particularly when applied in a GIS environment, the visualisation and exploration of spatial data provides valuable insights into the nature and extent of spatial clustering of economic variables (Dall'erba 2005; Patacchini and Rice 2007). The resulting maps directly reveal the pattern of spatial observations for analysis and interpretation (Unwin and Unwin 1998). ESDA includes a set of techniques for spatial association patterns such as global spatial autocorrelation, local spatial autocorrelation, and spatial heterogeneity (Unwin 1996; Boots and Okabe 2007; Yamamoto 2008).

Being aware that global values will not be universally applicable throughout the study region and may not reflect subtle difference on the finer level, researchers have particular interests in local statistics

(Anselin 1995; Unwin 1996; Unwin and Unwin 1998; Fotheringham and Brunsdon 1999; Boots and Okabe 2007). The aim of local statistics is to learn more about each individual datum by relating it in some way to the values observed at neighbouring locations. The focal location is the one for which information is sought, and its neighbourhood is the set of locations that influence it (Unwin and Unwin 1998). By means of that, the spatial heterogeneity is disclosed, which is in most cases of particular interest to understand the spatial pattern.

Local Indicators of Spatial Association (LISA) is a family of local statistics which are developed to empirically examine the spatial dependence on the local level. O and G statistics support distance-based point analysis intuitively providing a measure of the geographical concentration of values around a given location (Getis and Ord 1992; Ord and Getis 1995; Ord and Getis 2001). It is useful to reveal spatially homogeneous locations in terms of the concentration of high or low values (Unwin and Unwin 1998; Páez and Scott 2004). A rather different approach to disclose spatial autocorrelation is provided by Moran's I and Geary's C (Anselin and Getis 1992; Anselin 1995). The statistic of this type is mainly for lattice (areal) data revealing the spatial relationship of areas adjacent or within a given distance. By means of Moran's I or Geary's C, spatial spillovers or externalities can be explored. LISA statistics can also be aggregated in a certain way to produce a global autocorrelation measure, and therefore is useful to identify influential locations (Páez and Scott 2004).

LISA statistics suggest clusters based on the assumption that spatial pattern is non-random distribution of economic activities. The spatial process of economic activities can be understood as characteristics of the spatial arrangement of objects given by their spacing in relation to each other (Unwin 1996; Frank 2003). As regards areal units, the ones near to each other will tend to take more similar values than those far away (Banerjee, Carlin, and Gelfand 2003). The spatial pattern and the locale of spatial clusters are thus identified based on the heterogeneity or homogeneity of adjacent observations. This process also relates to concepts of market coverage, which can act as a guide to policies by private or public agents on their location to maximise potential markets and local economic development (Bennett, Graham, and Bratton 1999).

Among other LISA statistics, Anselin's local Moran's I has gained particular attention given its meaningful results about spatial manifestations. It has widely been used for exploring and analyzing spatial pattern of a variety of social and economic occurrences. For example, Pacheco and Tyrrell (2002) explore the clusters of

households in cities in Southern New England; Chakravorty *et al.* (Chakravorty, Koo, and Lall 2005) test clusters for industrial sectors in Indian Metropolises and relate empirical results to localization and urbanization economies; Moreno *et al.* (2004) and O hUallachain and Leslie (2005) investigate spatial convergence of innovation activities in Europe and the United States (US). The results from Moran's I can also provide basic facts for investigating urban and regional structure. Baumont (2004) studies the intra-urban spatial distributions of population and employment in Dijon in France to study complex urban growth patterns. Frank (2003) evaluates the spatial segregation pattern of household in the US. Yu and Wei (2008) identify the urban-rural structure in the Greater Beijing region. Further, some policies can be tested using Moran's statistics in a policy context such as the relationship between spatial distributions of regional income and regional development funds allocations in Europe (Dall'erba 2005), and the spatial clustering of property values for decentralization policy to redistribute urban social and economic activities (Han 2005). This research adopts the statistics of the global and local Moran's I to investigate the spatial clusters of key functional clusters in Beijing.

5.2 Methodology

5.2.1 Data description

The register data of business establishments from the Beijing Industrial and Commercial Registration System were prepared for examining spatial clusters. This is an obligatory system officially charged by the Beijing Municipal Bureau for Industrial and Commercial Administration, which requires the registration of all starting businesses. It records basic information of each company's name, address, postcode, employment, establishing date and business scope.

In order to facilitate the process, a fuzzy logic approach was employed to code each firm's economic activity with the Standard Industrial Classification (SIC). In total, 465,360 records were valid and processed covering the period 1956-2002 (for more details see Appendix II). For each industrial classification, around 30-70 entries, depending on the size of sectors, were then randomly selected and manually double checked for each period; the overall accuracy was above 93%. Employment of each business in each year was then aggregated for each sector representing the gross increase of employment in each postcode area. Figure 5.1 illustrates the work flow of dealing with this dataset to make it suitable for spatial cluster analysis.

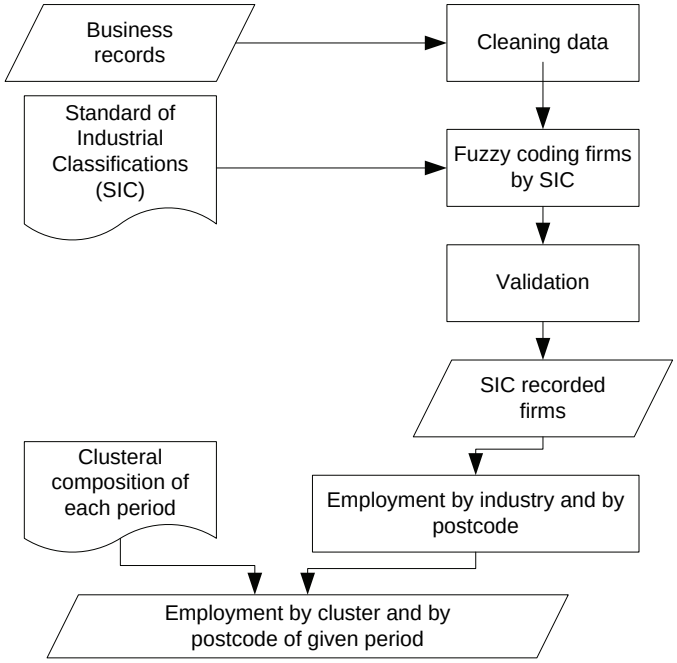


Figure 5.1Workflow of preparing business entrance dataset for exploring spatial clusters

Table 5.1 Summary of data of registered enterprise establishments and employment

Period of establishment	1956-82	1983-87	1988-92	1993-97	1998-2002
Enterprises	1,883	3,032	9,661	119,918	330,866
Employment (,000 persons)	425	589	786	4,029	8,250
Enterprises (with employment registration)	1,809	2,933	7,729	78,852	328,844
Average size (persons)	235	201	102	51	25

Table 5.1 summarises the dataset in different periods. As the first 5-year economic plan and economic development actually started from 1956, the data in 1956-82 was grouped. The analysis was however performed for the period 1983-2002 with a 5-year span corresponding to the I-O survey. This table shows that after the establishment of the market economy the size of enterprises has decreased from 200 employees in middle of 1980s to 25 in the 21st century. This corresponds to the transformation from a state-owned economy to a private economy in which many private, small and medium size companies started and big state-owned companies were restructured. The aggregate data smoothed the instability of the

business establishment which might otherwise be abnormally high or low in a specific year attributed to the economic transformation and uncertainty of the market economy.

Some cautions should be noted for this data. The dataset documents the business establishment including the firms that were established before the liberalisation and still maintained afterwards. As the system is a compulsory registration when firms start, it completely records business entrances of both public and private businesses. However, it hardly provides accurate numbers of employment of firms because a large number of informal employment exists, which may not be counted. On the other side, temporary employment is very common so that the data may over-estimate actual employment in full-time equivalents. The employment in each cluster derived from this dataset does not fully reflect reality. There were no records about the closing of or changes in of companies so that net employment development cannot be studied. Hence, the actual employment is unavailable for postcode areas. Despite this, given that the gross increase of employment reflected the strength of ECs in their capacity to encourage the creation of new business, it can be used as a proxy to measure the vitality of economic activities in each area. Moreover, employment is also a good indicator for both production and demand on facilities and services of a given area.

The main functional clusters derived from last chapter were examined, including the Finance, Insurance, Business and Real Estate (FIRE), Information and Communication Technology (ICT), Education and Sciences (ES), Manufacture of Machinery and Metalworking (MMM), Petroleum and Chemicals. The gross increase of employment was then grouped according to the constituents of functional clusters in different periods (details see Appendix I.9).

5.2.2 Postcodes as spatial units

Currently most business surveys are conducted at postcode level. More detailed information such as the actual site of plants or companies is not provided in many countries, including China, for a variety of reasons such as confidentiality and practicality. Postcodes therefore are the spatial analysis units most often used.

It must also be stated that the postcode map has been adjusted during 1983-2002. Referring to the officially published Postcode Atlas in 2004 in China (Chinese General Post Bureau 2006), the online Beijing postcode map, the paper-based map of the Beijing Post Office and the information inquiry system of postcodes in the Beijing Post Office[xvi], the adjustment was found with a detailed process of dividing post areas based on the standard of 1980. The change was quite

small and only for a few areas. The postcode map was finally prepared based on the 2004 standard with double checking the other three sources mentioned above. The final map consisted of 220 postcodes in the Beijing municipality, with area size ranging from 1.4 to 473 km^2 (Figure 5.2).

There is a big difference for the size of postcode in urban and peri-urban areas, which affects the analysis. Therefore, if necessary, the postcodes with centroids within the 5th ring road were extracted for further explorations. The postcodes of this region range from 1.4 to 59.7 km^2.

Figure 5.2 Postcode map of Beijing

The analysis at postcode level has some advantages. Postcodes can be aggregated as administrative urban districts so as to provide direct and detailed information for local planners about sub-districts. Compared to the point analysis, areal analysis is more appropriate for taking explicit account of the localised nature of public goods

(Webster 1993). This would facilitate analysis and decision making for urban planning. However, postcodes are still an arbitrary spatial division, which cannot fully reflect the actual boundary of spatial clusters.

5.2.3 Global and local Moran's I

The research used the global and local Moran's I to examine spatial clustering of firms in a particular predefined economic cluster, measured by their initial employment. The global and local Moran's I are measures describing overall spatial autocorrelation across all geographical units. The local Moran's I is a decomposition of the global Moran's I.

Formally specified, x_i is the observation x in area i, $\overline{x}$ is the average across the units , the global Moran's I is: $I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \overline{x}\right)\left(x_j - \overline{x}\right)}{\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2}$, where w_{ij} is the spatial weight ($j \neq i$). Local Moran's I: $I_i = \frac{(x_i - \overline{x})}{\sum_i (x_i - \overline{x})^2} \times \sum_j w_{ij}(x_j - \overline{x}) = z_i \sum_j w_{ij} z_j$, where z_i and z_j are the standard value of observation i and summation of surrounding areas j to the mean value respectively. The values are in the range $[-1,1]$.

The measure of spatial correlation is subject to the inference of the computational permutation test that the observation x_i at location i is controlled with the remaining values are randomly permuted over all locations. In order to avoid a great sensitivity on particular randomization 9,999 permutations were used here for both the global and local Moran's I to compute the empirical distribution (Anselin 1995; Anselin *et al.* 1996). Based on the computational permutation or saddle approximation (Tiefelsdorf and Boots 1995; Tiefelsdorf 1998), pseudo-significance levels *(p-values)* were obtained. Against *p*-values (0.05 in our analysis), significant Moran's I reveals that the spatial pattern was not random. Compared with the expected value $E(I) = -1/(n-1)$ (-0.0084 in this study, 220 postcodes), a high positive I indicates positive spatial autocorrelation, and a low a negative value indicates spatial dissimilarity.

The spatial weights matrix, important in calculating Moran's I, largely decides the examination and representation of the spatial linkage of spatial units (Anselin and Getis 1992; Anselin 1995; Rey and Montouri 1999; Anselin, Syabri, and Kho 2006; Yu and Wei 2008). Assumed from the different configurations of clustering economies, two types of devices were used to determine the spatial weights. First, spillover effects were assumed to be happening at a local scale. The conditions within a particular area mostly contributed to the forming of geographical concentrations of businesses and industries. The adjacent places were more alike than the distant ones, and similar economic activities grew and then diffused in the proximate geographical space. Boarder sharing proximity (rook contiguity weights) was accordingly employed to explore these localized spillovers. Second, provided the clustering of economies was also benefited from urban size, and market capacity may scatter citywide, a distance strategy was used to explore the spatial representation of functional relations under urbanisation economies. At the city level, the distance of establishing spatial weight matrix ranged from 16 to 110 km and the distance of 16 km was similar to the case of spatial bordering. Hence, the distances of 30 km, 45 km, 60 km, 90 km and 120 km were then selected as alternatives to approximate spatial patterns. On average 60 km is about one hour driving distance in Beijing, which made it possible to measure the interaction from the urban centre to all areas in the inner peri-urban areas and some areas in the exurban area.

The postcode however varies greatly in sizes especially between the urban centre and peri-urban areas. If necessary, the spatial pattern was therefore further explored for the urban centre, for which the distance for the spatial weight matrix ranges from 5.5 to 36.5 km. Besides the rook weight, the distances of 10 km, 15 km, 20 km and 30 km were selected for devising the local spatial pattern of selected clusters at the urban level.

Owing to the condition of Beijing city in the early periods, urbanisation externalities played a lesser role in economic development than localisation externalities. It was rational that the rook proximity was adopted as spatial weights to test the evolution of spatial clusters. However it should be noted that urbanisation externalities were increasingly important and therefore the distance strategy was worthwhile to explore different situations. The distance alternatives actually covered a wide range of spatial interactions for Beijing. The range can be used to investigate the hinterland of particular economic activities or the distance of spatial interactions which is significant for particular types of functional clusters. The

process was conducted with row standardisation of spatial weights in the GeoDa software environment (Anselin, Syabri, and Kho 2006).

Local spatial associations denote the spatial autocorrelation between an observed place and its neighbourhood compared to a random process over space. If the local association was insignificant, then the area was blank and that means observations are distributed randomly. The local Moran's I otherwise provides four types of spatial patterns. The positive correlation, High-High (HH) refers to an observation with a high value surrounded by observations with high values, and Low-Low (LL) indicates an observed low value is surrounded by observations with low values. The negative correlation also indicates two conditions: Low-High (LH) refers to an observation with low value surrounded by observations with high values, and High-Low (HL) represents an observation with high value surrounded by low values. These four patterns can be illustrated by a local Moran's I cluster map (Anselin 1995; Anselin, Syabri, and Kho 2006).

As regards the pattern of economic activities, the HH and HL can be taken as locales of spatial clusters in an economic sense. The other two types of spatial patterns represent relative stagnation. Specifically, these four patterns are:

- Hotspots (HH): the place and its surrounding area is a concentration point for a type of economic activity, significantly higher than the average level, suggesting spatial spillovers from the central place to its periphery;
- Islands (HL): the place itself is a concentration point for a type of economic activity but in its periphery the presence is lower than average, implying few spatial spillovers from the central place to its periphery;
- Atoll (LH): the place significantly lacking a type of economic activity while in its neighbouring areas this type of activity is overrepresented;
- Cold spots (LL): both the place and its peripheral areas are inactive with respect to a type of economic activity.

5.3 Results and interpretation

5.3.1 Finance, Business, Insurance and Real Estate (FIRE)

(1) The spatial evolution

As the business and finance activities were initially in different clusters, the real FIRE cluster did not emerge until 1993. Therefore, the spatial patterns of the business and finance dominated clusters were respectively examined during 1983-92 and the FIRE cluster was investigated during 1993-2002. Although the global Moran's I indicated there was no global association for the business-dominated cluster in 1983-87 and for the finance-dominated cluster in 1983-92 ($p > 0.5$, Table 5.2), a significant spatial association at the local level was identified (Figure 5.3).

Table 5.2 Global Moran's I of the FIRE cluster in each period (Rook spatial weight)

	1983-87		1988-92		1993-97			1998-2002		
	Finance	Business	Finance	Business	FIRE	Finance	Business	FIRE	Finance	Business
Municipal										
Moran's I	0.145	-0.015	-0.002	0.193	0.082			0.323		
p-value	0.005	0.480	0.864	0.004	0.005			0.001		
Urban*										
Moran's I	0.123	-0.044	-0.040	0.166	-0.026	0.081	0.004	0.005	0.112	0.073
p-value	0.048	0.023	0.358	0.008	0.458	0.095	0.099	0.186	0.026	0.089

*The finance and business were measured for sectors on the urban level while during 1993-87 and 1988-92 they were measured for related sub-clusters on the municipal level.

During 1983-92, the hotspots of the business-dominated cluster occurred in the key towns of the north of the municipality, rather than in the urban centre (Figure 5.3). The finance-dominated cluster was most active in the southwest in 1983-87 and shifted to the north corner of the urban centre. There were almost no island developments existing for both business and finance dominated clusters for the business-dominated cluster in 1983-87.

After 1993, the business and finance activities were functionally grouped together. The urban centre has been becoming a major place for the FIRE cluster. In 1993-97, the north of the urban centre was a hotspot and FIRE was gradually filling in almost all the urban centre. Some key towns in the north of the municipality also became FIRE islands.

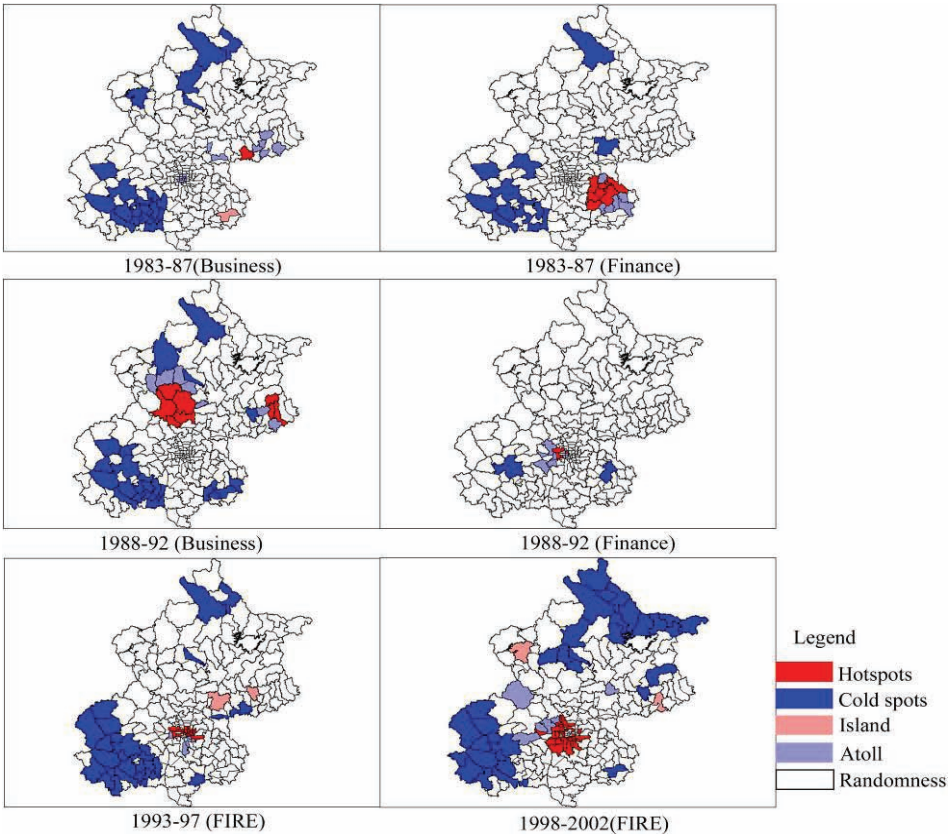


Figure 5.3 Spatial evolution of the FIRE cluster

Because FIRE activities are significant for the urban centre and include all kinds of related activities, further exploration was made at the urban level and for business and finance activities respectively (Figure 5.4). Since 1988, the business sector was mainly located in and finally developed into the current CBD area through the agglomeration of a large number of high-end business activities.

Different from the random distribution of business services during 1983-87, finance services were significant along the west 2nd-3rd ring roads in this period, where the headquarters of national banks were concentrated. During 1988-97, the finance activity was however salient with only some areas independently growing in the urban centre. In 1998-2002, the Financial Street became the main area for finance services. The alteration of place-based development suggests a quite clear functional change of finance activities during 1983-2002 as finance is transformed from an activity in support of transactions to a leading sector in the urban economy. This change is accompanied with functional changes while the location of financial services remains largely unchanged.

However, if all related activities are included, the FIRE cluster seems to be dispersed. It occupied a large area of the urban centre from the analysis on the municipal level during 1993-2002. This could be the reason why FIRE is neither contained in the CBD nor the Financial Street at the level of the urban centre. Instead, the place for general FIRE activities is quite flexible.

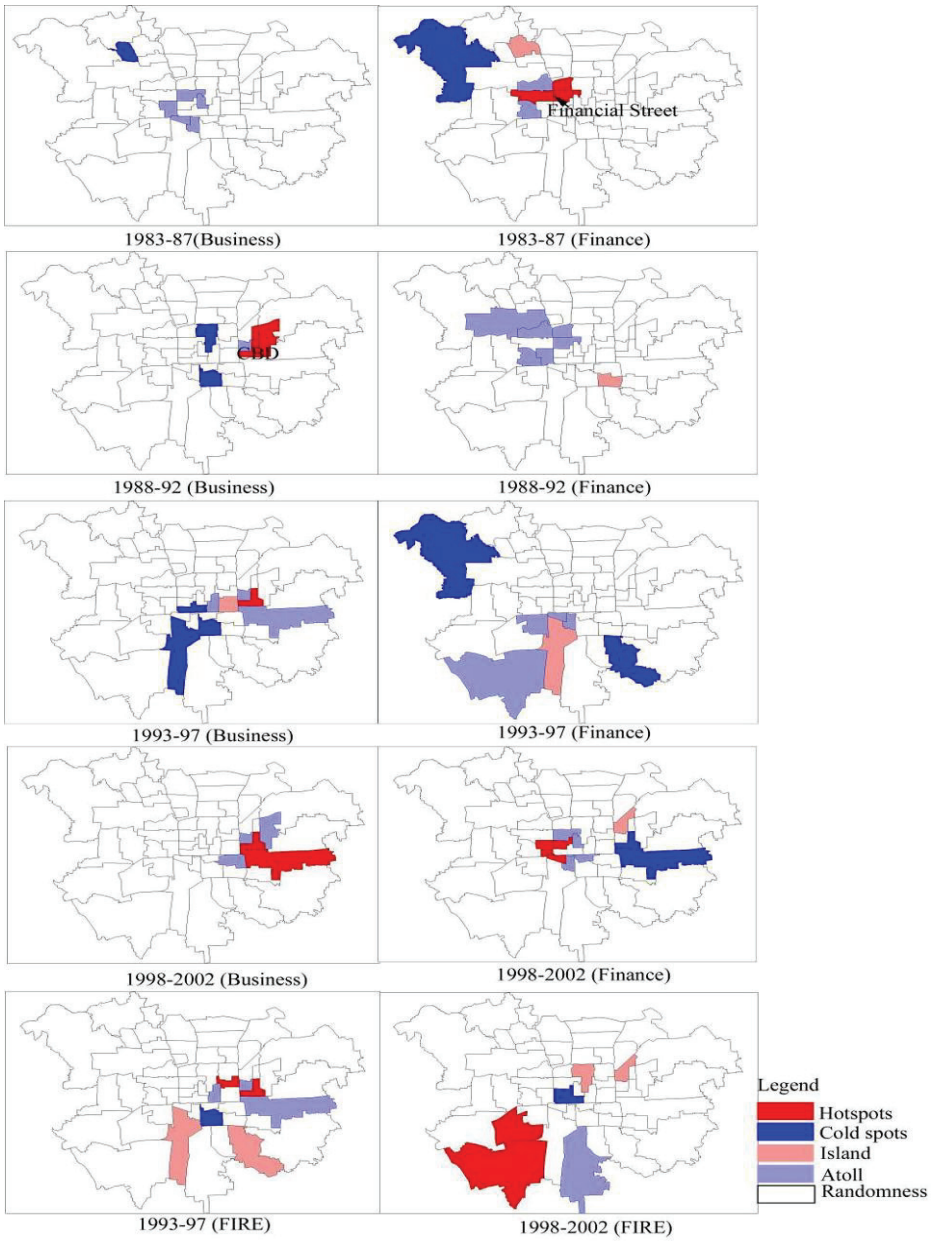


Figure 5.4 Business and finance and FIRE in the urban centre

(2) Explorations of distance weights in 1998-2002

Under the distance weights, the global Moran's I indicated strong global spatial association for the FIRE cluster at the municipal level (Table 5.3). However, there was a turning point at the distance from 60 km to 90 km where the global Moran's I changed from positive to negative and p value indicated such association was almost insignificant. It might be concluded that 60 km is generally the distance for spatial interactions within the FIRE sectors. The test also indicates that the global association of FIRE is insignificant in the urban centre.

Table 5.3 Global Moran's I of FIRE under different distance weights in 1998-2002

Municipal	Rook	30 km	45 km	60 km	90 km	120 km
Moran's I	0.323	0.206	0.103	0.031	-0.009	-0.016
p-value	0.001	0.001	0.001	0.002	0.044	0.001
Urban	Rook	10 km	15 km	20 km	30 km	
Moran's I	0.005	-0.036	-0.034	-0.020	-0.018	
p-value	0.186	0.279	0.138	0.499	0.578	

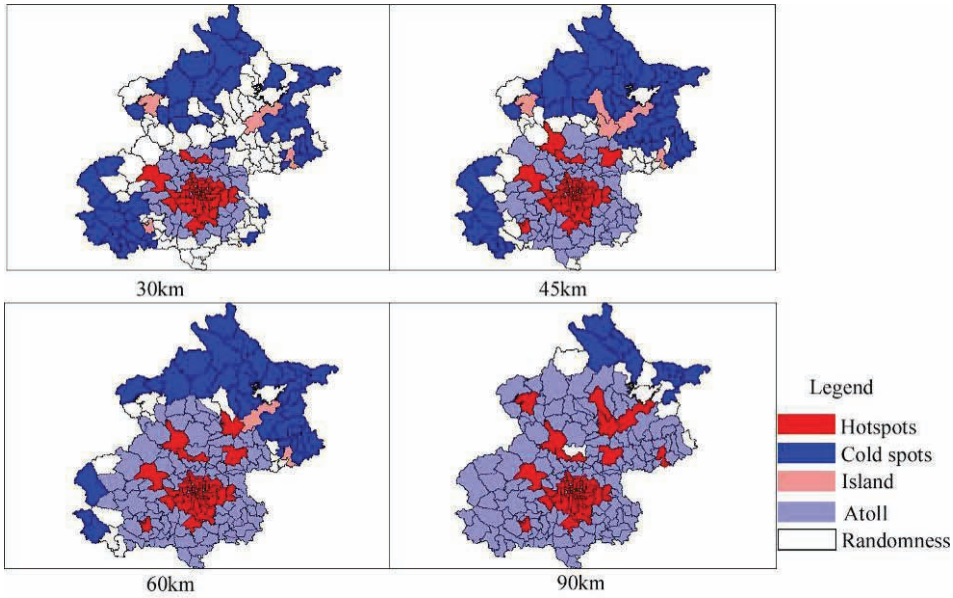


Figure 5.5 FIRE cluster weighted by distances in 1998-2002 (municipal level)

The local association demonstrated a mono-centric development for the FIRE cluster (Figure 5.5). The robust rook weight indicated that

FIRE was located within the 4th motorway with few blanks along the northeast corridor (the situation in 1998-2002, Figure 5.3). With the increase of the distance, the hotspots of the FIRE cluster expanded from the urban centre to the town seats of exurban districts and counties. Surrounding these hotspots several atoll areas of FIRE activities can also be observed.

The explorations at the urban level indicate that at different distances, the concentration of the FIRE activities is very uneven (Figure 5.6). It is evident in the southwest under the configuration of 10 km, but salient in the south at the distance of 20 km. At the measurement of 30 km distance, the urban fringe could be also an important area for the FIRE activities. This situation might suggest that the FIRE cluster is relatively concentrated in the urban centre.

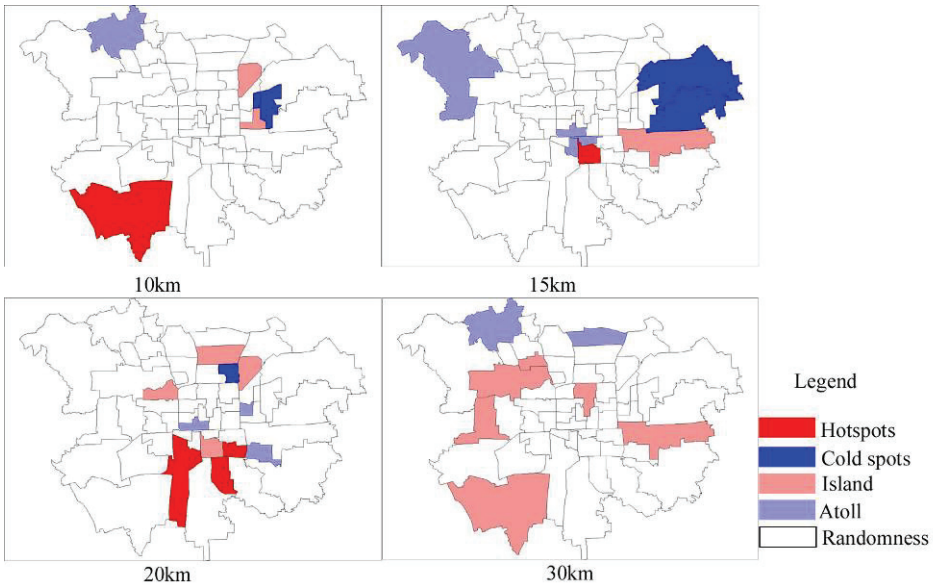


Figure 5.6 FIRE cluster weighted by distances in 1998-2002 (urban level)

5.3.2 Information and Communication Technology (ICT)

(1) The spatial evolution

The ICT cluster developed mainly based on the industries of computer manufacturing, customer electronics and information and communication facilities. The spatial association was not significant for 1983-87 and 1993-2002 on the global level but significant for the periods 1987-92 and 1993-97. In 1993-97, the ICT cluster was divided into to the sub-clusters of manufacture of computers and

information and communication facilities. The former appeared with a higher Moran's I than the latter (Table 5.4).

Table 5.4 Global Moran's I of the ICT cluster in each period (Rook spatial weight)

	1993-87		1988-92	1993-97	1998-2002
	Research & Development	Education	ES	ES	ES
Municipal					
Moran's I	0.001	0.090	0.284	0.327	0.260
p-value	0.226	0.014	0.002	0.001	0.001
Urban					
Moran's I	-0.020	0.218	0.159	0.036	-0.016
p-value	0.565	0.006	0.021	0.202	0.560

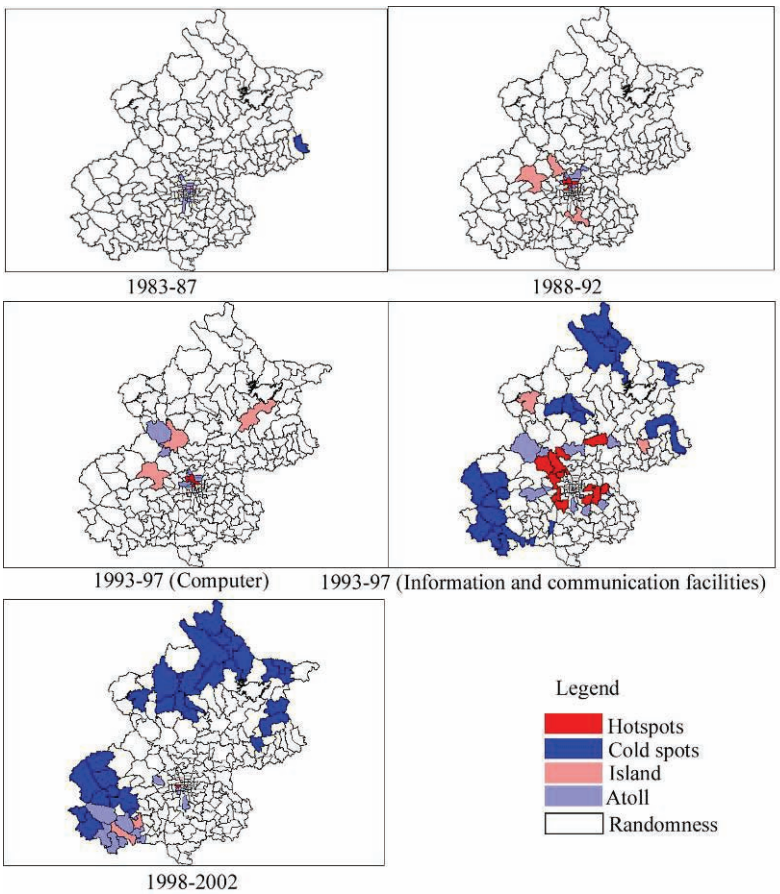


Figure 5.7 Spatial evolution of the ICT cluster

The local Moran's I cluster map demonstrates there were no hotspots for the ICT cluster during 1982-87; only 3 postcode areas

existed as islands in the north of the urban centre (Figure 5.7). These islands and their peripheral areas quickly grew up to hotspots during 1988-92. As regards the sub-clusters during 1993-97, the hotspots of information and communication facilities expanded forming a belt circling the urban centre; another sub-cluster, manufacture of computers, concentrated to the north of the urban centre. These two ICT-related clusters were combined and showed up in two postcode areas as significant as hotspots in 2002, with the locale and its surrounding areas higher than the average for the municipality.

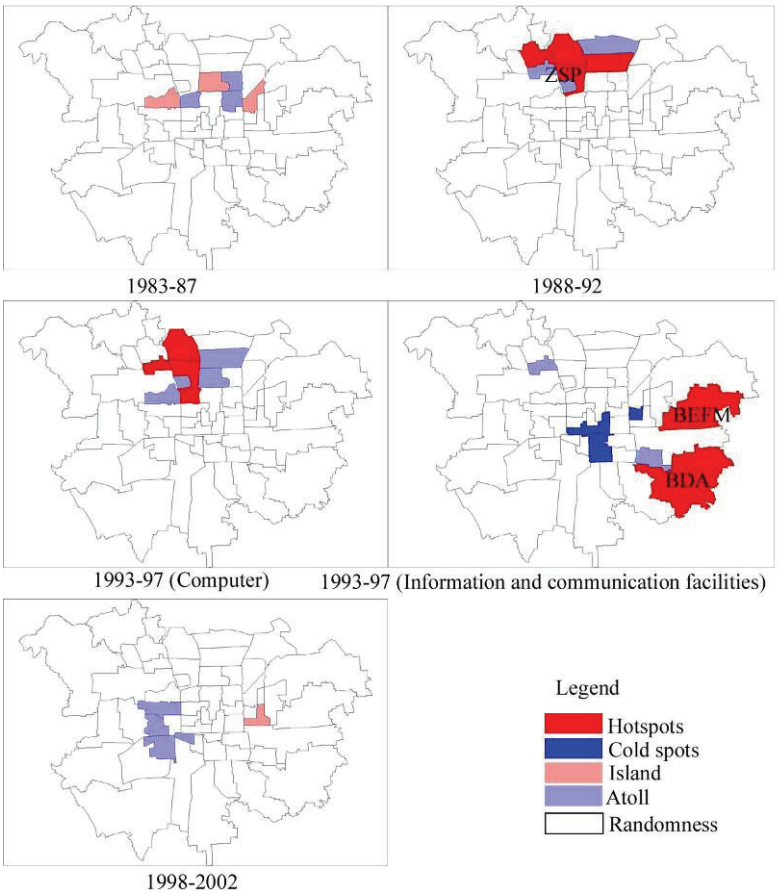


Figure 5.8 ICT cluster in the urban centre

In the urban centre, a place-based growth of the ICT cluster was clearly indicated during 1983-1997 (Figure 5.8). The manufacture of computers was concentred and maintained in the area alongside the 4th ring road until 1997. During 1993-97, the sub-clusters of the information and communication facilities were concentred in the east part of the city. One is the park of Beijing Electronic and Fibre Manufacturing (BEFM), which is close to the Beijing Development

Area (BDA), and the other is the new expanded part of Zhongguancun Sciences Park (ZSP) in the northeast. However during 1998-2002, the place for ICT concentration was not identical between the analysis on the municipal and urban level. The former maintained the place inherited from previous periods and the latter was close to newly expanded ZSP.

(2) Explorations of distance weights in 1998-2002

The global Moran's I shows the spatial association was not significant for the ICT cluster within the distance of 45 km. The global Moran's I was significant at the range of 45-90 km, and changed to insignificance for 120 km (Table 5.5).

Table 5.5 Global Moran's I of the ICT cluster weighted by distance

Municipal	**Rook**	**30 km**	**45 km**	**60 km**	**90 km**	**120 km**
Moran's I	-0.039	0.010	0.012	0.016	0.003	-0.004
p-value	0.093	0.107	0.037	0.006	0.013	0.878
Urban	Rook	10 km	15 km	20 km	30 km	
Moran's I	-0.109	-0.012	-0.023	-0.020	-0.018	
p-value	0.030	0.679	0.330	0.335	0.404	

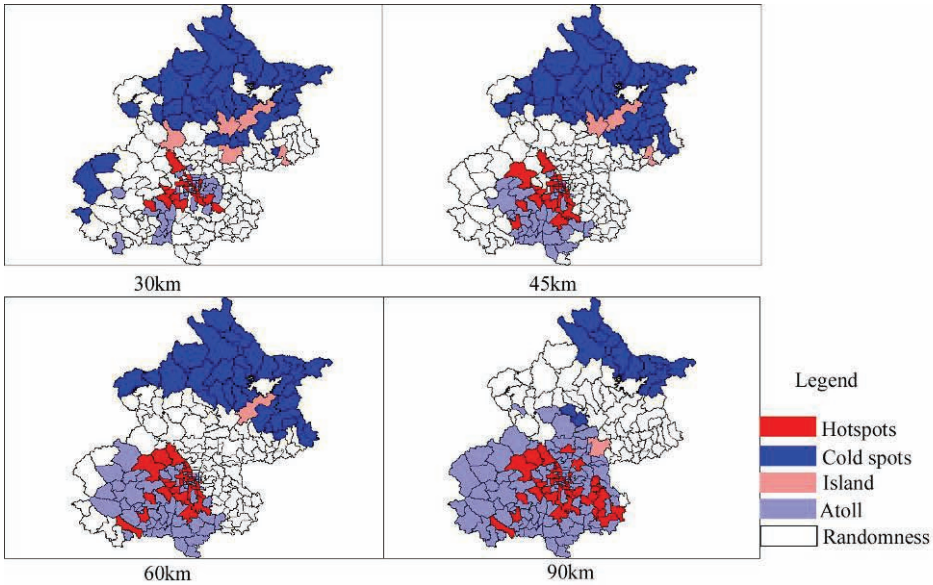


Figure 5.9 ICT cluster weighted by distances in 1998-2002 (municipal level)

The local statistics at municipal level illustrate how hotspots of employment grew along the northwest-southeast axis of the Badaling

Motorway (Figure 5.9). This situation was particular so for distances of 30 to 60 km. When the spatial weight was changed to 90 km, the hotspots extended to the Beijing-Tainjin Corridor. The ICT islands stayed in the key towns in the north of the municipality.

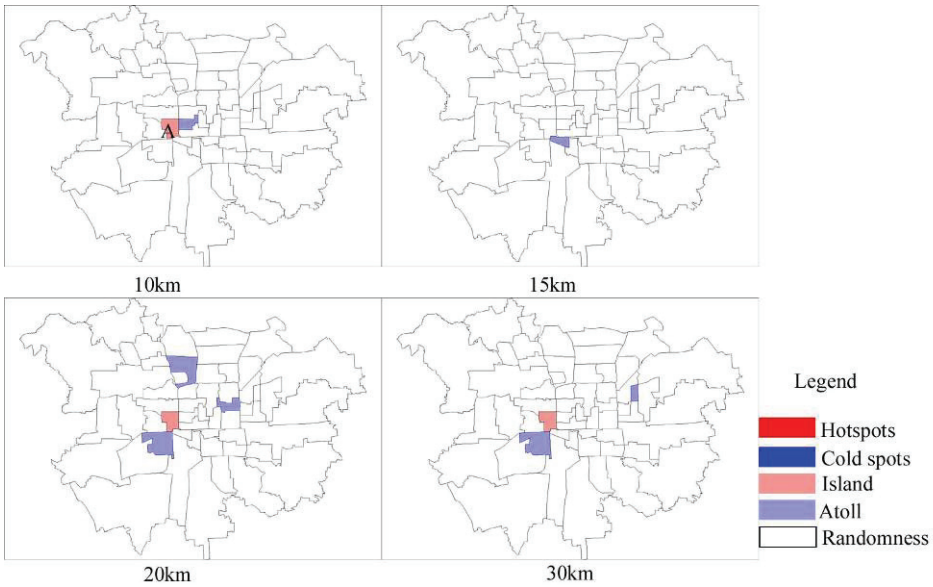


Figure 5.10 ICT cluster weighted by distances in 1998-2002 (urban level)

As the p value is greater than 0.05, the further exploration indicates the spatial concentration of the ICT cluster is not significant at the global level of the urban centre except for under the rook weight (Table 5.5). Similarly, at the local level of measurement, most ICT related activities were randomly distributed over the urban area, with the exception for one location as an island (A on the map, Figure 5.10), which does not fall in but besides the ZSP. Compared with the situation of the result at the municipal level, this suggests that the ICT activities can scatter over the urban centre.

5.3.3 Education and Sciences (ES)

(1) The spatial evolution

During 1983-87, the ES cluster did not exist. Two related sub-groups of education and research and development (R&D) were tested. There was no significant spatial association for the cluster of R&D but a significant association did exist for education on the municipal scale. For the other 3 periods, the global spatial associations were significant (Table 5.6).

Table 5.6 Global Moran's I of the ES cluster in each period (Rook spatial weight)

	1993-87		1988-92	1993-97	1998-2002
	Research & Development	Education	ES	ES	ES
Municipal					
Moran's I	0.001	0.090	0.284	0.327	0.260
p-value	0.226	0.014	0.002	0.001	0.001
Urban					
Moran's I	-0.020	0.218	0.159	0.036	-0.016
p-value	0.565	0.006	0.021	0.202	0.560

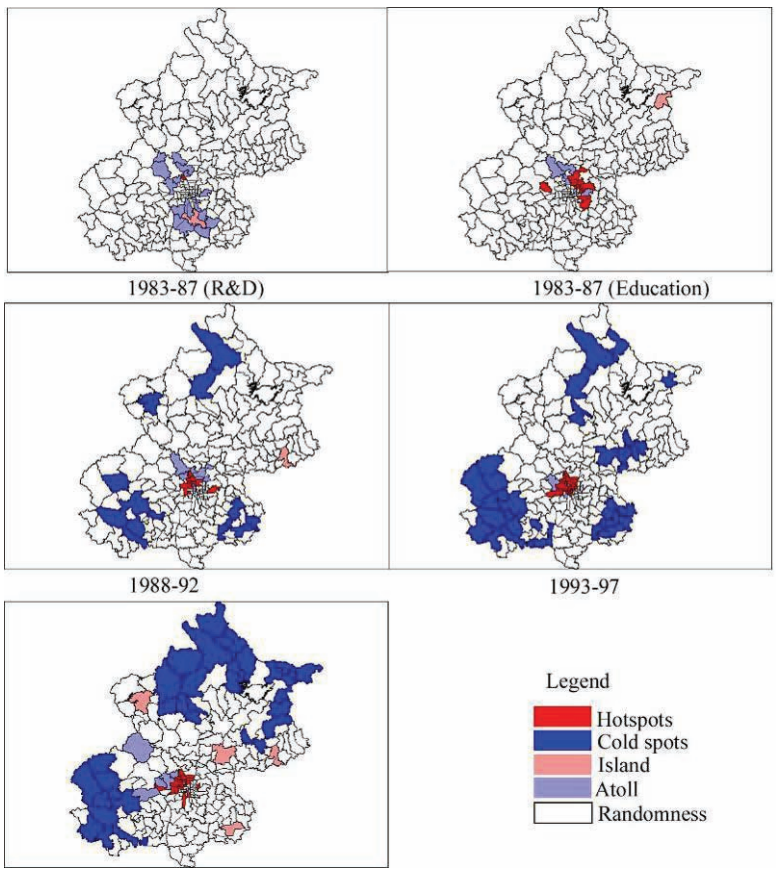


Figure 5.11 Spatial evolution of the ES cluster

During 1983-87, because the education sector was functionally combined with air passenger transport, air cargo and transportation related sectors, the increase of the employment of the education cluster was highly concentrated in the west part of the city, along the corridors to the Capital Airport and to Tianjin. In the same period,

there was only one hotspot for the R&D cluster. The places for the hotspots of the education and R&D clusters were not spatially overlapping. After 1987, the real EC cluster was gradually growing and concentrated in the northeast quadrant of the urban centre (Figure 5.11).

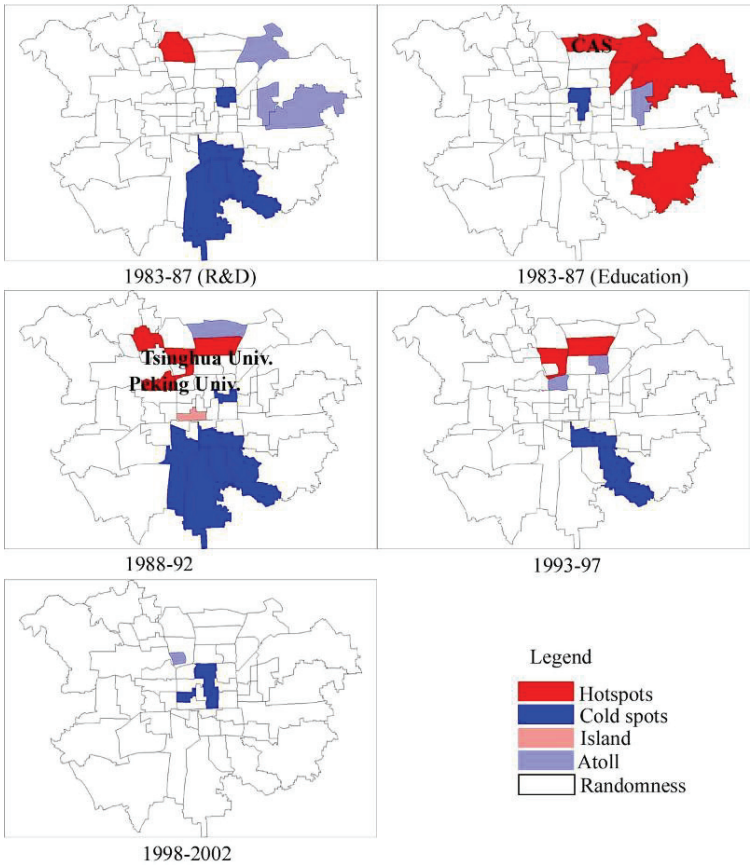


Figure 5.12 ES cluster in the urban centre

Owing to the same reason above, the exploration on the urban centre also indicates the education cluster was concentrated along the corridor to the Capital Airport and to Tianjin during 1983-87. During 1988-97, the education cluster was mainly developed in the area where Peking and Tsinghua Universities and the institutes of Chinese Academic Sciences (CAS) are. These places were, to a large extent, maintained until 1997, and overlapped or were close to the places where the ICT activities were concentrated (see Figures 5.8). During 1998-2002, the urban centre was almost a random space for the ES cluster, implying the ES activities could be located dispersed over the urban centre. This situation developed as the whole urban centre

becomes an agglomeration area for ES at the municipal level (Figure 5.12)

(2) Explorations of distance weights in 1998-2002

In the 1998-2002 period, the ES cluster demonstrated a strong spatial association on the global level within the distance of 60 km at the municipal level. A turning point occurred at the distance of 90 km where the global Moran's I became insignificant (Table 5). Hence, similar to the FIRE cluster, 60 km was the distance for spatial interactions of the ES cluster. The global associations were almost insignificant for all distances at the urban level.

Table 5.7 Global Moran's I of the ES cluster weighted by distance

Municipal	Rook	30 km	45 km	60 km	90 km	120 km
Moran's I	0.260	0.133	0.064	0.015	-0.007	-0.011
p-value	0.001	0.002	0.004	0.012	0.178	0.001
Urban	Rook	10 km	15 km	20 km	30 km	
Moran's I	-0.016	-0.051	-0.016	-0.019	-0.018	
p-value	0.560	0.046	0.625	0.424	0.327	

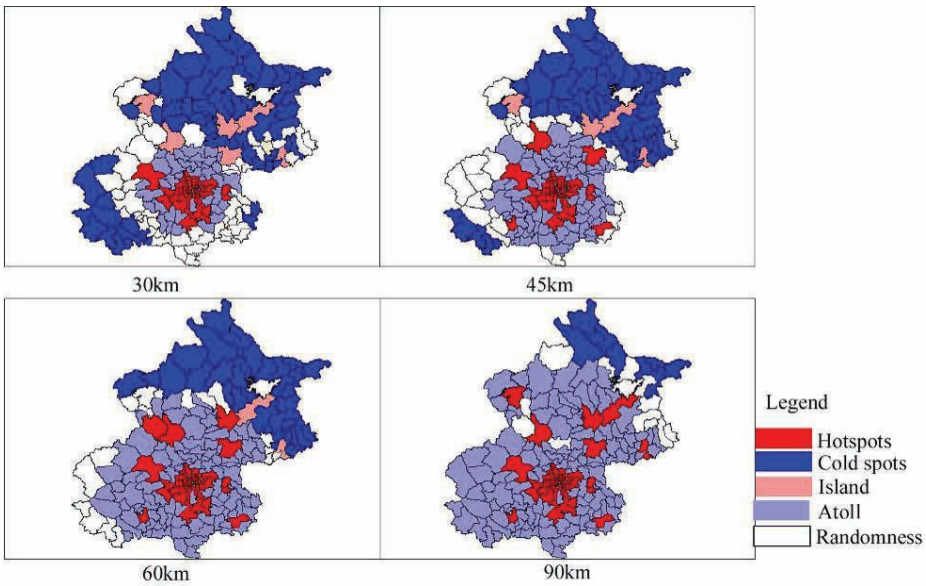


Figure 5.13 ES cluster weighted by distances in 1998-2002 (municipal level)

The distance-based local statistics show that the urban centre was the hotspot for the ES cluster (Figure 5.13). When the distance is increased, the key towns were changing from islands to hotspots, while other areas were relatively devoid of ES activities. This pattern is quite similar to that of the FIRE cluster.

Regarding the analysis of the urban centre, although explored at various distances, the place of ES concentration during 1998-2002 was also found in the previous periods (Figure 5.14). This indicates the location of the ES cluster in the past is very influential for the future pattern. Up-scaling of ES activities was apparently relatively easily achieved *in situ*, exploiting the residual capacity of existing ES facilities. Besides, with the increase of the distance, the numbers of the islands and atolls grows, which may suggest a relative concentration of the ES activities in the urban centre.

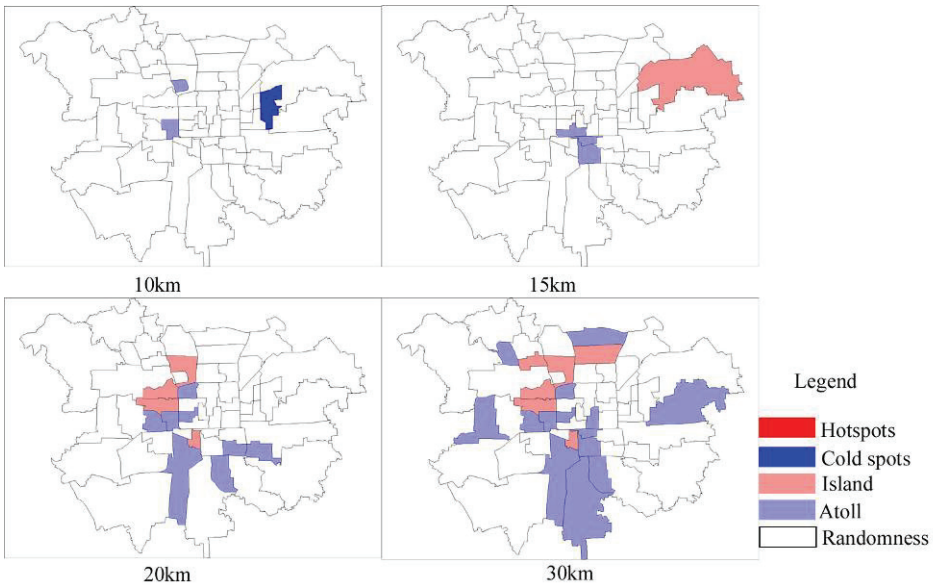


Figure 5.14 ES cluster weighted by distances in 1998-2002 (urban level)

5.3.4 Manufacture of Machinery and Metalworking (MMM)

(1) The spatial evolution

There was no significant spatial relationship for postcodes for the MMM cluster during 1983-92 and 1998-2002. Only during 1993-97 was there a significant global Moran's I value indicating a positive relationship among the spatial units (Table 5.8).

Table 5.8 Global Moran's I of the MMM cluster in each period (Rook spatial weight)

Municipal	1993-87	1988-92	1993-97	1998-2002
Moran's I	0.016	0.039	0.085	0.037
p-value	0.066	0.087	0.028	0.138

The hotspots barely changed for the MMM cluster between the periods 1983-87 and 1988-92, and they were in the north of the municipality outside the urban centre. During 1993-97, several hotspots were scattered around the urban centre. In 1998-2002, the hotspots geographically grouped along the southwest corridor from the urban centre to the outside (Figure 5.15).

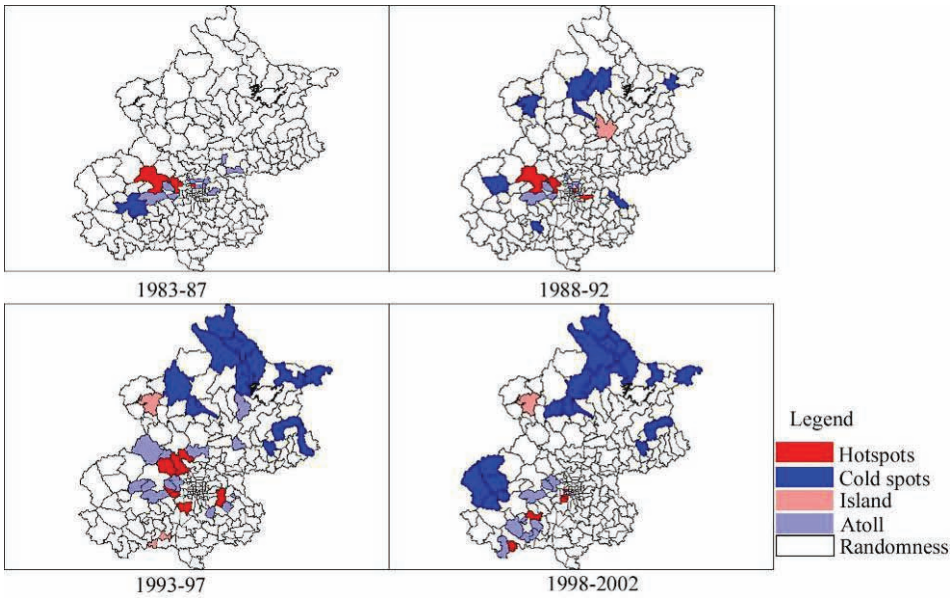


Figure 5.15 Spatial evolution of the MMM cluster

(2) Explorations of distance weights in 1998-2002

The global Moran's I indicated spatial association was insignificant for the adjacent areas, as p-value was high in the rook spatial weight (Table 5.8). Within 30-90 km, a significant spatial correlation exists for the MMM cluster (Table 5.9). However a random process was salient at 90-120 km because the Global I nearly approached 0 at 90 km. These results point to spatial spillover effects within the distance of 30-90 km for the MMM cluster on the municipal level.

The hotspots for the MMM cluster were in the south of the urban centre and in the exurban districts and counties in south of the municipality. The islands were in the northern part, and most areas in the southern part had an atoll pattern. In general, there was a divide for the spatial pattern of the MMM cluster: a random process in the north part of the municipality and a mixture of agglomeration and diffusion in the south.

Table 5.9 Global Moran's I of the MMM cluster weighted by distances

Municipal	Rook	30 km	45 km	60 km	90 km	120 km
Moran's I	0.037	0.046	0.028	0.014	0.004	-0.003
p-value	0.138	0.010	0.006	0.010	0.008	0.087

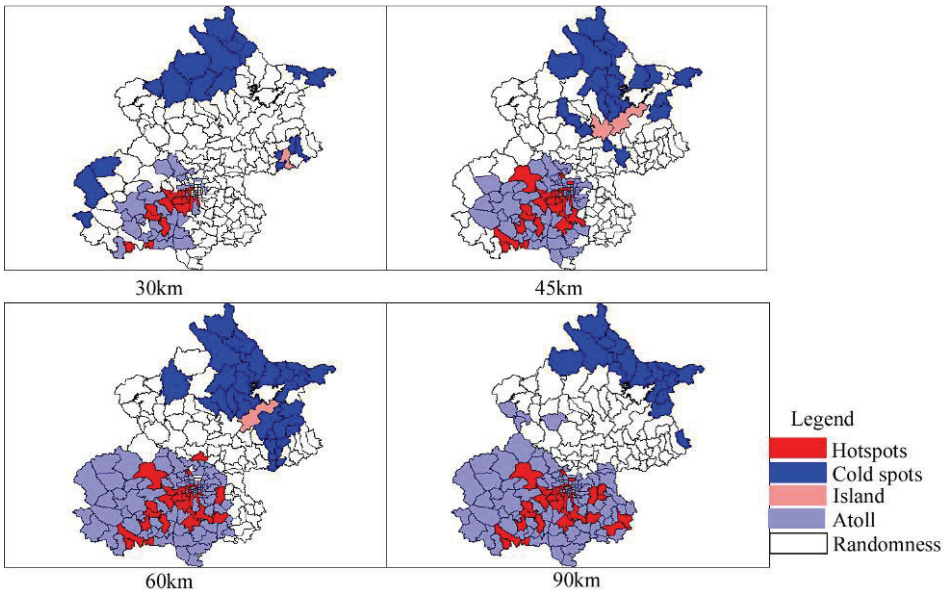


Figure 5.16 the MMM cluster weighted by distances in 1998-2002

5.3.5 Petroleum

(1) The spatial evolution

The development of the petroleum cluster only showed a significant global spatial association for the periods 1983-87 and 1993-97 (Table 5.10). Figure 5.17 indicates most key towns in the sub-urban area had the island pattern and the hotspot was along Badaling motorway during 1982-87. In the next period, some petroleum islands in the south disappeared and there were no hotspots. The hotspots re-emerged in the southwest of the municipality during 1993-97. During 1998-2002, there were two regions of petroleum hotspots respectively in the south and north.

Table 5.10 Global Moran's I of the petroleum cluster in each period (Rook spatial weight)

Municipal	1993-87	1988-92	1993-97	1998-2002
Moran's I	0.0857	-0.0127	0.1088	0.0343
p-value	0.0292	0.5621	0.0177	0.125

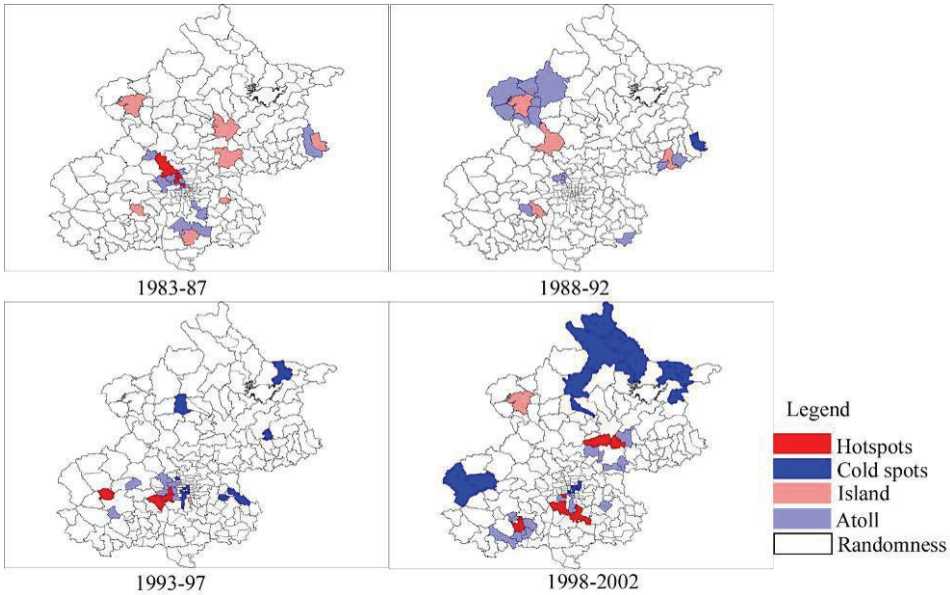


Figure 5.17 Spatial evolution of the petroleum cluster

(2) Explorations of distance weights in 1998-2002

None of global correlations were significant for the petroleum cluster at the tested distance (Table 5.11). Local statistics, with the distance matrix, indicated that localised spillovers gradually expand in Fengtai, Shunyi, Daxing, Changping and Tongzhou (Figure 5.18). The hotspot in Fengtai is adjacent to the biggest petrochemical complex, Yanshan Company, which has a history of over half a century and employs over 100 thousand persons. With the new petroleum industry established in Fengtai, Shunyi and Changping, some areas in these districts became hotspots for new employment in the petroleum cluster. There was a big variety in the spatial manifestation of the petroleum cluster. The hotspots were irregular at different distance spatial weight, with no location overlapping among the measures from 30 to 90km (Figure 5.18). That is perhaps the reason why the global correlations are not significant for the petroleum cluster.

Table 5.11 Global Moran's I of the petroleum cluster weighted by distances

Municipal	Rook	30 km	45 km	60 km	90 km	120 km
Moran's I	0.034	0.010	0	-0.002	-0.002	-0.003
p-value	0.125	0.117	0.741	0.720	0.902	0.916

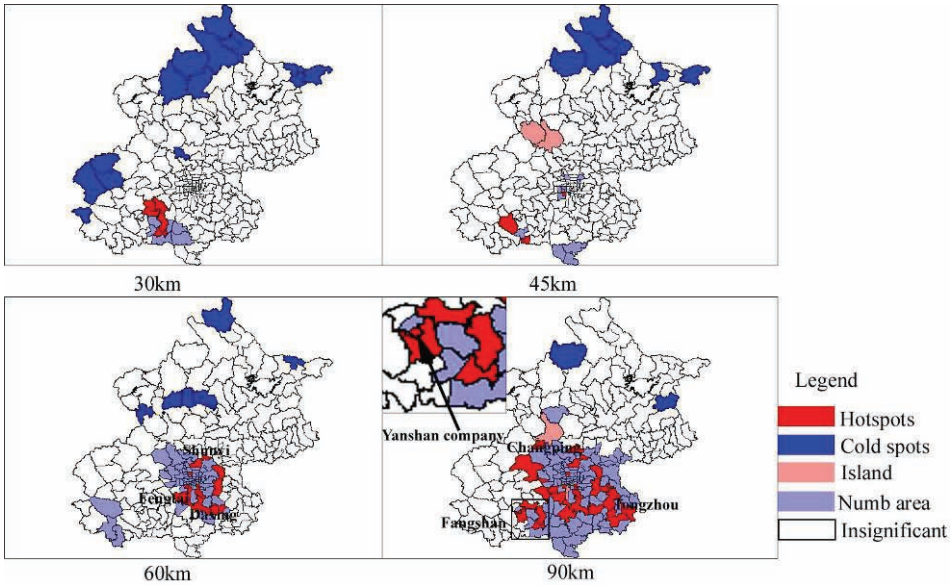


Figure 5.18 Petroleum cluster weighted by distances in 1998-2002

5.3.6 Chemicals

(1) The spatial evolution

The chemicals cluster was divided into two sub-clusters: chemical materials and organic chemicals in 1983-92. Both had no global spatial associations at the municipal level (Table 5.12). The global spatial association was significant only for the period of 1993-97.

Table 5.12 Global Moran's I of the chemical cluster in each period (Rook spatial weight)

	1993-87	1988-92		1993-97	1998-2002
Municipal	Chemicals	Chemical materials	Organic chemicals	Chemicals	Chemicals
Moran's I	0.006	-0.001	0.032	0.098	0.035
p-value	0.202	0.683	0.080	0.015	0.136

During 1983-87, the islands of the chemical cluster were in the key towns of the south and northeast. Besides, one hotspot stayed along Badaling motorway. Another two hotspots of the chemical materials arise along the Beijing-Tianjin corridor during 1988-92. During this period, the area containing the Yanshan petrochemical complex took on an island form circled by atoll areas. The hotspots expanded during 1993-97 along this corridor and this trend remained in 1998-2002 (Figure 5.19).

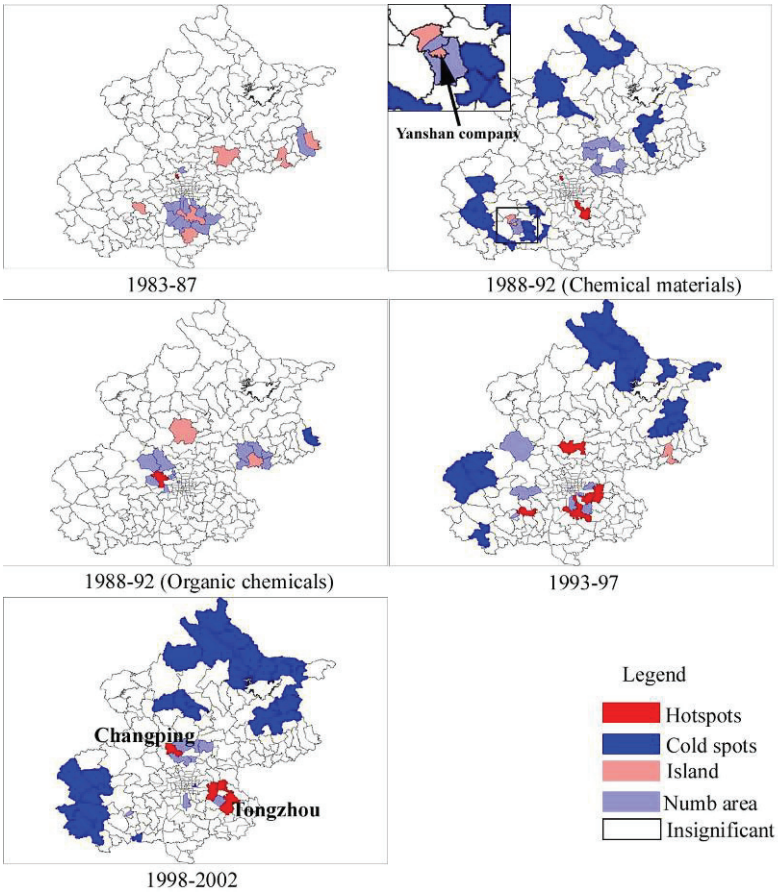


Figure 5.19 Spatial evolution of the chemicals cluster

(2) Explorations of distance weights in 1998-2002

As regards the different distances, the global Moran's I was only significant at the spatial weights of 45 km and 60 km. The local statistics illustrate under the bordering spatial matrix, the location for employment creation was at Tongzhou and Changping. Under the device of the distances, the spatial pattern of the chemical cluster varied greatly, and the hotspots grew mainly in the south of the municipality and along the Beijing-Tianjin corridor.

Table 5.13 Global Moran's I of the petroleum cluster weighted by distances

Municipal	Rook	30 km	45 km	60 km	90 km	120 km
Moran's I	0.035	0.007	0.016	0.013	-0.023	-0.006
p-value	0.136	0.186	0.021	0.012	0.083	0.063

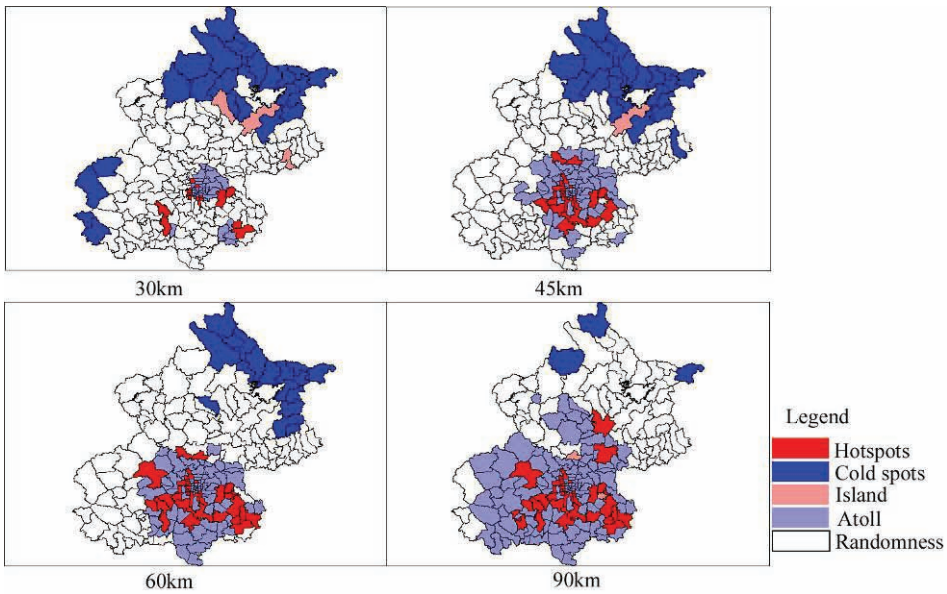


Figure 5.20 Chemical cluster weighted by distances in 1998-2002

5.4 Spatial clusters and urban dynamics

5.4.1 The role of global and local Moran's *I* in exploring spatial clusters

The geostatistical analysis presents an approach to examine the nature of the spatial characteristics of the earlier identified functional relationships among industries of the Beijing economy. Given the geographical elasticity, the method of LISA, specifically the global and local Moran's I, was selected as a means to explore the spatial manifestation of main functional clusters, including the use of different spatial weights. This method indicates the locale and spatial pattern of spatial clusters, making explicit the role of geographical proximity in the notion of ECs.

Compared with traditional models such as industrial districts, this method provides a way to objectively spatially identify clusters in the geographical space of the city. Although the actual boundary of the spatial cluster is not determined, the method reveals the diversity of ECs across city space. The conjunction of functional and geographical relations strengthens the forming and development of ECs, facilitating the understanding of the complex clustering process. The result contributes to a better understanding of urban economic-spatial organization and change, which is of particular importance to urban structure dynamics.

5.4.2 Spatial clusters and urban dynamics

Different clusters have different geographical propensities. Based on the bordering spatial weight, the Global Moran's I tells the service clusters tend to have more significant global spillovers than the manufacturing clusters, while the major manufacturing clusters are highly localised. Particularly during the 1998-2002 period, the service clusters are relatively concentrated and yet the manufacturing clusters seem to be more or less independent of adjacent areas.

The distance for spatial interactions of the FIRE and ES is roughly within 60 km. The ICT interactions are in the 45-90 km range, while the MMM is at 30-90 km and the chemicals is at 45-60 km. The variety of the distance for spatial interactions for the manufacturing cluster may be due to the influence of transportation. Yet, within the 30-45 km range, there is no spatial association. This again suggests the manufacturing clusters could be highly concentrated, but also perhaps relatively dispersed in peripheral locations.

The local spatial pattern of clusters to a large extent indicates city spatial organisation. The FIRE and ES clusters occupy the urban centre and key towns in the sub-urban hinterland. The ICT is mainly concentrated in the north quadrant of the urban centre and developed circles the urban fringe. The MMM cluster exhibits a converging-diffusing process in the southern part of the municipality. The petroleum and chemical clusters gradually evolve to quite similar spatial patterns. Both the Badaling motorway and Beijing-Tianjin corridor are important geographical axes for facilitating spatial interactions for the manufacturing clusters including the ICT, MMM, petroleum and chemicals.

These urban spatial dynamics also correspond to demographic changes. Besides a high-density urban centre, the inner urban area is increasingly becoming the main focus of population growth and destination for migrants. Fast growth of both economic activities and population exert a huge demand on services, facilities and transportation systems.

Most industrial and business parks can be related to the identified spatial clusters. The residential districts, the transportation system and main industrial parks constitute basic elements of the city spatial structure, which are mutually affected by the growth of spatial-economic clusters. The integration of functional-economic and spatial relationships is largely realised via ECs. This fact contributes to a better and deeper understanding of spatial-economic dynamics in the city and provides a clue to making urban planning more realistic and effective.

Endnotes:

[xvi] Beijing Post Online, available at http://www.bjpost.gov.cn/postcode/ybcx_index.asp; query system of Beijing postcode at http://html.bj183.com.cn/bj1832007ora/ybcx/ybcx_index.asp.

Chapter 6 Economic cluster-based urban spatial-economic dynamics and urban development

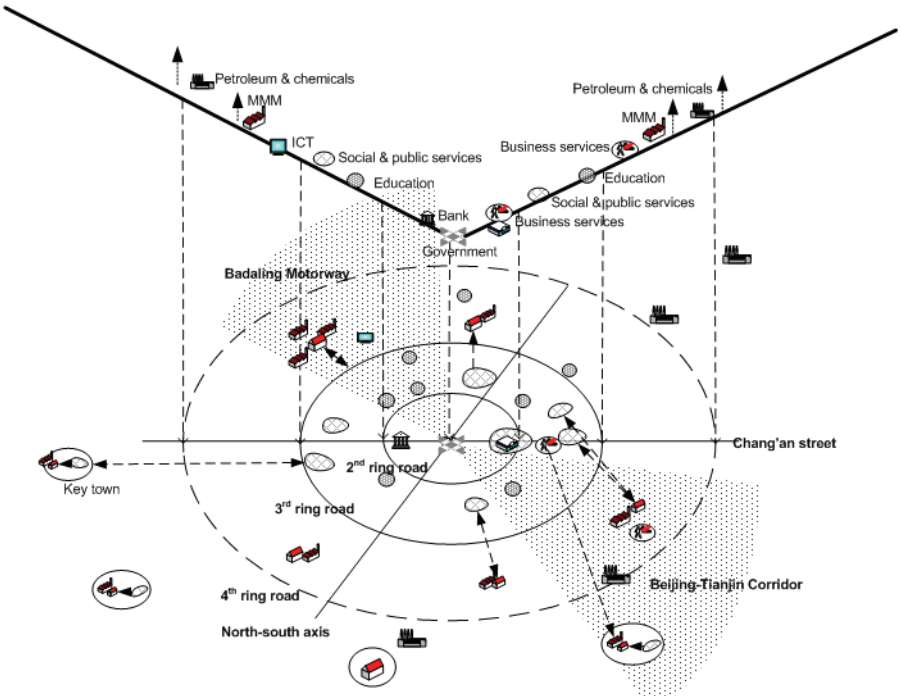
In the chapters 4 and 5, the economic and spatial dimensions of Economic Clusters (ECs) were examined empirically in Beijing. This chapter extends the analysis by examining the urban spatial-economic dynamics indicated by the identified functional and spatial clusters and their associated driving forces and effects. It discusses the roles of ECs in urban economic-spatial development and assesses related economic performance and spatial characteristics of land use and transportation. These analyses provide evidence for reflections on current and future urban economic and spatial planning policies.

6.1 Urban economic-spatial dynamics: a viewpoint of economic clusters

The functional clusters identified in Chapter 4 are an approximation of the economic and technological situation in the city by way of demand or supply patterns of industries. According to this cluster composition, the geographical analysis in Chapter 5 revealed the spatial patterns of these functionally related industries. In this way, functional and spatial dimensions are integrated in the examination of ECs, which offers an innovative method of looking at urban dynamics. Related to EC development, we analyse Beijing's urban dynamics, which can be divided into two periods: the manufacturing-driven period 1983-97 and the more recent service dominated period 1997-2002 (and onwards).

6.1.1 Manufacturing-driven urban dynamics

From 1983, Beijing started the transformation from a planned economy to a market economy. This process requires considerable time and even today some features of a planned economy can still be found in the urban structure. The area within the 2nd ring road is occupied by the central and municipal governments. Banks are concentrated near the 2nd west ring road. Between the 2nd-3rd ring roads are schools, universities and academic institutes. The 4th ring road was not completed until 2001. The urban centre is largely concentrated within the 3rd ring road (Figure 6.1). Some nearby towns, including the town seats of peri-urban districts and counties and some towns in the near peri-urban areas, obtained special policy and developmental support (see the zoning plan of Beijing in Figure 3.4).



Note: MMM = the cluster of manufacture of machinery and metalworking, ICT = the cluster of Information and Communication Technologies

Figure 6.1 Manufacturing-driven urban dynamics

During the 1983-97 period, manufacturing clusters dominated the economy (as identified in Chapter 4). Specifically, the Manufacture of Machinery and Metalworking (MMM) was the biggest functional cluster, which connected a variety of manufacturing activities. The spatial cluster analysis (in Chapter 5) showed that the MMM cluster was concentrated in the 3rd-4th ring roads, particularly along Badaling Motorway. Influenced by 1984 Beijing-Tianjin Regional Plan, Beijing-Tianjin (BT) corridor became another major location for the MMM during 1988-92. Petroleum and Chemical (PC) clusters, which are distributed in the more distant key towns, dot o some extent geographically overlap with the MMM cluster.

Business activities emerged in close proximity to the major places of manufacturing activities, particularly in some counties and alongside the BT corridor. The co-location of manufacturing clusters and associated service activities reflects the fact that the economic reform has started in the rural areas with manufacturing industries being the catalyst for the reform. Likewise, education activities grew rapidly close to the major manufacturing sites. Within the urban centre, the 3rd east ring road is another important place of the concentration of business activities. Although before the mid of 1990s a business-related cluster was not fully formed, there were signs of the

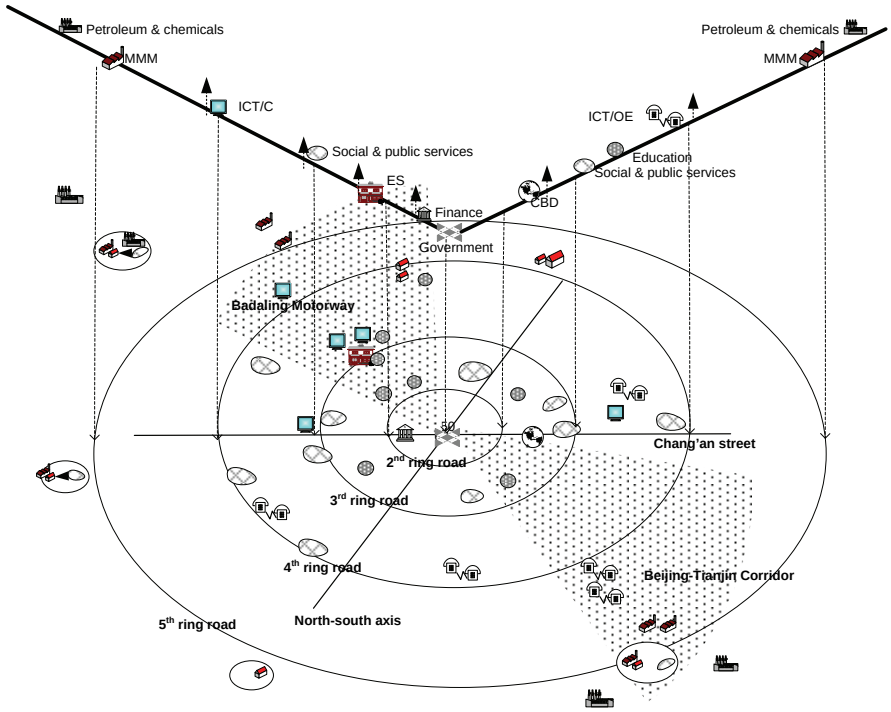
emergence of place-based developments with big shopping and service centre associated with the concentration of foreign embassies in Beijing.

In this period, the service economy mainly serves households and becomes gradually more oriented toward business services. In addition, health care and education are major service industries but run by the public sector. The reform of the services happened later than the reform of manufacturing; most locations of services were decided by planning and policy regulations. As a result, the linkages between manufacturing and service economies were relatively under-developed. One exception was warehousing activities in support of manufacturing industries.

Work-units strongly affected the spatial layout of the city. Working and housing places were closely linked, combined with personal services and low-end services. Services in the vicinity of the working place were however insufficient for the variety of demands. Consumer goods and services were generally in short supply during that time. People usually had to visit the urban centre for higher-class services and goods. As such, service activities were hierarchically distributed between the manufacturing clusters and the urban centre. A mono-centric urban structure was formed and continuously consolidated with the growth of manufacturing clusters and the dominance of services in the very urban centre, the neighbourhoods near Tiananmen Square.

6.1.2 Service-dominated urban dynamics

After 1997, the urban centre quickly expanded and changed (Figure 6.2). The analyses of functional and spatial clusters (Chapters 4 and 5) reveal that services replaced manufacturing as the major function of the city; the urban centre and immediately adjacent areas were gradually taken over by service clusters. Various service clusters were formed based on the places which used to be significant for other economic activities. The most salient case is banking cluster near the 2nd west ring road that was the basis for the Financial Street, while the area alongside the 3rd east ring road expanded to the city's Central Business District (CBD). Together, the Financial Street and CBD comprise of the cluster of Finance, Business, Real Estate and Insurance (FIRE). Besides, the cluster of Education and Science (ES) emerged and developed in the northern part of the city, around the knowledge places where Tsinghua and Peking Universities and the Chinese Academy of Sciences are located. It should be pointed out that business and education activities are found throughout the city, but not at the same high concentrations as in the Financial Street, CBD or knowledge parks.



Note: MMM = the cluster of manufacture of machinery and metalworking, ICT = the cluster of Information and Communication Technologies
ICT/C= Computer-based ICT, ICT/OC=Other electronics

Figure 6.2 Service-dominated urban dynamics

The change of the urban centre is further characterised by a diversification of service clusters. In the early of 1990s, as the market economy started to develop rapidly, financial services have been closely related to public administration and public services, reflecting the fact that Beijing, as the capital, is one of frontier cities participating in the globalisation of China. In the same period, business and real estate became increasingly connected, corresponding to the reform of the housing and property markets. After 1997, finance and business are functionally combined, mutually influenced or with complementary relationships, eventually giving rise to the formation of the FIRE cluster. The FIRE cluster tends to connect all kinds of service industries. The diversification of service clusters indicates more sophisticated and frequent interactions of flows of goods, services and information in the urban centre.

Traditional manufacturing was relocated beyond the 4th ring road, located in the faraway peri-urban area. Accompanied with the relocation process, the MMM cluster became more specialised economically and concentrated spatially. It gradually changed from a large single location with multiple-functions to several specialised clusters for steel processing, metal and machinery-manufacturing and

automobile. The demand and supply patterns of the traditional manufacturing were gradually more exclusive or less influenced by other manufacturing activities. Correspondingly, the MMM cluster is concentrated in several key towns near the 5th ring road. For example, the Beijing Development Area (BDA) along BT corridor became a main location for modern manufacturing industries. The clusters of petroleum and chemicals remained functionally connected and to some extent also geographically.

More sophisticated relationships exist between manufacturing and service clusters. The function of services is increasingly important for supporting all types of production and business. This generates more relations between manufacturing and services industries, such as the Information and Communication Technology (ICT) manufacturing and services, food production and services. The FIRE cluster is important for the outsourcing of the clothing industry. The steel industry also shows a strong connection to FIRE activities, which play a crucial role in upgrading traditional industries.

Interestingly, after 1997 energy production was combined with the FIRE and ES clusters (see Table 4.7). Energy consumption also indicates that business and services become a major part of city development. And in this period, FIRE and ES related activities were growing very fast.

However, the fastest growing cluster, in both economic and geographical terms, was the ICT cluster. The ICT cluster emerges in the 'knowledge district' in the 1980s. During 1983-87, the industries for the manufacture of computers, consumer's electronics, other information and communication facilities, and devices and gauges were increasingly functionally related and concentrated in this knowledge area. From this origin, the ICT cluster became gradually functionally related to other industries and expanded spatially. During the 1988-97 period the ICT cluster quickly developed between the 4th and 5th ring roads. In the latest period, the ICT cluster was divided into two clusters: the manufacture of computers became significant in the north corner of the urban centre while the manufacture of consumer's electronics and information and communication facilities became concentrated in the southeast part in between the 4th and 5th ring roads.

Another feature related to the change and expansion of the urban centre is the property shift and the massive construction of real estate. With the establishment of the market, the role in providing houses was gradually taken over from enterprises (usually state-owned under the work-unit mechanism) to private developers. This is a privatisation process including the establishment of housing and

land property markets and housing ownership. As a result, commercial housing is encouraged as the major form of housing provision. With the surge of the urban population, the urban centre expanded to beyond the 4th ring road. Meanwhile, many real estate projects were developed, including several residential blocks near the 5th ring road.

During this period and the following years, although manufacturing was still important in terms of employment and industrial outputs, the city structure became oriented to the development of service clusters. This trend is verified by the increasing role and fast growth of services and the specialisation of manufacturing and its more frequent interactions with services. More frequent connections within or between services and manufacturing clusters give rise to a vibrant and much more interconnected urban structure. The stronger role of services is expected to continue to drive the growth of the urban centre through an infill process with further accumulation of capital, population and employment based on the decreasing influence of the manufacturing-driven model.

6.2 Mechanisms of economic cluster development

6.2.1 Fundamental forces of urban and cluster development

Supported by the arguments of neoclassical and evolutionary economics (see the review section 2.3 in Chapter 2), three fundamental macro-trends dominantly influence city development in China. First, privatisation became a major instrument to promote the market economy. Second, correspondingly, the governing style has become more decentralised; municipal governments play more important roles in land management, financing, economic monitoring and infrastructure provision. Third, globalisation has significantly influenced Chinese development through the influx of Foreign Direct Investment (FDI) and Multinational Corporations (MNCs) (Zhao and Zhang 2007). In this process, some cities such as Beijing and Shanghai are emerging as global cities (Wei and Yu 2006). Despite the unleashing of market forces and increasing importance of globalisation, China remains a country with strong state-control. Decentralization, privatisation and globalisation constitute basic paths which are driving Chinese cities' development (Ma 2002). These 3 forces are inter-related. Privatisation opens the prologue of the changing of government and is catalysed by the process of globalisation.

The development of ECs is an important theme associated with the interplay of these forces and researchers have noticed the influential roles of ECs in Chinese cities. Various special districts foster technology transfer from foreign to domestic enterprises, and consequently exhibit an innovative production environment in China (Walcott 2002; Yu and Tong 2003). Wang and Wang (1998) claim that Zhongguancun Science Park (ZSP) represents the Chinese type of high tech industrial districts. The ECs are focal nodes for the global economic network to connect to local companies and organisations (Yeung, Liu, and Dicken 2006). The growth of cluster-based places also interacts with the transformation of a state-owned economic base towards the development of private enterprises and the effective use of human resources (Sonobe, Hu, and Otsuka 2006). With the increasing importance of ECs for maintaining development growth, they are now a crucial part of city development.

As China is in a transitional phase, the path of economic clustering differs from either American or European models. Key distinguishing factors are China's lower market pressure and strong government support. China's EC projects are expected to be realised by combinations of local and global investors with policy support via a range of instruments dealing with land, taxation and other financial incentives (Wang 2005). The designation of ECs stems from the desire to accelerate economic growth, making available a large volume of both state and private resources. The city development strategy needs to better manage the synergy between economic development and governments' interventions but to do so requires investigations into and knowledge of the underlying evolutionary mechanisms of ECs and associated urban development.

6.2.2 Decentralising government

In the early period of economic reform, the government played an absolute and decisive role in the forming of ECs. For example the Central and Beijing Governments decided to make Beijing one of the most important manufacturing bases in China (Beijing Statistical Bureau 1998), which gave rise to the development of the clusters of MMM, chemicals and petroleum in the 1980s. In this development phase several major projects, such as the Capital Iron and Yanshan Petroleum companies, each with over 10 thousand employees, were very influential. Likewise, the task of the city to supply food and other basic living materials in 1980-90s contributes to the forming of the cluster of the food & catering.

The economic growth and urban construction became gradually challenged by constrained public investment budgets in the planned economy, which basically was the consequence of limited fiscal

revenue. As public ownership became dominant, the fiscal revenue was directly obtained from firms' profits rather than by means of taxation. The obtained revenue was mostly delivered to the central government, which then redistributed finances to local government. Consequently, this fiscal system discouraged the productivity of firms and local governments to develop their economy. As fiscal revenue reached a plateau it constrained economic investment and urban construction. The inherent limits of this fiscal system and its tax incentives contributed to Chinese economic reform in 1984 (Zhang and He 1994).

The reform of the fiscal system was a complex process. In general it included two aspects: the development of a taxation system replacing the mechanism of directly harvesting firms' profits, and to share revenue between the central and local governments. The share of fiscal revenue is now quite even between local and central governments (Lu 2008). Local government was thereafter greatly encouraged to intervene and participate in economic development. The taxation system was also reformed and adapted to the market economy, particularly stimulating the institutional decentralisation.

This new institutional environment and its associated economic and spatial incentives requires government to play crucial roles in EC development. On the aspect of economic incentives, economic development is a major source for generating fiscal revenue. In Beijing in 2007, 7% revenue was from personal income tax, while 17% was from enterprise income and 32% from business tax (Beijing Statistical Bureau 2008). Another major source is the lease of public land use rights, which also includes a significant amount attributable to the creation of new business enterprises.

Revenues generated from public land leasing are in fact the biggest share of extra-budget revenue and they are completely retained in the hands of local governments (Ding 2009). It is estimated that land revenue accounts for 27% of budget revenue in Beijing in 2008 (Land List of China 2009). This revenue is an important motivator for local government to attract new firms and develop various economic zones.

Such large scale urban development has major implications for land supply. Usually land is leased, including the basic infrastructure, ready for building plants. Before 2006, the land for industrial use was leased by means of negotiation between local governments and developers. In order to attract firms, governments paid for land clearance and right-of-way. The land was then 'transacted' almost at zero cost to enterprises for industrial use. Yet the land for business use and real estate constitute the major source of revenue. This advantage makes Chinese cities very competitive worldwide for

international manufacturing and increasingly for business services. Various industrial parks have sprung up and become major locations for anchoring manufacturing and related businesses.

In addition, investment in infrastructure is a special economic incentive which has spatial effects. Infrastructure construction was vast over the last 15 years, greatly facilitating economic development and urban growth. Real investment in infrastructure increased by over 85% in each of the last 5 years and was over RMB 220 billion in the period 2003-07 (Table 6.1). In the period 1998-2002, the fastest increase of investment was in environmental protection and services, public transportation, water conservation and public services. In 2002-07, infrastructure investment maintained the high increase in public transportation, public services and environmental protection and services. In addition, inter-regional transportation became an important field for investment. The investment of infrastructure greatly contributed to the urban development, especially encouraging the service-dominated economy.

Table 6.1 Infrastructure investment by main sector

Unit: RMB, Million

	1993-97	1998-2002	Increase compared to previous period	2003-07	Increase compared to previous period	% of total, 2003-07
Energy	18,023	21,380	19%	32,038	50%	15%
Public services	7,470	26,520	255%	49,814	88%	23%
Inter-regional transportation	13,794	22,811	65%	53,408	134%	24%
Civic public transportation	2,461	10,314	319%	37,744	266%	17%
Posts and telecommunication	17,290	23,966	39%	23,371	-2%	11%
Water conservancy	1,101	3,759	241%	6,475	72%	3%
Environmental protection and services	1,233	6,179	401%	11,895	93%	5%
Other	1,156	1,576	36%	5,408	243%	2%
Total	62,529	116,504	86%	220,153	89%	100%

Note: The figures consider inflation and take the price of the investment on fixed assets in 1993 as the base price.

Source of data: Beijing Statistic Yearbook 1994-2008

Owing to these economic and spatial incentives, government actively promotes the development of ECs at an early stage. Besides, almost all major clusters have obtained government support at one time or another. For example, the ICT cluster ZSP was approved in 1988, but it is not at full strength until 1993 when Beijing government fully supported high-tech industries (Committee of Beijing City Planning, Research Institute of Beijing City Planning, and Association of Beijing City Planning 2007).

Insufficient government support may lead to a slow rate of cluster development. An example is that Beijing's CDB plan became effective 10 years later than Shanghai's CBD Lujiazui (Huang 2004). This delay partly explains why, until 2005, Beijing's financial services sector is still subordinate to that of Shanghai, as indicated by its lower LQ 0.6 compared to 1.2 of Shanghai (Table 3.1).

Not all government measures have however positively affected cluster growth. On the contrary, some policies have led to the decline of certain clusters. For example, the clusters of textile and wear apparel, and printing and paper-products have declined due to the increased consideration of environmental protection in the middle of 1990s (Committee of Beijing City Planning, Research Institute of Beijing City Planning, and Association of Beijing City Planning 2007). Yet the decline of these clusters does not necessarily mean a dis-benefit for the city's development in the long run. It does however indicate a change in demand and/or supply markets or reflects a new vision for the city's development and new clustering trends for the city economy. Correspondingly, employment may shift from low-end to high-end manufacturing or to services. Some of the service sectors did contribute to re-employment of low skilled workers

The provision of special tax and land incentives allow governments to target and select specific firms for the sustained development of ECs. For instance high-tech industries are a main policy focus area (Torch High Technology Industry Development Center 2005). The relatively low cost of land allows government to quite easily allocate space for ECs, which as a result quickly occupy a large amount of new land.

Associated with the feverish pace of development, a negative aspect is that governments are mainly interested in the initial stage of ECs. The government's pre-occupation with revenue generation from the initial stage of land leasing may lead to insufficient support in the following stages of the economic development process. According to a survey among national high tech development zones, most enterprises think the factors that hinder their technological innovations are the shortage of capital and talent, the immature market mechanisms and the financing system (Torch High Technology Industry Development Center 2005).

A crucial issue for governments is that their responsibilities are not clear and clarified (Torch High Technology Industry Development Center 2005). In Beijing this problem is pronounced with respect to the overlap of governments of different levels. According to our survey, 3 main forms exist for various industrial and business parks in Beijing. Most authoritative high-tech parks are supported by the municipal government therefore enjoy special both institutional and

financial support (e.g. ZSP). Another form of authoritative parks is developed and managed by the district government. An example is the CBD, which belongs to the Chaoyang District. This difference in administrative and support level means that the CBD authority enjoys less institutional and financial independence and privileges, and especially has fewer policy resources. Another form is a cooperative organisation, as typified by the Financial Street. The Financial Street is supported by the municipality, run by both public administration and a publicly held company. The CBD is the main business area including over 300 headquarters or agencies of the world Fortune 500 companies, while the Financial Street is the place accommodating the headquarters of all of China's biggest banks, insurance companies, and management firms (Zhou 1998; Pang and Song 2005). As shown in the functional analysis, the two locations together comprise the FIRE cluster. However, they are spatially separated and supported by different levels of governments. The differing power relationships could be a major reason for place based competition that may undermine the performance of the finance sector as a whole, if compared with Shanghai. Also, the well-performing business services, as indicated by its high LQ (5.2 on the nation and 3.1 on the city, Table 3.1), implies that the government role is not necessarily decisive in the actual growth and importance of specific ECs.

6.2.3 Privatisation

A main goal of privatisation is to improve economic efficiency through a change of ownership and associated management practices (Lin, Cai, and Li 1996). During privatisation, not only have many private and foreign companies been established, but also did state-owned companies change their ownership.

Privatisation has fundamental effects on the economy. A most striking case is perhaps found in the automobile industry, which was highly supported by the central government in the state planning period. At that time Beijing was 3rd largest location for the nation's automobile manufacturing, a situation that was not changed until 1987 when market mechanisms were introduced. With privatisation, automobile plants had to reform their business management, production and marketing strategies. Losing the support of the central government led to Beijing's automobile industry into decline. During 1992-2003, its output only increases by 153%, much less than its major rivals in Tianjin, Shanghai and Shenyang. For example in the same period, Shanghai's automobile output increases by nearly 10 times. Big automobile manufacturers in Beijing, including Beijing Jeep (ranking 4th in China in 1992), Beijing Motor (6th) and Beijing Light Car (9th), also lost their competitive status in China and after

2002 they do not appear in the list of top 25 largest automobile companies in China (Sohu 2005).

The privatisation process involves location and allocation of various endowments and productive components in a manner which can achieve efficient economic operation in the market economy. In this transformation, some resources in which Beijing has comparative advantages are transferred into competitive advantages, and the EC has become an effective economic-spatial actor to realise this transfer. For instance, Beijing is home to many top universities and academic institutes and the centre of culture and information in China (Pang and Song 2005). This advantage, under market driven circumstances, fosters the forming of the ES cluster and the emergence of a strong Culture and Information (CI) cluster. The relevant activities are very competitive. During 1996-2002, Beijing's share of the knowledge trade market in China was 18%, the highest of all cities. In particular, services related with information, communication and telecom account for 33% of China's information services market. Their output also increased, 53% annually during this period (Zhao and Wu 2006).

In addition to the promotion of service clusters, market forces also spur on the upgrading of manufacturing clusters, which are gradually changing their functions by involving new technologies and business processes. Under the influence of competition, manufacturing clusters such as the MMM become specialised. With continuous upgrading and renovation, big projects that have their origins in the planned period may be able to maintain their economic significance. For example, the largest company in the petroleum cluster, Yanshan Petroleum took more than 10 years to renovate its production and management techniques (Zhang 2008b). At the same time, the functional relationships of the cluster were adjusted. As the functional analysis shows, the petroleum industry was closely related to the chemical industries in 1987. It was combined with quarrying of non-ferrous-metallic ores in 1992 and connected to the mining of coal and lignite, quarrying and mining of stone, sand and clay, and the production of gases and water in 1997. By 2002, the petroleum industry was upgraded to be strongly associated with chemo-synthetic materials, manufacture of other non-metallic products, rubber and plastics. Such a change reflects its technological development path, which affects both the demand and supply markets.

During privatisation, spatial incentives also play roles in the development of ECs by means of land rents and the property market. The increasing land values force manufacturing clusters out of the 4th ring road area, and their sites are taken over by the ICT cluster and real estate development. This mechanism of land value intrinsically gives rise to the functional specialisation of places because private

developers have to pay reasonable land prices for their activities. This also explains why high end business and financial activities are agglomerated in the CBD and the Financial Street.

Privatisation however plays fewer roles in providing and developing necessary household and social services related to the new development of manufacturing clusters. These services are largely arranged by governments as part of the plan for industrial parks (Chen 1998). Land and services are packaged for leasing at almost zero rent for the purpose of industrial use. Except for the obligatory welfare provisions according to law, firms pay little compensation for the expense of long-distance commuting and inconvenient social services (Zheng 2002). They care much less about nearby social activities and facilities. Together with insufficient or low quality facilities on the sites of the industrial parks, these factors actually constrain the development of a full-fledged service economy. On the other hand, very high land rents must be paid for commercial land. High land rents obviously exclude manufacturing activities. Consequently, current market forces cause the functional specialisation of the manufacturing clusters which are therefore spatially separated from business or services clusters.

6.2.4 Globalisation

Globalisation has been shaping Beijing as the city became a part of global networks of economic, societal and cultural exchange. The influx of capital, technology and information has greatly facilitated the fast growth of ECs as well as upgraded their functions (Wei and Yu 2006; Zhao and Zhang 2007).

Beijing experiences reveal that significant competitive advantages are not established until an EC is involved in the global economy. The growth of the FIRE cluster reflects the increase of capital flows and trade as Beijing has become an interface between the Chinese and global economies. By virtue of cooperating with world-class companies, the Information Technology (IT) industry improves its ability in research and development and transfers new knowledge to occupy the high-end market, as demonstrated by the Lenovo Company. In the period 1997-2002, ICT gradually became Beijing's most important manufacturing cluster with all key members having above 15% output growth, and in which the LQ of the information industry is 2.4 on the city measure (Table 3.1). The IT cluster network is still expanding as demonstrated by the recent investments of global players, including Nokia in the telecom industry (Yeung, Liu, and Dicken 2006). Globalisation further extends the channels of transactions and information transmission via a diversified and high-quality labour force structure.

Globalisation however also contributes to the segregation of space because Multi-National Corporations (MNCs) locate their production in a certain place without seriously considering local exchange patterns and processes. Exploiting locations for cheaper production is the first step and premier aim of foreign companies (Kong 2006). In contrast, spins-off are still quite few (Qiu 1999; Wang 2005). Competition of foreign companies is more likely from their foreign fellows in the same sectors rather than from local ones (Wang and Li 2003). Particularly at the early stage of ECs, few business relations and interactions exist between local and foreign companies (Liu 2004). As a result, the city production space is segregated between foreign and local companies. This problematic situation could be changed over time as local business matures and MNCs become more localised.

Owing to their rapid economic development through attracting international capital and business, Chinese cities are currently active and highly visible players in the process of globalisation (Wang, Cui, and Ouyang 2003). The recent financial crisis of 2008 / 2009 has yet reminded them of the vulnerability associated with becoming over-reliant on an export-based economy. This is an important issue for the study of EC operation and performance but beyond the scope of this research.

6.2.5 Interplay of government decentralisation, privatisation and globalisation

Globalisation, privatisation and decentralisation are three main forces of city dynamics, which interplay with each other and affect the evolution of ECs (see Table 6.2). The decentralisation and privatisation forces are interrelated by means of the land and taxation systems. For the government, the land and taxation systems are the major incentives for catalysing ECs. They are also the instruments to balance power and align the development of ECs with the interest of governments. In the case of privatisation, the land and taxation systems largely determine operating costs. Businesses are always seeking the economically most favourable place and the lowest taxation. The currently favourable tax and land prices are important contributors to the competitive advantage of Chinese cities in attracting international capital. Stimulated by other elements of local market and supply conditions, numerous international production and business developers came to locate in China. Yet equally they could withdraw or move to other Chinese cities or even other countries if they find more favourable conditions there to make profits. Maximising profits dominates the interaction between privatisation and globalisation. In the interplay between decentralisation and globalisation, the flow of capital is the focal point. The local

government wants to attract capital so as to foster local economic development to realise economic growth and employment creation.

The interplay of some forces are in general more important than others in particular stages of ECs (Figure 6.3). The government and privatisation play roles in the emerging and declining stages. When cluster performance rises, policy initiatives and local markets constitute external conditions for agglomeration effects. A strong feature is that spatial plans, including the urban structure plan, bring with them a degree of inertia and have far-reaching influences on the spatial distribution of ECs. For instance the ES cluster developed near the knowledge area of Beijing; the ICT cluster evolves mainly in the area designated as the ZSP Park, enjoying a fairly independent management system in both economic and spatial planning terms.

Table 6.2 Roles of government, privatisation and globalisation in the forming of economic clusters in China

	Government	Privatisation	Globalisation
Economic mechanism	Taxation incentives, public investment	Ownership reform	Influx of capital, technology and information
Spatial mechanism	'0' land rental fee	Land property reform	Rent seek
Economic Impact	Fast growth of ECs	Functional upgrade/ enterprise life cycle,	Fast growth, functional upgrade
Spatial impact	Quick movement of clusters	Specialization of place	Segregation of space
Blind area	Power relations	Overlook of non-business activities	Urge to seek international capital
Gaming point of interplay	Government : Privatisation=land and taxation; Privatisation : Globalisation=maximum profit; Globalisation : Government= influx of international capital		

On the other hand, the decline of cluster performance may occur when governments interrupt cumulative processes. This is exemplified by the cluster of Printing and Paper Products during the 1980s-90s, when, because of environmental pollution regulations, many plants were closed (Committee of Beijing City Planning, Research Institute of Beijing City Planning, and Association of Beijing City Planning 2007). Decline can also be triggered when the local market seeks higher marginal profits, which happened with the textile and clothing industries in the middle of 1990s.

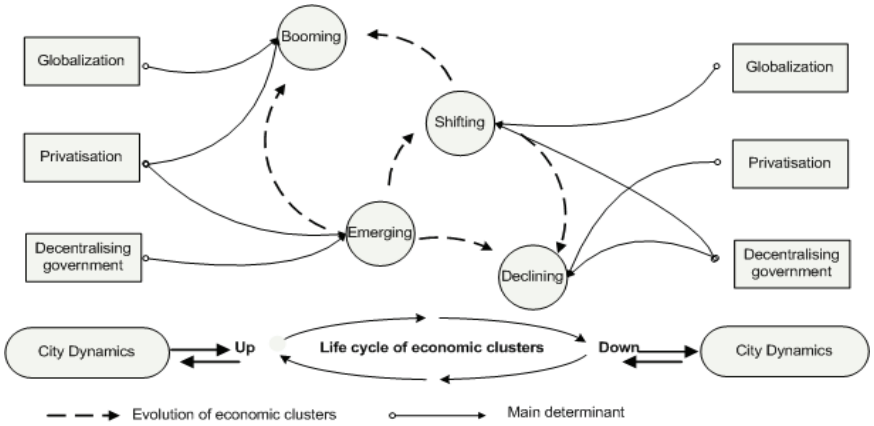


Figure 6.3 Mechanism of cluster evolution: decentralising government, privatisation and globalisation

Privatisation and globalisation determine to a large extent the prosperity of ECs. Some clusters can evolve into a booming stage under the right conditions: adequate labour quality, subsidies, entrepreneurship and supportive supply chains. These conditions may consolidate positive externalities especially if combined with global forces. The effect of globalisation in Beijing is generally positive for instance because the city is a main destination of FDI. If a city loses FDI, it may come into in a disadvantageous position, such as occurred in Japan in the 1990s, where globalisation played a negative rather than a positive role (Eichengreen and Tong 2007). The positive effects of the joint forces of privatisation and globalisation is most clearly demonstrated by the ICT and FIRE cluster developments. In these cases we observe that policy support is a necessary but insufficient condition for the rapid development of ECs. Public policy may, however, need a long period to achieve success.

Both globalisation and government intervention can cab also lead to shifts in the operation of a cluster. After contracting with European garment designers, local clothing related industries may be renewed after 2002, regaining some of their lost ground in economic performance and employment. Such a development is also accompanied by a complementary relationship with the FIRE cluster, which provides the necessary business services to support renewed global trade in textiles and clothing from Beijing. Similar processes are seen for the Automobile and Logistics (AL) cluster. The combination of complementary public policy measures with foreign investors creates cluster potentials, like Hyundai's involvement in the new Tianzhu Automobile Logistic Park (Industry 2005; Beijing Industrial Development Bureau 2007) and the renewal of the Capital Airport. However, due to the lack of a powerful local market, success

is not guaranteed. Other possible but uncertain clusters include the CI cluster that is expected to gain strength after the 2008 Olympic Games, and the MMM cluster where changes are due to the coming relocation of one China's biggest iron and steel companies, Capital Iron, to Caofeidian in Tangshan, Hebei Province.

By discussing and comparing different roles of main determinants for the ECs, we find that in general government plays important roles at the stages of emerging, declining and shifting of clusters. This result suggests that government should carefully justify their roles in participating in EC development. In order to effectively exploit its role in EC development, however, the government should also consider the impact of ECs on general city development.

6.3 Roles of economic clusters in urban development

6.3.1 Roles in economic development

The emergence of new functional clusters can restructure the local economy. By disclosing the latent structure of functional relationships, the functional clusters identified in Chapter 4 indicate the main demand and supply patterns of the local economy. The result (Table 4.1) reflects the majority of the local trading patterns and resource flows; about 85% for manufacturing economies and 90% for services economies.

Economic activities are concentrated in several functional clusters. Take 2002 for example, the 3 largest manufacturing clusters comprise 69.8% of the manufacturing outputs and the 3 largest service clusters share 63.6% of turnover in the service sector (see Table 4.2). The share in the demand-supply pattern is not necessarily proportional to the output. Relatively modest functional links can go hand in hand with a large share in output, such as the automobile industry shares 2.0% of variances of the structural patterns but has 3.6% of the outputs in manufacturing (see Table 4.2). In this sense, different functional clusters play different roles, but collectively they form the basic structure of Beijing's economy.

ECs are dominant elements in the restructuring of Beijing's economy and in the upgrading of its technological structure. During 2003-07, total employment increased by 15% for the municipality (Table 6.3). The employment in manufacturing levelled off but major job increases occurred in energy, transportation and storage, ICT, finance, real estate, business service, public services, health care, culture, art, sports and recreation, and public management and social organisations. Such changes further push the city economy towards a

service-orientation. At the same time, the professionals and technicians account for 29% of the employment, mainly increasing in the sectors of energy, transportation, ICT, finance, real estate, public services, health care and culture, art, sports and recreation. The increment of the professionals and technicians also implies improvement of innovative ability, contributing to the technological upgrade of the economic structure.

Table 6.3 Changes of employment and professionals by sector in 2003-07

Unit: person

Industry	Employment			Professionals and technicians			
	2003	2007	Change	2003	2007	Change	% of employment, 2007
Agriculture	29,114	27,113	-7%	6,919	6,318	-9%	23%
Mining	24,602	20,376	-17%	3,611	2,657	-26%	13%
Manufacturing	1,022,112	1,024,950	0%	206,732	201,838	-2%	20%
Energy supplying	37,764	67,024	77%	9,526	17,349	82%	26%
Construction	591,000	517,000	-13%	149,560	123,269	-18%	38%
Transportation and storage	306,787	458,886	50%	27,824	45,314	63%	10%
ICT	177,571	291,958	64%	96,086	156,467	63%	54%
Wholesale and retail	376,117	383,644	2%	79,497	86,925	9%	23%
Accommodation and food services	212,208	249,356	18%	26,093	26,227	1%	11%
Finance and insurance	140,187	208,440	49%	64,195	80,752	26%	39%
Real estate	189,309	263,378	39%	43,292	58,570	35%	22%
Business services	376,442	555,476	48%	88,426	96,489	9%	17%
Sciences	363,205	354,928	-2%	183,847	195,144	6%	55%
Public services	60,758	80,678	33%	7,899	11,663	48%	14%
Social services	91,688	91,309	0%	17,617	15,295	-13%	17%
Education	328,723	389,526	18%	225,510	241,987	7%	62%
Health care	136,283	177,056	30%	100,209	125,040	25%	71%
Culture, art, sports and recreation	119,183	145,071	22%	58,121	66,282	14%	46%
Public management and social organizations	269,554	326,575	21%	74,945	31,338	-58%	10%
Total	**4,912,329**	**5,632,744**	**15%**	**1,469,909**	**1,588,924**	**8%**	**29%**

Sources of data: Beijing Statistic Yearbook, 2004 and 2008

** The employment in construction is according to the annual report of construction industry in Beijing 2008 (Beijing Municipal Construction Committee 2008), while the number of professional and technicians is still according to Beijing Statistic Yearbook 2008.*

It should however be noticed that the increase of professionals is much less than that of employment in the sectors of finance,

insurance and business. This reflects that, as a general supporting activity, the FIRE grows faster than its high-end part. The finance and insurance is possibly facing a shortage of talent. It was reported that in the emerging insurance industry, professionals account for less than 40% in China. Likewise less than 50% of employees obtained vocational training in the sectors of banking, insurance and other financial business (China Economic Weekly 2009). The dramatic contrast in the increase of professionals and employment in such businesses indicates that high-end business activity, such as in the CBD, is a relatively small portion of the entire business activity.

There is a decrease in the construction, especially for professionals. Influenced by the 2008 Olympic Games, the urban constructions surged in early 2000s. As most projects were completed before 2008, developers were able to dismiss about 75% of their employees, especially engineers. Only a small part of technicians and particularly blue-collar workers remained for final completion of the project. This explains the 18% reduction of professionals in construction between 2003 and 2007.

With institutional transformation, the government is changing its role in economic management. Departments of economic affairs are relatively reduced in terms of employment. On the other hand, institutional transformation encourages the increase of workers in social organisation, social affairs, worker's unions, women's unions, industrial associations and neighbourhood community organisations. The growth of these organisations generates 21% more positions. However, although the reduction program can lead to a decrease of professionals in public management, the reason for the steep fall in such a complex institutional environment remains somewhat unclear.

Special attention should be given to tourism and culture related economic activities. Table 6.3 shows an increase of total employment and professional employment of 22% and 14% for this cluster. On the functional cluster template (Figure 4.7 page), after 2002, cultural and information is emerging as a cluster. Since Beijing is a historical and cultural capital and home to information, communication and education, the CI cluster has great developmental potential. Many cultural activities, tourism, conventions and exhibitions, although excluded from the cluster template due to their relatively low economic presence in 2002 (See Chapter 4), are very promising elements for the creation of a new important cluster. During 2005-2007, the outputs of these two industries respectively increased by 35% and 14% (Beijing Statistical Bureau 2007, 2008). There are over 660 tourist attractions and 13 main exhibition halls totally occupying 540 thousand m^2 floor space (Wei 2004; Shi 2005). This new emerging cluster has a wide range of connections with other

industries such as hotel, food services, transport, business and even manufacturing.

ECs are actively driving the city's participation in the global economy. The developments of the ICT and FIRE clusters in particular contribute to establish and consolidate a bridge to the world by attracting new investments, firms, and entrepreneurs and by absorbing knowledge and facilitate local production. This trend gradually penetrated into the manufacturing clusters by means of ventures of and joint-ventures with foreign manufacturers such as with Honda and Daimler Benz in automobile manufacturing (Association of Beijing Automobile Industry 2005). It is reported that China and Europe have been cooperating in textiles and garments (Information and Commercial Centre of Textile Clothing China 2008). As China intends to use its huge foreign exchange reserve to leverage further internationalisation, this process is likely to continue for Chinese firms for many years (China Market Survey 2009).

6.3.2 Roles in spatial development

ECs are also main shapers of the city's geographical space. The roles of ECs in spatial development are especially embodied as changes of land use and associated urban spatial growth, and expansion of the transportation network.

6.3.2.1 Land use and urban spatial growth

Land use change is a physically visible result reflecting the composite effect of social and economic activities in urban development. Only land use data of 1993, 2000 and 2004 were available for detecting changes in different periods. The data are based on remotely sensed images and a recent land use survey by the Beijing Land Use Bureau. Given the focus of this research, the data were re-categorised as built-up and non built-up areas. The built-up area includes constructed land in the urban area, towns, rural settlements, industrial enclaves and transportation areas (For more details see Appendix III).

Table 6.4 shows the conversion of land use in Beijing during these two periods. It indicates the urban spatial growth has much accelerated. The total newly built-up area during the recent 4 years (2000-04) is larger than that of the previous 7 years. During 1993-2000, the annual growth of built-up area was 418 km^2, an annual growth rate at 3.2%. It increases from 2098 km^2 in 2000 to 2616 km^2 in 2004, growing at 5.7% per annum.

Table 6.4 Conversion of land use in Beijing

Unit: km^2

		2000					2004		
		Other	Construction	Total			Other	Construction	Total
1993	Other	13,990	808	14,797	2000	Other	13,453	927	14,380
	Construction	390	1,291	1,680		Construction	409	1,689	2,098
	Total	14,380	2,098	16,478		Total	13,862	2,616	16,478

During 1993-2000, the urban centre expanded dramatically (Figure 6.4). Urban land grows contagiously particularly along the 4th ring road. Under the huge demand of housing and industrial construction, the expansion even encroaches on the 1st green belt that was established besides the 4th ring road. In between the urban centre and main satellite key towns, the construction land indicates the urban corridor is not sharply demarcated. Many construction areas, both newly added and original ones, appear to be scattered in the peri-urban area, most of which are former rural residential settlements. In the periphery of these areas, some constructed land is reversely transferred into other uses, constituting the major source of the reverse conversion of land use in this period, as observed in Table 6.4. This situation is caused by land that is temporarily used by farmers prior to its urban development and as a result impervious land is identified by remotely sensed images.

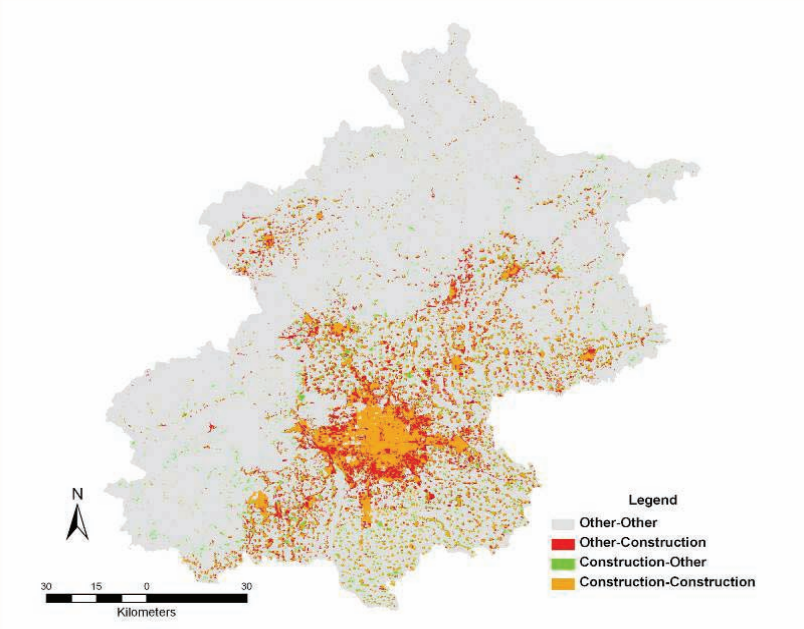


Figure 6.4 Land use change in Beijing, 1993-2000

Data source: Beijing Land Use Bureau

The urban land increase results in a large urban centre, which seems spatially saturated indicated by the land use change in the period 2000-04. Figure 6.5 illustrates that relatively little land is newly constructed within the urban centre. Yet some construction land grows at the north and south of the centre respectively along the corridors of Badaling and the BT Expressways.

At the periphery of the urban centre, part of the built-up land is reversely converted to other uses. Most of it is reversed to water surface. Together with other uses like grassland and forestry, this region is becoming a place for agro-tourism. In the peri-urban region, some reverse land conversion can also be observed. This can be attributed to the campaign of creating towns to replace scattered villages.

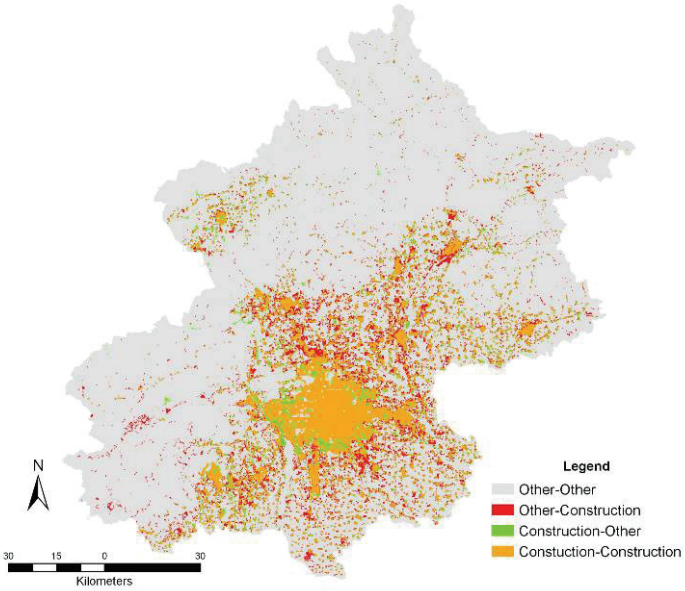
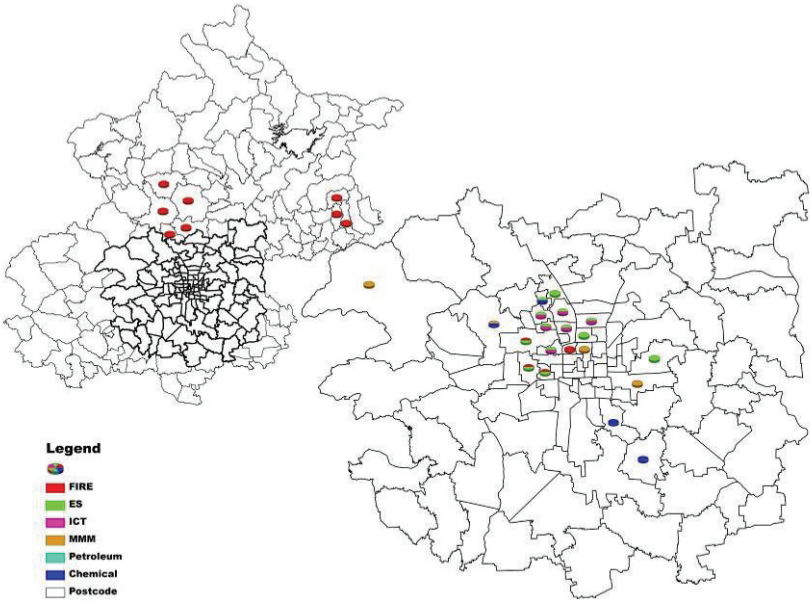


Figure 6.5 Land use change in Beijing, 2000-04

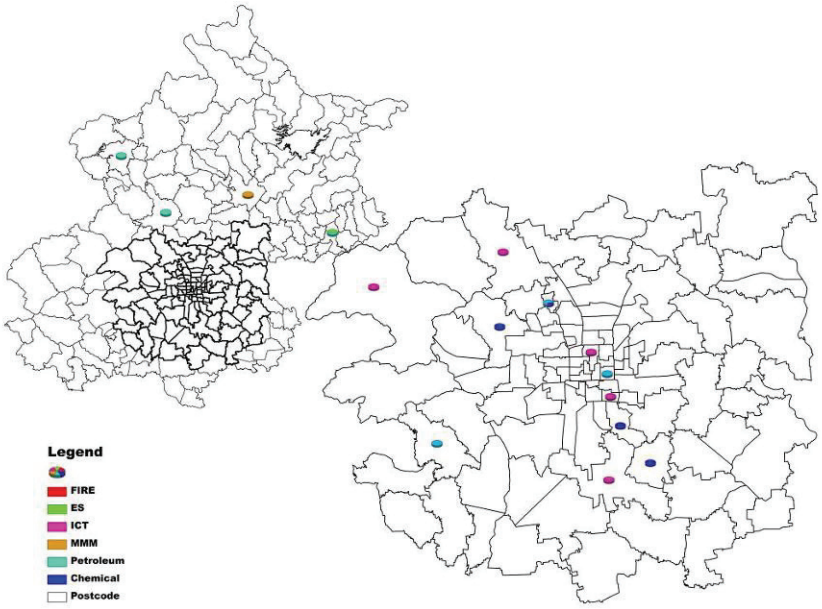
Data source: from Beijing Land Use Bureau

In addition to the growth of the outer area of the urban centre, much new urban area is created adjacent to key towns. The growth of these new built-up areas vividly indicates the appearance of urban corridors which physically link the urban centre and the towns. Besides, the towns themselves grow larger. These developments are the physical evidence that many peri-urban areas are now becoming important industrial places and are being transformed from rural to urban economic activities.

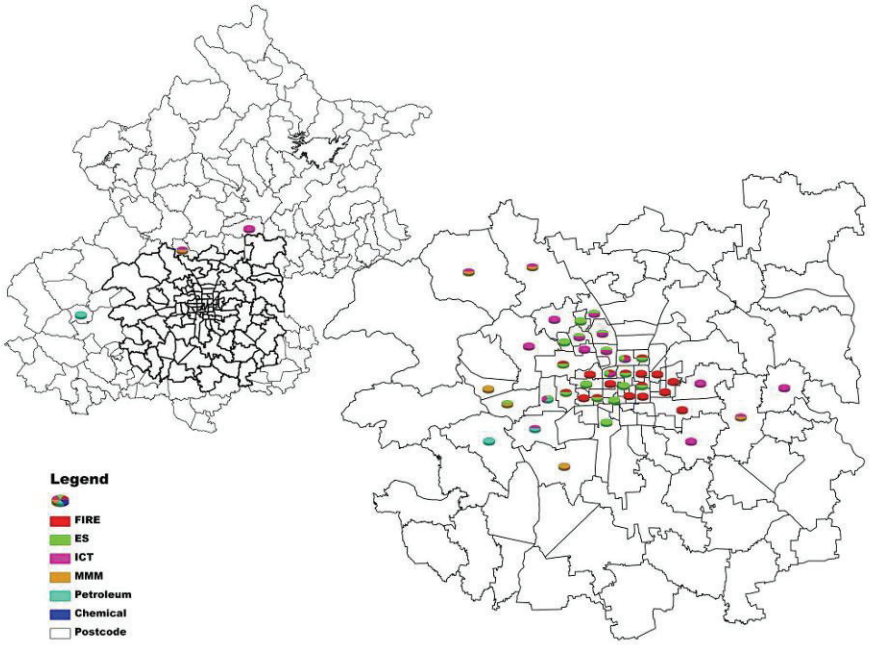
The changes in the built-up area also provide physical evidence to examine the spatial effects of ECs. The spatial development of the main ECs in 1988-1992 and 1993-97 (Figure 6.6 a-d) were compared with the land use changes during 1993-2000. The ECs in 1998-2002 (Figure 6.6 e & f) were checked with the land use changes during the 2000-04 period. The spatial analysis was based on postcodes, with which the boundaries of the ECs cannot exactly be represented. Changes in land use within the cluster zones and their direct neighbourhood were examined. In the current urban plan, the distance between two intersections of minor roads is 75-100m and above 400-500m for the intersections of sub-major roads. The minimum size of a postcode area is about 1.4 km^2. We therefore set buffer zones with 100m and 500m to detect the land use change related to ECs. The two types of spatial pattern of ECs, hotspots and islands, were separately examined.



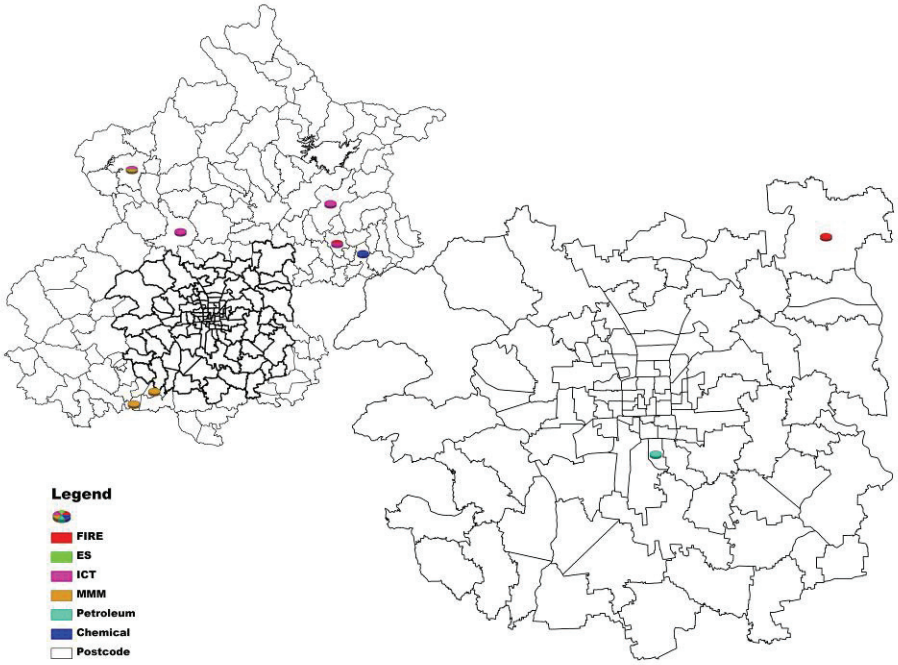
a) 1992 hotspot



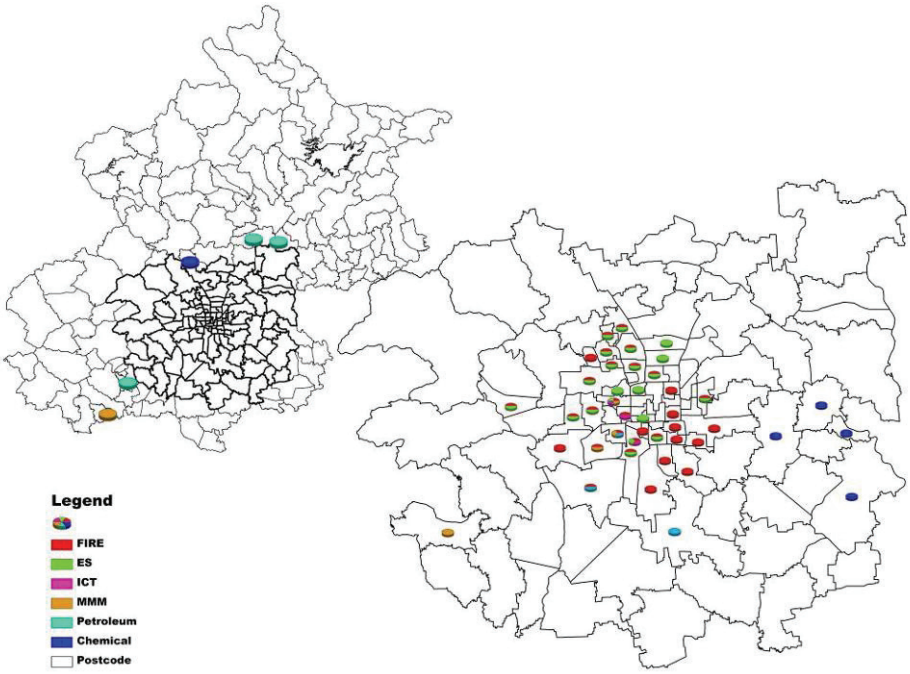
b) 1992 island



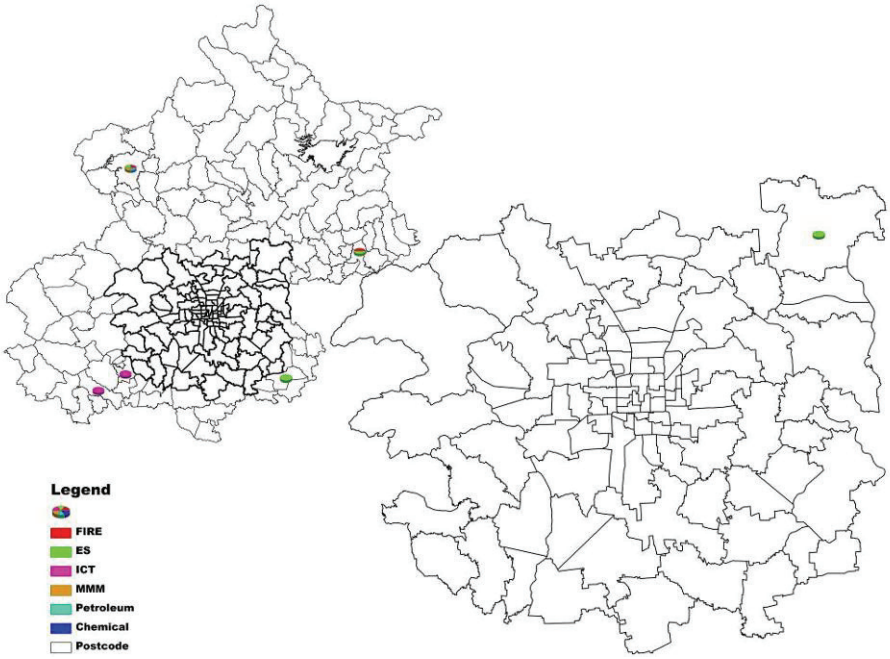
c) 1997 hotspot



d) 1997island



e) 2002 hotspot



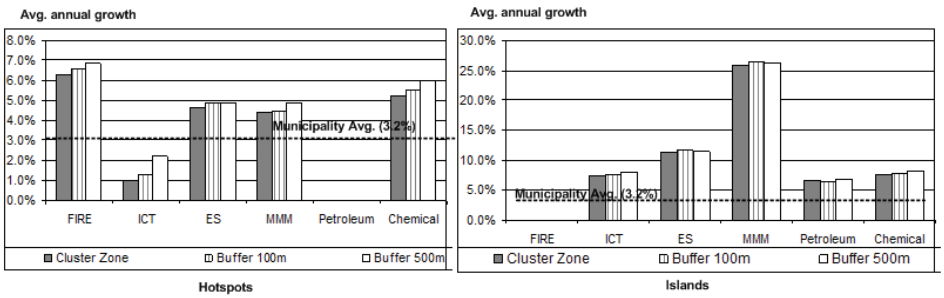
f) 2002 island

Figure 6.6 Cluster map of Beijing

During 1993-2000, the construction land generally grows faster in the cluster zone than the average rate of the municipality (Figure 6.7a & b). Based on the 1988-1992 cluster zones, the fastest urban growth occurs in the FIRE zone for the hotspot and the MMM zone for the island. Over 6% increases annually for the FIRE zone and its proximate area and above 25% yearly increase for the MMM zone and its neighbourhood. In the period of 1993-97, the construction land grows even faster for the hotspot site of the ICT, MMM, petroleum and chemical clusters, while the increase of construction area in the FIRE zones slightly slows down and levels off for the ES cluster. As regards the islands of ECs in 1993-97, except MMM and petroleum, the construction land use in all analysed ECs grows faster than the period of 1988-92. However, in the cluster zone and surrounding area of the MMM and petroleum clusters, the construction land use still keeps a high growth rate. It should be noticed that the land use change in 1993-2000 is a cumulative outcome of the EC in both 1987-1992 and 1993-97, and influenced by other socio-economic activities. Nevertheless, it is almost certain that the ECs play a pivotal role in urban spatial growth, although such a new area may increase from the demand of business and manufacturing growth as well as from new construction for facilities and housing.

Based on the analysis of spatial clusters of 1998-2002 and land use change during 2000-04, the impact of ECs on land use is also pronounced (Figure 6.7c). The construction land for the hotspots of the MMM, petroleum and chemicals increases faster than the average of the municipality. The FIRE and ES clusters require much less new lands. In the buffer area, the new construction land is added faster for the MMM and petroleum clusters and slower for the chemical clusters. As regards the island, except the chemicals, the new construction land increases much faster than the average.

The urban growth analysis indicates that the EC is a major force driving urban spatial development. In the cluster zone and its surrounding buffer area, the land use converted to construction use is higher than the average for the municipality. However, there are some signs that the FIRE and ES may not consume much new construction land, particularly in the latest period. Being located in the urban centre, these clusters are developed with a process of urban redevelopment or the relocation of manufactures. The MMM, petroleum and chemical clusters are located in the peripheral urban centre, largely occupying the new urban land to develop. The ICT cluster may stand in between. At its early stage, it is established partly on of new urban land and partly in industrial areas where its functional relations are. When the ICT cluster becomes mature, almost no construction land is needed as shown in the statistics for period 1998-2002 in Figure 6.7 c. However, the peripheral area of the ICT cluster becomes an attractive area for construction.



a) 1988-1992

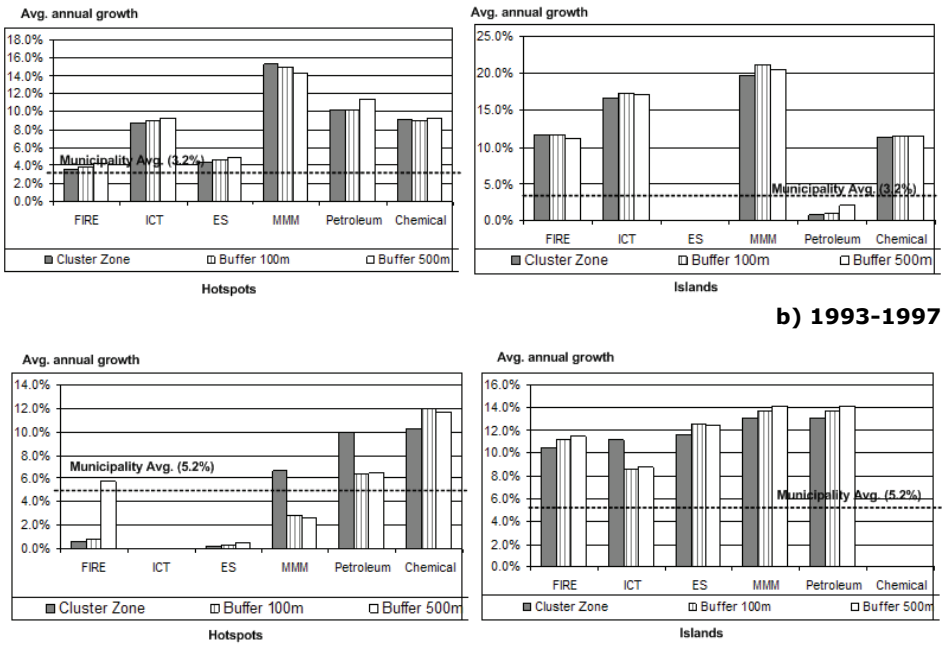


Figure 6.7 Increase of construction land of clusteral zones and their proximity

After comparing the spatial effects of the two spatial pattern of ECs on land use, a general trend can be observed that the island pattern of ECs leads to more land converted to construction use than the hotspot one (Figure 6.7). These islands are generally in the key towns which are far away from the urban facilities. Developing ECs in this area requires much land for auxiliary facilities and housing. The lower value of the land in this area could be another reason.

In general, the EC plays several roles in the spatial growth of the city. In the pattern of islands, it spurs on the increase of new construction land, and in the form of hotspots, it stimulates the functional upgrading of the place. Manufacturing clusters drive new urban land developments, while service clusters lead in the functional transformation or promotion of areas with subject to industrial relocation or urban renewal. It has been seen that the Financial Street, CBD and knowledge area have become concentrations for respectively the FIRE and ES clusters. Land use changes in the CI an tourism clusters are related to the protection and promotion of urban heritage and the 2008 Olympic Games.

6.3.2.2 Transportation Network

Based on the transportation network in 2005, the road density was measured for each postcode area. Classification of road systems is different between urban districts and peri-urban area. Different roads play different roles, but sometimes these roles cannot be clearly distinguished. For instance, expressways are a major connection between urban and non-urban areas and other major cities, but are also used by citizens, especially at peak time, when they commute between residences and work places. Another case are the motorways (ring roads), which are mainly for facilitating transportation in urban areas, but are also used as a connector of key towns in inner peri-urban areas. Branch roads in the urban area and lanes in countryside probably have more exclusive functions. The road network above the level of sub-major roads was analysed for the municipality and the system of minor streets and major roads was analysed for the urban area.

Road density is an important indicator measuring transport services of an area to accommodate the travel of people resulting from socio-economic activities. To a large extent, the higher density of a road system, the better the accessibility of economic activities in that area. But economic functions also generate new or upgraded roads. Road density can in these ways be related to economic development. In this research, the road density was measured by the total length of roads per unit area. In each postcode area (p), the road density (Rd_p) was $Rd_p = \sum L_i / A_p$, in which L_i was the length (km) of segment i of roads within the postcode area and A_p was the area (km^2).

The result shows the areas with the highest road density in de zones with ECs. At the municipal level, a very dense road network surrounds the urban centre, particularly along the BT and Badaling Expressways (Figure 6.8). At this level, the EC areas have a high road density in the network above sub-major roads. In this sense, the ECs geographically can expected to have a locational advantage from the municipal transportation network while at the same time the presence of ECs also helps to shape the network.

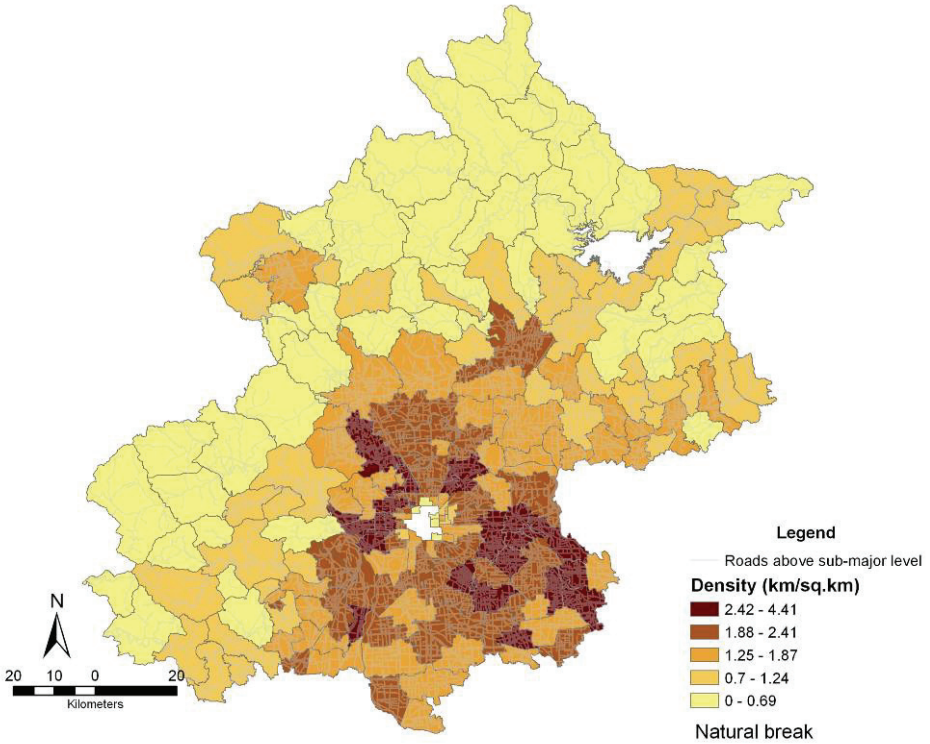


Figure 6.8 Road density of Beijing Municipality

Note: no data within the 2nd ring road; edge effect is for the centre area which has no data

Within the urban centre, the density of the major streets depicts a concentric pattern. The areas with highest density are found alongside Chang'an Street (Figure 6.9). However, the deviation of the road density is in general quite small, with 0.7 km/ km^2. Except for the Financial Street, the areas with the highest density are not the locations of the major ECs, for instance the CBD and ZSP only have a the second level road density. In the proximity of the CBD, however, the road density is sharply lower to 0.65 km/ km^2.

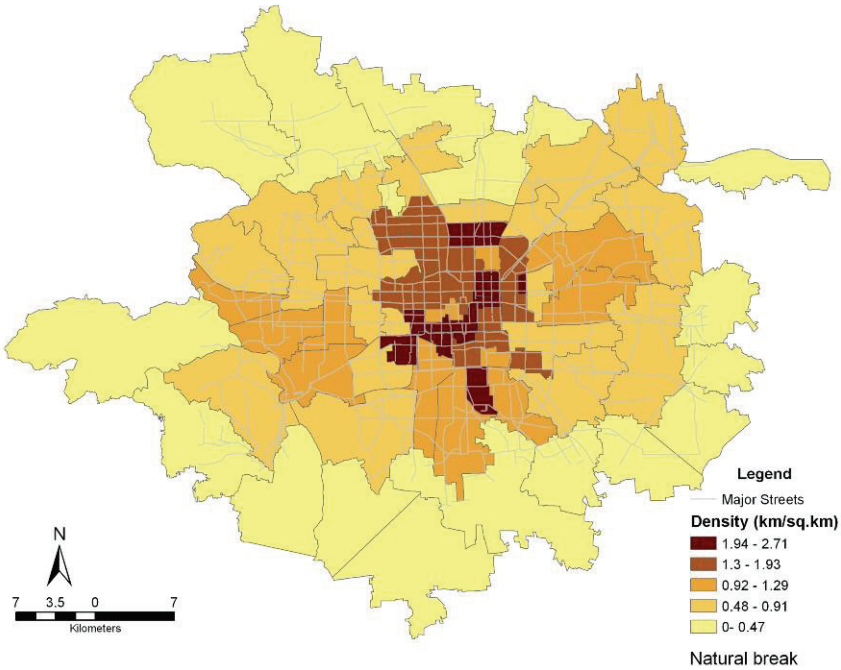


Figure 6.9 Road density of major roads in urban area, Beijing

Note: Edge effect exists for the outer area

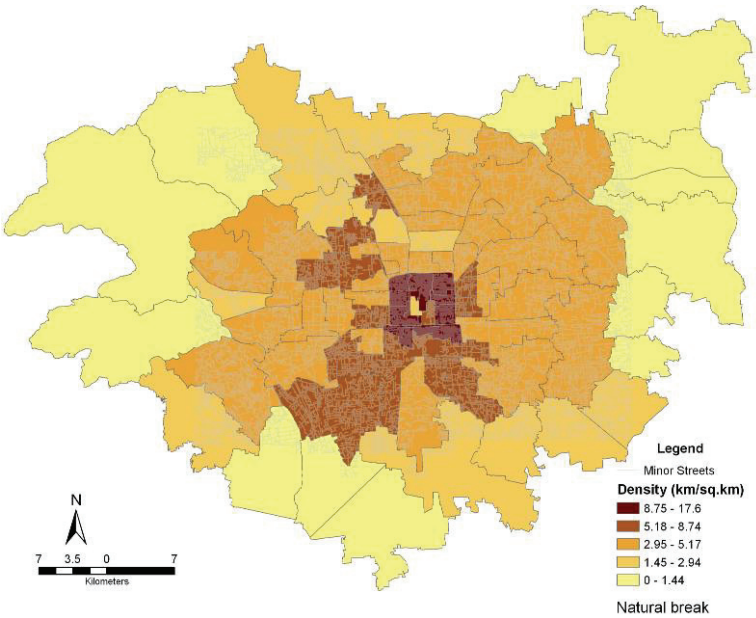


Figure 6.10 Road density of minor road in urban area, Beijing

Note: Edge effect exists for the outer area

The concentric pattern of road density is also present for the minor streets in the urban area (Figure 6.10). The Forbidden City has the highest road density due to the fact that many lanes were paved and the historical pattern was left unchanged. The high density area is the main location for the FIRE cluster including the Financial Street and CBD and of the ICT and EC clusters including the ZSP core area, Shangdi Park and of MMM where BDA is. The analysis of road density indicates the road network has basically developed according to the requirements of the main ECs. The road network is however constructed centrically, which causes capacity problems that reuire careful policy reflection. The variations in road density for the different levels of the transport networks is an issue which need further analysis.

6.3.3 Roles in urban development

ECs play important roles in the urban development. In case of Beijing, these roles are:

- The ECs are leading city economic growth. In each period of Beijing city's economy development, the most important activities or business can be summarised as several functional interconnected groups of industries that organise the local demand and supply markets.
- In the fast transformation of economies, the ECs drive and leverage the economic restructuring in general from manufacturing-dominated to service-oriented urban economies, which is key for urban development. In terms of functional interconnections identified by the ECs, the structural change is dramatic.
- The development of ECs stimulates spatial growth by adding new urban land and deep affecting the transportation network. During 1993-2004, most new construction land is directly and indirectly attributed to the EC development. The distribution of road network density basically complies with the layouts of the ECs.
- The developments of the FIRE and ES clusters are pivotal in urban redevelopment. During 2000-04, although the FIRE and ES clusters grew quickly, the new urban does not increase in their concentration areas. The spatial development of these clusters absorbs the land which is claimed by relocation or readjustment of manufacturing plants and old housing areas.
- Other possible emerging and important clusters are CI and tourism. These two clusters become functionally increasingly important. Attributed to the rich heritage, cultural and

information resource and especially the 2008 Olympic Games, CI and tourism are becoming important activities in the urban centre and in some of peri-urban areas.

- The development of the ICT cluster is a way to create an innovative economic space. Under the fast economic growth and transformation in China, the development of ICT is crucial for many cities. It helps cities to catch up the development of new economic activities and engage in the global economy.
- The EC functionalises the spaces, places and flow. Many cluster places are now symbolising certain areas of the city such as the ICT for ZSP and FIRE for the CBD. New infrastructure connects them.
- The ECs reposition city development. The increasing importance of FIRE, ICT, ES clusters functionalizes Beijing as a modern service-dominated city, and establishes strong linkages between the Chinese mainland and the world.
- To sum up, the ECs are both a major driver of economic development and a major shaping force for city space. The development of ECs is worthwhile examining and comparing with current economic and spatial policies.

6.4 Reflections on urban developmental policies

The EC provides a new perspective to think about current economic and spatial policies. A group of industries, conceptualised as the EC, becomes a basic unit for policy making and implementation. This is valued in economic policy by addressing underlying opportunities and potentials in the interaction of common and complementary economic activities. Economic incentives will be more realistic to implement by encouraging the development of interrelated industries rather than single industries. By connecting local resources and the global market, the EC offers a route to indicate strengths for economic policy makers, and is also a way to examine the changing of local economic system. Based on well performing ECs, economic policy can help drive economic development in conjunction with city functions and roles.

ECs provide a field for spatial policy to resonate with economic development. From an economic viewpoint, place and space are an important resource and that can be exploited when urban planning designates particular geographical locations and arranges supporting infrastructure and facilities. Correspondingly, urban planning, traditionally centred on physical elements, can place more efforts into the rationality of economic development. It is advanced from simply

segmenting geographical space such as through land use zoning, to include concerns of what should be rationally arranged for the space to become economically productive and successful.

With the rapid growth of ECs, urban economic and spatial developments can therefore be well integrated and contribute to functioning of the city. From this point of view, despite the generally successful picture, some challenges remain in the economic and spatial transformation of Beijing. There is still much room for improving current economic and spatial policies. Some strategic issues are described below.

6.4.1 Economic policy

6.4.1.1 Prioritised industries

A fundamental value of ECs is to help identify and exploit local development strengths. All functional clusters identified in this research are mentioned in the latest Beijing 5-Year Economic Plan in the form of individual industries. However, some prioritised industries do not appear as important functional constructs for the city economy. These industries are textile and garment industry, construction materials and food processing. The analysis of functional cluster's evolution indicates that construction materials do not appear on the cluster template after 1982, and the clusters of textiles and garments and food production and services are experiencing dramatic restructuring. Labelling these industries as key industries is perhaps overemphasising their importance and long term economic prospects. Policy design should recognise such trends and consider either substantiating and creating new stimuli for their transformation or perhaps even anticipating their further decline.

6.4.1.2 Industrial linkages and business environment

Current sector-based, blueprint style economic plans overlook the pattern of industrial linkages. Functional clusters help policy making deploy industrial policies in a unitary rather than zero-sum action to improve policy coherence. Success of one industry much relies on the developments of others. For instance, if the food processing and textile and garment industry can be successful, the linkages between them and the FIRE cluster should be consolidated. As indicated by the cluster evolutionary map, this sort of linkage has been emerging and developing.

An associated issue is that the business environment is not well linked into policy design. Currently, a major concern is the limitations in the institutional environment such as procedures for establishing

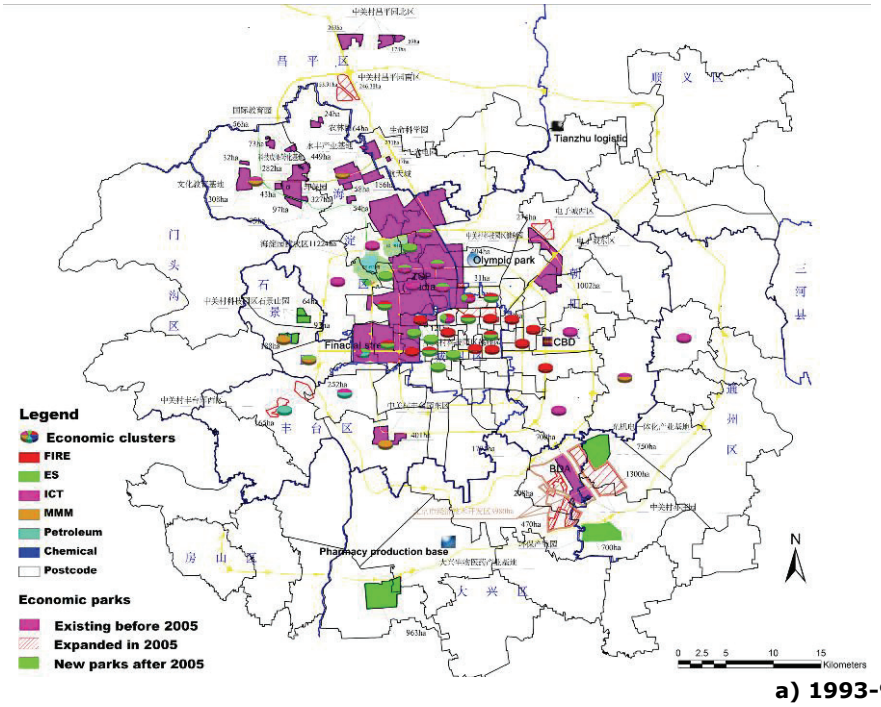
businesses. With upgrading of industries and business, other issues like schemes for labour training and industrial associations will be important elements for attracting and maintaining firms and investors in the long term. In order to create and shape a favourable business environment, policy design should favour functionally related industries. For example the ICT manufacturing and related technology services can co-strengthen and co-develop.

6.4.2 Urban planning

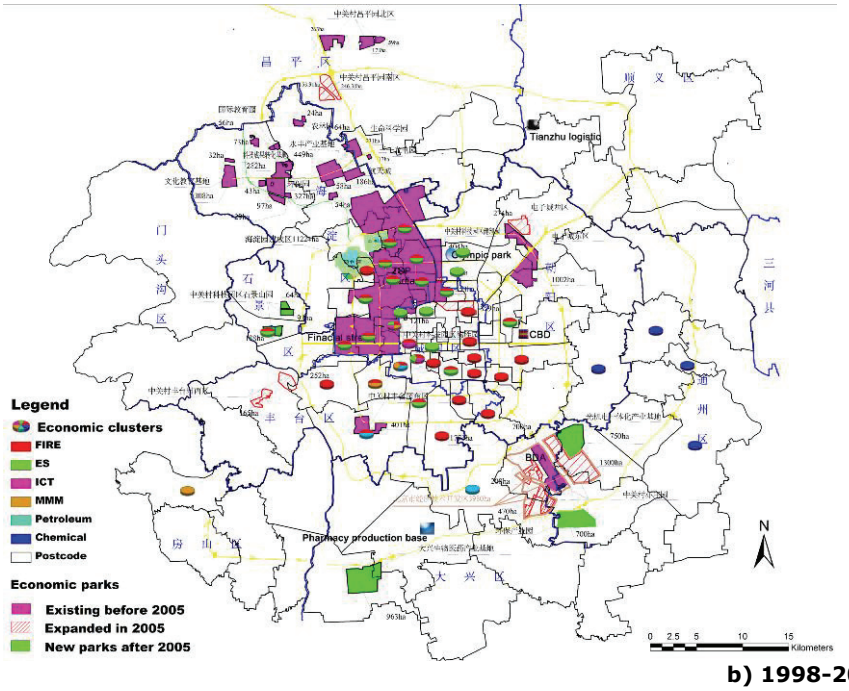
6.4.2.1 Prioritised spatial location

Designating locations of ECs is of particularly importance for rationally locating resources and realising anticipated urban structure. In the developing economy, efficient uses of land and facilities are the aim and task for urban planning, and to that point several places are often prioritised. Spatial clusters provide a means to identify such places and attribute them with development potentials since this has been significant for certain economic activities in the past. They also give reference to evaluate the policy measures of prioritised projects.

Economic or industrial parks are an instrument which is selected by urban planners to implement ECs. Illustrated by the overlay between the spatial clusters which are identified during 1993-97 and 1998-2002 and the map of main economic parks, the hotspots of the spatial clusters are basically distributed in correspondence with the designation of economic parks. This situation is particularly evident for ZSP (Haidian part), the CBD and Financial Street, and the knowledge area (Figure 6.11).



a) 1993-97



b) 1998-2002

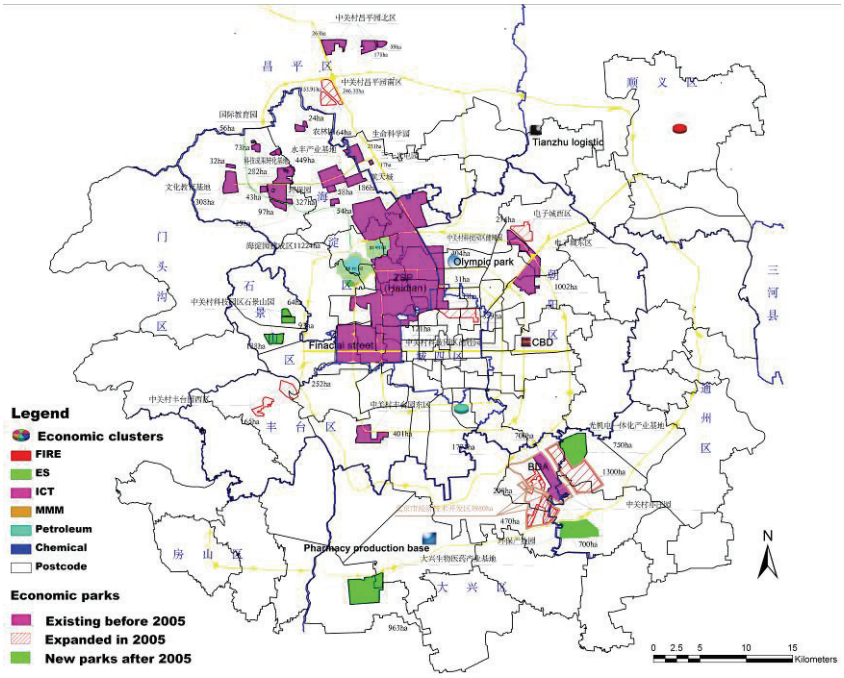
Figure 6.11 Overlay of main economic parks and hotspots of spatial clusters

The overlay map also indicates co-location of cluster activities. Although ZSP is designated for specialised ICT manufacturing, some mixed functions are also present, for example ICT and ES. The MMM and ICT cluster are both found in Yongfeng Park, the sub-park north of ZSP. The Jianxiang Park, despite being designated for ICT activity in the plan of economic parks, is also devoted into the FIRE and ES, providing business and knowledge support to ICT development. The FIRE in general covers a wide range of economic activities and is spread over almost the whole urban centre. A similar type of spatial distribution is found for the ES cluster. Co-location of specialised ECs is therefore apparent and is perhaps a necessary condition for success.

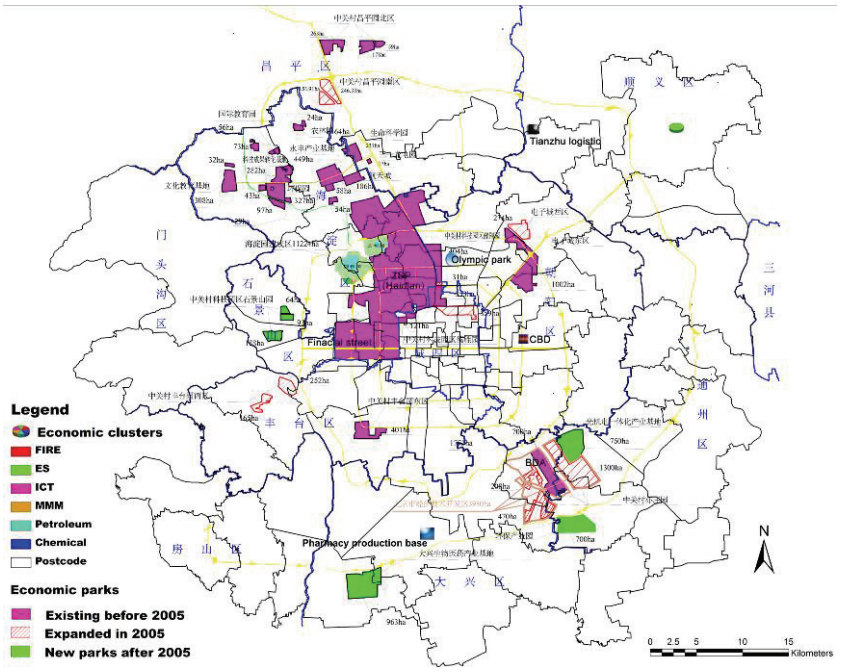
Some newly developed parks could not be illustrated in the empirical analysis. The development of BDA is not covered. In 1992, infrastructural construction for BDA starts, and in 1999 Nokia relocates its manufacturing operations to a new location within BDA, stimulating the establishment of Xingwang Park (Yeung, Liu, and Dicken 2006; Zhang 2008a). After authorised as the primary national economic and technology development zone in August of 2002, BDA quickly develops (Beijing Development Zone 2008; Zhang 2008a). As shown in Figure 6.11, after 2005, there is a large area designated for BDA development.

Newly developed parks also include Tianzhu logistic park in Shunyi and a pharmacy production base in Daxing. According to the functional cluster analysis, the cluster of health care and pharmaceuticals is becoming larger and the cluster of automobile and logistic could appear again (see Table 4.7). This trend is consolidated by the current spatial plan (Committee of Beijing City Planning 2005). The clusters of petroleum, chemicals and MMM are not illustrated on the map. They share locations inherited from previous times, some of which are now industrial parks but not with high authoritative level as ZSP, the BDA, Financial Street, logistic park and pharmacy base. Unlike in central city, manufacturing clusters are still the major economic activities in some key towns in Beijing's periphery.

Close to the urban centre, several EC concentrations in the form of islands are found. These islands include a FIRE cluster in the Shunyi District and a petroleum cluster in Fengtai in 1993-97. The place of the petroleum cluster will be occupied by the ES cluster in 1998-2002 (Figure 6.12). These islands are however not reflected in the current plan for industrial parks.



a) 1993-97



a) 1998-2002

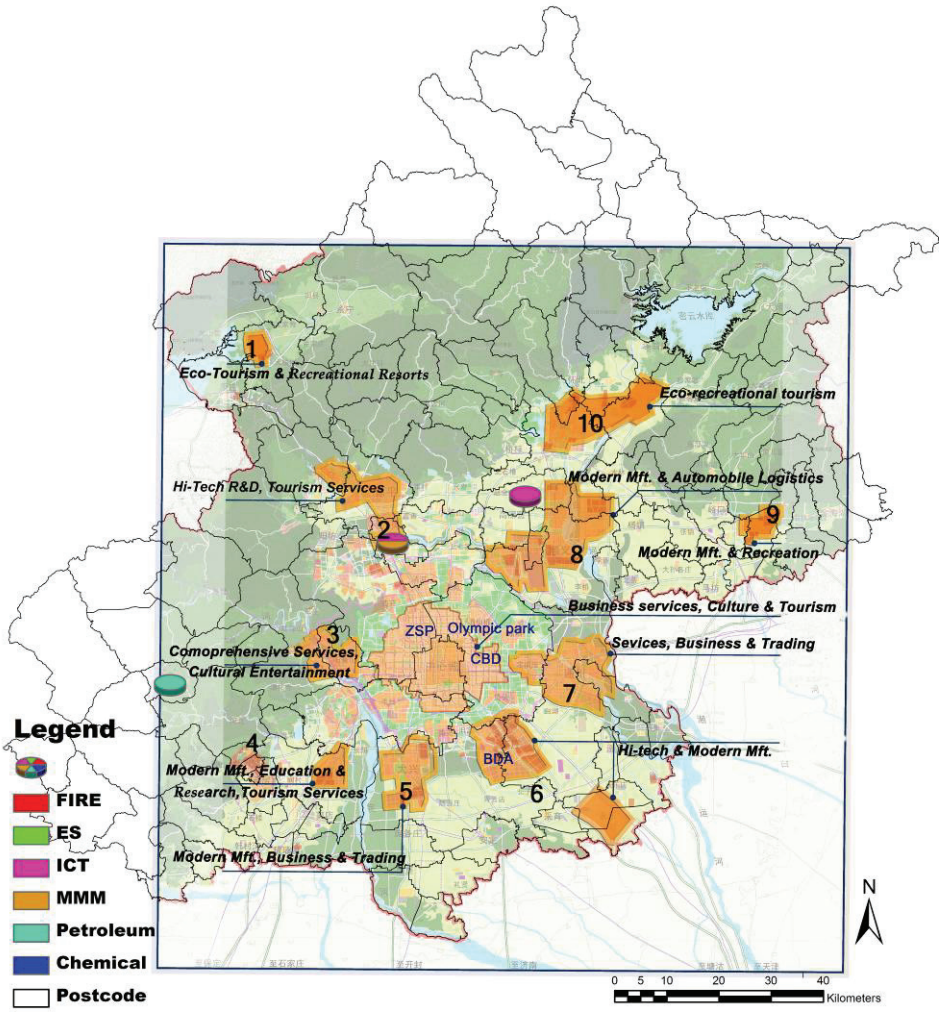
Figure 6.12 Overlay of main economic parks and islands of spatial clusters

Likewise, indicated in the hotspot map Figure 6.11, the spatial plan of the industrial parks overlooks the clustering trend in the southwest quadrant. Or it is attempting to break this trend. This part of city is mainly occupied by the MMM, petroleum and chemical clusters. In addition, the FIRE is relatively concentrated. This situation requires cautious policy design and implementation. Particularly the Beijing-Tianjin Corridor connects the two mega cities.

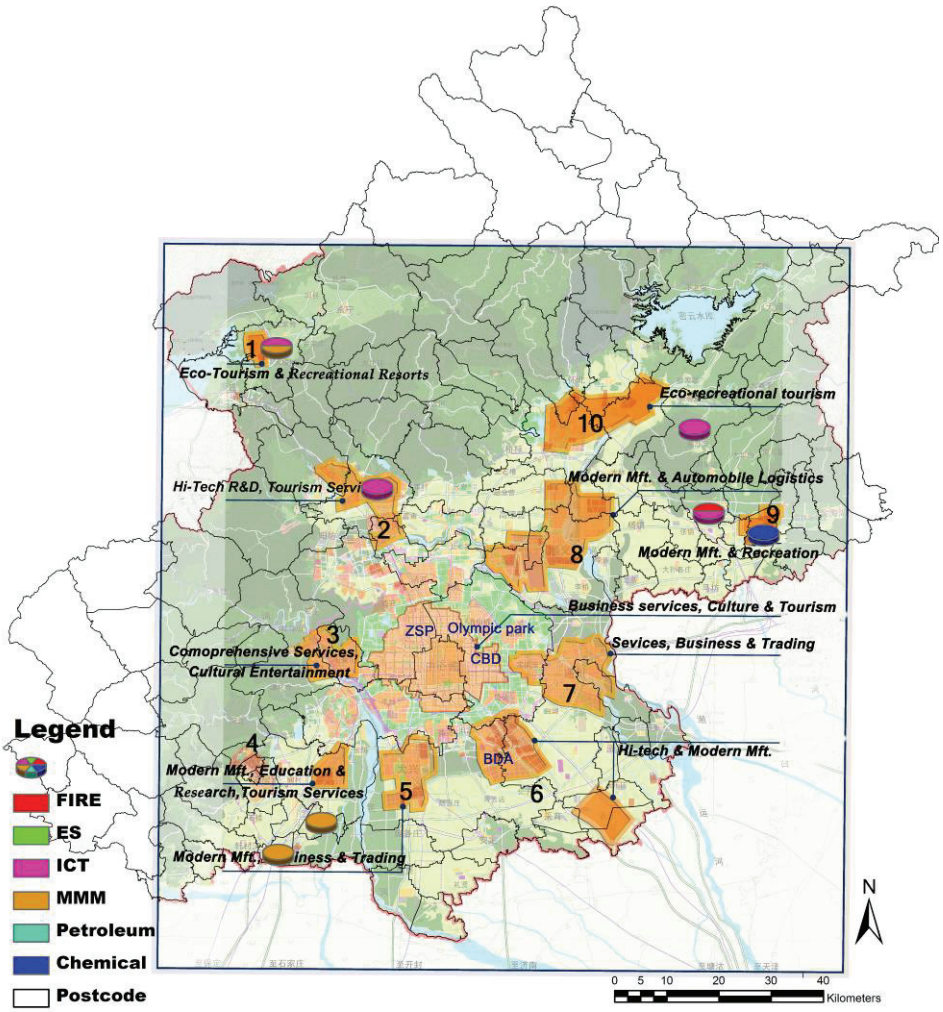
6.4.2.2 Urban structure

One major aim of Beijing's latest urban plan is to create a polycentric urban structure by creating 'multi-centres' and in doing so to realise 'two belts' (development corridors). The spatial distribution of ECs however implies that this scheme will meet big challenges. The analysis above suggests that the urban centre is predominately developed with various ECs. With the development of the ICT, ES, and FIRE clusters and the newly constructed Olympic Parks, the function of the urban centre largely achieves the goal of being the office services, culture and tourism centre proposed in the urban plan (Figure 6.13).

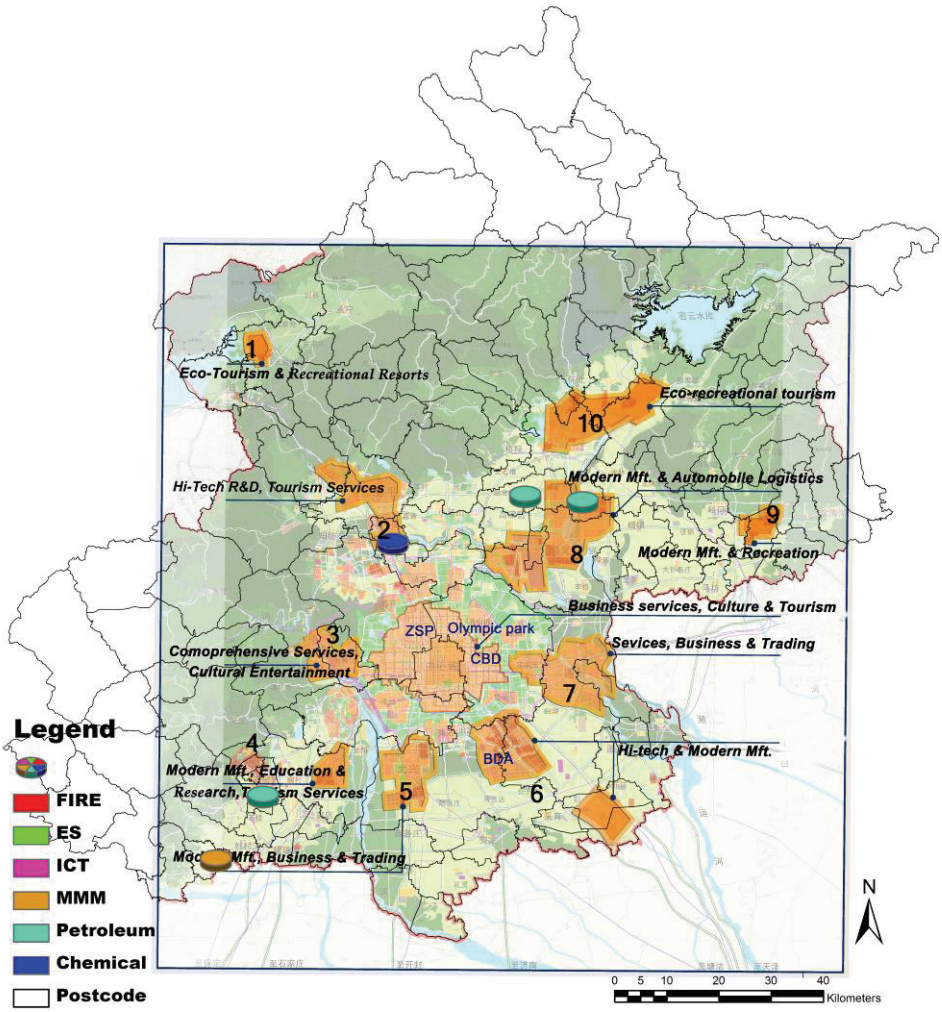
As regards the other 10 sub-centres, some of them are filled in by ECs in either hotspot or island form. The key town of Yanqing County (Site 1, Figure 6.13), partially because it is located far away from the centre, has several functions of ECs, the mixture of the MMM and ICT in 1993-97, and the FIRE, MMM, ES and petroleum in 1998-2002. Site 2 covers the area of the MMM, chemical and ICT clusters in a hotspot form and the ICT cluster in an island form during 1993-97 and 1998-2002. It is expected that this area, if designated with the function of high tech Research & Development (R&D) and tourism, will be led by R&D activity related to ICT, petroleum and modern manufacturing. Site 4 is a place for the petroleum cluster in 1998-2002. Site 5 is recently developed as a pharmacy base. Site 6 is BDA area and a petroleum cluster lies in the south as an island during 1998-2002. Both sites, 5 and 6, are not analysed in this research. Site 8 includes the clusters of the ICT, petroleum and the analysed automobile and logistic park. Site 9 is actually the place dominated by the chemical, FIRE and EC activities, although it is designated as a modern manufacture and recreational area.



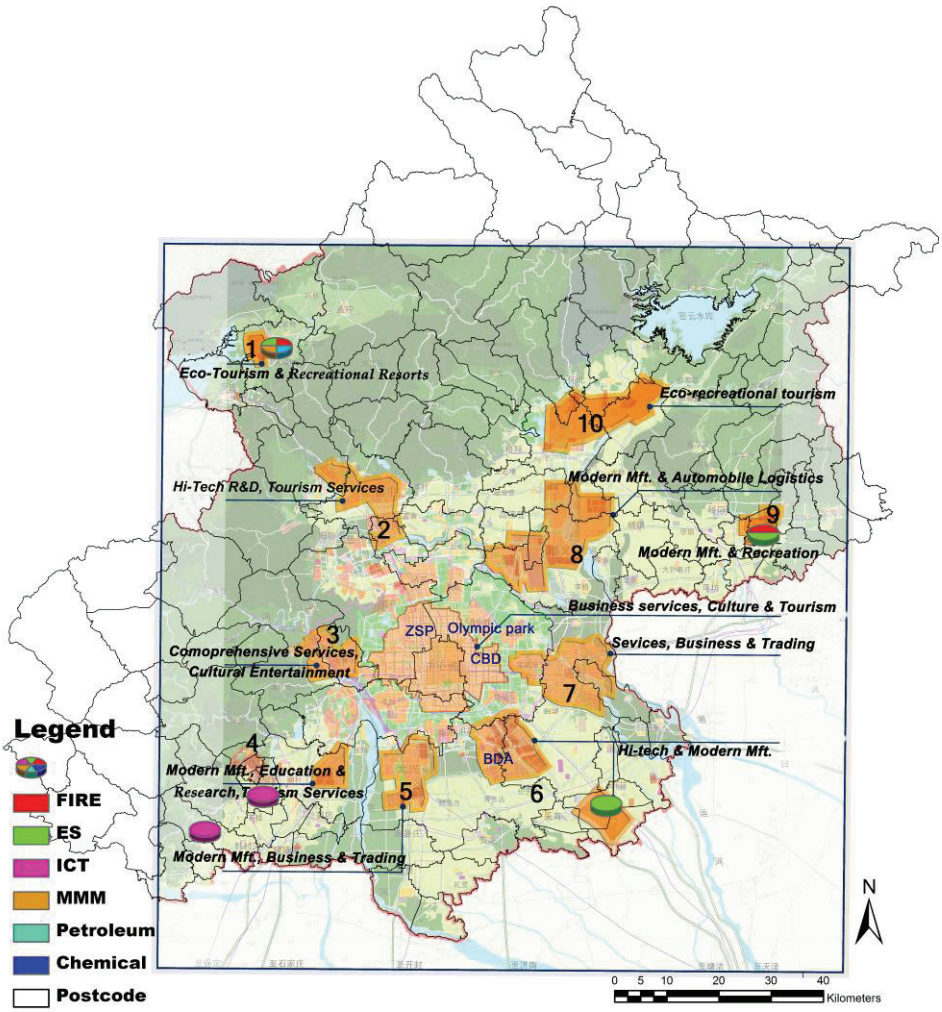
a) 1993-1997 hotspots



b) 1993-1997 Islands



c) 1998-2002 hotspots



d) 1998-2002 islands

Figure 6.13 Spatial clusters and multi-centre urban structure

The site-matching analysis illustrates that not all planned centres are now also locations for the identified economic clusters. Examples are sites 3, 7 and 10. Even though some sites have some cluster developments, their main function is often different, for example tourism and recreation. To locate tourism service outside the urban

centre seems to be related to the relatively easy supply of land and natural resources. This development will put pressure on the urban centre by generating commuting.

The space designated for business service functions, a sector the spatial cluster analysis showed to be underdeveloped, is still underestimated in the future plan. Only sites 3, 5 and 7 are designated for this type of economic activities. As more frequent interactions between service and manufacturing economies are expected, the urban centre will continue to prevails for business services and probably will expand into neighbouring districts. Therefore, Beijing's functionally mono-centric urban structure will remain for some time to come, despite the polycentric policy intentions.

The pattern of spatial clusters concentrated along the BT corridor also challenges the concept of two belts. This challenge is visible in the distribution of road densities (Figure 6.8).

Figure 6.14 Public transportation system

The mono-centric urban structure is supported by the transportation system. The bus network is largely concentrated in the urban centre and the outwards radial roads (Figure 6.14). Main stops, including major metro stations and key bus stops, basically circuit within the urban centre. Centre development around major stations on the ring roads is insufficient. Although this situation became slightly better after the construction of metro Line 5, as a major north-south axis this line cannot cope with passenger demand.

Figure 6.15 Traffics of Zhongguancun and CBD

The large and dominant centre and the nature of the transportation system cause problems of both over and under supply. At the gateway of the ZSP and CBD areas, the traffic is congested (Figure 6.15). As shown by the Figures 6.9 and 6.10, the road density surrounding ZSP and the CBD is quite similar to that of other areas. Limited 'oversupply' is due to high population density and associated demand of travel. In contrast, within the CBD, the traffic is in a

relatively good shape. Here, the transportation infrastructure is designed and implemented by the CBD authority after approval by the Beijing Urban Planning Committee. On the other hand, in and around the ICT parks in the peri-urban region, roads are not fully used. The relative low level of road usage is due to the fact that these parks are manufacturing dominated. Moreover, some parks are not yet fully developed and occupied by plants. Also, public transportation, like buses, is not fully provided.

The distribution of functionally connected spatial clusters and the road system contributes to severe spatial problems. Housing demand has dramatically increased along with economic development. Most houses between the 2nd and 3rd ring roads were developed before 1990 together with the work units of in time of central planning. After 1990, housing developments were dispersed beyond the 3rd ring road and gradually expanded outwards. Corresponding to the economic spatial pattern dynamics, the real estate construction in the northern part of the city is faster than the south. In the late 1990s, the rapid economic development pushed real estate development beyond the north 5th ring road. As most jobs are provided in the urban centre, this development brings about severe transportation and traffic problems.

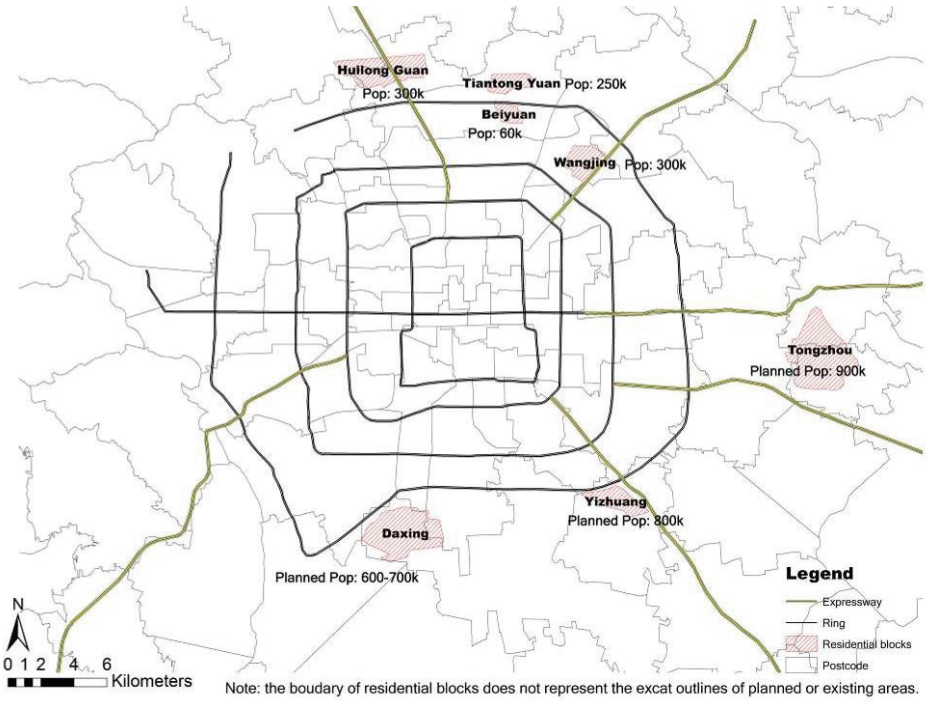


Figure 6.16 Large residential districts in Beijing

Particularly, social housing programs aimed at providing economically affordable houses for low and middle income people, and especially for young workers. As Figure 6.16 illustrate, three major social residential districts have been built up in the north, each of which accommodates more than 500,000 residents. Later, a comparable social housing program is carried out in Tongzhou (east). In the latest urban plan, Yizhuang and Daxing are designated to also provide social housing with a planned population of over 600,000. The locational choice of these social house programs is based on the proximity to the main sites of economic development for instance Tiantongyuan close to the ZSP, Tongzhou close to the CBD, and the new Yizhuang and Daxing districts near BDA. Yet such huge numbers of residents exerts a huge pressure on the transportation system, which is already now overloaded and does not provide good access to the main economic sites.

6.5 Future scenario and actions

6.5.1 Scenario

The EC-based analysis indicates that Beijing's economy has become dominated by the service economy and that the interaction between the manufacturing and service economies has been strengthened in recent years. The growth of ECs is a driver of urban spatial development. With the developments and the relocation of manufacturing clusters in the peri-urban, the urban form is now physically polycentric but functionally mono-centric. This is due to the inadequate development of service clusters in the peri-urban area and the over-concentration of service clusters in the urban centre.

In this context, the ECs are playing roles in creating high economic growth in the short or middle term but generating overwhelming pressures for the future spatial development of Beijing. The spatial problem is further aggravated by the current transportation system. The main road system, the metro and light rail transit systems are all concentrated in the urban centre. With the complement of the planned metro system extensions into the near peri-urban areas in 2020, the connection between the urban centre and key towns is expected to improve. However, considering high economic growth rate and urban economic-spatial tensions, the spatial problems probably will continue, such as high traffic congestion and inadequate provision of housing at the places of demand. If so, this will in turn undermine economic potentials by diminishing the attraction for firms and employees.

6.5.2 Actions of urban (spatial) planning

In order to achieve sustainable urban development, or more specifically to maintain a high economic growth and make a gradual transformation to a polycentric urban form, the EC analyses suggest that urban planning should:

Pay attention to interrelated economic and spatial dynamics, especially in urban planning. Economic analysis as part of planning should be improved and subsequent monitoring should be elaborated. Traditional sector-based analysis may not be appropriate for urban planning as economic activities have mixed geographical effects. ECs are better suitable as a concept in urban planning, because a group of functionally interconnected industries can be projected on geographic space, as a preliminary step for further planning analysis.

Be aware of cluster-based opportunities for industries as well as places. ECs, while acknowledging heterogeneity of spatial development, offer an approach to evaluate the potential and performance of locations, giving a reference for choosing candidate places. The spatial clustering trends should be compared to policy aims and treated with caution in planning and design.

Address service-dominated complementariness in the economic-spatial system. So far, urban planning pays most attention to manufacturing economies. With the increasing importance of service economies, new planning content should be added to deal with the functional linkages between manufacturing and service economies, the spatial requirements of business services and the facilities necessary to support commuter flows between working and housing places.

Diversification rather than specialisation should be promoted for economic parks. Over-specialised economic parks are less desirable. Although bringing high economic growth, they may lead to major problems for spatial development in the long run. At present, many economic parks, especially those dominated by manufacturing activities, lack basic social and residential services. Diversifying economic activities is also a source for the clustering of different economic activities, avoiding vulnerability to external threats. Accordingly, in the economic parks, multi-functional use of land is becoming a topic in land use planning.

Balance manufacturing and service clusters in city space so as to functionally realise the polycentric form. In the current multi-centre scheme, the functions and positions of the sub-centres should be better clarified and motivated and tested for their effects and possibility of realisation. Balancing services and manufacturing is

important for these sub-centres, which helps to realize a polycentric urban structure.

Carefully consider the role of the Beijing-Tianjin corridor. Both the indicators of spatial clusters and of road densities illustrate that the Beijing-Tianjin expressway is an important economic corridor for the Beijing municipality. Besides, this corridor connects Beijing and Tianjin, both playing an increasingly crucial role in regional development. The concept of two belts discards rather than takes advantage of this trend.

Optimise transport networks. Differentiate road density according to the pattern of main ECs to provide sufficient capacity between the main economic development sites and the rest of the city. Some nodes of high road density could be created at the major entrances to ECs for instance the CBD. Correspondingly, multi-functional use of space should be encouraged. The integration of internal and external transportation systems for ECs will be a mission for urban planners.

The ECs based analysis offers a new approach but, as well, raises many issues for urban planning. This research confines itself to the strategic level. This level is arguably the ideal way to adopt the cluster concept to link economic and spatial policies applied in urban master planning. The virtue of this is particular the case when urban planning takes a top-down approach. Based on the identified clustering locations, detailed micro analysis should also be further performed. Other important strategic issues not studied in this research include key specific planning regulations such as floor area ratios, the trade and lease of land and financing mechanisms.

Chapter 7 Findings and discussion: economic cluster analysis to improve urban planning support

Given the policy and research interests in Economic Clusters (ECs) within the theme of urban dynamics, the main objective of this PhD research is to explore the role of ECs in improving the analytical and monitoring ability of urban planning in coping with economic development. Such knowledge can be expected to contribute to managing city space towards sustainable urban development. The objective is elaborated into three research questions, respectively on conceptual, practical and instrumental aspects. The conceptual integration of ECs in urban planning is discussed in Chapter 2. With a case of Beijing, the practical implementation of an approach to analyse ECs for urban planning purposes is described in Chapters 3-6.

In this chapter, section 1 revisits the research questions on the conceptual and practical roles of ECs and major findings. Based on these series of analysis and the findings, section 2 proposes a framework to answer the research question of instrumentally integrating in urban planning support systems. The thesis finally reflects on the limitations of the research and gives suggestions about the data requirements and for future follow-up studies.

7.1 The value of economic clusters for urban planning support

7.1.1 Conceptual construct of integrating economic clusters in urban planning

The exploration on the evolution of the EC concept in major research lines within economic geography, business management and regional science contributed to better comprehend the underlying intrinsic economic–spatial relationship of the concept. To analyse ECs, their economic, geographical and temporal dimensions have be highlighted. Hence, functional clusters are defined as a group of economic- functionally interrelated industries (sectors and subsectors), and spatial clusters refer to the geographical concentration of these functionally related groupings of economic activities and their associated pattern in geographic space.

The exploration also shows the policy interest in the EC concept and the evolution of its practical value. By comparing the analytical approaches and foci of the different researchers, one can observe that they use either firms or industries as units of analysis, and

moreover concentrate on either representation in economic or in geographical space. Knowledge on ECs therefore still lacks sufficient comprehensiveness and coherence. In order to improve this situation, an analytical methodology is proposed where cluster studies can transcend from industry (sector) to firm levels and from economic to geographical spaces. This approach establishes a connection between quantitative, data-driven analysis (usually for a city or region) and qualitative case-based studies (usually for a cluster itself). Analysts and policy makers can in this way be informed about the urban spatial economy as a whole, but also about the details of the operation of ECs.

Chapter 2 also evaluates ECs as a component of urban spatial-economic dynamics and discusses how ECs are associated with current urban and regional development. It introduces well-known examples to illustrate the spatial-economic characteristics of main types of ECs. The illustration shows the broadening scope and complementary linkages of ECs, which make ECs a useful element in urban strategies. Referring to the schools of neoclassical and evolutionary economies, the three major driving forces - government, privatisation and globalisation - are elaborated, in particular in the Chinese context. The interplay of these forces constitutes a framework for understanding the development of ECs with city dynamics.

The policy relevance of ECs is discussed through their theoretical role of bridging economic and spatial developments and bringing urban and regional economic and spatial policies together. Theoretical linkages are analysed by comparing the agglomeration effects of urbanisation and localisation economies and the spatial and non-spatial factors behind them. In contrast to current emphasis on non-spatial factors and specialisation processes in economic space, this study stresses spatial factors and diversification processes. This research is restricted to the strategic level of urban economic and spatial developments and policies.

New perspectives of explicitly including ECs into policies are addressed. In general, the concept of ECs encourages shaping city competitiveness in a globalising economy and place-promoted programs in local development. A cluster policy is a broad approach involving economic, social and spatial elements, and also pertinent to institutional transformation. For economic policy, the EC gives insights into the organisation of the urban economy by addressing developmental potentials and strengths, and also recognising threats and weakness. It advances economic policies from a focus on individual sectors to leveraging the synergy of a group of functionally related industries. Regarding urban planning, the adoption of ECs as

a policy instrument is helpful to establish a fine tuning between spatial and economic development to shape a healthy urban structure. Strategically, the concept of ECs contributes to urban planning prominently on several aspects:

- The concept of EC contributes to long-term development. It helps understanding local economic structures. By indicating common or complementary demand and / or supply structures of the market, the EC informs urban planners about economic demand and potentials.
- The EC is a proper concept to strategically link economic and spatial policies. This concept gives an interface for integrating economic potentials and location preferences for urban development. It also provides a window to coherently examine the economic-spatial structure and change of the city.
- ECs are an instrument to mobilise urban strategy through planning actions. This strategy is based on a response to external competition and internally optimised management.
- ECs are a main field for urban planning to deal with major infrastructure and land use projects.
- EC development can also be related to environmental and social sustainability policies. Allowing for a high concentration of economic activities and population, this is however not studied in this research, environmental and social issues can be addressed such as traffic congestion, environmental deterioration and social segregation.

The conceptual exploration resulted in an empirical model for cluster analysis. This model covers functional clusters in economic space, spatial clusters in geographical space and specific geographical and planning analyses. The model also highlights that the types of functional relationships and the diversity of spatial agglomeration are the key in the formation of functional and spatial clusters.

7.1.2 Results and recommendations for Beijing urban planning

Elements of a practical implementation of ECs in the urban planning practice have been developed and assessed in Chapters 3-6, including a functional analysis, a spatial analysis and a planning analysis. Chapter 3 introduces the study area of Beijing and its institutional context, economic and spatial developments and policies and cluster initiatives. Chapter 4 answers the question of '*what are clusters?*' by statistically deriving functional clusters. Chapter 5 addresses the issue of '*where are clusters?*' by detecting spatial

clusters of functionally related economic activities and their pattern in the city. Based on the identified functional and spatial clusters, a planning analysis is performed in Chapter 6. The main interest is in current urban economic-spatial dynamics, mechanism and roles of developing and developed ECs and reflections on current strategic economic and spatial master plans.

Technically, based on Input-Output (I-O) tables, the method of Principle Component Analysis (PCA) with modifications is employed to explore functional relations of industries to generate functional clusters for the periods of 1983-87, 1988-92, 1993-97 and 1998-2002. According to these functional clusters, Local Indicators of Spatial Autocorrelation (LISA), more specifically general and local Moran's I, are used to examine the spatial clusters by proxy of gross increase of employment at a postcode level for the major functional clusters in each period.

The identified functional clusters are based on horizontal and complementary functional relationships, meaning that the industries within a given cluster share the same or complementary demand or supply structures in the market. The commonness and complementariness are also a major source for innovations. The identified functional clusters are therefore helpful to understand local economic structures and common strengths, weaknesses, opportunities and threats for local economies. Compared with previous studies, the way the PCA is applied improves the means of identifying service industrial classes. It makes monitoring and analysing urban economic development more transparent and policy relevant.

Because functional clusters do not necessarily concentrate geographically, LISA is a good method to analyse spatial clustering. It provides a reference to the spatial representation of the functional clusters and the associated spatial patterns. The locational characteristics of the clusters are measured relative to the spatial distribution of the given economic activities at the observed geographical scale. Compared to the traditional understanding in the form of industrial districts, this new method of identifying spatial clusters is more valuable because it gives clues to the spatial dependency of economic activities, which suggests agglomeration, spillovers and other spatial effects. The derived spatial clusters therefore to some degree capture invisible economic and even social interactions in the urban spatial structure. Identified spatial clusters may have similar spatial identities and requirements for facilities and infrastructures.

In Chapter 6, the identified functional and spatial clusters are used in analyses of spatial or physical urban planning. A perspective of ECs is taken to investigate the dynamics and trends in urban economic space after the establishment of the market economy in China. Further, referring to policy documents, in interviews with experts on industrial and economic parks and on relevant research outcomes, the operations and roles of ECs in city development are discussed. The major findings are:

- The major functional clusters in Beijing are: Finance, Business, Insurance and Real Estate (FIRE), Information and Communication Technology (ICT), Education and Sciences (ES), Manufacture of Machinery and Metal Products (MMM), and Oil and Chemical Industries. In addition, Culture and Information (CI) and Tourism are growing in importance.
- A structural turn happened around the mid 1990s when the service sector replaced manufacturing in dominating the economy of the city.
- Manufacturing clusters move out of the centre and inner city and are replaced by service clusters, leading to an expansion of the urban centre. Manufacturing clusters concentrate along the Beijing-Tianjin corridor and the Badaling Expressway. The ICT cluster is located at the city edge.
- Different clusters show a different spatial and economic development. Manufacturing clusters become more functionally specialised and highly concentrated in geographical space. In contrast, service clusters are inclined to functionally diversify and are relatively dispersed spatially. These trends allows urban planners be more flexible in planning for services locations, but the spatial layout of manufacturing dominated ECs requires tuned provision of land and infrastructure, and coordination with housing and residential development. Potentially, it also gives a clue for a layout of mixed manufacturing and service clusters.
- Three main driving forces initiate and influence EC developments. The privatisation process to promote market-led economic development and globalisation are strong forces shaping and consolidating a strong cluster, while governments play a determinant role in cluster growth, decline and restructuring. No ECs have emerged without policy intervention. This suggests that governments should actively participate in cluster development but cautiously determine their roles in the different stages of cluster development. These three forces are interlinked, for instance globalisation is powered by market-orientation and free trade. These developments are however embedded in institutional

contexts. It reminds policy makers to carefully deal with the intricate relationships among these forces and to take advantage of the possibilities for actively intervening in EC development.

These findings, plus the results of the geographical analyses on land use and transportation changes, allow reflecting on current economic and spatial policies. The main conclusion and recommendations are:

- Some functional clusters that are declining or restructuring are still promoted in current economic policies, examples are textile and clothing and construction materials. Policy makers should reconsider these policies.
- The EC is a driver of urban spatial growth and change with respect to land use and the spatial organisation of the transportation network.
- Although the urban structure is physically evolving towards polycentrism, functionally the city region is still predominantly mono-centric.
- The idea of 'multi-centres' proposed in the new urban master plan is sensible, as this concept is based on the functional structure of the region. Seven out of the 10 sub-centres proposed show up in this research. However, similar to the spatial analysis of ECs in this study, the proposed service centres are in the central part of the urban region and manufacturing clusters are located at the city edges. Therefore, this plan still is not yet a clear break with the mono-centric urban form.
- Traffic congestion and substandard living quality are important problems. They tend to become aggravated by improper design of residential blocks.
- Another proposed scheme in the latest urban plan, that of the 'two belts', largely overlooks the importance of the economic corridor of Beijing-Tianjin and the Badaling Motorway. The idea of the urban plan is conceptually attractive but potentially hampers planning cooperation at the regional level.
- A preliminary analysis shows that the transportation system also follows the mono-centric pattern. The consequence is that many transportation problems occur on the main access roads to ECs, while other parts of the road network are often not fully used.
- Another problem is that most ECs are mono-functional, especially the manufacturing-based industrial parks. This makes them less flexible and 'future proof', as land use, transportation, housing provision and facilities are very much dedicated to a single type of economic activity.

- Generally, the development of various types of ECs greatly contributes to the growth of the city economy, but also exerts a big pressure on spatial development. Particularly in the long run, bottlenecks in spatial development will undermine economic health, for example the high cost of living and the deterioration of environment.
- From the point of view of EC-planning, a better balance between the distribution of service and manufacturing clusters in the urban centre and peri-urban areas and a further diversification of existing economic parks should be aimed at. Multi-functional land use should be encouraged.

This study has demonstrated that a cluster-based spatial-economic analysis is an improvement in supporting urban planning with relevant information over traditional sector-based economic analyses. On the other hand, the zoning instrument commonly used in urban planning is very much a blue-print approach. It largely overlooks the demand side requirements of relevant functional economic entities. In fact, many economic activities are interconnected and as a group being distributed in geographical space. Analysing and monitoring economic development via ECs is more realistic for urban planning.

7.2 Framework of integrating economic clusters in urban planning support

The conceptual and empirical work in this thesis has shown the value of including ECs as an element of strategic urban planning. The prime added value is linking physical and economic aspects of urban development. Based on the findings, a framework is proposed to integrate ECs in urban planning support systems. It considers three aspects: conceptual and explanatory considerations, methods and contextual (institutional, organisational) considerations. All these aspects are driven by, and in turn contribute to visions on urban development and to developing planning goals (Figure 7.1).

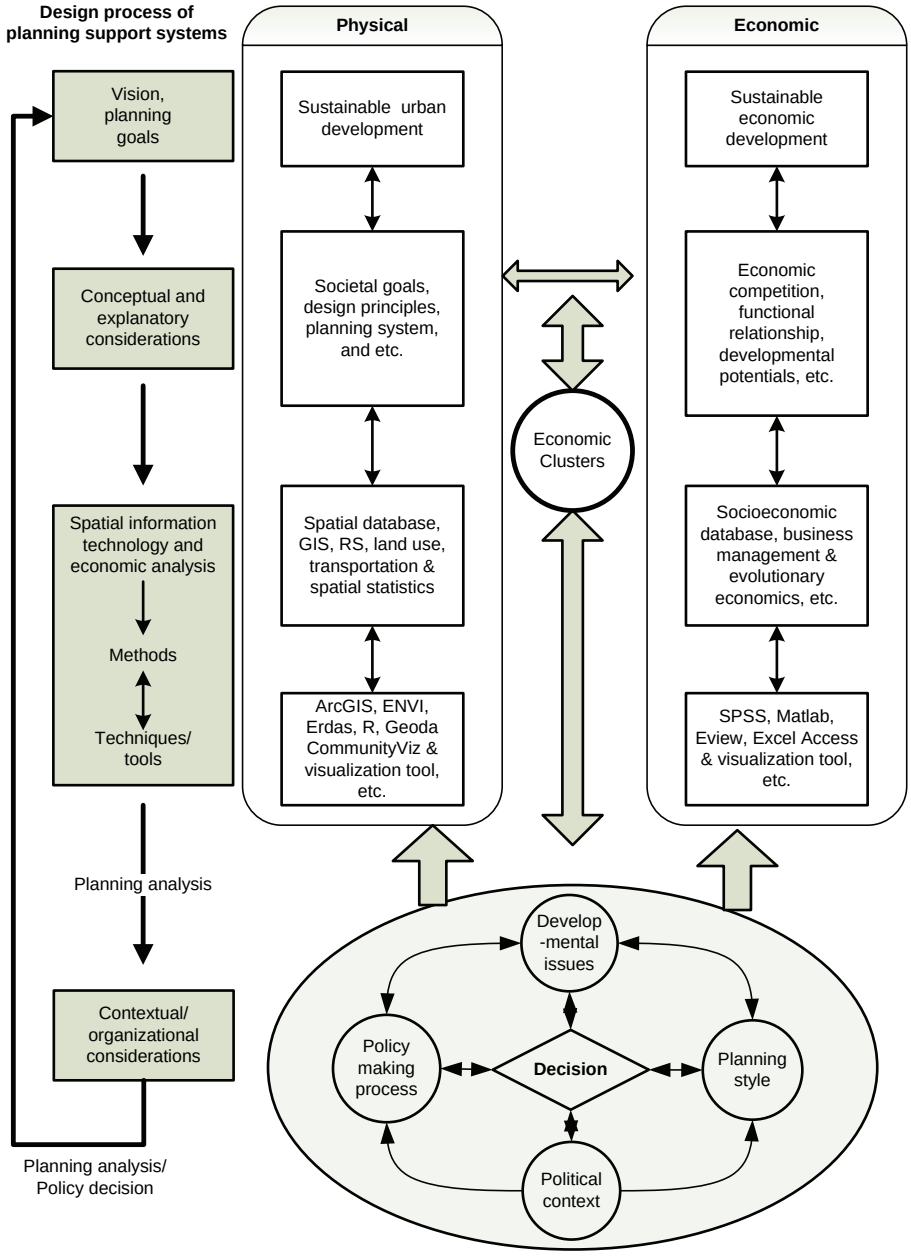


Figure 7.1 Framework of integrating economic clusters in planning support systems

Sustainable development is a strategic development goal and a planning vision for many cities. In order to achieve such a development path, the planning goal should include maintaining

economic growth, creating jobs and improving welfare of citizens. Related to this economic sustainability, the urban spatial structure should also provide good conditions for ecological preservation, efficient use of land and water and improving the quality of space for living. ECs are a good anchor point to elaborate these planning goals.

Regarding conceptual and explanatory considerations, this study touched upon the growth of ECs and city competitiveness, the roles of diversification and specialisation in agglomeration economies, and the elasticity of geographical proximity. The relationship with macro-trends like globalisation, economic competition and place-based promotion has also been addressed. On the physical side, themes like urban growth, quality of living, and efficiency and equity in the provision of services are highly relevant. Consideration should also be given to improving the effectiveness of the planning system and to city design principles.

With respect to methods used in planning support, this study used PCA to disclose horizontal and complementary functional relationships among industries. These related industries indicate supply and demand patterns and associated strengths and weaknesses. In turn, this knowledge leads to indications on how to best stimulate economic growth. Global and local Moran's I was used to explore spatial clusters by acknowledging the elasticity of geographical proximity and the spatial dependency of economic activities. Figure 7.1 gives an indication of the type of software which can be used in this type of research.

The identified functional and spatial clusters can be the focal points for a specific planning analysis that takes the context and organisational framework of planning into consideration. In the Chinese context, the major developmental issue is to maintain economic growth and find an appropriate sustainable urban-spatial development path. The planning style is gradually changing and becomes more market-oriented. This change runs parallel with a decentralisation of policy making processes, which requires collaboration especially for economic and urban planning departments. A clear role for ECs is expected to contribute to an improved planning and implementation process.

The methodology presented in Figure 7.1 provides a way to objectively monitor and analyse urban economic-spatial dynamics by means of ECs to supplement subjective knowledge. Local expertise and experiences however play critical roles in interpreting the results. The framework brings economists, geographers and planners together to communicate and share competences in the urban plan making process.

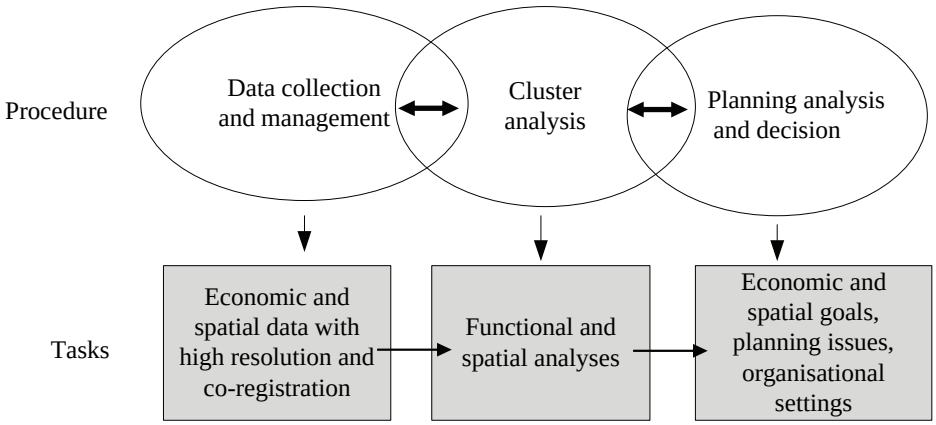


Figure 7.2 Implementation of economic cluster-oriented planning process

The implementation of this framework in urban planning requires three major steps: data collection and management, cluster analysis, and planning analysis and decision making. The analytical approach in this thesis is objective, which requires large volumes of data with high quality. Some data even need to be collected at fine spatial and thematic scales to provide detail information. Besides, co-registration between spatial and socioeconomic attributes, for example geo-coded thematic databases, is important. This research provides a good example for the cluster analysis by combing I-O and LISA techniques. In addition, geo-information science and technology data and methods (GIS, Remote Sensing) should be further explored in planning analysis. The results, presented as map, tables, figures and texts, should be presented to policy analysts so as to enable them to take into the local context into consideration. In policy analysis the tuning of economic and spatial developments and goals and the spatial effects of economic development are crucial issues.

The framework discussed should be partly implemented as an ICT-based planning support system. This system should be designed to also encourage interactive and collaborative planning with citizens and stakeholder involvement.

7.3 Recommendations for data provision and further research

7.3.1 Limitations of the analyses

This research had to face a number of limitations. The ability to use the I-O analysis to identify relevant clusters was limited by the lack of

more detailed data. An intrinsic shortcoming of I-O analysis is that it is basically static, with 5-year time slices and changes in classifications. However, for this study a time series was available which, with an adapted methodology, resulted in a useful trend analysis.

In the analysis of spatial clusters, the businesses were coded by fuzzy logic according to Chinese characters. Accordingly, the gross increase of employment could be used to approximate the spatial pattern of clusters on the postcode level, which is fine spatial scale providing useful information. In China, postcodes can be aggregated into administrative units and the economic survey is conducted on this level. The spatial unit is yet still quite large if we expect a high spatial resolution of ECs. The data of gross increase of employment can only be used to approximate the general pattern. Because people often change their jobs and there is lack of records of informal employment, this data is invalid if used to calculate accurate employment quantities. Owing to survey and confidentiality concerns, accurate employment data is not accessible, limiting our analysis.

In the planning analysis, land use data roughly matches the period for which spatial clusters are analysed. If time was available, this analysis could be improved by use of remotely sensed imageries. More detailed transportation analyses, such as accessibility studies, can be conducted if the required data such as population and employment of each postcode and the capacity of main bus and metro lines were available. The same is true for an analysis of traffic flows within the city.

7.3.2 Research data infrastructure

As this research demonstrates, the development of planning support systems needs to be based on a wide body of knowledge and various up-to-date and reliable data bases. Referring to the EC analysis in this research, the data availability should be improved at least in the following ways:

- Conduct a detailed and new type of I-O survey

It can be expected that high resolution of industrial classification will allow the extraction of more detailed functional clusters. The Chinese I-O survey is now basically at the 2-digit level. In order to adapt to the changing economic situation, updating the classification is necessary with respect to adding service sector classes and specifying information-related industries.

Generally, making the I-O survey is a supply-driven process. This is the case in many countries. More sensitivity to information demand

among the producers of I-0 tables and data files would be welcomed by many researchers of policy-relevant studies.

- Regularly reclassify business activities

As China is experiencing fast economic growth and change, the development of a database of business activities is necessary and will greatly facilitate urban planning analysis. This database should contain information on business activities, including basic characteristics such as starting-time, business categories, type of ownership, employment, address, and the life cycle of the establishment.

It is also necessary to provide a link-table and an overlap year between old and new business classification and coding systems so that time-series analysis is possible. The business classification system should also be compatible with economic statistics and the I-O survey to facilitate economic-spatial analysis.

- Smaller spatial units

It is expected that a large spatial scale is a premise to generate fine results. The currently used spatial units however hamper planning analysis. Main planning relevant phenomena are geo-coded by different geometrical systems, for instance land use by parcels, population by census tracts, and business registrations by postcodes. These coding systems are difficult to link, which constrains planning analysis. The best way forward is to perform these surveys and registrations based on geographical coordinates. This allows for flexible aggregation to flexible units such as raster cells, functional areas, homogenous areas and administrative units. The ongoing works of INSPIRE in Europe and GSDI at the global level provide references for China for establishing an adequate spatial information infrastructure.

- Publicise database for academic usage

In order to encourage public participation and academic research, most databases can and should be made available for academic research and for public participation and commercial exploitation. This is in particular true for records and statistics of basic socio-economic development and city (re)construction.

7.3.3 Future research

This research has focussed on the strategic level and on how to better exploit the role of ECs in urban planning. More analysis is needed for transportation issues related to EC development, such as the integration of parks and zones into urban transportation systems.

Also, at a lower spatial scale, within an adjacent to ECs, more insight into land use and density development, multi-functional land use and the link between internal and external transportation is desirable. Policy analysis should focus on specific incentives including tax facilities, public-private partnerships, planning and building control (planning and development guidelines and codes) to examine the effect these policy instruments and learn lessons from it.

This research only completes the first part of the proposed conceptual analytical framework of cluster studies, mainly at the macro level. It could continue with an in-depth, more qualitatively oriented analysis of the planning, realisation and operation of economic clusters and business parks and zones. At the micro (firm) level, based on identified spatial clusters, more detailed analysis can be conducted following the classic industrial districts model to investigate location choice, economic performance and social and economic relations. These more detailed and survey-based studies could complement the findings of the macro-level analyses to arrive at more balanced expertise on the relation between EC development and urban development.

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Summary

Realising an integrated approach of economic and spatial developments is an important issue in urban policy analysis and design. As Economic Clusters (ECs) become an important issue in contemporary urban development in both economic and spatial practices, the research addresses the potential role of ECs in improving urban planning support. Specifically, the aim of this PhD research is to explore the roles of ECs in strengthening the analytical and monitoring the ability of urban planning through better accommodating urban economic dynamics.

The aim is examined by three research questions, respectively on conceptual, practical and instrumental aspects. The research includes an empirical study of Beijing analysing the evolution of ECs in both economic and geographical spaces and the relationship between cluster developments and urban growth.

Theoretical explorations conceptually show the value of incorporating ECs into models of urban planning processes by providing fine tuning between economic and spatial developments. Theoretical analysis also indicates the need for an empirical approach to address the nature of EC development in economic space (functional clusters) and in geographical space (spatial clusters).

With the case study of Beijing, elements of a practical implementation of ECs in urban planning practice are developed and assessed, which includes identifying functional and spatial clusters and examining their developments in relation to urban growth and change. Based on input-output tables, statistical analysis derives functional clusters, answering the question of 'what are clusters?' Correspondingly, spatial statistics techniques addresses the issue of 'where are clusters?' by detecting spatial clusters of functionally related economic activities and their patterns in the city. Further, planning analysis is implemented with concerns of urban spatial growth, transportation and housing. The major empirical findings are: ECs are a key driver and closely related to current urban economic-spatial dynamics; the cluster pattern changes indicate that Beijing's urban structure is physically evolving towards polycentrism, functionally the city region is still predominantly mono-centric, which challenges the current urban plans. Accordingly, cluster-based recommendations stress strengthening manufacturing-services relationships, balancing diversification and specialisation in spatial development, and integrating clusters into the functioning of places for healthy and sustainable urban spatial-economic development.

Based on the conceptual and empirical work in this thesis, a framework is proposed to integrate ECs as an instrument in urban planning support systems. It considers three aspects: conceptual and explanatory considerations, methods and contextual (institutional, organisational) considerations. In order to realise such a system, suggestions are also given on building data capacity and on additional case-based qualitative-oriented research.

The prime value added by the research is linking the physical and economic aspects of urban development and addressing the issue of ECs as an organising principle and driver for the current and future urban growth. The research presents the theoretical rationale, an implementation approach and an institutional framework.

Keywords: Urban Planning Support; Economic Clusters; Urban Economic-Spatial Dynamics; Urban Growth; Development Strategy; Input-Output Analysis; Spatial Analysis; Beijing

Samenvatting

Economische clusters en een betere ondersteuning van de stedelijke planning

Voor stedelijke ontwerpers en planners is een geïntegreerde benadering van economische en ruimtelijke ontwikkelingen een belangrijk thema bij de beleidsvoorbereiding. Economische clusters (EC's) zijn een verschijnsel van betekenis geworden in de huidige ontwikkeling van steden, zowel economisch als ruimtelijk. Dit onderzoek analyseert de potentiële rol die EC's kunnen spelen in het ondersteunen van de ruimtelijk-stedelijke ontwikkeling en het beleid. Met name de rol die EC's kunnen spelen bij het versterken van de mogelijkheden van monitoring en analyse krijgen de aandacht. Economische dynamiek moet een onlosmakelijk deel gaan uitmaken van de ruimtelijke planning.

Het doel van de studie is in drie onderzoeksvragen uiteengelegd. De vragen zijn respectievelijk conceptueel, praktisch en instrumenteel van aard. Een belangrijk onderdeel van de analyse is een empirische studie van de evolutie van EC's in de regio Beijing, zowel in de economische als de geografische ruimte. Daarbij is gezocht naar verbanden tussen clusterontwikkeling en ruimtelijke groei.

De theoretische verkenningen tonen, op conceptueel niveau, de waarde aan van het opnemen van EC's in modellen voor stedelijke planningprocessen. Op die wijze kunnen economische en ruimtelijke ontwikkelingen beter op elkaar afgestemd worden. De literatuurstudie laat ook zien dat een empirische benadering noodzakelijk is om de aard van de clusterontwikkelingen in de economische ruimte (functionele clusters) en de geografische ruimte (ruimtelijke clusters) te doorgronden.

Doormiddel van de gevalstudie van Beijing kunnen aspecten van een praktische implementatie van de voorgestelde aanpak ontwikkeld en geëvalueerd worden. Het identificeren van functionele en ruimtelijke clusters en het nagaan van hun ontwikkeling in relatie tot stedelijke groei en verandering vormen daar belangrijke onderdelen van. Op basis van inzet-afzet tabellen worden met statistische analyses functionele clusters geconstrueerd om de vraag 'wat zijn clusters?' te kunnen beantwoorden. Geostatistische methoden zijn gebruikt om de vraag 'waar zijn clusters?' van een antwoord te kunnen voorzien. Het gaat dan om ruimtelijke clusters van functioneel samenhangende economische activiteiten. De uitkomsten worden doorgetrokken naar

een plannings/beleidsanalyse waarbij ruimtelijke groei, vervoer en huisvesting in de beschouwing worden betrokken. De belangrijkste uitkomsten zijn: EC's zijn een belangrijke drijvende kracht van de huidige economische en ruimtelijke stedelijke dynamiek; de patroonveranderingen van de economische clusters in Beijing duiden op geleidelijke wijzigingen in de stedelijke vorm richting polycentrisme; functioneel is de stad nog overwegend monocentrisch en dit vormt daarom een uitdaging voor de huidige stedelijke plannen. Uit de clusteranalyses blijkt dat de industriële sectoren en de dienstverlening steeds meer verweven raken en dat een nieuw evenwichtig gevonden moet worden tussen diversificatie en specialisatie in de ruimtelijke ontwikkeling. Ook dienen de clusters beter ingepast worden in het functioneren van locaties om een gezonde en duurzame ruimtelijk-economische ontwikkeling te bewerkstelligen.

Gebaseerd op de conceptuele en empirische analyses in dit proefschrift, wordt een model voorgesteld om EC's als een instrument op te nemen in informatiesystemen die stedelijke planning ondersteunen. Drie aspecten daarvan worden belicht: de te gebruiken concepten en verklaringsgrondslagen, de toe te passen methoden en de contextuele (institutionele, organisatorische) overwegingen. Om zo'n systeem te kunnen realiseren worden ook suggesties gegeven over de noodzakelijke gegevensbasis en over aanvullend kwalitatief georiënteerd onderzoek aan de hand van gevalstudies.

De belangrijkste toevoeging aan de wetenschappelijke kennis van deze studie is het verbinden van economische en ruimtelijke aspecten van stedelijke ontwikkeling. Daarbij is vooral gekeken naar de rol van economische clusters als organisatieprincipe en als stuwende factor voor toekomstige stedelijke groei. Het onderzoek geeft zowel een theoretische verantwoording als een aanpak voor implementatie en een institutioneel kader.

摘 要

经济集群对提高城市规划决策支持中的作用研究

提高经济与空间的整合机制是城市政策分析与设计的重要议题。在当代城市的实践中，经济集群已成为经济发展和城市建设的重要组织形式。本文关注经济集群在提高城市规划决策支持中的作用，其中心目的是以产业集群为抓手加强城市规划对经济动态的分析和监控能力。

论文的研究目的通过概念理论、实证方法和政策性工具三个方面来实现。实证研究以北京案例，探讨和分析集群在经济空间和地理空间上的增长与演变，检验集群发展与城市增张之间的关系。

具体来说，理论探索从概念层面剖析了经济集群在城市规划模型中的价值，指出集群有利于建立经济与空间发展之间的互动响应机制。理论剖析同时也阐发了实证研究的技术路线，这一技术路线可以统一考虑经济集群发展中两个最核心的问题：经济空间上的功能性集群和地理空间上的空间集群，从而提高城市规划决策支持的能力。

根据理论剖析的结果，具体开发了将经济集群纳入规划的技术方法，并以北京为案例，对这一方法的应用作了分析与评价。这一方法包括三个部分：鉴别功能性集群、空间集群和检验集群发展与城市增张间的关系。具体来说，利用投入产分析揭示出功能性产业集群，回答了“城市的产业集群有哪些和产业构成”的问题。相对应于集群的产业构成，通过空间统计等技术手段回答了“产业集群在哪”的问题，并揭示了在产业功能关联的情况下空间集群的分布情况及其相对应的城市空间组织模式。进而在规划分析中，对经济集群与城市空间增长、交通和住宅安置等方面进行具体的讨论。主要实证结果包括：经济集群和目前城市经济——空间动态存在密切的关系，是城市经济空间组织形态的主要动力，集群视角揭示了北京城市结构空间上正在向多中心演变，而经济活动的空间结构仍然是单中心，这一局面对目前规划（多中心规划）的可行性提出了质疑。此外，根据集群研究的结果，作者对未来发展提出了如下建议，根据集群化思路（1）加强制造业——服务业之间的联系；（2）平衡和综合考虑空间发展中经济活动的多样化与专业化；以及（3）充分利用集群来实现空间定位问题，实现城市的健康和可持续发展。

在概念理论研究和实证分析的结果上，论文最后提出了将经济集群作为政策性工具纳入城市规划系统的框架。这一框架充分考虑三个方面：概念性和理论性的相关性，方法与技术上的操作性，以及制度和组织环境上的可实践性。为了实现这一框架，论文根据实证分析过程对数据支持体系建设和未来更加细微的定性化研究提出了建议。

论文的主要价值在于以经济集群联系了城市发展中的经济与空间两个方面，并强调集群化发展将是未来城市增长的核心动力。并且，论文提供了理论上的合理性分析和具体实证方案，为政策性框架的改进提供了依据。

关键词：城市规划决策支持；经济集群；城市经济——空间动态；城市增长；发展战略；投入产出分析；空间分析；北京

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Appendix I Principle component analysis

Since 1974, China has started surveying its economy and making Input-Output (I-O) tables, under the commission of the Statistic Bureau, Committee of Reform and Development, and other institutes and universities. The first complete I-O table was made for the year of 1987 and later every 5 years, the I-O survey is conducted and a table is produced. The latest I-O survey for 2007 was finished in 2009 and the table is not published yet. Therefore, there are four I-O tables of 1987, 1992, 1997 and 2002 with industrial classifications comparable to the International Standard Industrial Classifications at 2- or 3-digit levels. Table Appendix I.1 lists a comparison between Chinese SIC for the I-O table in 2002 and ISIC of the United Nations. These tables are available for the nation and almost all provinces (including provincial cities) (Chinese Statistical Bureau, 2003; Zhang, 2006).

Table Appendix I.1 Comparison between Chinese SIC and ISIC from the United Nation, by case of Beijing I-O table in 2002

2 位上的中国投入产出行业分类	Chinese SIC at 2-digit	ISIC
煤炭开采和洗选业	Mining of coal and lignite	2
黑色金属矿采选业	Mining of ferrous-metal ores	0
有色金属矿采选业	Mining of non-ferrous metal ores	0
其他非金属矿采选业	Quarrying of stone, sand and clay	3
谷物磨制业	Grain mill products, starches and starch products	3
饲料加工业	Manufacturing of prepared animal feeds	3
植物油加工业	Vegetation oil	0
屠宰及肉类加工业	Meat processing	3
水产品加工业	Processing of fish, crustaceans and molluscs	3
其他食品加工和食品制造业	Other food products	3
酒精及饮料酒制造业	Manufacturing of alcohol and beverages	2
其他饮料制造业	Other beverage production	0
烟草制品业	Tobacco	2
棉、化纤纺织及印染精加工业	Cotton, spinning, weaving and finishing of textiles	3
毛纺织和染整精加工	Wool textiles	0
麻纺织、丝绢纺织及精加工业	Flax and silk textiles	0
纺织制产品制造业	Fabric goods	0
针织品、编织品及其制品制造业	Knitting	0
纺织服装、鞋、帽制造业	Wearing apparel	2
皮革、毛皮、羽毛（绒）及其制品业	Leather and related production	2
木材加工及木、竹、藤、棕、草制品业	Woods, bamboo products except furniture and articles of straw and plaiting materials	2
家具制造业	Furniture	2
造纸及纸制品业	Paper and paper products	2
印刷业和记录媒介的复制业	Printing and reproduction of recorded media	2
文化用品制造业	Manufacturing of art and cultural goods	3
玩具体育娱乐用品制造业	Sports and entertainment goods	3

石油加工业	Oil industry	2
炼焦业	Coke	2
基础化学原料制造业	Basic chemical materials	3
肥料制造业	Fertilizer	3
农药制造业	Pesticides	0
涂料、颜料、油墨及类似产品制造业	Manufacturing of dye, oil paint and other related products	0
合成材料制造业	Chemosynthetic materials	0
专用化学产品制造业	Manufacturing of specialized chemical products	0
日用化学药品制造业	Daily-used medicinal chemical goods	3
信息化学品制造业	Manufacturing of semiochemicals	0
医药制业	Pharmaceuticals	2
化学纤维制造业	Manufacturing of man-made fibres	3
橡胶制品业	Manufacturing of rubber	3
塑料制品业	Manufacturing of plastic products	3
水泥、石灰和石膏制造业	Cement and asbestos products	0
玻璃及玻璃制品制造业	Glass and glass products	3
陶瓷制品制造业	Pottery, china and earthenware	0
耐火材料制品制造业	Fireproof products	0
其他非金属矿物制品制造业	Other non-metallic mineral products	3
炼铁业	Manufacturing of basic iron	3
炼钢业	Manufacturing of basic steel	3
钢压延加工业	Steel-processing	0
铁合金冶炼业	Casting of metals	3
有色金属冶炼业	Non-ferrous metal processing	0
有色金属压延加工业	Non-ferrous metal smelting	0
金属制品业	Metalworking	3
锅炉及原动机制造业	Manufacturing of boiler, engines and turbine	0
金属加工机械制造业	Manufacturing of metalworking machinery	0
其他通用设备制造业	Manufacturing of other general-purpose machinery	3
农林牧渔专用机械制造业	Special machinery for agriculture	0
其他专用设备制造业	Manufacturing of other special-purpose machinery	3
医疗仪器设备及器械制造业	Manufacturing of pharmaceutical equipments	0
铁路运输设备制造业	Special machinery for transport	0
汽车制造业	Manufacturing of automobile	3
汽车零部件及配件制造业	Manufacturing of auto-parts	3
其他交通运输设备制造业	Other trailers and semi-trailers	3
电机制造业	Manufacturing of generators	0
家用器具制造业	Manufacturing of household goods	0
其他电气机械及器材制造业	Manufacturing of other electric machinery and equipment	0
通信设备制造业	Manufacturing of communication equipment	3
电子计算机整机制造业	Manufacturing of computers	3
其他电子计算机设备制造业	Manufacturing of computer parts	3
电子元器件制造业	Manufacturing of electronic components	3
家用视听设备制造业	Manufacturing of consumer’s electronics	3
其他通信、电子设备制造业	Manufacturing of other communication equipments	0
仪器仪表制造业	Manufacturing of measuring, testing, navigating and control equipment; watches and clocks	3
文化、办公用机械制造业	Machinery for culture and office goods	0
工艺美术品制造业	Manufacturing of art crafts	3

其他工业	Other manufacturing	0
电力、热力的生产和供应业	Electricity, steam and hot water production and supply	2
燃气生产和供应业	Gas production and supply	2
水的生产和供应业	Water supply	2
建筑业	Construction	1
铁路旅客运输业	Railway passenger transport	3
铁路货运业	Railway freight transport	3
道路运输业	Land transport except railway and public transport	3
城市公共交通运输业	Public transport	3
水上运输业	Water transport	2
航空旅客运输业	Air passengers transport	3
航空货运业	Air freight transport	3
仓储业	Warehousing	2
邮政业	Postal and courier activities	2
信息传输服务业	Information communication services	2
计算机服务业	Computer services	2
软件业	Software	2
批发和零售贸易业	Retail and wholesale	2
住宿业	Accommodation	2
餐饮业	Food and beverage services	2
金融业	Finance	2
保险业	Insurance	2
房地产开发业	Real estate	2
物业管理业	Property management	2
租赁业	Rental and leasing activities	2
商务服务业	Business services including activities of head of offices, management and consultancy activities	2
旅游业	Tourism	0
广告业	Advertisement	2
会议及展览服务业	Conventions, meeting and exhibition services	0
科学研究事业	Scientific research and development	2
专业技术服务业	Professional technical services	2
科技交流和推广服务业	Technology communication and services	2
地质勘查业	Geological prospecting and water management	0
水利管理业	Water management	0
环境资源管理业	Services to building and landscape	2
公共设施管理业	Public facility management	0
居民服务业	Personal and household services	2
其他服务业	Other services	0
教育事业	Education	2
卫生事业	Human care	2
社会保障和社会福利业	Social work	2
文化艺术和广播电影电视业	Culture, arts and broadcasts	2
体育事业	Sports activities	2
娱乐业	Entertainment	2
公共管理和社会组织	Public administration and non-government organisation	0

Note: 1. International Standard Industrial Classifications (ISIC of United Nations) are available at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27&Lg=1, last assessed on 2009-05-01.

2. The ISIC code: 2: at 2-digit, 3: at 3-digit, 0: not comparable, but most are more detailed than the 2-digit. Only construction is at 1-digt in ISIC.

Like in other countries, the input-output depicts inter-industry relations of an economy, by showing how the output of one industry is an input to each other industry. A given input is typically enumerated in the column of an industry and its outputs are enumerated in its corresponding row. This forms a transaction matrix. A typical I-O table, taking Beijing as example, is as Table Appendix I.2. The total output comprises of intermediary outputs and final demand, which should equal to the total input consisting of intermediary inputs plus value added.

Table Appendix I.2 An example of input-output table of Beijing

		Transaction matrix						Final demand				Total output
		A	B	C	D	E	F	Final consume	Capital accumulation	Import	Export	
Input	Industry A	10	15	10	2	5	6	2	1	1	0	52
	Industry B	5	17	7	7	3	8	1	1	2	1	52
	Industry C	7	3	8	4	5	3	3	3	2	2	40
	Industry D	11	5	2	13	6	4	5	2	0	9	57
	Industry E	4	0	1	14	3	6	2	3	2	0	35
	Industry F	2	6	7	10	2	6	4	7	1	4	49
Value added	Basic depreciation	4	2	1	1	3	2					
	Depreciation for fix assets	4	1	1	1	2	1					
	Labors' payment	3	1	1	3	1	5					
	Profits and tax	1	1	1	1	3	3					
	Welfare funds	1	1	1	1	2	5					
	Total input	52	52	40	57	35	49					

The process of PCA for generating clusters is as follows (For more detailed information, see the statistic book '*Discovering Statistics Using SPSS'* (Field, 2005, p619-679)). Take the data of Table Appendix I-2 for example. The technical coefficient was calculated by the transaction flows divided by the total intermediary inputs or output. The purchase coefficients were obtained as:

	A	B	C	D	E	F
A	0.256	0.326	0.286	0.040	0.208	0.182
B	0.128	0.370	0.200	0.140	0.125	0.242
C	0.179	0.065	0.229	0.080	0.208	0.091
D	0.282	0.109	0.057	0.260	0.250	0.121
E	0.103	0.000	0.029	0.280	0.125	0.182
F	0.051	0.130	0.200	0.200	0.083	0.182

and the sale coefficients were:

	A	B	C	D	E	F
A	0.208	0.313	0.208	0.042	0.104	0.125
B	0.106	0.362	0.149	0.149	0.064	0.170
C	0.233	0.100	0.267	0.133	0.167	0.100
D	0.268	0.122	0.049	0.317	0.146	0.098
E	0.143	0.000	0.036	0.500	0.107	0.214
F	0.061	0.182	0.212	0.303	0.061	0.182

For each pair of industries A and B, the demand and supply structures were:

$$P_A \begin{pmatrix} 0.256 \\ 0.128 \\ 0.179 \\ 0.282 \\ 0.103 \\ 0.513 \end{pmatrix}, \quad P_B \begin{pmatrix} 0.326 \\ 0.370 \\ 0.065 \\ 0.109 \\ 0 \\ 0.130 \end{pmatrix} \quad S_A \begin{pmatrix} 0.208 \\ 0.106 \\ 0.233 \\ 0.268 \\ 0.143 \\ 0.061 \end{pmatrix}, \text{ and } \quad S_B \begin{pmatrix} 0.313 \\ 0.362 \\ 0.100 \\ 0.122 \\ 0 \\ 0.182 \end{pmatrix}$$

The structural similarity between A and B can be assessed by correlation analysis of these four structures.

The demand similarity: $r(P_A, P_B) = 0.201$;

The supply similarity is $r(S_A, S_B) = -0.231$;

The demand (A) – supply (B) similarity is $r(P_A, S_B) = 0.139$;

The supply (A) – demand (B) similarity is $r(S_A, P_B) = -0.177$.

The maximum value 0.201 was taken as the most important linkages that connect A and B together. Likewise for the other industries, and the maximum structural similarity matrix was obtained as:

	A	B	C	D	E	F
A	1.000	0.201	0.056	-0.160	0.982	-0.437
B	0.201	1.000	0.698	-0.591	-0.019	0.635
C	0.056	0.698	1.000	-0.741	0.000	0.112
D	-0.160	-0.591	-0.741	1.000	-0.049	0.586
E	0.982	-0.019	0.000	-0.049	1.000	-0.660
F	-0.437	0.635	0.112	0.586	-0.660	1.000

This matrix was used as the variable for the PCA in SPSS 15. The table of explained variances indicates under the condition that eigenvalues>=1, 96.66% variances would be extracted. Hence, two factors were finally derived. According to the component matrix

rotated by the varimax method, factor 1 has more information on sectors A, E and F since their factor loadings are high. Likewise, factor 2 should be explained by referring to industries B, C and D.

Table Appendix I.3 Total variances explained

	Eigenvalues	% of Variance	Cumulative %
1	3.13	52.12	52.12
2	2.67	44.55	96.66
3	0.15	2.54	99.20
4	0.05	0.79	100.00
5	0.00	0.00	100.00
6	0.00	0.00	100.00

Table Appendix I.4 Component matrix

	Component	
	1	2
A	0.981	
B		0.924
C		0.989
D		-0.915
E	0.994	
F	-0.981	

Note: Varimax method rotation; factor loadings only showed with absolute value no less than 0.4.

Table Appendix I.5 Component matrix of key industries, 2002

Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Eigenvalues	**7.5**	**5.5**	**5.0**	**4.6**	**4.5**	**3.3**	**2.4**	**2.1**	**1.5**
% of Variance	**18.7**	**13.7**	**12.4**	**11.6**	**11.3**	**8.1**	**6.0**	**5.2**	**3.8**
Other food products							**0.92**		
wearing apparel	**0.52**								**0.59**
Printing and reproduction of recorded media			**0.43**		**0.49**				**0.57**
Oil industry			**0.94**						
Manufacturing of basic chemical materials			**0.95**						
Chemosynthetic materials			**0.96**						
Pharmaceutical products and preparations						**-0.95**			
Other non-metallic mineral products			**0.78**						**0.44**
Steel processing	**0.63**	**0.44**			**0.49**				
Metalworking		**0.84**							
Manufacturing of other general machinery		**0.94**							
Manufacturing of other special machinery		**0.88**							
Manufacturing of auto vehicles		**0.56**							
Manufacturing of other electric machinery and equipment		**0.63**							
Manufacturing of communication equipments				**0.87**					
Manufacturing of computers				**0.80**					
Manufacturing of computer parts				**0.79**					
Manufacturing of electronic components				**0.88**					
Manufacturing of measuring, testing, navigating and control equipment, watches and clocks				**0.77**					
Electricity, steam and hot water production and supply	**0.75**		**0.48**						
Construction		**0.86**							
Land transport except railway and public transport	**0.96**								
Air passengers transport	**0.53**		**0.66**						
Information communication services								**0.83**	
Computer services				**0.42**				**-0.43**	
Software		**-0.57**	**-0.41**						

Accommodation	**0.83**								
Food and beverage services							**0.90**		
Finance	**0.95**								
Real estate	**0.98**								
Property management	**0.93**								
Business services including activities of head of offices, management and consultancy activities	**0.89**								
Advertisement									
Scientific research and development					**0.92**				
Professional technical services						**-0.95**			
Technology communication and services					**0.85**				
Education					**0.94**				
Human care						**-0.95**			
Culture, arts and broadcasts								**0.77**	
Public administration and non-government organisations					**0.76**				

Note: for clarity, only industries with factor loading>=0.4 are showed for appendices I-5-7.

Table Appendix I.6 Component matrix of manufacturing industries, 2002

Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Eigenvalue	**12.5**	**10.9**	**6.2**	**5.6**	**4.8**	**4.6**	**3.4**	**3.2**	**2.8**	**2.3**	**2.1**	**1.8**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**
% of Variance	**15.9**	**13.8**	**12.5**	**7.0**	**6.1**	**5.8**	**4.4**	**4.0**	**3.6**	**2.9**	**2.7**	**2.2**	**1.8**	**1.7**	**1.6**	**1.5**	**1.4**
Mining of coal and lignite			0.90														
Mining of ferrous-metal ores								0.95									
Mining of non- ferrous-metal ores													0.70				
Quarrying of stone, sand and clay									0.92								
Grain mill products, starches and starch products											0.68						
Manufacturing of prepared animal feeds											0.64				-0.52		
Edible vegetation oil											0.44						
Meat processing											0.58						
Processing of fish, crustaceans and molluscs				0.94													
Other food products											0.81						
Beverages and liquor	0.56		0.47														
Other beverage production							0.79										
Tobacco							0.58										
Cotton, spinning, weaving and finishing of textiles					0.90												
Wool textiles														0.58			
Flax and silk textiles					0.90												
Fabric goods					0.87												
Knitting					0.69												
Wearing apparel					0.82												
Leather and related production																0.74	
Woods, bamboo products except furniture and articles of straw and plaiting materials						0.94											
Furniture						0.96											
Paper and paper products							0.80										
Printing and reproduction of recorded media							0.86										
Manufacturing of art and cultural goods						0.95											
Sports and entertainment goods	0.51					0.66											
Oil industry												0.79					
Coke			0.95														
Manufacturing of basic chemical materials				0.83													

Fertilizer																	
Pesticides															-0.69		
Manufacturing of dye, oil paint and other related products				0.65													
Chemosynthetic materials				0.71								0.59					
Manufacturing of specialised chemical products				0.92													
Daily-used medicinal chemical goods																	
Manufacturing of semiochemicals				0.84													
Pharmaceuticals															-0.82		
Manufacturing of man-made fibres				0.93													
Manufacturing of rubber												0.54					
Manufacturing of plastic products												0.68					
Cement and asbestos products			0.58						0.61								
Glass and glass products			0.66														
Pottery, china and earthenware	0.44		0.66														
Fireproof products									0.88								
Other non-metallic mineral products									0.73			0.41					
Manufacturing of basic iron	0.72																
Manufacturing of basic steel								0.91									
Steel process								0.90									
Casting of metals										0.90							
Non-ferrous metal processing										0.84							
Non-ferrous metal smelting										0.90							
Metalworking	0.87																
Manufacturing of boiler, engines and turbine	0.96																
Manufacturing of metalworking machinery	0.73	0.53															
Manufacturing of other general-purpose machinery	0.90																
Special machinery for agriculture	0.81																
Manufacturing of other special-purpose machinery	0.90																
Manufacturing of pharmaceutical equipment																	0.64
Special machinery for transport	0.56												0.52				
Manufacturing of automobile																0.73	
Manufacturing of automobile accessories	0.80																
Other trailers and semi-trailers																	
Manufacturing of generators	0.83																
Manufacturing of household goods	0.79																

Manufacturing of other electric machinery and equipment	0.43																0.50
Manufacturing of communication equipments		0.96															
Manufacturing of computers		0.96															
Manufacturing of computer parts		0.96															
Manufacturing of electronic components		0.95															
Manufacturing of consumer electronics		0.95															
Manufacturing of other communication equipments		0.88															
Manufacturing of measuring, testing, navigating and control equipment, watches and clocks		0.85															
Machinery for culture and office goods		0.95															
Manufacturing of art crafts														0.83			
Other manufacturing			0.49			0.64											
Electricity, steam and hot water production and supply			0.94														
Gas production and supply			0.89														
Water supply													0.68				
Construction	0.88																

Table Appendix I.7 Component matrix of service industries, 2002

Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Eigenvalues	**14.3**	**5.6**	**5.6**	**4.3**	**2.6**	**2.1**	**1.5**
% of Variance	**35.7**	**14.0**	**13.9**	**10.7**	**6.4**	**5.2**	**3.7**
Railway passenger transport	0.88						
Railway freight transport	0.95						
Land transport except railway and public transport	0.96						
Public transport	0.93						
Water transport	0.95						
Air passengers transport	0.85						
Air freight transport	0.76						
Warehousing	0.90						
Postal and courier activities				(0.46)	0.54		
Information communication services						0.88	
Computer services		0.75			0.45		
Software		0.78					
Retail and wholesale	0.65		0.71				
Accommodation	0.93						
Food and beverage services			0.94				
Finance	0.76		0.60				
Insurance			0.92				
Real estate	0.88						
Property management	0.89						
Rental and leasing activities	0.92						
Business services, including activities of head of offices, management and consultancy activities	0.80		0.52				
Tourism			0.75				0.41
Advertisement	(0.45)						
Conventions, meeting and exhibition services							0.88
Scientific research and development		0.70					
Professional technical services		0.75					
Technology communication and services	(0.42)	0.80					
Geological prospecting and water management		0.68		0.45			
Water management				0.88			
Services to building and landscape				0.88			
Public facility management					0.70		
Personal and household services			0.91				
Other services	0.90						
Education		0.72					
Human care					0.83		
Social work				0.90			
Culture, arts and broadcasts						0.88	
Sports activities	(0.41)	0.58					
Entertainment	0.79		0.55				
Public administration and non-government organizations		0.64					

Table Appendix I.8 Comparing communalities of variables between the aggregate and separate approaches in PCA, Beijing, 2002

Key Industries	Communality of the aggregate approach	Communality of the separate approach
Other food products	0.97	0.90
wearing apparel	0.87	0.91
Printing and reproduction of recorded media	0.91	0.83
Oil industry	0.96	0.83
Basic chemical materials	0.95	0.94
Chemosynthetic materials	0.97	0.96
Pharmaceuticals	0.99	0.86
Other non-metallic mineral products	0.96	0.95
Steel-smelting	0.92	0.99
Metalworking	0.88	0.93
Manufacturing of other general machinery	0.94	0.90
Manufacturing of other special machinery	0.88	0.93
Manufacturing of automobile	0.59	0.76
Manufacturing of other electric machinery and equipment	0.54	0.67
Manufacturing of communication equipments	0.93	0.98
Manufacturing of computers	0.96	0.98
Manufacturing of computer parts	0.97	0.97
Manufacturing of electronic components	0.92	0.93
Manufacturing of measuring, testing, navigating and control equipment, watches and clocks	0.78	0.76
Electricity, steam and hot water production and supply	0.96	0.96
Construction	0.96	0.95
Land transport except railway and public transport	0.98	0.98
Air passengers transport	0.97	0.93
Information communication services	0.92	0.91
Computer services	0.89	0.89
Software	0.89	0.66
Accommodation	0.96	0.95
Food and beverage services	0.98	0.93
Finance	0.94	0.99
Real estate	0.98	0.97
Property management	0.98	0.95
Business services including activities of head of offices, management and consultancy activities	0.96	0.98
Advertisement	0.54	0.54
Scientific research and development	0.94	0.90
Professional technical services	0.98	0.77
Technology communication and services	0.92	0.88
Education	0.98	0.85
Human care	0.99	0.85
Culture, arts and broadcasts	0.81	0.92
Public administration and non-government organization	0.93	0.84

Appendix II: Industrial classification coding for business by fuzzy logic

Chinese characters are a combination of picture, sound and meaning. By comparing, the character is more related to the meaning than the sound, and that, is the meaning of the character can be directly read out. Usually 2 or 3 or sometimes 4-6 characters are combined to a term, which specifically expresses a meaning with less uncertainty especially for scientific and technical usages.

When registering, most companies clearly state their business scopes such as textile, glass manufacture, leasing or hair cut. As a Chinese custom, they are also like to literately indicate their business in their titles for instance XXX haircut shop, XXX printing, and XXX restaurant. Therefore, analysing and coding Chinese characters according to business scopes and titles is an ideal way to extract standard classifications for each company from messy entries with a verity of expressions.

There are 465,360 entries for the business establishments in the period of 1956-2002, in which 418,358, about 90.3% enterprises indicate their enrolled employment in the registration. This data set is too large to manually code. Fuzzy coding is therefore employed according to the logic of Chinese characters.

The coding process included trial, coding and verifying steps. The trail process was to try out the term which was appropriate for a particular code. The term was usually comprised of 2-4 characters. According to Chinese Standard Industrial Classification (SIC, see appendix I) on the 2-digit level, we selected terms starting form mostly used ones and gradually tried out the words less used for each industrial classification. Avail of the Visual Basic language in Access, the dataset of the period 1998-2002 including 330,866 was used for test. Two purposes were involved in the trail process: to improve the accuracy of the words for the coding and to minimally reduce the records that were not coded. Finally, keywords were resulted prepared for coding the whole database.

In the coding process, the item of business scope worked as the first option, which was scanned and coded by the computer. However, the dataset was not very neat. Some business only had their titles. In that case, the business title works as an alternative.

The verifying process was to check the accuracy of the coding and missing entries. It must be stated that it is possible that a company belongs to different categories of business activities. In order to solve this problem, the coding process was run twice and then the code of

the companies was finally decided by higher engaged industrial classification for instance the finance is higher than business, and R&D is higher than retailing. Finally, for each industrial classification, around 30-70 entries for each period were randomly selected and manually double checked. Overall the accuracy was above 93%.

It is a very complex and laborious process for fuzzy coding. The term selected for coding is much dependent on researcher's experiences and quite often we had to look up into the SIC table for the details. Sharing more than one industrial classification is quite common for service companies. In order to reduce the complexity and make the research feasible, a makeshift, as we did, is to select the code of higher economic activities. This treatment is yet at expense of overlooking subtle characteristics of business activities. The multiple industrial classifications may be of more interest for more detailed studies on clusters and the internal structure of business.

These limitations may require further work from computer programmers and semanticists to improve the accuracy and efficiency of fuzzy coding related techniques. Or probably the most urgent requirement is to improve the database of recoding business establishments. If more detailed records such as business shift and dying-out are available with quality, the economic cluster-related or firm-level studies could be further advanced.

Appendix III: Land use change and urban development

Land use change was detected by the data of 1993, 2000 and 2004, which is vectorised map for actual land use based on remotely sensed images and land survey by Beijing Land Use Bureau. For 1993 and 2002, the land use data was classified as 8 general types, for 2004 a 3-digit classification was adopted, and the categories were very detailed. Comparing these 2 systems, many differences appeared in the land that is not used for construction.

For the interest of research, the data were re-categorised as built-up and non built-up areas. The built-up area includes constructed land in the urban area, towns, rural settlements, industrial enclaves and transportation areas. Special land used for environmental and historical protection areas was excluded. A binary map was finally prepared for detecting land change. In the GIS workshop of ArcGIS 9.3, tools of spatial union, buffers and statistics were employed to analyse land use change.

The land use of 1993 is the earliest data with digitised format that comprehensively documents actual land use situation of Beijing. After that, relatively comprehensive survey has been regularly conducted since 2000. A concession in this research is therefore made to detect the land use change of 1993-2000 compared with the spatial clusters that grew in the periods of 1988-92 and 1993-97 to analyse the impacts of these spatial clusters' developments on land use. And the impact of the cluster developed in 1998-2002 was examined with the land use change in 2000-04