UNIVERSITE PARIS-DAUPHINE
Ecole Doctorale EDOCIF, Centre de Recherches LED

Growth, Productivity and Spillovers from Openness to Foreign Direct Investment and Trade in China

THESE

Pour l'obtention du titre de :

DOCTEUR EN SCIENCES ECONOMIQUES

(Arrêté du 7 août 2006)
Présentée et soutenue publiquement par

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Le 12 Juin 2009

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«La faculté n'entend donner aucune approbation ni improbation aux opinions émises dans cette thèse; ces opinions doivent être considérées comme propres à leur auteur».

To my parents

不闻不若闻之，闻之不若見之,

見之不若知之，知之不若行之.

荀子

"Tell me and I'll forget;

Show me and I may remember;

Involve me and I'll understand."

Xunzi

ACKLOWLEDMENTS

I would like to express my deep and sincere gratitude to my supervisor Prof. Bernard Guillochon for his continuous support in the Ph.D. program. He always had confidence in me and guided me patiently through my studies. I am also grateful to Prof. Jean-Marc Siroën for recruiting me to the Master program in the University of Paris-Dauphine in 2004, without which, this thesis wouldn’t be realised. My special thanks are directed to my co-advisor, Thierry Blayac, for his encouragements and constant guidance through the whole period.

Besides my advisors, I would like to thank the rest of my thesis committee: Prof. Sandra Poncet, Prof. Marie-Françoise Renard, Prof. Mouhoub El. Mouhoud and Jiemin Guo for kindly accepting to participate to the defence and for their challenging questions, constructive comments and recommendations which substantially improved the thesis.

I would also like to thank Prof. Geoffrey Hewings for his encouragements and Prof. Gunter Maier for recruiting me to the ERSA/ PREPARE 2008 summer institute on spatial econometrics and computable general equilibrium models. This intense training period gave me the opportunity to receive theoretical and technical support from Prof. Rosina Moreno, Prof. Luc Anselin and his assistants Julia and Nancy, which has considerably improved the empirical analysis conducted in the second part of the thesis.

I am also greatly indebted to teachers Pascal Michelena, Prof. Xiaolan Fu, Prof. Harry X. Wu, Sylvie Démurger, Cécile Batisse, Jean Pascal Guironnet and Prof. Harry Wu for their insightful remarks on my research.

I would also like to thank my Ph.D. student friends from LAMETA Patrice, Julie, Leslie, Mourad and Dorian for interesting discussions and their humour which kept things light and me smiling. Beautiful weather in Montpellier kept me always in good spirits and our Friday night (dance) fevers considerably helped to reduce stress.

I am grateful to my overseas friends Lili Wang, Joanna Feng, Jun Hu, Navida Wang and Lena Birkelöf for their friendship and encouragements.

I must give a huge thanks to my parents for giving me life in the first place, for their love and understanding during the long years of my education. They gave me unconditional support and encouragement to pursue my interests, even when the interests went beyond the boundaries of language and geography. I would also like to express my gratitude to Türkay Üst for his material and motivational support over the past ten years. Last, but not least, I thank Mari Elise Hareide for being a great flatmate and proofreading the manuscript; Sam Ulrich for listening to my complaints and frustrations, and for believing in me; and Ceylan Tartanoglu for behaving like a sister to me over all these long years.

RESUME

Cette thèse de doctorat analyse le développement économique de la Chine et les politiques de réforme qu'elle a engagé depuis ces trois dernières décennies. Ce travail empirique contribue à deux apports majeurs : premièrement, à l'élaboration d'une base de données récente; deuxièmement, à l'usage de méthodes paramétriques novatrices. L'objectif principal de cette thèse est de fournir une analyse systématique et intelligible de la croissance économique et de la productivité en Chine. Notre principal intérêt est d'examiner l'éventuelle existence d'externalités positives sur l'économie chinoise, provenant de l'ouverture aux investissements directs étrangers (IDE) et du commerce international.

Selon cette approche, trois résultats majeurs peuvent être distingués: *i*) en Chine, l'accumulation du capital physique est la principale source de croissance, tandis que les gains de productivité et d'efficacité technique ont positivement contribué à la croissance économique depuis les trois dernières décennies ; *ii*) nos travaux empiriques révèlent l'impact significatif de l'ouverture aux IDE et aux échanges internationaux sur la croissance et la productivité ; *iii*) les analyses spatiales soulignent l'importance des dynamiques régionales et des interactions spatiales dans le processus de développement économique.

Mots Clés: Chine; Croissance; Productivité; Investissement direct étranger; Commerce international; Retombées positives.

ABSTRACT

This thesis focuses on the issues associated with China's rapid economic development and reform initiative over the past three decades. The study presents new empirical evidence which relies on comprehensive data sets and recently developed parametric methods.The major objective of the thesis is to provide a systematic and comprehensive analysis of China's recent economic growth and productivity performances. The main focus is directed to the investigation of spillovers to Chinese economy arising from openness to foreign direct investment (FDI) and international trade.

The major findings of the study are: (*i*) Over the past three decades, physical capital accumulation has been the main driving force of China's rapid economic growth, while productivity and technical efficiency gains have also contributed to economic growth; (*ii*) openness to FDI and international trade exert a positive impact on growth and productivity; (*iii*) the spatial econometric analyses highlight that regional dynamics and spatial interactions play a crucial role in the process of economic development.

Keywords: China; Growth; Productivity; Foreign Direct Investment, International Trade, Spillovers.

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ABBREVIATIONS

CCP Chinese Communist Party

CEE Central and Eastern European

CPI Consumer price index

CRS Constant returns to scale

DC Developing countries

ESDA Explanatory spatial data analysis

EU European Union

FDI Foreign direct investment

FE Fixed effect

FOE Foreign owned enterprises

GDP Gross domestic product

GMM Generalised method of moments

IDD Independent and identically distributed

IMF International Monetary Found

IV Instrumental variables

LR Likelihood ratio

MNC Multinational Company

N/A Not available

NIE Newly industrialised economies

NIFA Newly increased fixed assets/

OECD Organisation of economic development and cooperation

OLS Ordinary least squares

PPP Purchasing power parity

PRC People's Republic of China

R&D Research and Development

RMB Ren Min Bi (Chinese Yuan)

RPI Retail Price index

SOE State-owned enterprises

SSB State Statistical Bureau

TVE Township village enterprises

TFP Total factor productivity

SARMA Seasonal autoregressive-moving average

SPF Stochastic production frontier

PIM Perpetual inventory method

USD United States Dollar

US United States

VRS Variable returns to scale

WTO World Trade Organisation

ZES Zone economic special

GENERAL INRODUCTION

China's unprecedented rapid economic growth and its recent emergence as a leading global partner have marked the world economy over the past three decades. From being a self-reliant, autarchic economy until the late 1970s, China has progressively moved towards a market based economy. Since the introduction of economic reform and opening up policies in 1978, China's Gross Domestic Product (GDP) has grown at an average rate of 9.5 per cent.

China's opening up initiative turned to be a remarkable success: today China ranks third among the top trader countries and it is the major host for FDI (Foreign Direct Investment) inflows in the world. China's outstanding economic rise helped a substantial part of the population to rise out of poverty. However, rapid economic growth also resulted in widening income disparities between the inland and coastal regions, and between the urban and rural areas.

China's rapid economic development generated increasing interest among scholars and policy makers. Over the last few decades, understanding the main driving forces of China's robust economic growth has become a widespread research question. During this period, an abundant literature investigating the nexus between the opening up initiative and economic development in China has evolved.

This economic evolution of China provides us with capital statistical data and a unique model to explore the long-term relationship between openness to the world and economic spillovers to host developing countries. In the Chinese economy, it is striking that, FDI and trade are highly inter-related and the processing trade accounts for a substantial part of exports and imports.

This thesis focuses on the issues associated with China's rapid economic development and its reform initiative over the past three decades. It presents new empirical evidence which relies on comprehensive data sets and recently developed parametric methods.

The major objective of this thesis is to provide a systematic and comprehensive analysis of China's recent economic growth and productivity performance. The main focus is directed to the investigation of spillovers to Chinese economy via openness to foreign investment and trade. The thesis explores five major research questions:

1. What are the driving forces of growth and productivity in the Chinese economy?

2. Is China's economic rise sustainable in the future?

3. Does openness to foreign trade and investment induce spillovers to the Chinese economy?

4. What is the importance of regional dynamics in the processes of growth and productivity?

5. Which policy recommendations could be proposed that would sustain China's economic development in the future?

The thesis proposes four macro-level studies to explore the patterns of total factor productivity (TFP), technical efficiency (TE), labour productivity and income per capita in China. To achieve this, time series, panel, cross-section and stochastic production estimation techniques, based on the national, provincial and prefecture level data, are all employed. Exploratory spatial data analysis (ESDA) and spatial regression techniques are also utilized in econometric analysis. The core body of the dissertation consists of five chapters divided into two parts. A brief outline of the chapters is presented below:

Chapter	Title	Description
1	China's Economic Outlook After 30 Years of Economic Reforms	Discussion
2	Assessing for the Total Factor Productivity Growth in Chinese Industry: 1952-2005	1952-2005, National level, Time Series, Parametric approach, OLS estimator, Growth Accounting
3	Technological Use and Scale Effect Evaluation: Evidence from Chinese Provinces (1994-2006)	1994-2006, 30 provinces, Panel, Parametric Approach, Stochastic Production Frontier, OLS estimator.
4	Regional Assessment of Openness and Productivity Spillover in Post-Reform China: a Space-Time Model	1979-2006, 30 provinces, Panel, ESDA and Spatial Regression, OLS and ML estimators.
5	A Fresh Scrutiny of Openness and Per Capita Income Spillover in Chinese Cities: a Spatial Econometric Perspective	2004, 367 cities, Cross Section, ESDA and Spatial Regression, OLS, ML and GMM estimators.

The ***first part*** of the dissertation investigates the driving forces of China's recent rapid economic growth and its sustainability in the future. It focuses on productivity, efficiency and growth patterns in the Chinese economy. Part I is composed of three chapters:

Chapter 1 presents a comprehensive discussion on the contemporaneous issues of the Chinese economy. It generates fundamental insight into the issues introduced by reform policies and China's ongoing economic transition. The main purpose of the chapter is to give a baseline for the comprehension and interpretation of the empirical analysis undertaken in the following chapters. The key issues arising from China's recent economic rise are discussed through six major axes, namely economic reforms and growth, ownership composition and productivity, financial and banking system reforms, opening-up to the world, human capital and research & development, and unbalanced regional development.

Chapter 2 presents the estimates of total factor productivity (TFP) growth in Chinese industry over the past half century. The chapter improves on earlier estimates in several respects. First of all, relying on national income accounts data over the period 1952-2005, the study develops more comprehensive data series for labour and capital. Second, the production function is estimated with fewer restrictive assumptions and allows for variable returns to scale production technology and factor-augmenting technological progress. Furthermore, the adjustment of the TFP estimates for cyclical factors is one of the key contributions of the study.

The major findings are: over the whole period 1952-2005 capital accumulation was the main source of industrial output growth; over the reform period (1979-2005) the TFP growth also contributed significantly to output growth in Chinese industry. We also detect an accelerating trend in the TFP growth since the late 1980s, probably as a result of the changes in the pattern of ownership and the increased integration of China into the world economy.

Chapter 3 explores regional economic growth and technical efficiency patterns in China through the Stochastic Production Frontier (SPF) approach. The study focuses on a panel of 30 Chinese provinces over the period 1994-2006. The SPF approach extends the traditional growth accounting methodology by dividing technical efficiency into its two major components, namely pure technical and scale efficiency. In addition, our approach also allows for variable returns to scale production technology.

The main findings of the chapter are: physical capital accumulation could be recognized as the main driving force behind China's rapid economic growth; openness to foreign trade and FDI, human capital development, population growth and the removal of price controls also exert a positive effect on economic growth. Despite the general concern of the widening regional inequalities, our analysis detects a striking trend of convergence among the Chinese provinces over the past decade. The study also reveals the substantial contribution of technological progress to raise productive efficiency.

The economic theory considers that the significant contribution of productivity gains to economic growth indicates the sustainability of growth in the long run. On the outcome of Chapters 2 and 3 one can draw the conclusion that China's rapid economic growth is sustainable in the near future.

The ***second part*** of the dissertation explores the spillovers to the Chinese economy introduced by openness to FDI and foreign trade from a spatial econometric perspective. Part II contains two empirical analyses:

Chapter 4 investigates the impact of inward foreign direct investment (FDI) and international trade on labour productivity in 30 Chinese provinces over the period 1979-2006. In the regression analysis, labour productivity is modelled as dependent on FDI, foreign trade and other key variables such as capital intensity, infrastructure and human capital development. The study extends previous research by introducing additional variables such as spatially lagged independent and dependent variables.

The main findings show that, consistent with economic theory, human capital, infrastructure development and capital intensity could be recognised as the main determinants of labour productivity. The empirical outcomes also give support for the positive and significant impact of FDI and foreign trade on labour productivity.

Chapter 5 explores openness and per capita income spillovers over 367 Chinese cities in the year 2004. In the econometric analysis per capita income is explained through investment, physical and social infrastructure, human capital, governmental expenditure and openness to the world. The regression results reveal that in the Chinese cities, physical and social infrastructure development, human capital and investment could be recognised as major driving forces of economic development. The results also support the existence of spillovers via FDI and foreign trade to Chinese economy.

The spatial analyses presented in Chapters 4 and 5 highlight the importance of regional dynamics and spatial interactions in the process of economic development. Put differently, in China, the labour productivity and per capita income of a given region are jointly determined by those of the surrounding regions. This finding indicates that preferential policies consisting of opening up and developing a specific region are not optimal. Development strategies should rather follow a coordinated, nation-wide perspective by reinforcing complementarities and interactions across regions. In addition, government authorities should pursue the policies to remove restrictions to the free movement of production factors across regional borders.

The next section presents a review of the sizeable literature on the openness spillovers in developing countries (DCs) and discusses the controversies on the subject. In this way, we seek to establish the theoretical framework for the econometric analyses carried on in later chapters.

LITERATURE REVIEW

Openness and Economic Spillovers in Developing Countries

1. Introduction

Since the 1980s, the World economy has been marked by progressive opening up of developing countries (DCs) to international trade and foreign investment. In the 1950s and 1960s, most developing economies manifested hostile behaviour towards globalisation of the markets. They have built their economic development strategies on import substitution and protectionism. In the late 1970s, a progressive shift from protectionist to liberalist policies has emerged. During the past three decades, the import-substitution strategies with high barriers to trade gradually gave way to liberalisation and market-oriented government policies. In addition, debt crisis in the 1980s pushed DCs to look for other way of funding rather than international loans. The incentives of liberalisation have been pursued in a number of emerging capital markets.

In the developing world the evidence was clear: no country over the recent decades has accomplished economic success (in terms of growth and reduction of poverty) without being open to the rest of the world. Today, it is common knowledge that outward-oriented economies tend to grow faster than economies which are inward-looking. In this context, a shift from restrictive to permissive policies has progressively emerged in developing economies. In the 1980s, substantial change in trade patterns took place: in order to promote opening up, governments set up a range of incentives such as establishment of Special Economic Zones (SEZs)[1], tariff liberalisation, dismantling of quantitative restrictions and liberalisation of capital markets. As a consequence, foreign direct investment (FDI) started to

[1] According to the World Bank, in 2007, more than 3000 economic projects have been undertaken in the SEZs over 120 countries.

flow to developing economies. Among DCs, a fierce competition to expand trade and foreign investment has gradually emerged.

Openness policies in DCs have been pursued by various expectations. First of all, promotion of FDI and export is expected to induce direct growth enhancing effects on host economies, through job creation and capital accumulation. In addition, outward orientation of a country brings about specialisation and enables it to develop competitive advantages in the manufacture of certain products. Foreign investment and trade also generate financial sources which are usually scarce in recipient countries. Hence, they ease credit constraints which might constitute an obstacle to investment. Outward orientation contributes to accumulate foreign exchange reserves and reduce current account deficits of balance of payments. Furthermore, foreign exchange reserves also constitute major funding for import of advanced technology, machinery and equipment.

Outward orientation of an economy is also expected to raise productivity through some indirect effects. In the literature, these indirect effects of openness are generally called "spillovers" (Blomström and Kokko, 1996). Generally speaking, productivity gains can take three major forms (Caves, 1974), namely through a better allocation of resources, technical efficiency improvement and technology diffusion to local economy. Contrary to direct effects of openness, productivity spillovers possess tacit and intangible features which are difficult to quantify in empirical analyses.

Before starting our analysis, it is crucial to make the distinction between two major types of foreign investments, namely FDI and portfolio investment. According to IMF (1993), FDI designates an investment made to acquire lasting interest in a firm, operating outside of the economy of the investor. As a matter of fact, foreign direct investment confers to the investor an effective voice and control in the management of the invested firm. As Dunning (1981) points out, FDI involves a direct and long-run relationship which gives control and participation to decision making of the firm. It implies the transfer of a range of resources, both tangible and intangible, from the investor to the host economy.

In contrast, portfolio investment is generally motivated by short-term performance. It designates an agreement of the supply of capital, from a lender to a borrower. It requires borrowers to pay back the 'loan' plus interest over a number of years. Thus, portfolio investment tends to imply merely transfer of capital and limited control. It is generally motivated by return on capital rate. In the 1990s, Asian (1997-1998), Mexican (1994-1995) and Brazilian (1999) financial crises showed that short-term capital can easily quit the economy and generate destabilising effects in capital markets (Baharumshah and Thanoon, 2006; Noorbakshsh *et al*., 2001).

To summarise, in DCs, FDI constitutes more stable funding and implies longer-term commitments than portfolio investment. It implies greater physical contact and gives more opportunity for interactions between host and home economies. Accordingly, one can consider that the scope for spillovers through portfolio investment is virtually non-existent. In this study, we therefore confine our attention solely to FDI and trade as key drivers of economic growth and development.

In most DCs, international trade and FDI are closely interrelated to each other due to processing trade. Foreign invested enterprises account for a substantial part of exports and imports of host countries. Thereby, vertical FDI shows a complementary pattern to trade and play an "export catalysing" role for local firms. Vertically integrated FDI is essentially attracted to DCs by cheap production costs. It generally takes the form of export processing manufactory bases, whose activity consists of assembling imported parts and components in order to export to other markets (i.e. FDI-driven labour-intensive processing type exports).

Since the 1980s, the effect of openness to developing economies has been of great interest to both academics and governments. During this period, a considerable literature on openness spillovers in DCs has recently evolved. However, nowadays, the empirical evidence on the subject remains a contentious issue. As Rodrick (1999) says, "Today's policy literature is filled with extravagant claims about positive spillovers from FDI but the evidence is sobering".

An analytical review of recent literature on openness spillovers in developing countries is presented in this study. The controversial literature shows that openness to FDI and trade do not necessarily lead to economic spillovers. Lack of common pattern in DCs could be attributed to some characteristics of host countries such as poor absorptive and innovative capabilities, which impede technology diffusion[2]. Moreover, empirical analyses represent severe methodological shortcomings which might be the origin of the lack of common evidence.

[2] In this study the term of "technology" is used in a broader sense: it includes knowledge embedded in products and processes as well as intangible assets such as organisational managerial practices and know-how.

The paper is organised as follows: The second section summarises main conduits for FDI and trade spillovers to take place. The third section discusses the origin of the controversial evidence on openness spillovers to DCs. The last section concludes and gives some policy recommendations.

2. Main mechanisms of FDI and trade spillovers in DCs

This section presents a descriptive analysis of the mechanisms through which openness to FDI and trade are likely to induce positive spillovers to DCs. The investigation of FDI spillovers implies, first of all, to understand the decision of a firm to become multinational and invest in a country abroad. Why would a firm undertake investment abroad to produce goods? Why will it choose to establish overseas subsidiaries instead of exporting directly or licensing their products or technologies?

In the 1960s, the multinational firm theory has been built on the following postulate; a MNC might exploit its specific advantages in a better way by overseas production (Hymer, 1960; Kogut and Zander, 1993). To be more precise, foreign firms possesses inherent advantages such as advanced technology, more qualified workforce, organisational and managerial knowledge, integration into international networks and so on. Thanks to its specific assets, a MNC can overcome the costs of setting up business and compete with local firms which enjoy a better knowledge of market and business practices.

Dunning (1981) provides comprehensive explanation on the multinationalisation of firms through his “eclectic” theory (see the OLI paradigm). Accordingly, the motivation beyond the overseas expansion of a firm lies on the simultaneous exploitation of three sets of advantages; namely ownership (firm-specific), internationalisation and location (country-specific) advantages. Besides that, in DCs, FDI represent an effective way to jump-off tariff barriers and benefit from market imperfections in production factor costs (Kumar 1996).

To summarise, foreign invested firms usually constitute genuine sources of advanced technology for developing economies. In most DCs, production technologies of MNCs are more capital and technology intensive and they enjoy higher productivity than the domestic counterparts (Blomström and Kokko, 1996). When a MNC establishes a subsidiary abroad, it transfers a “technological package” composed of advanced technologies, organisational and managerial know-how (Hymer, 1960). This package constitutes the specific advantage of the firm to compete with local firms which benefit from a superior knowledge of business environment.

Nowadays, transfers of newly developed sophisticated technologies are largely operated in inter-firm level. MNCs generally prefer to set up plants overseas or acquire foreign plants in order to internalise certain transactions and protect their brand, technology and marketing advantages (Görg and Greenway, 2004). However, in some cases, when a multinational sets up a subsidiary abroad; it might be unable to prevent the benefices of its firm specific advantages from spilling over to indigenous firms. Despite multinational's incentive to internalise technology transfer, some positive externalities to domestic economy (i.e. to competitors, suppliers and customers) could take place.

2.1 Main Channels of Technology Diffusion

In this section we summarise five main channels through which technological knowledge brought by foreign-invested firms is expected to "spill over" to host economy.

- **Demonstration-Imitation-Contagion**

In DCs, local firms are likely to improve their production technologies by observing and imitating foreign firms operating on the market (through learning by watching and learning by doing). In their pioneering contributions, Arrow (1971) and Findlay (1978) put the emphasis on the demonstration and contagion effects of foreign invested firms. They consider technology as analogous to the spread of a contagious disease, which can be easily diffused through personal contact (Arrow, 1971). Put differently, advanced technologies brought by MNCs could be imitated and assimilated effectively by local firms if continuous physical contact takes place between the two counterparts. In this way, given the long-term commitments and greater physical contact it implies, FDI represents an important conduit of technology transfer.

As a matter of course, for a firm, copying a product implies lower costs than designing and generating an entirely new product. Local firms can learn substantially from foreign-owned firms by copying their technologies and products (Bouoiyour *et al.*, 2009). In the 1970s and 1980s, economic success of South Korea shows that reverse engineering constitutes a very effective channel of technology transfer. However, the scope of technology diffusion depends closely on the complexity of products and processes to be adopted. Generally speaking, technology diffusion through reverse engineering starts by low value added assembly and processing activities. Afterwards, the receiver progresses and gradually moves up step by step the technology ladder to more complicated tasks such as designing and producing its own products.

- **Competition**

Productivity spillovers through competition imply a relatively complicated mechanism; their occurrence is closely related to the host economy's inherent capabilities. In developing economies, the competition of foreign firms could spur local firms to adopt more efficient allocation of existing resources and upgrade their production technology. It also stimulates domestic R&D and innovative efforts.

In addition, when MNCs enter into industries with high entry barriers, they usually reduce monopolistic distortions (Blomström and Kokko, 2001). Furthermore, for FDI firms, competition also determines the quality of technology to be transferred. In case of fierce competition on the host market, foreign investors are expected to bring in relatively new and sophisticated technologies to their affiliates in order to retain their market shares (Sjöholm, 1999).

However, under some circumstances, competition of foreign firms could exert a detrimental effect on the host economy and drive local enterprises out of the market. In DCs, MNCs usually enjoy greater competitiveness due to their firm-specific advantages, bigger production scale and lower marginal costs. In Venezuela, Aitken and Harrison (1999) detect negative spillovers because of "market stealing" effect. In other words, local firms which were unable to compete with foreign-invested companies had to give up their market shares to foreign invested companies. Moreover, in some cases, foreign presence constraints local enterprises to reduce their production scale and move up their average cost curve.

In countries and industries where local firms are less competitive, foreign owned firms might operate as enclaves. In enclaves, neither products nor technologies of FMN have much in common with those of local firms (Blomström and Kokko, 2001). Thus, economic activities of foreign invested firms are largely linked to international markets. Foreign technologies are not compatible with host country's source endowments. In other words, in enclaves, interactions with upstream and downstream industries are limited; spillovers to local economy are virtually nonexistent.

In contrast to other transmission channels (such as demonstration-contagion effect), spillovers through competition are not necessarily proportionate to the degree of foreign presence in the host economy. In some sectors, a strong foreign presence could even hint at low competitiveness of local firms and their poor absorptive capabilities.

- **Training and R&D**

Technologies which are transferred from MNCs to local subsidiaries are not solely embedded in equipment, machinery and patent rights. FDI is also expected to transfer unembedded technologies in the form of human capital, organisational, managerial and marketing skills. First of all, a substantial part of the worldwide private R&D efforts is undertaken by MNCs (UNCTAD, 2005). Given the relative scarcity of human capital and qualified workforce in developing economies MNCs also undertake a considerable part of human resource development and labour training activities in the world (Lipsey and Sjöholm, 2002).

The origin and motivation of FDI determine largely its need for qualified workforce and the intensity of training activities it will undertake. For instance, Kumar (1996) shows that vertical FDI, which is mainly attracted by cheap labour costs, is expected to be less intense in capital and qualified workforce. That is to say, in low technology sectors, like export processing manufacturing or row materials extraction, MNCs show a small potential of carrying out labour training activities (Marin and Narula, 1996). In contrast, in the case of market seeking FDI, the production process tends to be more intense in capital and the demand for qualified workforce is likely to be greater. Thus, host market oriented horizontal FDI is, in general, actively involved in human capital formation of local workforce (Kumar, 1996). Knowledge generated by MNCs human capital formation and R&D activities is expected to diffuse to local economy in two major ways: through labour turnover and when the ex-employees of foreign-invested firms set up their own businesses (Kokko, 1996).

However, it should be stated that the presence of MNC might also exert a detrimental effect on host country's human capital formation. Given higher salaries and wages they offer, the presence of foreign-invested firms might trigger "brain drain" of local talents and qualified workforce from local economy.

In host countries, R&D activities of MNCs are expected to stimulate domestic R&D and innovation initiatives through complementarily effects (Cohen and Levinthal, 1989). Yet, it should be mentioned that, nowadays, the bulk of the R&D activities of MNCs remain largely confined to a number of developed countries. This concentration is the outcome of a number of factors such as scale economies, scarcity of human capital stock and the weakness of property rights in DCs (Globerman, 1997). According to Mansfield (1994), in DCs, the weakness of intellectual property rights does not directly influence the volume of FDI flows. However, it constitutes a major obstacle to MNCs' R&D incentives in host countries and then hinders the transfer of recently developed technologies.

- **Vertical Linkages**

In DCs, technological knowledge brought by MNCs is expected to leak to local economy through backward and forward linkages (Javorjik, 2004). For vertical spillovers to take place, the size of the domestic market and the local content of produced goods are primordial. The more the host market is large, the more foreign investors have the potential to integrate vertically into the production chain and develop inter-industrial linkages (Narula and Portelli, 2004).

  - Backward linkages

In DCs, FOEs could prefer to source their inputs and intermediate goods from local suppliers due to a number of factors. For instance, in case of host market oriented production, large geographic distance, high transport and transaction costs and so on. In order to satisfy FOE's demand, local producers might be spurred to improve the quality of goods and services and innovate their production technologies. In addition, MNCs could also push local suppliers to upgrade their technology and production process by imposing to them higher quality standards and on-time delivery requirements. In view of raising the quality of inputs they purchase, MNC may also provide to their local counterpart technical assistance, training and assistance in the organisation of production process, (Blomstrom and Kokko, 2001).

Furthermore, increasing demand of inputs can also generate scale economies for local suppliers. Javorcik (2004) highlights that in DCs backward linkages to MNCs constitute the most effective way of spillovers. In fact, MNCs have no incentive to prevent technology diffusion to upstream sectors given that they could fully benefit from the improved performance of local input suppliers.

- Forward linkages

Forward linkages refer to the relations between MNCs and local customers through sale of output. The more the technology content of local production increases (e.g. when a country moves up to the specialisation ladder), the more local firms would purchase good quality, technology intense intermediate goods from foreign-invested companies. In that case, MNCs could stimulate technological upgrade of their local customers by providing to them complementary services (e.g. after sale services) and training. Yet, to our best knowledge, empirical evidence on forward linkage spillovers has been hitherto very scarce.

- **Export Promotion**

In DCs, FDI is expected to stimulate export orientation of the host country and generate "export access" spillovers. Generally speaking, export activity involves high entry barriers and fixed costs in the establishment of distribution and information networks, marketing services, infrastructure facilities in communication and transport, and so on. In DCs, export oriented foreign firms are likely to enhance local firms' export potential in various ways.

In DCs, MNCs are generally more integrated into international networks than their local counterparts. This is mostly due to some specific assets they possess, namely abundant financial funds, greater marketing and sale experience, more advanced technology, high skilled workforce, and so on. Thereby, MNCs can play an "export catalysing" role and ease the access of local firms to international markets. First of all, MNCs could reduce the cost of entry into export markets by demonstration effect. In addition, they could spill over to local economy information on global markets, regulatory arrangements, export potential, distribution networks and so on (Görg and Greenaway, 2001). Through sub-contracting and other forms of economic cooperation, MNCs can also give the opportunity to domestic firms to get information at a lower cost on international demand, quality of goods, product differentiation and customer preferences (Kumar, 1996).

There is an abundant empirical literature investigating the nexus between FDI and host economy's export orientation. Among many others, Lipsey (2000) shows that in South Asia, American MNCs enabled domestic exporters to improve their know-how and increase the quality of their products. Aitken and Harrison (1999) find that for a Mexican firm, the possibility to engage in export activities is positively correlated to geographic proximity to

MNCs. In Bangladesh, Rhee and Belot (1990) demonstrate that Korean multinational firms promote export orientation of local firms in clothing sector. Kokko et al. (1996) highlight the export enhancing effect of FDI in Uruguay. UNCTAD (1999) also reports the positive effect of FDI on export performances and technological sophistication of export goods for a sample of thirty three DCs.

The remarkable economic success of the NIEs in the 1970s and 1980s, along with China's spectacular growth since three decades highlight export expansion as a key engine of economic growth (Mucchielli, 2002). In the next section, we discuss the mechanisms of trade-related spillovers to DCs.

2.2 Trade Spillovers to Developing Countries

Since the 1960s, the role of exports as "engine of growth" has been emphasized by academics (e.g. Nurkse 1961; Krueger 1978) and policy makers. Endogenous growth literature (Grossmann Helpman, 1981; Coe and Helpman, 1995) shows that outward orientation of a country is likely to enhance its economic growth and development *(i.e. export-led growth hypothesis).* In addition, recent studies generally highlight that in DCs, export-oriented firms exhibit higher productivity than non-exporting firms operating in the same sector (Görg and Greenaway, 2004).

Outward orientation of a country is expected to bring about both static and dynamic gains. Static gains from trade are closely linked to conventional trade theory (see Ricardo's *comparative advantages theory*). For instance, in developing economies, openness to international trade enables to overcome the narrowness of the domestic market and provides an outlet for the surplus product above domestic requirements (see *vent-for-surplus theory*, Myint, 1958)[3]. To summarize, under the hypothesis of free movement of production factors across sectors, trade is expected to generate substantial gains in two major ways: by specialisation in production according to country's comparative advantage and by reallocation of resources between traded and non traded sectors. Fu (2004) outlines that dynamic gains arising from trade orientation generally take place in the form of X-inefficiency and productivity gains. The conduits for productivity spillovers to local economy through international trade are outlined below:

[3] For a complete and comprehensive study on export spillovers, interested reader could refer to Fu (2004).

- In the same way as FDI, export could improve a country or firm's productivity through "competition" effect. Exposure to international competition could constrain firms to increase X-efficiency (through a better allocation of existing resources, cut costs, improvements in managerial and organizational efficiency improvements etc.). In addition, facing global competition could motivate firms to upgrade their production process, encourage quality improvement and move up to the specialization ladder. Greater export competition could also trigger domestic R&D and innovation efforts of local firms in order to preserve their market shares.

- Trade is likely to constitute an effective conduit for international transmission of know-how and technology diffusion (Grossman and Helpman, 1991). A trading nation could improve the skills and dexterity of its labour force through "learning by exporting". Exposure to new technologies could facilitate the transmission and absorption of new technologies across borders. In addition, integration into global innovation networks and international marketing contacts might provide ideas to local producers to innovate and develop new products. The extension of the market size due to export orientation is likely to bring about scale economies in production (Krueger, 1978). In the same way, the enlargement of the market size is expected to enhance technological upgrade by inducing scale economies in R&D and innovative activities (Grossman and Helpman, 1991).

- In DCs, export constitutes a major source of foreign exchange which enables to alleviate capital and foreign exchange shortage and resorb current account deficits of balance of payments. In addition, Export generates funding for the importation of advanced equipment and machines which might encourage technological upgrade (Fu, 2004).

- In developing economies, import of high technology capital and intermediate goods could raise productivity and encourage imitation, innovation and the use of such knowledge in local production.

Recent literature highlights that trade spillovers are not systematic and require a number of conditions to be in place. For instance, in order to induce spillovers, technologies in the export sector should be more advanced than those already in use by local firms. Furthermore, technological congruence between the export sector and the rest of the economy is fundamental. In DCs, export oriented firms should tie effective linkages to the rest of the economy and must be able to pull or push other industries. Yet, in export processing zones, exporter firms tend to have very limited interactions with local economy (see the previous section).

Trade composition of a country significantly matters in the occurrence of spillovers. Keller (2000) highlights that the level of technological development of trade partners determines the occurrence of technology diffusion: for a trading nation, the pattern of its intermediate goods imports affects its level of productivity. DCs which import capital and intermediate goods from technology leaders are expected to receive more advanced technology than those importing essentially from follower countries. Coe and Helpman (1995) find the empirical evidence that a country's TFP is not only determined by its own R&D stock but also by the R&D stock of its trade partner.

Technologies of production in the trade sector should be more advanced than those already in use in local economy. If a DC is essentially specialized in the production of low skilled products the scope for spillovers through foreign trade would be virtually nonexistent. However, a shift in export composition could induce spillover effects and encourage technology diffusion (Fu, 2004). For instance, along its development path, a country could gradually move up the comparative advantage ladder. It can progressively shift its production from low skilled primary or manufacturing goods to higher value added capital intense goods. It is worth noting that capital intense goods generally induce greater income elasticity to demand and higher vertical integration to local economy.

Empirical investigation of export spillovers requires great caution. To date, evidence on the direction of causality is not conclusive. In DCs, causality might run the other way round and validate the "growth-led exports" hypothesis rather than the "export-led growth" one. In DCs, economic growth and technological upgrade may create comparative advantages in new sectors and then spur exports. In addition, the "self selection bias" of exporters should be borne in mind (Fu, 2004). Indeed, entering export markets do not systematically improve a firm's productivity. On the contrary, successful firms are expected to be more engaged in export activities (Görg and Greenaway, 2004).

3. Discussion on the inconclusive results

The early literature (Caves, 1974; Globerman, 1979) has established a common belief on the existence of spillovers through foreign direct investment. Despite the economic theory which identifies a number of channels for spillovers to occur, in DCs, empirical support for outward orientation and positive spillovers is inconclusive even controversial. Table A summarises empirical findings of some recent studies investigating into FDI-led productivity spillovers. Our analytical study highlights that the occurrence of spillovers are reliant on a number of preconditions being in place in host economies. An adequate minimum level of absorptive capability should be initially present before a country opens up to foreign trade and investment. In addition, empirical analyses manifest methodological shortcomings which could explain the mixed results. In this section, a comprehensive discussion on the origin of the controversial results regarding openness spillovers is presented.

3.1 Assimilation and Absorptive capabilities of host countries

In DCs, technology diffusion is not an automatic consequence of the presence of foreign firms and their superior knowledge. The occurrence of technological spillovers is closely linked to host economies' assimilation and absorptive capabilities (Blomström et al., 2000; Narula, 1996). True, FDI and export transfer technology embedded in products, however, tacit knowledge to assimilate them should be developed endogenously. Host economies which receive new technologies should complement the process of transfer by in-house innovation and R&D efforts.

Until the last few decades, the notions of assimilation and absorption were overlooked by economists. In 1960s, neoclassical growth framework (Solow, 1957) mainly attributed growth to the accumulation of production factors such as capital, labour and intermediate inputs, with diminishing returns to scale. The neoclassical theory treats technological progress as an exogenous input and focuses instead on capital accumulation as a major engine of growth. Given the assumption of diminishing returns to production factors, all economies were expected to converge towards a steady state rate of growth in the long term.

The emergence of endogenous growth framework in the late 1980s (Lucas, 1988; Romer, 1990; Grossman and Helpman, 1991) shifted attention to human capital formation, technology diffusion and innovation as key vehicles of economic growth. Thereby, creation of technological knowledge and its transmission became the main focus. Endogenous growth literature demonstrated that it is possible to offset the diminishing returns to scale of production factors by the externalities that R&D, innovation and investment in knowledge creation could generate. In this context, a large literature on technological assimilation and absorption capabilities has evolved.

Dahlman and Nelson (1995) define a nation's absorptive capability through its ability to learn and implement the technologies and associated practices of leading economies. In economic literature, absorptive capability were extensively analysed in firm level due its relative simplicity of measurement. According to Cohen and Levinthal (1989), absorptive capabilities of a firm refer to "the fraction of knowledge in the public domain that the firm is able to assimilate and exploit". In the same way, Narula and Portelli (2004) infer that a firm's absorptive capability designates the ability to incrementally increase its knowledge stock through the adaptation and application of outside knowledge sources.

In his seminal contribution, Abromowitz (1986) puts the emphasis on the notion of "social capability", which includes a variety of issues such as adequacy of human capital stock, infrastructure development, quality of institutions, economic systems, and so on. Chesnais (1988) highlights "cumulativeness property" of the learning process. He stresses that technology diffusion is a cumulative process and depends on the complexity of the knowledge and technologies which have already been assimilated over time. In other words, for a country or for a firm, the ability to evaluate and assimilate outside knowledge is a function of the prior related knowledge (Cohen Levinthal, 1989). In this view, an economy's productivity level is essentially determined by its cumulative R&D efforts and its effective knowledge stock, with the two being inter-related (Griliches, 1979; Coe and Helpman, 1995).

If a technology is intensive in tacit knowledge, its assimilation requires extensive in-house R&D and innovation efforts. Transfer of tacit knowledge is a dynamic process which requires cooperative efforts between host and home economies. In order to decodify intangible technology, the recipient should make substantial learning efforts in learning and innovation.

3.2 Human capital and threshold effect

Recent literature highlights a strong complementary effect between openness and human capital construction (Levine and Renelt, 1992). Developing economies are more expected to benefit from FDI spillovers if they already possess an abundant supply of qualified workforce. Countries with highly skilled labour force are reckoned to be more attractive to technology intensive FDI (Blomström and Kokko, 2001). For instance, Ritchie (2001) reports that among the East Asian countries, South Korea and Taiwan could reap more benefit from FDI thanks to their significant efforts in human capital constitution prior to opening up.

In empirical analysis, human capital is frequently used as a proxy for absorptive capabilities. Recent empirical literature highlights that acquiring and sustaining a threshold level of human capital stock are crucial for spillovers to take place (Nelson and Phelps, 1966). FDI is expected to exert positive impact only on host economies which have already attained an adequate minimum level of human capital development. In the same way, Romer (1990) and Cohen et al (1997) reveal that for trade spillovers to be generated by imports of machinery and equipment, a threshold level of human capital is required.

Xu (2000) and Borensztein et al. (1998), henceforth BGL, demonstrate empirically the existence of the threshold effect of human capital development. BGL find that FDI has a positive effect on growth only when it is interacted with the level of human capital. They find out that 0.52 years of minimum secondary school attainment is a precondition for FDI-related growth spillovers to take place. Xu (2000) investigates the occurrence of productivity spillovers through FDI. He detects the same threshold level effect; for FDI-related productivity spillovers to take place: 1.9 years of minimum male secondary school attainment is the precondition. One can observe that most DCs have already reached the threshold level of BGL but not yet the one fixed by Xu. This outcome could bring new insights into the inconclusive and controversial evidence on FDI-led productivity spillovers.

3.3 Technological gap

The technology gap between host and investor countries is a key determinant of FDI and trade led spillovers. The theory of convergence puts the main focus on the “catch up” hypothesis.

Accordingly, in the long run, all economies should converge in terms of per capita income and productivity. In this view, follower countries represent a greater potential to grow, given that they can replicate production methods and technologies in place in leading economies. In other words, the larger is the technology gap the larger would be the potential for imitation and adoption of new technologies brought by FDI and trade (Findlay, 1978).

However, a big technology gap could also indicate poor absorption capabilities of the host economy (Haddad Harrison, 1993). Countries lagging too far behind can be unable to internalise efficiently FDI and trade related technologies. Those economies would represent a very limited potential to develop human capital, infrastructure facilities and distribution networks to support inward investment.

However, it should be considered that a too small technological gap may also limit the scope for spillovers. As a country approaches the technological frontier, technologies to absorb become more complex and exhibit higher level of tacitness. In that case, the decodification of external knowledge occurs at a slower pace and the potential for their assimilation becomes reduced. As the follower closes the technology gap, the cost of imitation increases, the number of technologies to copy declines and the absorption of new technologies induces higher costs and more intensive R&D efforts (Barro and Sala-i Martin, 1997).

One can consider that a certain extent of technology gap stimulates the occurrence of technology diffusion. However, when the gap is too big, host country's poor absorption capabilities could impede the assimilation of new technologies. That is to say, not all sectors are expected to benefit equally from openness spillovers. On one hand, in relatively backwardness sectors low absorption capabilities could hinder the diffusion of technologies. On the other hand, in high-tech sectors, the potential for spillovers could be limited due to the complexity of technologies to assimilate.

Sectorial studies highlight the importance of technology gap in the occurrence of spillovers. Among many others, Blömstrom *et al.* (1994) analyse the impact of FDI in 101 host countries. They detect the existence of FDI spillovers to middle income countries but no spillovers to less developed countries. Kokko (1994) reveals that in Mexico, FDI spillovers are weak in sectors where MNCs use highly sophisticated technologies (high-technology is proxied by capital intensity and large payments on patents). The authors reach the conclusion that in Mexico, in enclaves, there is no technological congruence. Thus, foreign technologies are too difficult to implement for local firms. Sjoholm (1999) adopts an intermediate approach; he reports that in Indonesia, the nexus between technology gap and spillovers is not linear. That is to say, spillovers are greater if the technology gap is big and competition is fierce. In addition, Aitken and Harrison (1999) for Venezuela and Haddad and Hanson (1993) for Morocco show that productivity spillovers through FDI occur easily in low technology sectors. However, this finding is in contradiction with current policies of DCs' governments which are mainly oriented to attract FDI to high-tech sectors.

3.4 Methodological issues

In the previous sections, we put the emphasis on the fact that host country's characteristics determine the pace and the extent of spillovers. In other words, the pattern of technology diffusion relies on the complexity of the knowledge to be transferred and the technological gap between host and home countries. A minimum level of absorptive capability is required for productivity spillovers to take place.

We also consider that some methodological shortcomings might explain the failure to obtain a common pattern in DCs. To start with, most empirical studies suffer from a number of measurements and specification issues. Studies on DCs considerably differ in time period, industrial coverage and data quality. They are likely to present data-related inherent weaknesses due to aggregation bias and omitted variables. For instance, most cross-country estimations fail to control for country specificities. They overlook structural differences between countries and generate mixed results according to the country studied.

In addition, empirical analyses do not study systematically the direction of causality. However it should be considered that causality could not necessarily run from openness to productivity but the other way round. That is to say, FDI could flow into highly productive companies or sectors rather than rising their productivity (Haddad and Harrison, 1993; Hanson, 2001). In the same way, the "self selection bias" of firms in export orientation should be taken into consideration. Successful firms are more expected to engage in export activities than the less productive ones.

Failure to control for the "two way causality" could render the empirical outcomes questionable. Nevertheless, most of the studies presented in Table A rely on the Ordinary Least Squares (OLS) estimator without any prior investigation of endogeneity. Among some others, Hanson (2001), Haddad and Harrison (1993), Liu and Wang (2003) and Madariaga and al. (2007) constitute an exception: after detecting endogeneity, they rely on Instrumental Variables (IV) or Generalised Method of Moments (GMM) approaches. However, finding reliable instruments which are correlated with the regressors but not with the error term constitute a major difficulty to the application of the alternative estimators.

It should be outlined that inverse causality associated to the use of cross-sectional techniques could generate unreliable estimates. For instance, high-productive sectors (say electronics or manufacturing) are likely to enjoy bigger potential to export or to attract FDI. In the same way, low-productive sectors (say food or row materials) would be less attractive to foreign investment. However, if time invariant sectorial differences are not controlled for, cross sectional analysis would detect a significant and positive relationship between openness and economy-wide productivity.

Technology diffusion is a dynamic process extended in time and space. However, empirical studies generally overlook the time dimension of technology diffusion due to data scarcity. Among many others, Mansfeld and Romeo (1980) show that in host countries FDI-led spillovers take approximately two years to be observed. Accordingly, cross-sectional analysis has limited explanatory power: it would be more appropriate to investigate the evolution of productivity over a longer time span rather than relying on one point in time.

Along with the time dimension, spillovers to local economy represent a dynamic process in space. To illustrate, firms can reap substantial benefits by locating near each other. If related firms cluster together, they can attract more suppliers and customers than a single firm could alone. That is to say, economies of agglomeration and network effects give rise to lower production costs and greater market size (Krugman, 1991). Furthermore, geographic proximity to multinationals is expected to facilitate flows of knowledge (Madariaga and Poncet, 2007). In other words, the probability that knowledge would be transferred decreases with distance. Domestic firms which locate near MNCs are expected to benefit more from positive spillovers.

This hypothesis has to be analysed empirically, by explicit consideration of spatial effects through exploratory spatial data analysis (ESDA) and spatial regression methods. To our best knowledge, Madariaga and Poncet (2007) constitute so far the only FDI spillovers analysis which introduces spatial information into the regression scheme. However, it was recently demonstrated that (Abreu *et al.*, 2005) the use of geographic data could imply two major statistical issues, namely spatial dependence and spatial heterogeneity[4]. In the presence of these issues conventional regressors such as the OLS, could generate unreliable parameters and statistical inferences (see chapter 4).

Considering all these issues, one can infer that the big controversy in the empirical evidence might be the outcome of some methodological shortcomings. Today, with the increased availability of geo-coded socio-economic longitudinal data, more systematic and discriminating research is needed. New analytical approaches which exploit simultaneously individual, space and time dimensions of spillovers are expected to give more robust results.

Conclusion

Over the past three decades, FDI and trade have been recognised as major engines of economic development in DCs. Our review of empirical literature shows that in DCs, adequate level of social and economic development has to be in place for spillovers to occur. Governments should implement supportive policies and institutions to FDI and Trade. Improvements in human capital and education are essential for the assimilation and creation of new technologies and for generating sustainable long term growth. Hence, priority should be given to education and training policies to raise general skill level of labour force.
A country's in house R&D and innovation efforts are crucial in keeping pace with FOE's technologies and absorbing the knowledge they diffuse. Governments should implement policies to stimulate both public and private R&D and innovation initiatives. They should reinforce cooperation between foreign-owned firms and local partners such as R&D, universities, public research institutes, information centres, and so on. They should encourage foreign-owned firms to integrate into the local economy through vertical linkages (i.e. customers and suppliers). Public initiative is also needed for the development of adequate transport and communication infrastructure facilities. Furthermore, in order to attract further FDI and enhance economic integration of FDI firms, public authorities should look forward to establish governance and favourable business environment by effective fight of corruption and reinforcement of transparency and rule of low.

[4] Spatial dependence designates the coincidence of value similarity and location similarity (Anselin, 2001). Spatial heterogeneity refers to the situation where the estimated parameters vary across regions depending on their location (Baumont et al. 2000). The presence of spatial heterogeneity violates the Gauss-Markov assumption of existence of a single linear relationship with constant variance across the entire data sample. The econometric issues arising from the use of geographical data are extensively discussed in Chapter 4.

Table A: Summary of Empirical studies on FDI spillovers in Developing Countries

The table below summarises the main findings and methodology of the empirical studies which investigate FDI spillovers to developing countries. The studies on DCs considerably differ in time period, data aggregation level and regional/industrial coverage. It can be clearly observed from the table that in DCs, the empirical support for economic spillovers arising from the outward orientation is inconclusive, even controversial. Most of the studies which detect the existence of spillovers rely on cross-sectional techniques and overlook the space and time dimension of technology diffusion.

Author; Country	Time; Methodology	Results
Aitken and Harrison (1999) Venezuela	1976-1989; Panel Firm level	No spillovers, productivity spillovers to local economy are exclusively captured by joint-ventures.
Aslanoglu (2000) Turkey	1988-1993; Panel Firm level	No direct productivity spillovers, positive effect on the competitiveness of local firms.
Baharumshah and Thanoon (2006) South Asia, 8 countries	1892-2001; Panel National level	Positive impact of FDI on growth, existence of productivity spillovers in host economies.
Blomström and Persson (1983) Mexico	1970; Cross section Industry level	Positive effect on labour productivity of domestic firms; but the direction of the causality between FDI and productivity should be analysed empirically.
Blomström and Wolff (1994) Mexico	1970 and 1975; Cross section Industry level	Positive spillovers; significant productivity convergence between foreign and local firms.
Blomström and Sjöholm (1999) Indonesia	1991; Cross section Firm level	Positive spillovers merely through the competition channel.
Borensztein; Gregorio and Lee (1998) 69 DCs.	1970-1989; Panel National level	Positive growth spillovers in countries which have already reached the threshold level of human capital development (0.52 years of minimum secondary school attainment).
Bouoiyour *et al.*(2009) 63 DCs	1960-2004; Panel National level	No productivity spillovers to host countries; education exerts a negative effect on growth and positive effect on productivity.
Chuang and Lin (1999) Taiwan	1991; Cross section Firm level	Productivity spillovers and technology diffusion to local economy.
Djankov and Hoekman (2000) Czech Republic	1993-1996; Panel Firm level	Negative spillovers to firms which do not have foreign partnership.

Author; Country	**Time; Methodology**	**Results**
Gersl *et al.* (2007) CEE countries	2000-2005; Panel Firm level	No common pattern; negative spillovers in many cases through "brain drain" and "market stealing"; vertical spillover effects are greater than horizontal ones.
Görg and Strobl (2002) Ghana	1991-1997; Panel Firm Level	Productivity spillovers to local firms.
Haddad and Harrison (1993) Marocco	1985-1989; Panel Firm level	No spillovers to local economy although MNCs enjoy a greater TFP than local firms.
Hale and Long (2007) China	2001; Cross section Firm level	No significant TFP and labour productivity spillovers to local firms.
Hu and Jefferson (2002) China	1995-1999; Panel Firm level	No significant spillovers to textile and electronic sectors.
Hu and Tong (2003) China	1995; Cross section Firm level	Positive spillovers; FDI from the OECD countries is more likely to raise overall productivity than overseas FDI from Hong-Kong, Taiwan and Macao.
Javorcik (2004) Lithuania	1996-2000; Panel Firm level	Spillovers only occur through backward linkages from foreign affiliates to their local suppliers in upstream industries in domestic-foreign joint ownership enterprises.
Kathuria (1998) India	1976-1989; Panel Firm level	Positive spillovers in high technology sectors due to greater absorptive capabilities.
Kinoshita (2000) China	1990-1992; Panel Firm level	No spillovers to local economy; productivity gains solely stem from catch-up effect and labour force training.
Kokko (1994) Mexico	1970; Cross section Industry level	Positive labour productivity spillovers to domestic firms.
Kokko *et al.* (1996); Uruguay	1988; Cross section Firm level	Positive labour productivity spillovers to domestic firms which have already acquired adequate absorptive capabilities.
Kugler (2001) Colombia	1974-1998; Panel Industry level	No consistent evidence on spillovers.
Li and al. (2001) China	1995; Cross section Firm level	Existence of spillovers; magnitude and the channel of spillovers are closely related to ownership: private sector mainly benefit from contagion-demonstration effect while state sector benefit more from competition.
Liu (2002) China	1993-1998; Cross section Industry level	No direct spillovers to host industries; positive spillovers to complementary industries.

Author; Country	Time; Methodology	Results
Liu and Wang (2003) China	1995; Cross section Firm level	Positive productivity spillovers; human capital variable is only significant if it is in interaction with FDI.
Madariaga and Poncet (2007) China	1990-2002; Panel City level	Positive spillovers; existence of spatial dependence; Chinese cities do not only take advantage of their own FDI inflows but also of FDI flows directed to neighbouring cities.
Marin and Narula (1996) Argentina	1992-1996; Panel Firm level	No spillovers to local economy.
Sjöholm (1999) Indonesia	1980-1991; Panel Firm level	Positive spillovers to highly competitive industries (due to greater absorption capabilities) and backward industries (through catch-up effect).
Thuy (2005); Vietnam	1995-1999; 2000-2002 ; Panel Industry level	Positive productivity spillovers; expansion of the private sector is fundamental for the diffusion of advanced technologies.
Xu (2000) US FDI in 20 DCs	1966-1994; Panel Firm level	Positive productivity spillovers in countries which have already reached the threshold level of human capital development (1.9 years of secondary schooling).
Yu and Démurger (2002) China	1988-1994; Panel Industry level;	Positive spillovers to commodity sector; controversial results in intermediary goods machinery and equipment sectors.

PART I

PRODUCTIVITY, EFFICIENCY AND GROWTH IN CHINESE ECONOMY

Chapter 1

China's Economic Outlook after 30 Years of Reform

1.1 Introduction

China's recent emergence as a major global partner has been one of the most remarkable economic developments in the past decades. Being a self-reliant autarchic economy until the 1980s, China has transformed itself into a leading global partner. It played an active role in the integration of the world economies through trade and foreign investment. China's recent emergence has noticeably changed the world economic geography. Over the last two decades, economic reforms and opening-up polices it initiated have not only contributed to its own prosperity, but also created a strong momentum in the global economy. Today, China constitutes an important link to regional production networks in East Asia and serves as a key export platform to many MNCs from developed countries.

China's opening up initiative was introduced in 1978 accompanied by a series of economic policies. Chinese governments have achieved considerable progress in globalizing the economy. Over the past three decades, China has gradually reduced or eliminated barriers to the cross-border movement of goods, services and capital. Prices have been largely deregulated and pro-trade and pro-investment policies have been set up. China's opening up initiative generated rapid and impressive results. Today, China ranks third among the top trader countries and it is the major host for FDI inflows in the world. Besides, China's World Trade Organisation accession in 2001 also gave a strong momentum to its integration into global markets.

Over the past decades, Chinese economy has been through significant changes. After the 1980s, China transformed itself from being an agrarian economy to a major industrial power. The relative size of the state sector declined gradually while the non-state sector gained importance in terms of employment and production share. Today, it is commonly accepted that the emerging non-state sector in China exhibits higher productivity than the state sector. Besides, during the reform period, the emergence of small-scale industry in rural areas and foreign invested enterprises in coastal regions significantly propelled economic growth. A greater openness to the world and deregulations gave greater reign to market forces and competition.

The Chinese economy exhibited unprecedented and sustainable growth rates over the last three decades. Two factors have played a capital role in China's recent economic rise: Firstly, Chinese governments have successfully pursued the East Asian NIEs' development pattern by export promotion. Secondly, China has achieved rapid capital accumulation through high rates of domestic savings and FDI inflows. Today, despite considerable reform initiatives, China's financial sector remains relatively small and state-dominated. Thus, FDI and export contribute significantly to allocate financial resources to the developing private sector.

The main purpose of this study is to constitute a baseline for the comprehension and interpretation of the empirical analysis presented in the following chapters. We therefore give comprehensible insight into the issues introduced by reform policies and China's ongoing economic transition. The issues on China's recent economic rise are discussed through six major axes, namely economic reforms and growth, ownership composition and productivity, financial and banking system reforms, opening-up to the world, human capital and research & development; and unbalanced regional development.

1.2 Economic Reforms and Growth

The People's Republic of China (PRC) was funded in 1949 by Mao Zedong. Over the past sixty years, we can clearly distinguish two major phases in China's economic development: the Maoist phase (1949-1977) and the reform phase (1978-onwards).

- The Maoist period in China is, above all, marked by self-reliance and isolation from the world economy. During the Maoist period, the Chinese economy was highly regulated; production and price decisions were largely controlled by the central government authorities. Under the command economy, foreign direct investment to China was virtually nonexistent and foreign trade was a state monopoly. The bulk of the imports were concentrated on essential capital goods and technology from the Soviet Bloc countries (Maddison, 1998).

- Economic reform in China was initiated in 1978, by Mao's successor Deng Xiaoping. The reform initiative introduced a major political shift towards a socialist market economic system. In this regard, radical policy changes have been implemented by the government (Table 1.1). As a first step, reform policies started in the farming sector through the establishment of a household responsibility system and the liberalization of price and output decisions. In the 1990s, further reform initiatives were pursued by the deregulation of almost half of the prices in the industrial sector. Along with the deregulation of the economy, considerable effort has been made to open up China to the world.

Table 1.1: The timeline of economic reforms in China (1978-2004)

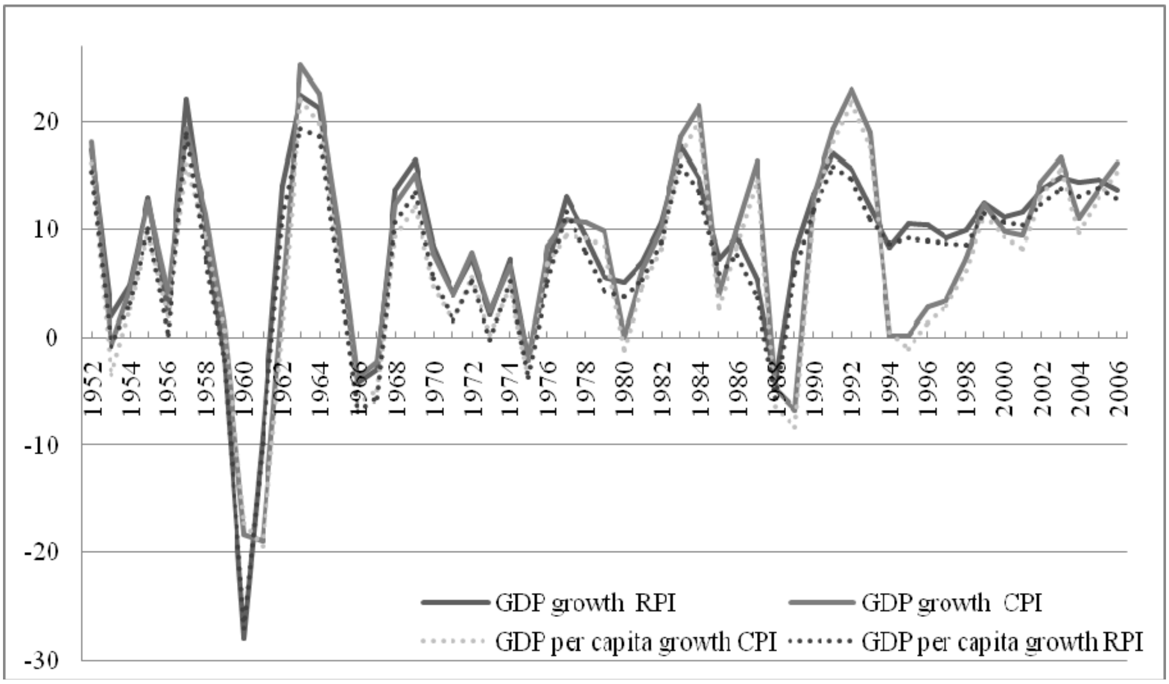
Year	Policy change
1978	Initiation of the "Open door" policy, beginning of foreign trade and investment
1979	Decision to turn collective farms over to households
	Township and village enterprises (TVEs) given stronger encouragement
1980	Special economic zones created
1984	Self-proprietorships of less than 8 persons encouraged
1986	Provisional bankruptcy law passed for state owned enterprises
1987	Contract responsibility system introduced in state owned enterprises
1988	Beginning of retrenchment of TVEs
1990	Stock exchange started in Shenzhen
1993	Decision to establish a "socialist market economic system"
1994	Company law first introduced
	Renminbi begins to be convertible on current account
	Multiple exchange rates ended
1995	Shift to contractual terms for state owned enterprise staff
1996	Full convertibility for current account transactions
1997	Plan to restructure many state-owned enterprises begins
1999	Constitutional amendment passed that explicitly recognises private ownership
2001	China accedes to the World Trade Organization (WTO)
2002	Communist party endorses role of the private sector, inviting entrepreneurs to join
2003	Decision to "perfect" the socialist market economic system
2004	Constitution amended to guarantee private property rights

Source: OECD (2005).

Economic reform in China turned out to be a real success and produced immediate results. Since 1979, The Chinese economy has grown at an annual average rate of 9.5 per cent. We can observe from Figure 1.1 that economic growth has been extremely volatile between 1952 and 1978. Over the pre-reform period, political upheaval introduced by the Great Leap Forward Movement (1858-1960) and Cultural Revolution (1966-1976), dramatically deteriorated the country's economic performance. In contrast, during the reform period, China has exhibited more sustained economic growth at an annual rate of 10 per cent on average. One can also notice from the table that over the entire period of 1952-2007, the rate of per capita growth remained slightly below the overall GDP growth rate.

Despite recent considerable efforts of the Chinese statistical authorities, Chinese official statistics might represent some bias and inconsistencies. Hence, official growth figures should be interpreted with great caution. A detailed discussion on the reliability of Chinese statistics is presented in the next chapter.

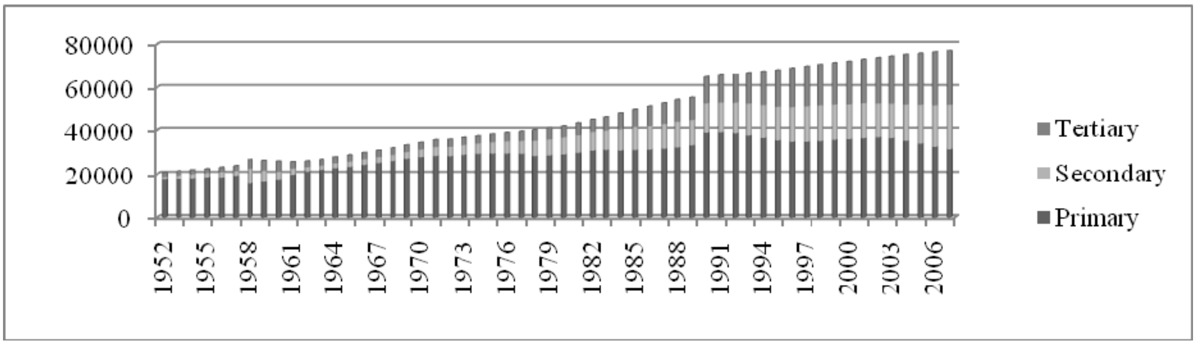
Figure 1.1: Overall real GDP and real GDP per capita growth rates in China (1952-2007)



Sources: SSB (various issues) and author's calculations. **Note:** GDP series are expressed in 1952 constant prices; RPI and CPI designate respectively retail price index and consumer price index.

China's impressive growth over the last three decades has largely been driven by the following factors: rapid capital accumulation through high rate of domestic savings, greater exposure to foreign trade and investment and structural transformation of the economy. Over the last thirty years, The Chinese economy has been through remarkable structural changes common to fast growing DCs. China has transformed itself from being an agrarian economy to a major industrial power. We can clearly observe from Figure 1.2 that, since 1978, the share of agriculture in total employment has considerably decreased. Besides, modernization of agriculture brought major changes in production patterns. For instance, the use of more capital intensive technologies has enhanced technical efficiency and substantially reduced needs for labour in agriculture. It should be outlined that China's recent economic rise has essentially been driven by the rapid expansion of the industrial sector. In addition, since the 1990s, the contribution of the service sector to total output and employment has increased considerably (Figure 1.2). China's WTO membership in 2001 has also triggered the expansion of the service sector via openness to foreign competition.

Figure 1. 2: Employed persons by industry (10000 persons)



Source: SSB

1.3 Ownership composition and productivity

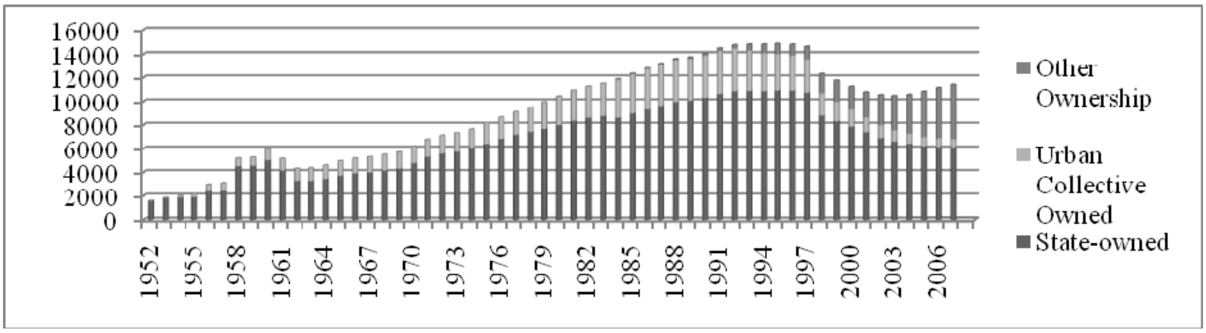
During the reform period, China has shifted from total reliance on state sector to a mixed economy where private sector gained growing importance. Today, we can distinguish three major categories of ownership in Chinese industry:

- **State Sector**

The state sector is predominantly characterised by excessive investment in capital, overly large size and lax budgetary constraints. As a consequence, despite its intensity in skilled labour and physical capital, the Chinese state sector exhibits relatively poor economic performance and inefficient organisation of production.

In China, development of a non-state sector became one of the major axes of economic reform policies. Since the late 1980s, Chinese government made considerable effort to eliminate inefficiencies and to restructure loss-making state enterprises. In addition, the Chinese government introduced important reforms in property rights. In 2003, in order to rationalise its control over state-owned enterprises, it initiated the transformation of most state-owned enterprises (SOE) into corporations (OECD 2005).

Figure 1.3: Staff and workers by ownership (10000 persons)



Source: SSB

Figure 1.3 displays that, on one hand, in the late 1990s, government policies resulted in a dramatic decline in the relative importance of the state sector. On the other hand, the decline in the state sector has been substantially offset by the rapidly growing private sector. During the reform era, non-farming private enterprises have emerged as the most dynamic component of the economy. In this way, an important amount of laid off employees from the state sector have been recruited by market oriented foreign owned and township-village firms.

- **Township Village Enterprises (TVEs)**

The reform initiative in China started successfully in the farming sector. Consequently, rapid improvement in agricultural efficiency gave rise to substantial surplus labour in rural areas. Yet, under the *hukou*[5] system, migration of surplus rural workers to urban areas was highly restricted. In this context, township-village enterprises (TVEs) have been developed in rural areas by ex-farmers. In the 1980s, TVEs became the most dynamic component of the economy and absorbed a substantial part of surplus labour in farming and state sectors.

[5] The *hukou* (household registration) system was introduced in the 1950s under the command economy in order to regulate labour force and insure structural stability by controlling rural-urban migration.

In China, TVEs generally take the form of small scale production units which exhibit high efficiency in resource allocation. Unlike the state sector, TVEs are subject to budget constraints and market competition. They do not benefit from a state bail out and could therefore go bankrupt. Besides, TVEs are usually outward-oriented and show a great potential for the assimilation of advanced technology through competition, demonstration and imitation.

- **Foreign Owned Enterprises (FOEs)**

In the Chinese economy, foreign owned enterprises generally utilise more capital intensive production technologies, and enjoy higher capital and labour productivity than local firms (Sun, 1998). The foreign sector in Chinese industry tends to be very heterogeneous in size and capital intensity, according to the country of origin. For instance, FOEs from the overseas Chinese are generally small scale and take the form of low capital intensive export oriented manufacturing basis. In contrast, FOEs from the OECD countries are generally capital-intensive big production plants, oriented to China's fast growing huge domestic market.

Table 1.2: GDP share of industrial enterprises by ownership (100 million Yuan)

Year	**1997**		**2002**		**2007**	
		%		%		%
Total GDP	113733	100	110776.5	100	405177	100
State-owned Enterprises	35968	31.6	17271.1	15.6	36387	9.0
Collective-owned Enterprises	43347	38.1	9619.0	8.7	10170	2.5
Cooperative enterprises	20376	17.9	3202.9	2.9	3561	0.9
Joint ownership enterprises	-	-	941.9	0.9	1583	0.4
Limited Liability corporations	-	-	20069.8	18.1	90336	22.3
Share-holding Corporations	4976	4.4	14119.0	12.7	40159	9.9
Private Enterprises	-	-	12950.9	11.7	94023	23.2
Other Enterprises	20982	18.4	142.6	0.1	1328	0.3
Enterprises Funded by Foreigners	14399	12.7	18790.5	17.0	85211	21.0
Enterprises with Funds from Hong Kong, Macao, Taiwan	-	-	13668.8	12.3	42418	10.5

Sources: Various issues of China Statistical Yearbook. **Notes:** In 1997 enterprises funded by foreigners category includes enterprises with funds from Hong Kong, Macao, Taiwan.

It is generally asserted that, given their technology intensive production methods, FOE from the OECD countries represent a bigger potential for technology diffusion (Hu and Tong, 2003). In addition, domestic market oriented FDI is more expected to generate direct job opportunities by hiring the local labour force and also indirect opportunities through vertical linkages they tie to the local economy (i.e. suppliers and clients).

Table 1.2 displays the dramatic transformation in ownership structure of Chinese industry since the late 1990s. We can clearly observe that between 1997 and 2007, the share of state sector in total GDP reduced threefold. Besides, the GDP share of the private sector has doubled since 2002. In addition, the table shows a sharp decline in the share of collectively-owned and cooperative enterprises over the same period. Furthermore, between 2002 and 2007 enterprises funded by foreigners and overseas Chinese accounted for more that 30 per cent of total GDP. One can observe that the relative share of enterprises funded by overseas Chinese has declined over the period 2002-2007, whereas foreign enterprises in the economy gained a larger importance.

1.4 Financial System

Since the introduction of reform policies, China has followed a steady and gradual approach of capital account liberalisation. Unlike the farming and industrial sectors, reforms in the banking and financial sectors were implemented very slowly. Today, the Chinese banking and financial sector is characterised by massive inflows of household funds, very high levels of bank deposits (due to high saving rates) and extensive controls on capital outflows. Moreover, the financial market remains underdeveloped and largely state-controlled.

China's capital market was recently created by the establishment of security exchanges in Shenzhen and Shanghai, respectively in 1990 and 1991. Over the last decade, the relative importance of the capital market has grown progressively; between 1995-2000 equity market capitalisation has risen at a rate of 400 per cent.

In China, the banking system is marked by state domination and low efficiency. Over the last decades, non-performing loans due to financial support to state-owned enterprises and huge capital injections from the state have substantially impeded the profitability of the banking sector. In addition, inefficient allocation of funds throughout the banking system hindered industrial productivity. Despite its higher productivity, financial resources in China flow very poorly to the private sector. Private enterprises have a more difficult access to financial resources than state-owned firms. Thus, misallocation of capital and inefficient use of financial resources through the banking sector can jeopardise China's sustainable economic growth in the future.

Since the 1990s, the government authorities made significant effort to restructure and liberalise the banking and financial sector in China. In accordance with its accession commitments to the WTO, in 2006, Chinese government opened up a substantial part of the banking sector to foreign competition. Yet, much more has to be done to reform the banking and financial sector in the future: deepening the domestic financial sector, further integration into international capital markets, reduction of the relative importance of the state and efficiency improvement in the banking sector constitute key challenges for China's future reform agenda.

1.5 Opening up to the World

Since 1979, the government has successfully introduced a series of initiatives to open up China to the global economy. Along with the reform policies, China's trade has showed a gradual shift from import substitution and self reliant policies to export promotion strategies.

- ***Special Economic Zones (SEZ)***

China's opening up to foreign investment and trade was initiated in 1979, with the promulgation of the Law on Chinese Foreign Equity Joint ventures.

Given the lack of adequate infrastructure facilities and high economic regulation, FDI flows to China remained very low during the early years of opening up. In order to overcome the difficulties of opening up and to attract foreign investment, the Chinese government set up Special Economic Zones (SEZ) in the early years of reform. In 1979 and 1980 four SEZ were established on the southeast cost, in Guangdong and Fujian provinces. In 1984, the SEZ was extended to fourteen coastal cities (Table 1.3).

Table 1.3: Chronology of opening-up policies in China (1979-1994)

Year	Type	Location
1979	3 Special Economic Zones	Guangdong
1980	1 Special Economic Zone	Fujian
1984	14 Coastal Open Cities 10 Economic and Technological Development Zones	Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Guangxi Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Zhejiang, and Guangdong
1985	1 Economic and Technological Development Zones 3 Coastal Open Zones	Fujian, Pearl River delta (Guangdong), Yangtze River delta and Fujian
1986	2 Economic and Technological Development Zones	Shanghai
1988	Open Coastal « Belt » 1 Special Economic Zone 1 Economic and Technological Development Zone	Liaoning, Shandong, Guangxi, and Hebei Hainan Shanghai
1990	« Pudong new area » zone	Shanghai
1992	13 bonded areas in major coastal cities 10 major cities along Yangtze River 13 Border Economic Cooperation Zones All capital cities of inland provinces and autonomous regions 5 Economic and Technological Development Zones	Tianjin, Guangdong, Liaoning, Shandong Jiangsu, Zhejiang, Fujian, and Hainan Jiangsu, Anhui, Jiangxi, Hunan, Hubei, and Sichuan, Jilin, Heilongjiang, Inner Mongolia, Xinjiang, Yunnan, and Guangxi All inland provinces Fujian, Liaoning, Jiangsu, Shandong, and Zhejiang
1993	12 Economic and Technological Development Zones	Anhui, Guangdong, Heilongjiang, Hubei, Liaoning, Sichuan, Fujian, Jilin, and Zhejiang
1994	2 Economic and Technological Development Zones	Beijing and Xinjiang

Source : Chen (2004).

A number of incentives were introduced in the SEZ to attract foreign investors and promote exports. For instance, in the SEZ foreign-invested enterprises were offered monetary and political advantages including favourable tax conditions, lenient environmental regulations, provision on infrastructure, financial support, and so on. In addition, duty exemptions were granted to import goods if they were processed for an export purpose.

Over the early years of reform, the instauration of the SEZ generated remarkable success: FDI flowed to the southeast regions and exports expanded considerably. However, the instauration of the SEZ also brought about serious distortions. In some areas, the SEZ disadvantaged local producers and encouraged "round tripping6". Moreover, in the SEZ, foreign invested firms had a tendency to operate as enclaves. Their products and technologies did not have much in common with those of local firms. They interacted on a limited basis with local partners in the upstream and downstream sectors. That is to say, in the SEZ, the scope for spillovers to the rest of the economy was generally limited.

Besides, it is generally argued that the SEZ triggered the polarisation of the economy and led to unbalanced regional development (Fu, 2004). Hence, in 1992 the Chinese government manifested its determination to carry out more harmonious economic development policies and expanded the SEZ to all inland provinces.

- ***The WTO membership***

China applied for membership of the WTO in July 1986. After a process of sixteen years of lengthy negotiations, the PRC joined the WTO on 11 December 2001. The aspiration to become a member of the WTO triggered substantial reforms in Chinese economy. China's WTO membership inaugurated a new stage of economic integration through the benefits and challenges it generated.

In order to join the WTO, China committed to a far-reaching opening by further tariff reductions in the trade sector. In addition, it accepted to open up the service sector to foreign competition in a wide range of areas such as banking, insurance, telecommunication, distribution and many other industries. In exchange, the WTO members offered to abolish discrimination against Chinese products in their domestic market.

[6] Round tripping refers to Chinese capital recycled through Hong Kong in order to take advantage of preferential policies.

It should be stated that China's WTO accession does not only imply further market opening commitments. The WTO membership also signifies the harmonisation of the Chinese economic regime with those of the advanced countries. In this view, China has committed to establish a more equal economic environment by reinforcing transparency, the rule of law and intellectual property rights.

In the future, China's WTO membership is expected to considerably expand the volume of foreign trade and investment. In addition, recent exposure to competition in some sectors is expected to benefit Chinese consumers and bring about better production efficiency to local firms.

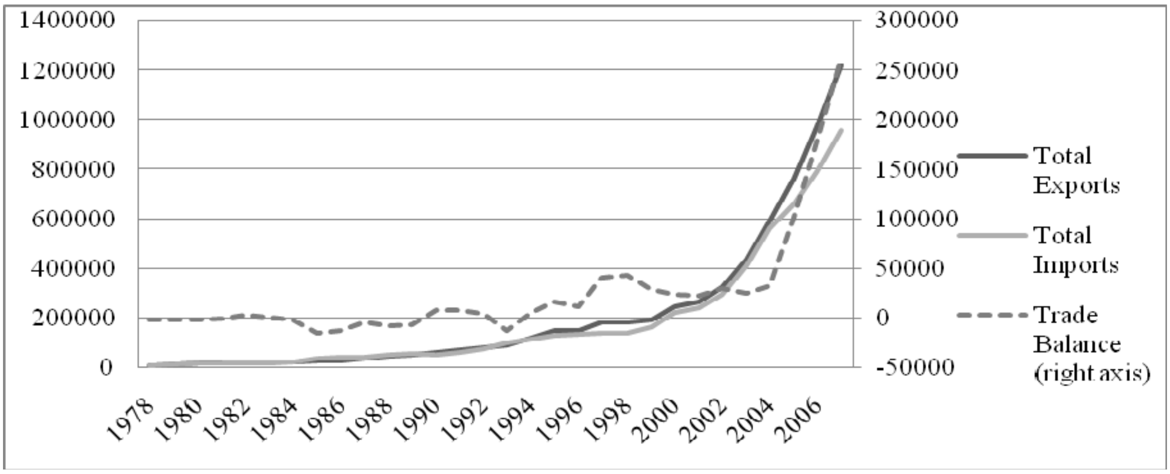
- ***Processing Trade and Specialisation***

Over the last three decades, China has followed with great success, the development path of the East Asian NIEs via export promotion. Alongside the opening up initiative, China has started to exploit its comparative advantage in labour intensive manufacturing goods for exports. Figure 1.4 illustrates the rapid expansion of China's total exports and imports since the late 1980s. Today, the Chinese economy is integrated into global production networks including the high-tech sectors.

In the Chinese economy, it is striking that FDI and trade are highly inter-related; the processing trade accounts for a substantial part of exports and imports. MNCs which carry out different stages of manufacturing activities in different locations generally choose to establish export platforms in China. That is to say, they produce different components of an export good in various countries and assemble them in China due to cheap labour costs. Today, export-oriented-FDI firms account for up to half of China's total exports.

In should be highlighted that in processing trade the parts and components are generally imported rather than being processed by local producers. The substantial part of manufacturing trade occurs at the intra-industry and intra-firm levels. Fu (2004) argues that in China, processing trade gives limited scope for spillovers through vertical linkages to upstream and downstream sectors.

Figure 1.4: Total imports and exports in China (USD 1 million)



Source : China Statistical Yearbook (various issues).

In China, export oriented FOE generally enjoy higher productivity performances than local firms (Sun, 1998). In addition, export orientation of a country encourages scale economies and specialization according to its comparative advantage. In DCs, export activity might also enhance productivity of local firms through competition and demonstration effects[7].

In China, the expansion of exports has generated massive foreign exchange reserves since the late 1990s (Appendix 1). Between 2004 and 2005, China's trade surplus rose threefold and reached 102 USD billion (Figure 1.4). In this way, in 2005, China overtook Japan and became the world's largest foreign exchange reserve holder. In Chinese industry, the accumulation of exchange reserves played an important role in financing the import of technologically advanced machinery and equipment.

Today, export activity in China is mainly concentrated on the southeast coast because of prior preferential regimes, superior infrastructure, relative abundance in skilled labour, and geographic proximity to international market hubs. By the same token, export composition is more sophisticated in coastal and eastern regions due to higher intensity in physical and human capital. In these regions, export goods include a substantive part of equipment, machinery and electronic products.

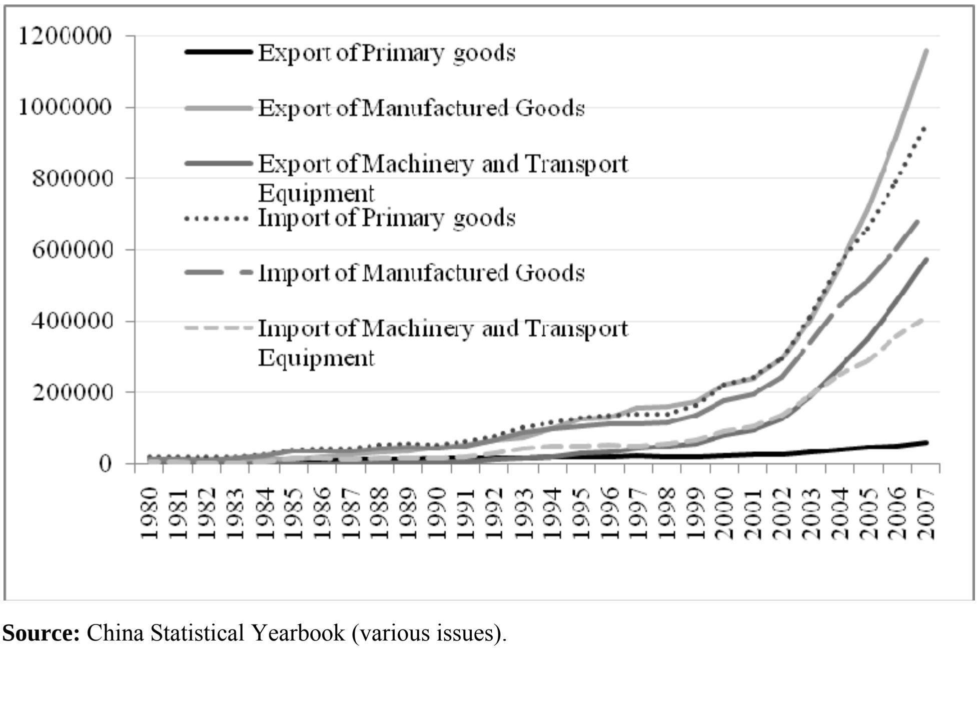
The export composition of a country reflects its level of economic development. That is to say, as long as a country moves up the comparative advantage ladder, its exports tend to become

[7] In the investigation of the nexus between export orientation and productivity, *"self selection"* bias of firms should not be disregarded. Successful firms in an economy generally enjoy a greater potential for engaging in export activities (Görg and Greenway 2004; Fu 2004).

more intensive in capital and technology. Over the last decades, along with the rapid and sustainable economic growth, noticeable changes have taken place in China's trade composition.

China's main comparative advantage lies in the abundance of a relatively qualified cheap labour force. Thereby, China has integrated into the world supply chain through processing trade, by specialising in labour-intensive manufactured products and raw materials. Its major export markets are the USA, the EU, Japan and Hong Kong.[8] During the early years of opening up, the contribution of primary goods and manufacturing goods to China's total export earnings was equal. Since the mid 1980s the manufacturing sector has started to overtake the primary sector. Since the last decade or so, we can observe a progressive shift in China's export specialisation from primary goods to commodities. It is common knowledge that export specialisation merely based on cheap labour generates limited potential for spillovers and technology diffusion. That is to say, a shift in export composition and new comparative advantages created in capital and knowledge intensive sectors are expected to stimulate a technological upgrade.

Figure 1. 5: Export and Import composition (USD 1 million)



Source: China Statistical Yearbook (various issues).

8 According to Chinese custom statistics, in 2005, trade surpluses with the USA and the UE showed a dramatic increase and reached respectively 114 billion USD and 70 billion USD.

Figure 1.5 highlights that processing trade accounts for a substantial portion of China's total imports and exports. One can observe that export of manufactured goods constitutes the most dynamic component of China's foreign trade. Over the last few decades, along with greater involvement in processing trade, China has exhibited rapidly growing demand for raw materials and primary goods. The figure also displays that since the mid 1990s, export of primary goods has remained stable while the import of primary goods has expanded dramatically. Over the last few years, export of machinery and transport equipment has increased whereas the share of primary goods in total exports earnings has decreased substantially.

Table 1.4: China's top five exported products (1985, 2005)

Year	Product Code	Product Name	Value (billion USD)	Share in Total Export (%)
1985	33	Crude oil and products	6.9	20.8
	65	Textile fibres and related products	4.3	12.8
	84	Garments and accessories	3.7	11.1
	26	Cotton and other fibres	2.1	6.2
	05	Vegetables and fruits	1.3	3.8
2005	85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles	172.3	22.6
	84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	149.7	19.6
	62	Articles of apparel and clothing accessories, not knitted or crocheted	35	4.6
	61	Articles of apparel and clothing accessories, knitted or crocheted	30.9	4.1
	90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments	25.5	3.3

Sources: Bureau of Customs of China. **Notes:** The classification of commodities for 1985 is SITC-Four digits. The classification of commodities for 2005 is HS-Six digits.

Along with economic reforms and transition, technological sophistication of produced goods in China has increased gradually (Appendix 2). Table 1.4 compares China's top five exported products in 1985 and 2005 and provides substantial evidence of technological sophistication of Chinese exports. The data from custom statistics convey that, between 1985 and 2005, Chinese exports decisively moved away from resource based products to more sophisticated electronic and manufacturing goods. Put differently, China managed to create new comparative advantages in the production of goods which imply greater income elasticity and added value. This outcome is also promising for the sustainability of China's economic growth in the future and hints at the potential to catch up with leading technology economies.

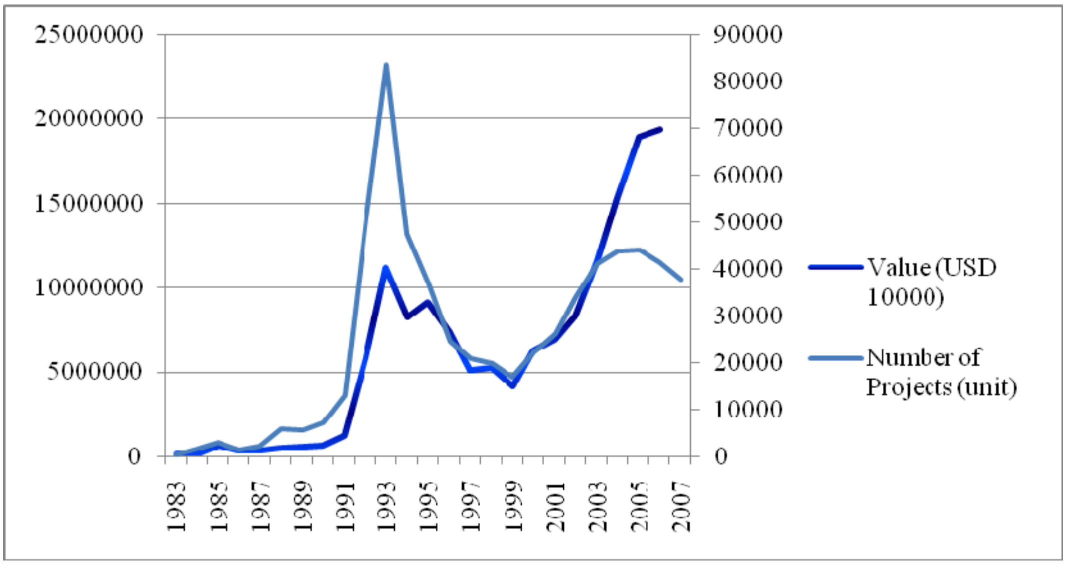
- ***Foreign Direct Investment***

Since the late 1980s, China has been attracting huge amounts of FDI flows and has become the favourite destination of foreign direct investors between DCs. Furthermore, in 2002 China outpaced the USA to emerge as the world's largest recipient of FDI flows (Wu, 2004). China's outstanding success in attracting FDI can be attributed to the following factors:

- Abundance of cheap and relatively qualified labour
- Fast growing, big domestic market
- Rapid and sustainable economic growth
- Government's political and financial incentives to open-up
- Role of the overseas investors

Figure 1.6 illustrates the evolution of FDI flows to China since the 1980s. We can notice that during the early years of China's opening up, FDI flows remained negligible. Since 1984, following the establishment of new SEZ in 14 coastal cities, FDI to China started to grow progressively. During this period, the bulk of FDI were largely concentrated on the southeast coast where the SEZ were set up. In 1992, Deng Xiaoping's tour to the south coast emphasized China's commitment to the open door policy and established greater confidence from foreign investors. The government implemented a series of new policies and regulations to encourage China's economic integration. The same year, the establishment of a "socialist market economy" was declared by the central committee of the Chinese Communist Party (CCP).

Figure 1.6: FDI flows to China



Source: SSB (various issues)

This further opening up initiative turned out to a remarkable success: FDI flows to China reached their peak level between 1992 and 1994. However, between 1998 and 1999, FDI flows slowed down dramatically due to the Asian financial crisis. The WTO membership in 2001 triggered the rapid expansion of foreign investment. In 2002, China overtook the United States to become the world's largest FDI recipient country by attracting 53 billion US dollars of FDI flows. Since 2005, FDI flows to China tend to involve bigger sized projects than before. One can notice from Figure 1.6 that over the period 2005 and 2007 the number of FDI projects decreased whereas the amount of FDI flow continued to grow steadily.

During the early years of the opening up initiative, a major proportion of the FDI flows has been drawn towards labour intensive[9] manufacturing and real estate sectors. However, over

[9] **Labour-intensive** sectors include food processing, food manufacturing, textiles, clothing and other fibre products, leather and fur products, timber processing, furniture, paper and paper products, printing, cultural education and sports goods, rubber products, plastic products, non-metal mineral products, metal products, and others.
Capital-intensive sectors include beverage manufacturing, tobacco processing, petroleum refining and coking, chemical materials and products, chemical fibres, ferrous metal smelting and pressing, non-ferrous metal smelting and pressing, and transport equipment.
Technology intensive sectors include medical and pharmaceutical products, general machinery, special machinery, electrical machinery and equipment, electronics and telecommunication equipment, and instruments and meters (OECD 2000).

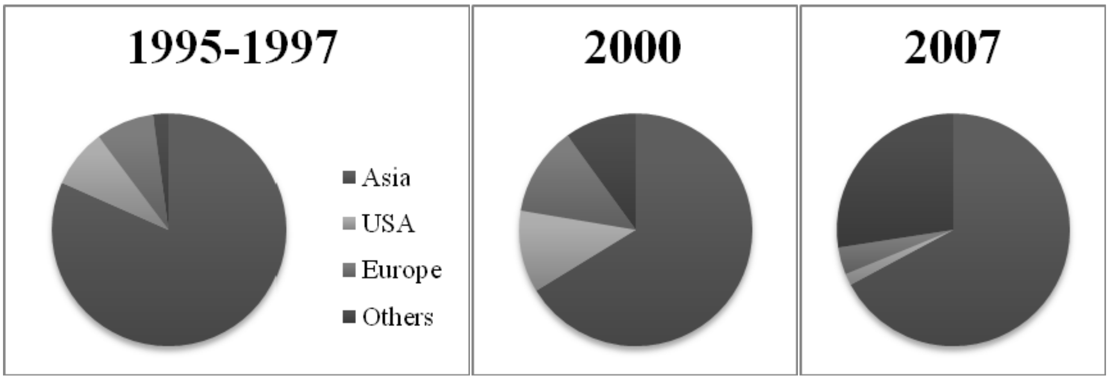
the last decade, technology and capital intensive sectors have been attracting a growing amount of FDI. Table 1.5 shows that between 2000 and 2007, the most attractive sectors to FDI were manufacturing, transport, trade, real estate, scientific research and education. We can also observe that after the WTO accession in December 2001, FDI to the service sector (e.g. insurance, finance and distribution) expanded considerably.

Table 1. 5: FDI Actually Utilised by sectors (USD 10 000)

	2000	2003	2005	2007
Total	4071481	5350467	6032469	7476789
Agriculture, Forestry, Animal Husbandry and Fishery	67594	100084	71826	92407
Manufacturing	2584417	3693570	4245291	4086482
Production and Supply of Electricity, Gas and Water	224212	129538	139437	107255
Construction	90542	61176	49020	43424
Transport, Storage and Post	101188	86737	181230	200676
Information Transmission, Computer Services and Software	N/A	N/A	101454	148524
Wholesale and Retail Trades	85781	111604	103854	267652
Hotels and Catering Services	N/A	N/A	56017	104165
Financial Intermediation	7629	23199	21969	25729
Real Estate	465751	523560	541807	1708873
Leasing and Business Services	N/A	N/A	374507	401881
Scientific Research, Technical Service	5703	25871	34041	91668
Geologic Prospecting, Management of Water Conservancy, Environment and	N/A	N/A	13906	27283
Public Facilities, Services to Households and Other Services	N/A	N/A	26001	72270
Education	N/A	N/A	1775	3246
Health, Social Security and Social Welfare	10588	12737	3926	1157
Culture, Sports and Entertainment	5446	5782	30543	45109

Source: China Statistical Yearbook (various issues).

Figure 1.6: Foreign direct investment to China by regions



Source: China Statistical Yearbook (various issues).

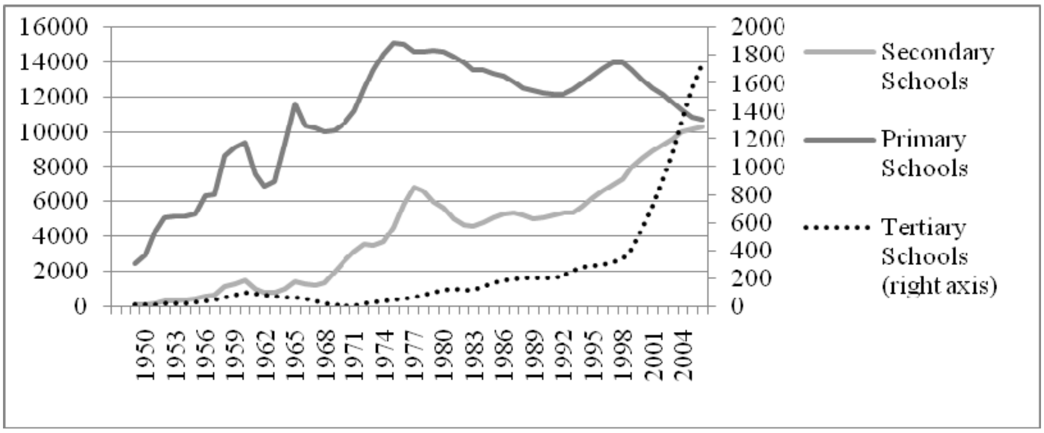
In China, the motivation of FDI is particularly determined by its geographic origin. For instance, investors from overseas China are mainly attracted by cheap labour costs while the bulk of investment from the OECD countries is driven by China's rapidly growing domestic market (Liu and Wei, 2006). Given the cultural, historical and geographic proximities; FDI from Hong Kong, Singapore, Taiwan and Macao accounts for a substantial share of total investment. Over the period 1979-1991, FDI from overseas China corresponded to 80 per cent of total flows. In the 1990s, geographic origin of main investors changed progressively. The share of overseas investors reduced whereas the share of FDI originated from the OECD countries expanded rapidly. The WTO accession of China and further opening up incentives it implied encouraged FDI from western countries. We can observe from Figure 1.7 that between 2000 and 2007, the share of overseas investors stabilized around 60%. In contrast, during the same period, the relative share of FDI from the USA and Europe reduced due to the sharp expansion of FDI from Latin America (up to 21 per cent in 2007).

1.6 Human Capital and Research & Development

During the reform period, in parallel with physical capital accumulation, the Chinese government has manifested great interest in raising the level of education and qualifications of the population. Over the last few decades, China has achieved remarkable progress in the area of human capital development. In 1986, the government launched "children's nine years compulsory schooling" initiative. Consequently, between 1986 and 2000, the percentage of the age group receiving six years of primary education rose from 85% to 100% (OECD, 2005).

Figure 1.8 highlights that during the Maoist period (1949-1977), incentives in human capital formation were mainly concentrated on the expansion at the primary and secondary level. Over the reform period, the priority has been directed to secondary and tertiary level of education. In 1999, the Chinese government set out a plan to double the size of tertiary education institutes in particular in the field of science and engineering (OECD, 2005). This initiative generated great success; the school enrolment tripled over the period 2000-2007.

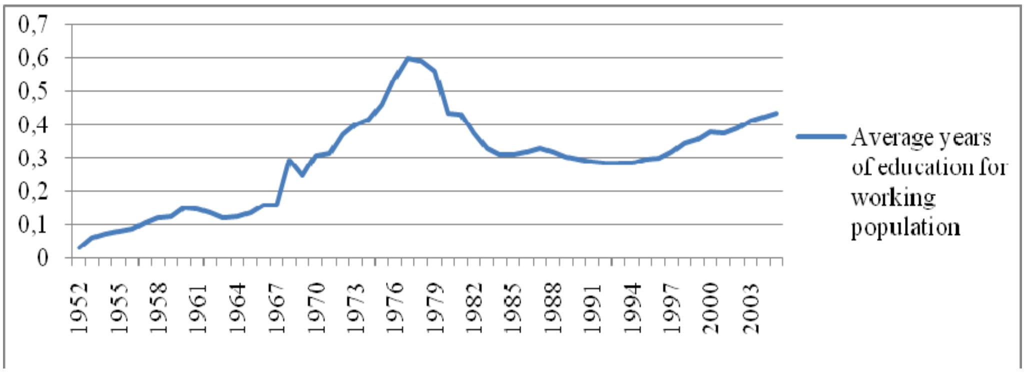
Figure 1.7: Number of school enrolment by type of schools (10000 persons)



Source: SSB (various issues) **Note:** Tertiary schools designate regular institutions of higher education.

As a matter of fact, progress in raising the average level of education actively contributed to raising the quality of the labour force (Figure 1.9). In addition, improvements in health standards and an increase in life expectancy also enhanced the production potential of the Chinese labour force. It is undeniable that an abundant human capital and a qualified workforce constitute key advantages to attract capital intensive FDI.

Figure 1.8: Average years of education for working population

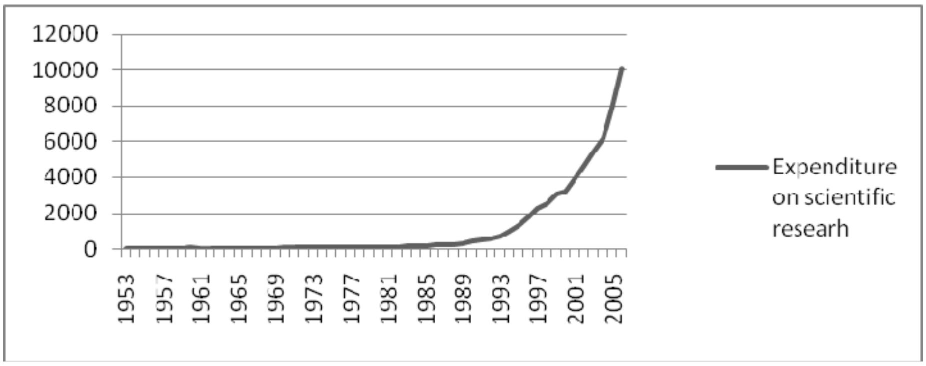


Source: State Statistical Bureau (various issues) and author's calculations. **Notes:** The series of average years of education for working population (15-64 ages) are computed by the author based on the number of graduates from primary, specialized secondary, junior secondary, senior secondary and tertiary schools. The stock of the previous year is depreciated by the death rate.

Furthermore, the constitution of an adequate human capital stock and generation of absorptive capabilities through R&D and innovation are major preconditions for technology diffusion via FDI and trade.

Over the last decade, The Chinese government has manifested its intention to create a favourable policy environment for innovation and assimilation of imported technologies. In order to catch up with the world's leading economies, the government showed a growing interest in the development of science and technology. In 2006, the Chinese government set the goal of being a technology leading country in the future and promulgated the National Medium and Long -term Science and Technology Development Plan (2006-2020).

Figure 1. 9: Total expenditure on research and development (100 million Yuan)



Source: State Statistical Bureau (various issues)

In parallel with private spending, Chinese authorities engaged in active government spending on research and development[10]. Over the last decade, in China, funding for research and technology has grown at a faster pace than the GDP growth. Figure 1.10 displays a dramatic expansion of the expenditure on research and development from the early 1990s onwards. Today, China ranks second in the World ,just below the USA, in the number of people involved in R&D activities and in the amount of spending on R&D (1.2 million USD in 2006).

[10] Over the period 1996-2005, China's government spending on R&D and education grew at an annual rate of growth of 9.3 percent while government spending in health sciences grew at a rhythm of 12.7 percent.

1.7 Unbalanced Regional Development

China's 30 years of economic reform has brought about a higher per capita income and a substantial reduction in poverty. In 1992, income per capita in China outpaced the average level of low income DCs. Yet, China has more to do in the future in order to catch up with industrialised countries. In 2007, its GDP per capita reached only half of that of middle income DCs.

Today, it is a common belief that reform policies in China led to unequal regional development. Despite the substantial part of the population which rose out of poverty, the general perception is that reform policies resulted in worsening regional disparities. Preferential open up policies coupled with some other geographical, political and structural factors manifestly favoured the development of coastal regions. Since the introduction of economic reforms, inland regions have fallen far behind while export and FDI oriented regions have enjoyed higher income growth paces.

In the 1990s the widening regional inequalities became a growing concern for the Chinese authorities. The deepening income gap between regions started to be recognised as a threatening factor to social, political and economical harmony. In 1992, the Chinese government manifested its intention of turning away from special regimes towards nation-wide opening-up strategies. Thus, the government's recent initiatives shifted the focus back to the development of interior regions. In 1999, the government launched the Western Development Strategy in order to establish a favourable business environment in Western China (by developing human capital, natural resources, transport and communication infrastructure, and so on). The Western Development Strategy produced immediate results; it diverted considerable amounts of both domestic and foreign investment to relatively backward western regions. Since 1999, China's western regions have reported annual growth rates above the national average.

The existence of strong economic linkages is a key factor for the fast growing coastal regions to drive the rest of the economy. In the future, Chinese authorities should look forward to remove barriers to labour movements between regions and between urban and coastal areas. In addition, in backward regions, human capital construction through education should be made a priority. It should be highlighted that the lack of skilled workers in central and westerns regions is likely to limit their outward orientation.

In China, the assessment of persistent regional inequalities became of particular interest among scholars and policy makers. In literature, widening income and the evolution of regional inequalities are generally analysed at two major levels, namely between regions (inland and coastal) and between rural-urban areas within the same region. The dominant view is that regional inequalities in China have worsened during the first two decades of economic reform[11]. Chapter 3 presents an extensive discussion and new empirical evidence on regional disparities in China over the period 1994-2006.

Conclusion

Over the last 30 years of reform, China has successfully followed a resource-intensive and outward-oriented economic development model. Since the implementation of reform policies, China has gradually embraced the principles of a market based economy. It transformed its economic structure from a state dominated, self-reliant economy towards a dynamic private-sector-led open economy.

China's rapid economic growth over the last few decades has largely been driven by capital accumulation and integration into the global economy through FDI and trade. China has successfully exploited its comparative advantage in abundant cheap labour and specialised in the production of labour intensive manufacturing goods. Improvements in technological efficiency, better reallocation of resources across sectors and structural transformation have substantially raised its productivity.

Today, China's economic transformation still remains unfinished; in order to sustain the pace of economic growth more has to be done in the future. Despite the governments' considerable efforts over the last three decades, the Chinese economy still exhibits some structural weaknesses in the agricultural, financial and state sectors. That is to say, reform initiatives in the state, banking and financial sectors have to be pursued. Better transparency should be established, besides intellectual property rights, property rights in rural areas need to be reinforced.

In the future, China's economic development could be constrained by bottlenecks in the field of energy, natural resources and environment. Rising income inequalities, environmental

[11] For a detailed summary of empirical studies on regional disparities in China over the period 1978-1995 see Wu (2004, pp. 50).

deterioration and external trade frictions due to the ongoing global economic crisis might jeopardise China's robust economic growth. In the near future, Chinese government authorities should look forward to meeting the needs and challenges of sustainable economic development and promote a more harmonious society. They should pursue their incentives to relax formal restrictions and informal barriers to labour mobility. Establishment of a nation-wide social security system is also expected to reduce income imbalances. In addition, active government spending in human development, construction of adequate infrastructure facilities and a greater outward orientation are needed to encourage the development of inland regions and to promote innovation-driven growth.

Chapter 2

Total Factor Productivity Growth in Chinese Industry: 1952-2005*

Abstract

This study analyses the total factor productivity (TFP) growth in Chinese industry over the period 1952-2005.The paper improves substantially the previous literature in serious respects: First of all, it proposes a comprehensive discussion on Chinese economic statistics. Second, the use of economic tools enables to relax some restrictive hypothesis of the neoclassical growth framework. Third, it adopts the Hodrick-Prescott filter approach to isolate the short-run business cycle from the long-run economic growth. Forth, the paper proceeds to a broader interpretation of the TFP residual which captures a number of factors rather than pure technological change.

Our major findings are: (*i*) In Chinese industry, between 1952 and 2005 capital accumulation has been the main engine of economic takeoff. (*ii*) During the post-reform period, TFP growth contributed significantly to economic growth. (*iii*) TFP gains have exhibited a sharply increasing pattern since the late 1980s, along with the efficiency improvements in State-Owned Enterprises (SOE) and China's integration into the world economy.

Keywords: Total factor productivity; Production function estimations; Capital stock; Transition economies, Chinese economy.

JEL classification: O47; P27; L60.

*I am indebted to two anonymous referees for very helpful comments. I would also like to thank Harry X. Wu, Shuanglin Lin and Derek Blades for constructive criticisms and suggestions. I am also grateful to the participants at the Chinese Economists Society 2007Conference in Changsha and the IARIW-NBS 2007 International Conference in Beijing for their valuable insights on this research. Any errors or omissions remain my responsibility.

Résumé

Cette étude analyse la croissance de la productivité totale des facteurs (PTF) en Chine pendant la période 1952-2005. L'article contribue à améliorer la littérature de plusieurs manières : premièrement, il présente un débat sur la fiabilité de l'appareil statistique chinois; deuxièmement, il utilise des outils économétriques qui permettent de relâcher les hypothèses restrictives de la théorie néoclassique ; troisièmement, il applique le filtre de Hodrick-Prescott aux estimations de PTF afin d'isoler les effets à court terme des cycles d'affaires de la croissance à long terme; quatrièmement, nous adoptons une interprétation plus générale du résidu (i.e. PTF) qui inclut différents éléments comme le changement technologique pur.

Nos principaux résultats empiriques sont les suivants : (i) dans l'industrie chinoise, pendant la période 1952-2005, l'accumulation du capital physique a été le principal moteur de la croissance économique; (ii) pendant la période après réforme, la croissance de PTF a significativement contribué à la croissance économique; (iii) avec les améliorations de productivité dans le secteur d'Etat et l'intégration de la Chine dans l'économie mondiale, les gains de PTF ont manifesté une forte accélération depuis la fin des années 80s.

Mots clés: Productivité totale des facteurs; Estimation de fonction de production; Stock de capital; Economies en transition; Economie de la Chine.

JEL classification: O47; P27; L60.

2.1 Introduction

China has undergone a continuous and spectacular economic growth since the beginning of the economic reform policy, in the early 1980s. Along with the rapid economic takeoff, Chinese economy has experienced a progressive transition from a centrally planned to a market based economy. The structural transformation of Chinese economy over the past two decades is striking: Prior to 1978 China was, above all, an autarkic country isolated from the global economy. Since 1978, it emerged progressively in the global economy as a major trading partner. Besides, China's opening up to the world boosted inward foreign direct investment (FDI). Starting from the late 1990s, China has become the largest recipient of FDI among developing countries.

Over the past two decades, the rapid industrialization of China was mainly marked by the surge of small-scale enterprises in rural areas which absorbed huge amounts of surplus labour in agriculture. As a consequence, during the reform era, substantial efficiency gains have been reaped from the reallocation of resources to higher productivity sectors (Maddison, 1998; Wu, 2004; World Bank, 1997[12]).

Investigating on major sources of Chinese economic growth became a particular concern between economists. Since the last decade, with improved data availability, assessment of the contribution of productivity gains to economic growth aroused great interests among researchers. Most growth accounting studies on the East Asian newly industrialized countries (NICs) (Kim and Lau, 1994; Young 1992, 1995) inferred that the great success of the East Asian "Tigers" has largely been driven by massive factor accumulation, rather than innovative activities and technological progress. In this way, Krugman (1994) reached the conclusion that, the input driven economic growth in the NICs would not be sustainable in the long run. However, unlike the NICs, most studies on China (Chow, 1993; Borensztein and Ostry, 1996; Hu and Khan, 1998; Chow and Li, 2002; OECD, 2005), infer a significant contribution of TFP to economic growth during the reform period.

The purpose of this paper is to analyse the main sources of economic growth in Chinese industry between 1952 and 2005. Using annual aggregate data, the paper investigates empirically to what extent factor accumulation and TFP growth have contributed to output growth in Chinese industrial sector. The study period (1952-2005), which covers both centrally planned and reform periods, enables us to explore the impact of economic reforms and the open-door policy on productivity performances in Chinese industry.

This paper discusses extensively some crucial data issues prevailing in most previous studies. In the production function estimates we rely principally on the official national data provided by the National Bureau of Statistics (NBS). Besides, we compute a new aggregate capital stock data set for Chinese industrial sector for the period 1952-2005. The use of the parametric approach in the production function estimates allows us to relax some restrictive assumptions of the neoclassical growth theory. In this way, our productivity analysis

[12] According to the World Bank (1997), labour reallocation from agriculture to industry contributed about a percentage point to China's overall output growth.

incorporates non-competitive pricing behaviour of firms, variable returns to scale production technology and both Hicks neutral and factor-augmenting technological progress. The impact of capacity utilisation through business cycles is also taken into account into TFP growth estimates. Moreover, this study deals with important econometric issues such as heteroscedasticity and autocorrelation. In addition, it tests for the inter-temporal stability of the production function parameters over the pre-reform and post-reform eras.

The paper is organised as follows: Section 2 contains an extensive discussion of underlying data series used in the empirical analysis. Section 3 provides an account of the estimation procedure of production function parameters. Section 4 describes estimation results and discusses empirical findings. Section 5 provides some concluding remarks.

2.2 Data Issues

One of the major obstacles standing against an accurate analysis of China's industrial productivity is, undoubtedly, the accuracy and availability of official Chinese statistics. China's Statistical System was originally inherited from the Soviet Material Product System. Along with the gradual alignment with the international System of National Accounts (SNA), sectorial coverage of Chinese data has been subject to several changes. China's National Bureau of Statistics (NBS) formerly the State Statistics Bureau (SSB) made significant revisions in 1984 and in 1994 to make Chinese data more in line with the international standards of international classification (ISIC). Besides, during the pre-reform period, the political upheaval introduced by the Great Leap Forward Movement (1958-1960) and Cultural Revolution (1966-1976)[13] gave rise to serious inconsistencies in official Chinese statistics.

The productivity analysis performed in this study requires constant price measures of GDP and investment data. Yet, in China, price indexes prior to 1978 have only became available very recently. Thus, some previous studies (Chow, 1993; Chow and Li, 2002; Jefferson et al. –henceforth JRZ- 1992) consider that under the centrally planned economy, changes in prices were negligible despite high inflation figures in the early 1960s. A detailed discussion about the construction of data series used in the growth accounting analysis is provided below.

[13] Chow (1993), Chow and Li (2002) exclude the years 1958-1969 from aggregate production function estimates due to the data inconsistencies.

2.2.1 Output

In this study, for accuracy and data availability considerations, industrial output is represented by gross domestic product (GDP).Thereby, in the production function, only primary factor inputs, namely capital and labour, are taken into account. For the period between 1952 and 1995, industrial value added data are originated from "GDP 1952-95", while value added figures from 1978 to 2005 come from the various issues of "China Statistical Yearbook" (CSY). It should be stated that between 1978 and 1995, both "GDP 1952-95" and "China Statistical Yearbook" report identical values.

China's official GDP statistics are far from being flawless and may present some inconsistencies. In 1994, the Chinese national income accounting system changed in order to be in line with the international standards of National Income and Product Accounts (NIPA). Compared with the former "National Income" data, the new GDP series include a broader coverage of economic activities[14]. Moreover, China's system of industrial classification changed three times in the reform period (Holz, 2006a).

In the literature, it is generally asserted that official Chinese statistics underestimate inflation and overstate real output growth (Maddison, 1998[15]; Young, 2000). In fact, China's official statistics are mainly based on the reports of local officials. Especially in rural areas, many collective enterprises are believed to report equal rates for both nominal and real changes in output (Woo, 2000). Besides, it is often claimed that political pressure to meet central policy growth targets might push local governments into exaggerating output performances (Chow and Li, 2002). Moreover, a potential downward bias on Chinese official statistics due to the exclusion of the underground economy should also be taken into consideration. However, it is very hard to say to what extend these two opposite biases cancel each other out. According to Chow (2006) and Holz (2006b) despite some accuracy problems, which are common in developing and transitional countries, the official Chinese statistics remain mostly reliable and useful for drawing economic conclusions.

In the literature, the implicit GDP deflator[16] is commonly used to obtain output data in real terms. Some previous studies (Woo, 2000; Young, 2000[17]) suspected that the implicit price

[14] Up to 1994, "National Income Available" equalled to consumption + accumulation. Since 1994, "Gross Domestic Product" corresponds to final consumption expenditure + gross capital formation + net exports.

[15] Maddison (1998) proceed to a downward adjustment of GDP and reduces China's (official) average growth rate from 9.88 percent to 7.49 percent.

[16] The implicit GDP deflator refers to the ratio of nominal to real GDP.

deflator systematically understates the underlying inflation rate. Yet, a possible upward bias in the output data could induce a bias in growth accounting exercises by exaggerating the TFP growth. In this study, the ex-factory price index is used to convert industrial value added to constant price values. It should be noted that, the ex-factory price index indicates substantially higher inflation rates when compared with other deflators, namely the implicit GDP deflator and the retail price index. Consequently, we expect that the use of the ex-factory price index will lower the overall rate of industrial growth in the reform period and cancel out a potential upward bias.

2.2.2 Labour Input

The OECD (2001) highly recommends the use of the total number of hours worked to measure the contribution of labour force to output[18]. However, given the data limitations, in this study labour is measured in terms of number of workers rather than hours worked. The year-end values of number of employed persons are derived from the "Labour Yearbook 1996" and "China Statistical Yearbook 2006". Employment series for industry are obtained by subtracting labour force in construction sector from secondary sector total employment figures.

The official Chinese employment data has several shortcomings: Starting from the year 1998, official annual employment data exhibit some discontinuities. Prior to 1998, employment data included "staff and workers" who were *de facto* laid off[19] (JRZ, 2000). In addition, the official employment statistics reported in the CSY were revised in 1997 in order to be in line with the results of the annual Survey of Population Change.

Previous studies based on number of workers statistics assume systematically a fixed work week. By doing so, they ignore the regulations that reduced the work week in Chinese industry for "staff and workers[20]". In fact, in China, the work week was shortened from a 48-hour-week to a 44-hour-week on March 1994 and to a 40-hour-week on May 1995. In this

[17] Young (2000) infers that the official real GDP growth is overestimated by about a 2 percentage points.
[18] The use of hours worked statistics allow us to isolate the effect of evolution of part time jobs and double jobs as well as shifts in normal hours. For further discussion see OECD Manual "Measuring Productivity" (2001, pp. 39).
[19] In China, especially in state-owned enterprises (SOEs), it should be considered that some workers could be furloughed or take long absences and still remain on the payroll for some political reason (JRZ, 1996).
[20] « Staff and workers » is a sub-category of total employment which refers to formal employment, particularly, in urban sectors.

study, we attempt to compute a consistent employment series by taking into consideration the shortened work week. In this regard, starting from March 1994, we build the 48-hour-week equivalent series for "staff and workers" sub-category by deducting the effect of typical work week declines on annual employment figures[21].

2.2.3 Capital Input

Data issues for China become more problematic when capital input is in question. First of all, China's official statistics do not report capital stock estimates which satisfy international national accounting standards. As a result, most researchers are brought to derivate their own capital stock series following different methods. Capital stock estimates are extremely sensitive to the functional form of depreciation, choice of deflators, aggregation level, capacity utilisation adjustments and contents of the investment data (inclusion of land, inventories, residential buildings, etc.). Hence, it is hardly surprising that in the literature, Chinese capital stock estimates exhibit, in many cases, seriously different patterns.

In this study, we compute a new net capital stock[22]data set following the perpetual inventory method (PIM) introduced by Goldsmith (1951). In sum, the PIM consist of adding the net investment data of the current year to an assumed base year of capital stock. The capital stock series for Chinese industry are computed following Equation 1, where K is capital stock, I is net investment, δ is the depreciation rate and t denotes time.

$$K_t = (1-\delta)K_{t-1} + I_t \tag{1}$$

The amount of the initial capital stock in 1952 is originated from Chow's (1993) estimates of 15.8b Yuan RMB (in 1952 constant prices) for Chinese industrial sector. In the previous literature (Hu and Khan, 1997; Young, 2000), the measurements of investment expenses are usually based on Gross Fixed Capital Formation (GFCF) or Investment in Fixed Assets (IFA) statistics. However, it should be noted that, not all investment increases led to increases in fixed assets. Put differently, in a centrally planned economy, as the Chinese one, some IFA projects may not immediately produce results that meet the standards for fixed assets or some

[21] For further information see JRZ (2000, pp. 809).

[22] Due to the lack of data, the contribution of capital input to output is approximated by the use of "capital stock" data instead of "flows on capital services" as recommended by the OECD (2001).

of them could even be wasted[23]. In this study, we use the economy-wide "newly increased value of fixed assets through investment" (effective investment) data obtained from Holz (2006a[24]). Effective investment refers exclusively to a fraction of the GFCF or IFA expenditures that have been turned into new fixed assets. Hence, we consider that it is more in accordance with the SNA concept of investment. In China, the investment price index has only been available since 1990. In this study, to derive inflation free investment series, the implicit GFCF deflator is used for the period prior to 1990 and the investment price index, for the years 1990-2005.

The official Chinese statistics do not provide information about sectorial distribution of the GFCF. Thereby, in the existing literature, national investment statistics for industrial sector are usually obtained by summing up provincial data. However, in many cases, these estimates display serious discrepancies when compared with national aggregated figures. In this study, to obtain investment series for industrial sector, national investment data are weighted by the share of industry in Newly Increased Fixes Assets (NIFA) statistics of each year[25].

As long as a fixed asset gets older, both its efficiency and price go down. The concept of depreciation refers to changes in the value of assets along with aging and obsolescence. In order to compute net capital stock series, capital goods should be disaggregated into the relevant categories and depreciated separately for each type of asset. This requires information about average service life, retirement pattern, age-efficiency and age-price profile of each type of fixed assets. However, data on depreciation patterns are not available for Chinese industrial sector over the study period. Moreover, official depreciation data in national accounts are based on historical costs and the underlying depreciation methodology remains unclear. In addition, official depreciation rates range from 4.1 to 4.6 percent which are far below international standards for transitional economies (Chen *et al.*, 1988).

[23] For further discussion see Chow (1993, pp. 816).

[24] Holz (2006a, pp. 263) indicates that the economy-wide (total) effective investment data (1981-2005) originated from "Investment 1950-2000 " (2002, pp.77); "Investment Yearbook " (2003, pp.3); (2004, pp.27) and "Statistical Abstract" (2006, pp.52).

[25] Due to the data limitations, for the period 1952-1985 the weight of the year 1985 (0.42) is used to compute investment data for industry. The weight of 0.42 is also consistent with the industrial share of the NIFA in SOEs, available starting from the year 1952 (CSY, 1997).

Table 2.1: Average Growth Rates of China's Capital Stock

Source	Period	Growth Rate (%)
Industrial		
This study	1952-1978	12.2
	1979-2005	9.6
Chow (1993)	1952-1985	12.6
Jefferson and al. (1996)	1980-1992	7.4
National		
Borensztein and Ostry (1996)	1979-1994	9.9
Hu and Khan (1997)	1979-1994	7.7
Maddison (1998)	1952-1978	7.6
	1978-1995	8.8
Wu (2004)	1979-1997	9.6

Some previous studies adopted systematically the official depreciation method without any empirical justification (Chen *et al*. 1988; Chow 1993; Hu and Khan, 1997). In this study, in the same manner as Wu (2004), Young (2000) and Bosworth and Collins (2007), we set the depreciation rate with arbitrary assumptions. Thereby, we assume a geometric depreciation pattern suggesting that the efficiency of assets decays at a constant rate over time. Accordingly, we consider that the depreciation rate covers both the loss of efficiency of fixed assets due to aging and retirement from service (scrapping) [26] .The annual constant depreciation rate is set to 7 percent[27]. This is also in line with most previous studies (JRZ, 1996; Wu, 2004; OECD, 2005; Bosworth and Collins, 2007). The comparison of our capital stock estimates with those of some other authors is summarised in Table 2.1.

[26] In China, there is little information about scraping rates. Hence, most studies (Chen et al., 1988; Wu, 2004; Li et al, 1993) disregard scrapping issues in capital stock estimates.
[27] We also generated five different capital stock series using the constant depreciation rates of 5, 6, 8,9 and 10 percent. On the outcome of several regressions, we found out that production function parameters are not veritably sensitive to the choice of depreciation rate.

2.3 Estimation Methodology

China's aggregate industrial output is represented in the Cobb-Douglas production functional form in Equation 2. Where, Y is industrial value added, K and L are respectively capital and labour inputs, t indicates time, α and β denote output elasticities with respect to capital and labour. A corresponds to Solow (1957) residual which is, in general, identified with technological change. All variables are expressed in 1978 base year prices.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \tag{2}$$

By taking the logarithm on both sides we obtain the estimation equation below, where ε denotes a stochastic error term that is assumed to be a white noise.

$$\ln Y_t = \ln A_t + \alpha \ln K_t + \beta \ln L_t + \varepsilon_t \tag{3}$$

In the empirical literature, productivity analyses are mainly based on two different approaches: On one hand, the parametric approach applies econometric techniques to estimate parameters of production function. On the other hand, the non-parametric approach approximates factor elasticities by means of index numbers techniques (based on the factor shares in national income).

The non-parametric approach assumes firms to operate in distortion-free perfectly competitive markets. It should be noted that the perfect competition hypothesis implies that firms are profit maximisers and factors are paid to their marginal product. In this manner, output elasticities of factors equal to their respective shares of payment in national income. However, in transitional and centrally planned markets, like the Chinese one, assuming perfect competition and profit maximisation could not correspond to the reality. In China, particularly, during the pre-reform period, prices were highly controlled by political authorities. In the case of distorted prices, the use of factor shares as output elasticities may be inappropriate and could result in some biased parameter estimates.

In this study, the parametric approach is adopted to estimate the production function parameters. By applying econometric tools, we avoid postulating a relationship between income shares and factor elasticities. In this way, we also relax some restrictive hypothesis of the neoclassical growth framework such as perfect competition, constant returns to scale (CRS) production technology and Hicks neutral technological progress.

Most of the previous productivity analyses in the literature impose CRS restriction to production function estimates. In this study, we do not assume, *a priori,* CRS of production technology. The relaxation of CRS hypothesis implies that factor elasticities do not necessary have to add up to unity ($\alpha+\beta\neq1$).

Growth accounting literature assumes systematically technological change to be Hicks-neutral[28]. Thus, TFP growth is usually captured by the inclusion of an exponential time trend to the regression analysis (Chow and Li, 2002; Chow 1993; Wu, 2004). In the production function estimates, we relax Hicks neutral technological change assumption and allow for factor augmenting technological progress. Thereby, the constant term in the regression analysis captures any form of technological change, namely both Hicks-neutral and factor-augmenting (capital-augmenting and labour-augmenting).

Table 2.2 summarises the OLS estimates in levels of the Cobb-Douglas production function. We preferred to estimate in levels since the first difference operator could remove some information about the long-run relationship between factor inputs and output, and also emphasise the short-run fluctuations. According to Table 2.2, most of the coefficients of the model variables (except the constant term in the VRS regressions) are highly significant. The Adjusted R-squares of both regressions are close to one, indicating a very good fit of the model. In addition, the F-Statistics presented below, illustrate that all regressions are globally significant at the 1 percent level.

Variable returns to scale (VRS) estimates are presented on the left side of Table 2.2. In the non-restricted OLS specification we can observe that the sum of the coefficients is slightly lower than one, supporting the assumption of decreasing returns to scale production technology. To determine whether this outcome is statistically significant, we perform the Wald coefficient restriction test. The associated F-statistics of the Wald test show that the null hypothesis of CRS cannot be rejected even at the 5 percent level. In addition, the ARMA (1,1) specifications illustrated in columns (3) and (5) yield almost the same output elasticities, which sum to unity, whether or not the CRS restriction is imposed. These results give strong

[28] Hicks-neutral technological change hypothesis implies that technological progress increases the marginal productivity of both capital and labour to the same extent.

evidence on the existence of CRS production technology in Chinese industry over the period 1952-2005.

To detect a likely heteroscedasticity of the error terms, the White heteroscedasticity test is performed. The associated *p*-values of the F-Statistics give evidence about the existence of heteroscedasticity in the OLS estimations. Besides, the White test results indicate that the null hypothesis of homoscedasticity of residuals cannot be rejected at the 5 percent level in the ARMA (1,1) estimations.

The major shortcoming prevailing in most previous studies is, undoubtedly, the serial correlation of errors. According to Table 2.2, in the OLS specifications, the associated Durbin-Watson Statistics reveal a significant positive serial correlation. This outcome is also confirmed by the Breusch-Goldfrey Lagrange (LM) test performed with 4 lags. In order to correct for the autocorrelation issue, we proceed to an ARMA specification under both VRS and CRS hypothesis (columns 3 and 5). Eventually, the D-W statistics of residuals for ARMA (1,1) regressions reveal no remaining autocorrelation. In addition, the F-statistics associated to LM test also confirm the absence of serial autocorrelation of residuals.

The use of an aggregate production function assumes factor elasticities to be constant across the entire period observed. However, alongside the reform policies, Chinese industry underwent substantial structural changes that may have had an effect on production technologies. Hence, before validating the ARMA specification, it is crucial to investigate empirically on the inter-temporal stability of production function parameters. Thereby, we perform the Chow forecast test with different time breaks in the years 1978, 1979, 1980 which correspond to the introduction of reform policies. For those three breakpoint years, the F-statistics of the Chow forecast test indicate that the null hypothesis of no structural change in the production function parameters could not be rejected at the 5% confidence level. Consequently, we consider that in Chinese industry, production function elasticities remained constant between 1952 and 2005.

Table 2.2 : Regression Results for the Aggregate Production Function of Chinese Industry: 1952-2005

Independent Variable: GDP	Variable Returns to Scale OLS	Variable Returns to Scale ARMA(1.1)	Constant Returns to Scale OLS	Constant Returns to Scale ARMA(1.1)
Constant	-0.21 (-1.38)	-0.43 (-1.08)	-0.31*** (-3.98)	-0.41*** (-3.16)
Ln K	0.76*** (1.40)	0.79*** (15.83)	-	-
Ln L	0.19* (9.95)	0.21** (1.89)	-	-
lnK/L	-	-	0.73*** (18.51)	0.78*** (11.06)
AR(1)	-	0.67*** (4.69)	-	0.67*** (3.85)
MA(1)	-	0.67*** (4.02)	-	0.67*** (3.78)
Adjusted R^2	0.98	0.99	0.91	0.98
Number of observation	54	53	54	53
Residual Sum of Square	1.89	0.57	1.90	0.47
Model F-Statistic	1320 [0.00]	2358 [0.00]	555 [0.00]	710 [0.00]
Akaike Info Criterion	-0.40	-1.53	0.43	-1.72
White test	3.10 [0.02]	1.56 [0.19]	5.97 [0.00]	2.16 [0.12]
Durbin-Watson Statistics	0.38	1.99	0.36	1.99
Serial Correlation LM Test	61.61 [0.00]	0.10 [0.89]	60.04 [0.00]	0.07 [0.92]
Test for CRS restriction	-	-	F(1.51)=0.35 [0.55]	F(1.48)=0.00 [0.96]

Notes: *** significance at the 1% level, ** significance at the 5% level, * significance at the 10% level. All numbers in parentheses are White heteroscedasticity-consistent t-statistics while figures in squared blankets are p-values.

In view of these results, the CRS restricted ARMA (1, 1) specification turns out to produce the best statistical results. Furthermore, the ARMA (1, 1) specification yields almost identical coefficient estimates (which add up to unity) whether or not the CRS restriction is imposed[29]. Accordingly, the output elasticities of 0.78 with respect to capital and 0.22 with respect to labour are used in the growth accounting analysis below. It can be observed that the capital elasticity of 0.78 is slightly higher than those in the literature[30]. However, we consider that

[29] We also tried several auto-regressive and moving-average specifications with different time lags. To save place only the OLS and ARMA (1,1) estimation results are reported in table 2. The MA (1) and AR (1) results are available on request from the author.

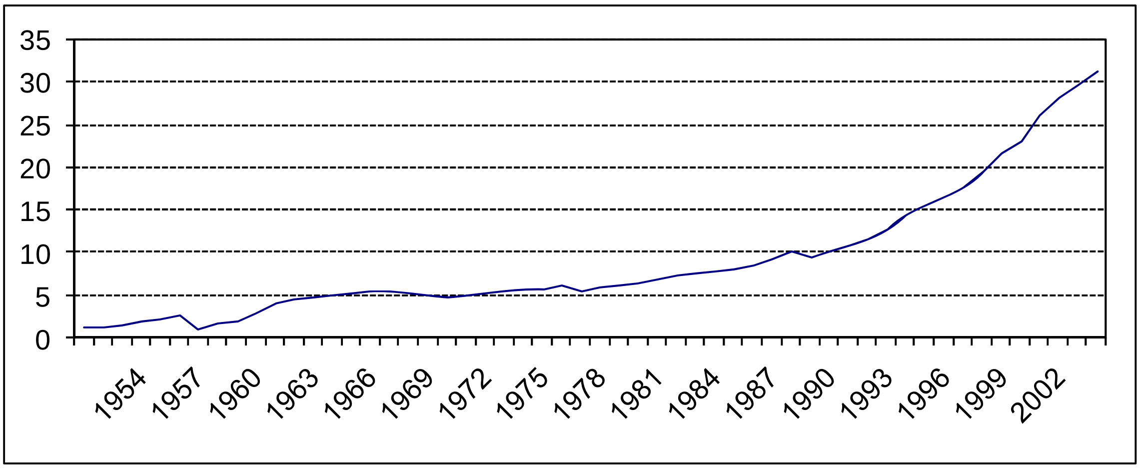
[30] For Chinese industry, the output elasticity for capital is estimated to be 0.75 in Chow (1993) for the period 1952-1985 and 0.72 in Xu and Wu (2001) for the period 1979-1997.

these results are in accordance with the reality: Low labour elasticity as well as high capital elasticity are major characteristics of transitional economies where labour is abundant whereas capital is scarce.

2.4 Productivity Performances of Chinese Industry

Industrialisation of the Chinese economy began in the early 1950s, just after the foundation of the People's Republic of China in 1949, by Mao Zedong. Besides, physical capital accumulation speeded up in the reform period due to the high level of both investment and domestic savings. Investment in Chinese industry indicates a significantly changing pattern between 1952 and 2005. On one hand, under the centrally planned economy, investment was fully funded by government and particularly concentrated in heavy industries. On the other hand, in the reform period, a growing part of investment was financed by household savings and oriented towards labour-intensive manufacturing industries.

Figure 2.1 : Capital intensity in Chinese Industry (Capital/Employment ratio)



Source: SSB (various issues), author's calculates.

Figure 2.1 displays that in the course of the reform period the capital/labour ratio in China exhibited an increasing trend. Moreover, Figure 2.1 also highlights that the capital intensity shifted strikingly starting from the early 1990s. The substantial increase in capital/labour ratio expresses the changes in the allocation of productive factors, for instance substitution of capital for labour. Undoubtedly, the elimination of redundant workers in SOEs has also contributed to enhance capital intensity in the industrial sector. Furthermore, China's rapid exposure to foreign trade and FDI inflows has accelerated capital formation since the last decade. In this section, extended overviews of both multifactor and single factor productivity performances for the period from 1952 to 2005 are presented.

2.4.1 TFP Growth

In the neoclassical growth framework, TFP growth is calculated as a residual term, by subtracting the contribution of capital and labour inputs from output growth. In other words, TFP growth corresponds to the portion of growth left unaccounted by increases in factor inputs (see TFP debate, in Appendix 1). We derive the year-to-year estimates of TFP growth

$$\frac{\partial \ln TFP}{\partial t} = \frac{\ln GDP}{\partial t} - \alpha \frac{\partial \ln K}{\partial t} - \beta \frac{\partial \ln L}{\partial t} \tag{4}$$

Since the use of inputs is subject to cyclical factors, economic activities tend to fluctuate over the business cycle. As a consequence, TFP estimates exhibit procyclical behaviour and need to be adjusted for capacity utilisation (Hulten, 2000). For instance, downturn periods in demand are characterized by excess capacity whereas during upturn periods production capacities are fully utilised. Hence, TFP estimates could be biased if capacity utilisation is overlooked in productivity analysis. In addition, pro-cyclical fluctuations of TFP growth are likely to obscure some information about the movements in the long-run components and conceal some significant breaks in the time trend (Hulten, 2000).

In the literature, capital stock statistics are usually adjusted for capacity utilisation by means of inventory data, unemployment statistics or power utilisation rates (Jorgenson and Griliches, 1997). However, in China, there is no direct measure of capacity utilisation available over the period 1952-2005. Hence, we obtain smoothed TFP series by applying the widely used Hodrick-Prescott (H-P) filter. In summary, the H-P is a linear filter suggested by Hodrick and Prescott (1997) which removes the cyclical components of the long run path of the residual. It proceeds by decomposing the original series (y_t) into two components: long term trend component (g_t) and cyclical component ($c_{t)}$), that is:

$$y_t = g_t + c_t \tag{5}$$

Solving the following minimisation problem allows us to determine the growth component:

$$\underset{\{g_t\}_{t=1}^{T}}{Min}\sum_{t=1}^{T}(y_t - g_t)^2 + \lambda\sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \quad (6)$$

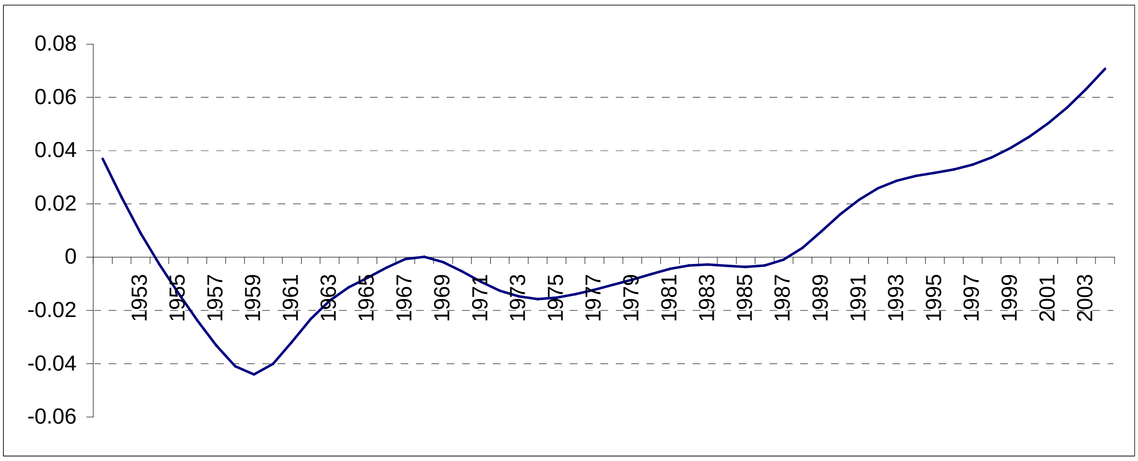
The first term is the sum of the squared deviations from trend whereas the second term is the multiple λ of the sum of squares of the trend component's second differences. The parameter λ[31] penalises variability in the growth component. The H-P filter consists of a trade-off between the cost of incorporating fluctuations in the growth series (i.e. good fit) and the prescribed smoothness of the trend component. In this study, the smoothing parameter λ is set to 100 following the suggestion of Hodrick and Prescott (1997) for annual data.

In the last decade, some critical literature pointing out several shortcomings of the H-P filter has blossomed (Cogley and Nason, 1995; Harvey and Jaeger, 1993). Critics of the H-P filter mainly focus on the likelihood of spurious cycles estimates, particularly while filtering difference stationary data series. Some likely autocorrelation issues related to H-P filtered time series are also addressed in the recent literature. However, presenting a detailed discussion about the drawbacks and shortcomings of the H-P filter is beyond the scope of this paper.

Under the neo-classical assumptions, the residual is confined to exogenous, disembodied and Hicks-neutral technological progress (Chen, 1997). In this study, we proceed to a wider interpretation of the residual. To begin with, in our analysis TFP involves all kinds of disembodied technological changes (new managerial and organizational methods, R&D and innovation activities, etc.) which improve production efficiency. Besides, the residual captures a mix of factors that enhance economic growth (scale economics, spillover effect, improvements in resource allocation, institutional and political factors) and measurement errors.

[31] Note that while λ approaches to 0, the trend component becomes equivalent to the original series, i.e. y_t=g_t. While λ goes to infinity the growth component converges to the OLS estimates of y_t's linear time trend.

Figure 2.2: The HP Filtered Total Factor Productivity Growth Estimates



Source: Author's calculates.

The Chinese economy has been experiencing a process of technological development and institutional change, since the beginning of the reform period. In a centrally planned economy, allocation of resources and investment decisions are not determined through market mechanism but by the government's budget allocation policy. Besides, industrial prices and wages are highly regulated by the central authority. Consequently, Chinese industry has severely suffered from the inefficient allocation of factor inputs in the central planning period. Alongside the extended reforms policies, significant efforts have been made to establish a capitalist market economy.

The H-P smoothed TFP growth series between 1952 and 2005 are illustrated above. It is obvious from Figure 2.2 that political turmoil introduced by the Great Leap Forward Movement (1958-1960) and the Cultural Revolution (1966-1976) undermined dramatically the TFP outcomes of Chinese industry. According to Figure 2.2, in the central planning period, TFP growth was negative. The outcome of negative TFP growth during the pre-reform era is also in line with most previous studies (Chow, 1993; Chow and Li, 2002) which infer the absence of technological progress in the pre-reform period.

Figure 2.2 displays negative TFP growth estimates until the late 1980s. This finding is also consistent with some previous studies (JRZ, 1992; Wu, 2004; Wu and Xu, 2001) which detect a productivity decrease in Chinese industry in the middle of the 1980s. Weak productivity performances during the first decade of the reform period could be attributed to several factors: First of all, in the beginning of the reform era, in Chinese industry, TFP gains were hampered by the sluggish economic performances of the state sector. Given soft budget constraints, in state-owned enterprises (SOEs), there were very few incentives to enhance productivity. As a consequence, during this period, the Chinese state sector was mainly characterised by overstaffing, excess investment in fixed capital and poor management. In the mid 1980s a series of industrial reforms was conducted in order to restructure the economic system and introduce a market based economy. However, the implementation of those reform policies turned out to be very complicated and needed more time to produce results (Wu, 2004). Under the dual-track system, productivity performances of Chinese industry were impeded. Moreover, owing to some political reasons, resources were globally allocated into loss-making SOEs rather than into the growing private sector. Consequently, bank debts and non performing loans to support SOEs also undermined productivity performances of Chinese industry. In addition, poor TFP performances until the late 1980s could well be related to the inefficient utilisation of production factors, especially in the state sector. In fact, a possible overstatement of factor inputs could lead to an underestimation of the residual over this period.

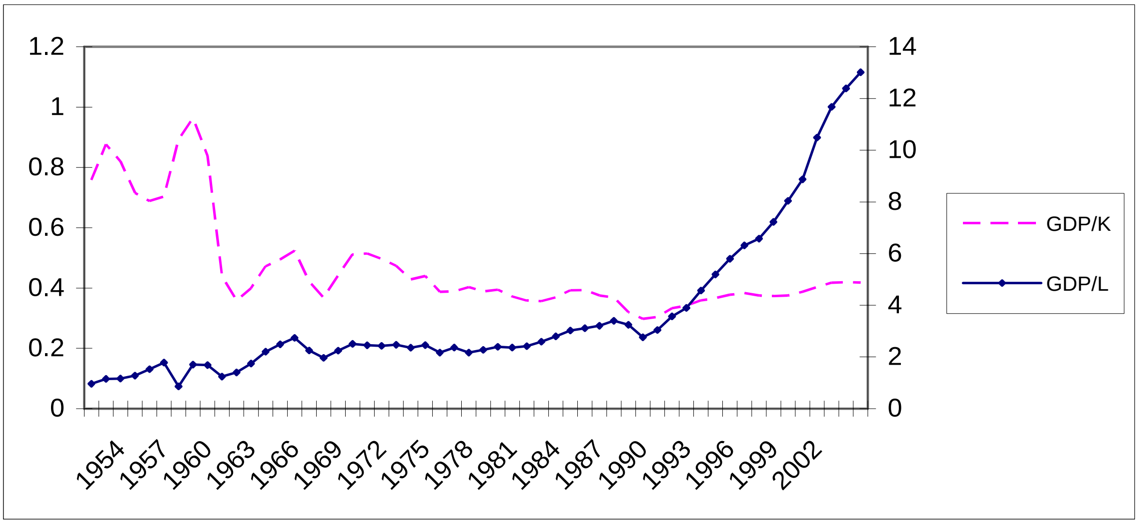
The reform period in Chinese industry is largely marked by the huge expansion in industrial activity outside state sector. Along with the structural transformation of Chinese industry, the relative importance of the state sector has declined continuously. In the 1980s, township and village small-scale enterprises emerged in rural areas. Furthermore, by the early 1990s, foreign-invested enterprises gained important market shares in industrial sector.

According to Figure 2.2, since 1988, with a gradual adoption of a distortion-free market economy, TFP in Chinese industry started to exhibit positive growth figures. During this period, institutional reforms carried out in the state sector as well as in the banking sector began progressively to bear fruit. The reallocation of the labour force out of SOEs gave substantial opportunities for achieving efficiency gains. Furthermore, by the early 1990s, the government had undertaken comprehensive reforms to open-up China to the world economy. In this regard, significant efforts have been made to reduce barriers to foreign trade and investment. China's rapid integration into the world economy resulted in a massive inflow of FDI flows and the expansion of foreign trade. Thereby, starting from the late 1990s, China has become the largest developing-country recipient of FDI. It also joined the World Trade Organization (WTO), in December 2001. In China's industrial sector, the growing share of foreign-owned enterprises (FOEs) is likely to involve spillover effects. In fact, a reinforced competition on domestic markets may increase overall productivity by constraining local enterprises to upgrade their efficiency and competitiveness. Furthermore, substantial improvements in human capital, recorded since the last decade, probably contributed to TFP gains in the industrial sector.

2.4.2 Single Factor Productivity

Under the centrally planned economy, labour movements between sectors had been tightly restricted through the *hukou* (household registration) system. Consequently, in the pre-reform era, a massive labour surplus in rural areas developed due to technological improvements and democratic increase. Alongside the market-oriented reform policies, barriers to labour migration between urban and rural sectors have been lowered. The expansion of small-scale enterprises in rural areas contributed to improve labour productivity in Chinese industry. Figure 2.3 illustrates the positive long-term trend of labour productivity in industrial sector during the reform era. Besides, since the early 1990s, the output per worker ratio has shown an impressive accelerating growth pattern. The improvement of labour productivity performances could largely be attributed to the high rate of capital formation, substitution of capital for labour and to a better resource allocation across sectors. Moreover, the elimination of redundant workers in SOEs has, doubtlessly, contributed to reap labour productivity gains in Chinese industry.

Figure 2.10: Single Factor Productivity: output /labour and output/capital ratios



Source: SSB (various issues), author's calculates.

In contrast to increases in output per worker, Figure 2.3 depicts a globally declining trend in output per unit of fixed assets, particularly in the second half of 1980s. The capital productivity slowdown during this period could stem from the excess investment and inefficient capital allocation, especially in SOEs. Over the past decade, capital productivity pictures a slightly accelerating pattern which could be attributed to the rapidly growing share of private enterprises in low-capital intensive industries.

2.4.3 Growth Accounting for Chinese Industry 1952-2005

Neoclassical growth accounting framework identifies two major sources of economic growth, namely factor accumulation and TFP growth. Given that capital accumulation is subject to the law of decreasing returns, theoretically, an input-driven economic growth could not be sustainable. Hence, in the long run, growth should be generated by advances in knowledge or technology, through better policies and improved management. In other words, a sustainable long term economic growth should essentially lie on TFP growth.

In order to inquire into the main sources of economic growth in Chinese industry, we perform the conventional growth accounting analysis[32]. A summary of the average growth rates of output and primary factor inputs are presented in Table 2.3 From Table 2.3 we observe that both the Chinese industrial output recorded a steady rate of growth of about 10 percent between 1952 and 2005. However, following a sharp rise from 1966 to 1978, the growth rate of employment has been continuously declining during the post-reform period. Moreover, employment figures continued to decrease dramatically in the early 1990s. This phenomenon could largely be attributed to the replacement of laid-off state workers by the labour force reallocated from farming to industry (OECD, 2005).

Chinese industry has been marked by a rapid capital formation since the early 1950s. During the pre-reform period, capital accumulation growth rate exceeded the overall GDP growth, whereas since the early 1990s the physical capital accumulation rate has fallen behind the GDP growth rate.

[32] In the growth accounting exercise the weights assigned to capital and labour inputs are respectively 0.82 and 0.18. However, in most previous studies output elasticity with respect to capital is usually set about 0.6. Consequently, in this study, the use of greater output elasticity for capital input is expected to reduce TFP estimates.

Table 2.3: Average Annual Growth Rate (%)

Period	Output	Capital	Labour
1952-2005	**9.8**	**11.0**	**4.5**
1952-1965	10.8	14.5	3.0
1966-1978	7.7	10.1	9.8
1952-1978	**9.7**	**12.4**	**6.3**
1979-1992	8.6	9.9	4.9
1993-2005	11.4	9.5	0.7
1979-2005	**10.0**	**9.6**	**2.8**

Source: Author's calculates.

The average contributions of input factors and TFP to economic growth are summarized in Table 2.4. At first glance, we observe that during the whole study period, capital accumulation has been the main growth engine of Chinese industry and accounted for 88 percent of output growth. Besides, TFP growth has shown an accelerating trend and contributed positively to economic growth at a pace of 1.9 percent. According to Table 2.4, in Chinese industry, growth in labour input explains 10 percent of output growth between 1952 and 2005.

Table 2.4: Average contributions of input factors and TFP to economic growth in Chinese Industry: 1952-2005

Period	Output Growth	TFP Growth	Capital contribution	Labour Contribution	TFP Contribution
1952-2005	**9.8**	0.2	0.9	0.1	0.0
1952-1965	10.8	-1.2	1.1	0.1	-0.1
1966-1978	7.7	-2.3	1.0	0.3	-0.3
1952-1978	**9.7**	-1.4	1.0	0.1	-0.1
1979-1992	8.6	-0.2	0.9	0.1	0.0
1993-2005	11.4	3.8	0.7	0.0	0.3
1979-2005	**10.0**	1.8	0.8	0.1	0.2

Source: Author's calculates.

In contrast to some previous studies, Table 2.4 gives evidence about the absence of TFP gains under the centrally planned economy. It also illustrates that TFP growth figures remained positive in the overall reform period despite a slight decline from 1979 to 1992. Furthermore, Chinese industry recorded the best TFP performances starting from the early 1990s. Since 1993, TFP has grown at a rate of 3.8 per cent, supporting China's ability to sustain these high rates of economic growth in the near future.

Concluding Remarks

This study investigates empirically the driving forces of economic growth in Chinese industry through a parametric approach. The use of econometric tools in production function estimates enables us to relax some behavioural assumptions of the neoclassical growth theory such as constant returns to scale, Hicks neutral technological change and perfectly competitive markets.

The major outcome of this paper is that massive capital accumulation has been the driving force of the spectacular economic performances in Chinese industry, between 1952 and 2005. Besides, TFP gains contributed positively to economic growth during the post-reform era. Our empirical results yield no support for the concern of TFP slowdown as expressed in some recent studies. Besides, our TFP estimates exhibit an accelerating growth pattern since the early 1990s, giving consistent evidence about the sustainability of economic growth in the near future.

In this study, we proceed to a broader interpretation of the conventional Solow residual: Our TFP estimates include both embodied and disembodied technological change, effects of resource allocation between sectors, scale economics, institutional and political factors which affect growth and measurement errors.

Issues of data availability are of a great concern in Chinese studies. In this way, some data accuracy problems are likely to threaten the robustness of our results. In the literature, it is often asserted that China's official GDP statistics may display an upward bias. Thereby, understatement of the real inflation rate may exaggerate the measured growth rate of output and lead TFP to overstate the truth. Furthermore, careful interpretation should be made of employment statistics: The employment data only cover formal economy, although the proportion of labour force in the informal sector is estimated to be very high.

Data accuracy issues become more problematic as far as capital input is concerned. Chinese statistical authorities do not yield capital stock estimates that satisfy international standards. Moreover, official depreciation rates are generally ambiguous and range far below international standards. Yet, an overstatement of capital stock due to under-depreciation could reduce the TFP residual. In this study, we compute a new data set for capital input which may also have several shortcomings. Due to the lack of data availability, investment data are not decomposed into their major components and deflated separately for each major asset type. Yet, the application of a single deflator to heterogeneous investment goods could be, somehow, problematic and may induce an aggregation bias (Jorgenson and Griliches, 1967). In addition, capital and labour input measurements overlook the value of the underutilisation of production factors, especially in SOEs. However, a possible overestimation of factor inputs is likely to understate the TFP residual estimates. Finally, it is very hard to predict the net effect of measurement errors in input and output statistics on productivity estimates.

The TFP analysis presented in this study consists of isolating the Solow residual using an improved data set and robust econometric tools. Our findings direct attention to several opportunities for further research. In the neoclassical growth framework, innovation is considered as exogenous to the economic system. In the 1980s, the introduction of new growth theories give scope to separate investigation on the contribution to economic growth of human capital, R&D activities, improvement in allocation efficiency and technology transfer. In addition, our empirical findings show that the TFP growth in Chinese industry has increased dramatically since the last decade. These findings give room to further scrutiny on spillover effects resulting from China's accelerated integration to the world economy through FDI and foreign trade.

Appendices

Appendix 1: TFP Debate

Since the initiation of the neoclassical growth theory, conceptual problems about the TFP have been the subject of a heated debate between economists. Hence, we consider that it is vital to clearly define the concept of TFP before interpreting empirical results. An extended discussion about the contents and definition of the TFP residual is presented below.

The TFP concept takes its origin from the pioneering works of Tinbergen (1942) and Solow (1957). According to Solow's growth framework, the residual refers to the part of output growth that could not be explained by the growth in inputs. In this way, TFP is interpreted as a shift of the production function over time, whereas the growth in factor inputs refers to movements along a production function. In the neoclassical growth theory, the residual is viewed as an exogenous technological change that takes place like "manna from heaven". Consequently, its occurrence is completely independent of other components of the economy such as investment and capital accumulation. Abromovitz (1956) call the residual "measure of our ignorance", since it does not only contain technological change but a mix of unwanted components, namely measurement errors, aggregation biases, omitted variables, business fluctuations, model misspecification, etc. However, according to Jorgerson and Griliches (1967) the TFP residual is nothing else than a result of mis-measurement. Hence, it should disappear if factor inputs were measured correctly.

Under the neo-classical assumptions, the residual is confined to exogenous, disembodied and Hicks-neutral technological progress (Chen, 1997). In this study, we proceed to a wider interpretation of the residual. To begin with, in our analysis TFP involves all kinds of disembodied technological changes (new managerial and organizational methods, R&D and innovation activities, etc.) which improve production efficiency. Besides, the residual captures a mix of factors that enhance economic growth (scale economics, spillover effect, improvements in resource allocation, institutional and political factors) and measurement errors.

According to the embodiment hypothesis, a significant part of technological change could be embodied in factor inputs. As for capital input, this refers to advances in the design and quality of new vintages (OECD, 2001). On that account, fixed asset series should be deflated by price deflators which take into consideration quality changes in capital stock by type, model and vintage. As regards labour input, improvements in labour force skills could lead to substantial efficiency gains. Hence, employment series should be adjusted for changes in quality, in accordance with the age-sex composition and level of educational attainment of labour force.

In the case of quality adjusted factor input series, factor contribution estimates capture both the effect of changes in input qualities and quantities on output growth. The magnitude of the residual depends deeply on the extent of quality adjustments. Put differently, if quality improvements in input factors are overlooked, the residual term should be expected to be higher since it shows up the effects of changes in the quality of capital inputs and improvements in human capital[33]. In this study, given that factor input measurements do not include quality improvements, TFP estimates are expected to capture technological change both embodied and disembodied.

[33] Young (2000) estimates the contribution of human capital improvement to output growth about 1.1 percentage points per year for the period 1978-1998.

Chapter 3

Technological Use and Scale Effect Evaluation: Evidence from Chinese Provinces (1994-2006)

Jean-Pascal Guironnet* and Selin Özyurt

Abstract

This study investigates the driving forces of China's recent rapid economic growth and its sustainability in the future. We adopt a Stochastic Production Frontier approach (SPF) to investigate regional productivity performances in China over the period 1994-2006. The use of the stochastic production function improves the existing literature in several respects: First, it introduces various returns to scale production technology (VRS); second, it allows the best practice among provinces. Furthermore, our analysis enables to decompose regional productivity scores over time into two major components, namely scale efficiency (SE) and pure technical efficiency (PTE).

Despite the general concern of widening regional inequalities in China, we detect a striking trend of convergence among Chinese provinces over the last decade. The catching-up process turns out to occur at a faster rate in coastal provinces. Our empirical results also reveal a significant contribution of FDI and foreign trade to economic growth.

Keywords: Chinese economy; technological change, Stochastic Production Frontier; productivity analysis.

JEL-Classification: O11; O18; O33; O47

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Résumé

Cette étude analyse les principaux moteurs de la croissance économique en Chine et sa soutenabilité dans le futur. Les performances productives de la Chine sont analysées sur la période 1994-2006 depuis une approche de frontière stochastique. L'utilisation d'une fonction de production stochastique représente de multiples avantages: premièrement, elle permet d'introduire des technologies de production à rendements d'échelle variables ; deuxièmement, elle autorise la meilleure pratique parmi les régions. De plus, notre analyse décompose les scores de productivité dans le temps en deux composants principaux, notamment l'efficacité d'échelle et l'efficacité technique.

Malgré l'inquiétude générale sur le creusement des inégalités régionales en Chine, notre étude détecte une tendance de convergence régionale depuis la dernière décennie. De plus, le processus de rattrapage se produit à un rythme plus élevé dans les régions côtières. Nos résultats empiriques révèlent des effets significatifs de l'investissement direct étranger et des échanges internationaux sur la croissance économique.

Mots clés: Economie chinoise; Changement technologique; Analyse de frontière de stochastique; Analyse de productivité.

JEL-Classification: O11; O18; O33; O47

3.1 Introduction

Since the introduction of economic reform policy in the early 1980s, Chinese economy has experienced a continuous and spectacular economic growth (at an average official rate of 9.5 per cent). Along with the impressive economic take off, over the past decades, China has undergone a progressive transition from a centrally planned to a market economy. Prior to 1978, the country was a totally autarchic economy isolated from the rest of the world; its governmental policies were mainly directed to insure self reliance and to promote heavy industries. Since 1978, with the implementation of the open-door policy, China has emerged progressively in the global economy as a major trading partner. In addition, its opening up to the world boosted inward foreign direct investment (FDI). In 2002, China overtook the United

States and became the largest recipient of foreign direct investment (FDI) in the world. What is more, in 2006, it outpaced major trading countries and emerged as the world's third largest trading partner.

The neoclassical economic growth framework (Solow, 1957) attributes the process of economic growth to two major sources, namely factor accumulation and total factor productivity (TFP) growth. It recognises technological progress as an exogenous factor to economic system. Given that capital accumulation is subject to the law of decreasing returns, neoclassical theory infers that an input-driven economic growth could not be sustainable in the long run. That is to say, a sustainable long term economic growth should essentially lie on productivity growth generated by innovation and advances in technology and management. Otherwise, the endogenous economic framework (Lucas, 1988; Romer, 1990) argues that technological progress and human capital development could be the driving forces of sustainable economic growth. However, even if this approach is theoretically suitable, it generally fails to generate robust empirical results (Aghion and Howitt, 1998). Thereby, in this study, we essentially base our empirical strategy on the neoclassical growth model (Mankiw *et al*., 1992).

Most growth accounting studies on the East Asian newly industrialized economies (NIEs) (Kim and Lau, 1994; Young, 1992, 1995) infer that the great success of the East Asian "tigers" has largely been driven by massive factor accumulation, rather than innovative activities or technological progress. According to Krugman (1994), the input driven economic growth in the NIEs could not be sustainable in the long term. Thereby, investigating on the main driving forces and sustainability of Chinese economic growth has generated growing interest among academics and policy makers. An abundant literature on China's recent growth experience has progressively emerged over the last decades.

However, today, the empirical evidence on major driving forces of China's rapid economic growth is mixed, even controversial. To name only a few, Borensztein and Ostry, (1996); Hu and Khan (1998); Chow and Li (2002) detect a significant contribution of TFP to economic growth, whereas Young (1999) concludes that the rapid economic growth of China could be essentially attributed to scale effect rather than innovative activities.

China is a huge country characterised by heterogeneous space and striking economic disparities between regions and between urban and rural areas. The opening up of China to the world implied a gradual and spatially uneven process. In addition, economic reform policies introduced a shift from Mao's Soviet-style egalitarian regional development policies to preferential policies which manifestly favoured coastal regions. Thereby, since the last decades, widening disparities between inland-coastal regions as well as between urban-rural areas within the same regions became a rising concern on social, political and economic harmony.

The main purpose of this study is to improve our understanding of China's recent economic performances by bringing new empirical evidence to the following issues. Is China's economic development sustainable in the near future? Does China's outstanding economic growth performance rely merely on the increasing use of inputs and scale effects rather than pure technological progress? Is the technological gap between Chinese provinces widening over time?

The methodology we adopt improves empirical research in several respects. First of all, the use of the stochastic production frontier approach enables us to decompose changes in TPF into two major components, namely changes in technical efficiency and changes in scale efficiency. Second, our methodology allows comparisons of technical efficiency scores between regions and over time. Third, our approach captures time-invariant region-specific effects through fixed effect (FE), "within" and "between" effects.

The reminder of this paper is as follows: the second section provides an outline of the economic and historical background. The third section discusses the underlying data and methodology; empirical results are presented and interpreted in the section 4.

3.2 Economic and Historical Background

In this section, after a brief description of institutional changes introduced by reform policies, the focus will be driven to regional development and opening-up strategies.

3.2.1 The impact of reforms policies on Chinese economy

The Chinese economy has been challenging a gradual process of technological development and institutional change since the early 1980s. The reform period in Chinese industry has been mainly marked by a huge expansion in industrial activity outside state sector. In the 1980s, township and village small-scale enterprises emerged in rural areas, while in the early 1990s, foreign-invested enterprises has started to gain important market shares in the urban sector.

In China, the economic reform program was built, by and large, on the promotion of industry at the expense of agriculture. During the pre-reform period, the *hukou*[34] (household registration) system was established in order to restrict labour movements between sectors and regions. Yet, under the *hukou* system, technological improvements and demographic increase led to a massive labour surplus in rural areas. Alongside the market-oriented reform policies, barriers to labour migration between urban and rural sectors have been lowered progressively. In this way, in rural areas, the recent surge of small-scale industrial enterprises absorbed huge amounts of surplus labour in agriculture and raised the overall productivity. That is to say, during the reform era, substantial efficiency gains have been reaped from the reallocation of resources from agriculture to more productive sectors (Maddison, 1998; Wu, 2004; World Bank 1997).[35]

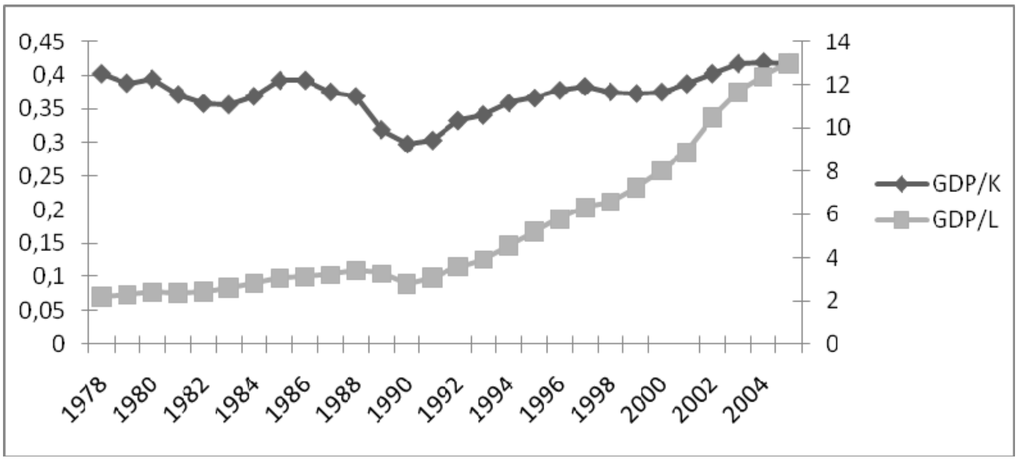
Over the last two decades physical capital accumulation in China speeded up due to the high level of both investment and domestic savings. It should be highlighted that reform initiative has significantly changed the investment pattern in China: over the reform period a growing share of investment projects has started to be funded by private savings and to be oriented towards labour-intensive manufacturing industries (rather than heavy industries). Figure 3.1 illustrates the rising trend of single factor productivity in industrial sector over the reform era. We can clearly observe that since the early 1990s, output per worker ratio has grown rapidly. The improvement of labour productivity over the last two decades could be essentially

[34] The *hukou* system was introduced in the 1950s under the command economy in order to regulate labour force and insure structural stability by controlling rural-urban migration.

[35] According to the World Bank (1997), labour reallocation from agriculture to industry contributed about a percentage point to China's overall output growth.

attributed to massive capital accumulation, substitution of capital for labour and effective resource allocation across sectors. Moreover, the elimination of redundant workers in SOEs has considerably contributed to improve labour productivity in Chinese industry.

Figure 3.1: Evolution of single factor productivity in Chinese industry (1978-2005)



Source: SSB (various issues), author's calculates.

3.2.2 Regional Development Strategies in China

Under the command of Mao Zedong, regional development policies in China relied largely on the principles of equality and self sufficiency. The reform initiative introduced radical changes in China's regional development strategy: by the implementation of the economic reform and open-up policies, priority was given to coastal regions. Under the leadership of Deng Xiaoping, the coastal development strategy has been formulated in order to attract foreign direct investment to coastal regions. Once the development of coastal regions is accomplished, economic development was expected to be carried to inland regions through trickledown effect.

Since the implementation of the open-door policy in the 1980s, coastal provinces in China have exhibited faster growth rates than the inland ones. In the 1990s, widening regional disparities became a rising concern, compromising the country's political and social harmony. As a consequence, in the second half of the 1990s, the government policies gradually shifted from preferential to a national-wide development strategy: the 8th and 9th Five-Year Plans

(1991-2000) fixed co-ordinated regional development and reduction of inequalities between western and eastern regions as priority objectives. Since then, continuous support has been provided to western and inland regions. In 1999, under the leadership of Jiang Ziemin, the Western Development Strategy was launched, in order to establish a favourable business environment in Western China [36] (through the development of human capital, natural resources, transport and communication infrastructures, and so on). The Western Development Strategy produced immediate results. It directed substantial amounts of both domestic and foreign investment to Western China. After its implementation, China's western regions reported average annual growth of 10.6 per cent over the period 2000-2006; which is above the national average.

3.2.3 Opening up to the world

By the early 1990s, the Chinese government undertook comprehensive reforms to open up China to the world economy. In this regard, significant effort has been made to reduce barriers to foreign trade and FDI. China's progressive integration into the world economy resulted in a massive inflow in FDI and rapid expansion of foreign trade. Thereby, starting from the late 1990s, China became the largest recipient of FDI between developing countries and one of the world's largest trade partners.

In developing countries, which are generally scarce in capital, FDI and foreign trade represent effective ways to alleviate capital shortage and create employment opportunities. Furthermore, FDI and international trade are expected to induce spillover effects to local economy through some indirect effects (see the literature review). Generally speaking, multinational companies (MNC) which operate in developing countries enjoy higher productivity rates than domestic counterparts. Advanced technologies brought by MNCs could potentially leak out to local firms through various channels such as imitation-demonstration and contagion effects, competition, labour turnover, and vertical linkages.[37] In addition, the expansion of foreign trade and investment is likely to raise technical efficiency through scale economies. Moreover,

[36] The 12 western regions covered by the Western Development Program include five autonomous regions (Tibet, Inner Mongolia, Guangxi, Ningxia and Xinjian), six provinces (Suchuan, Guizhou, Yunnan, Shaanxi, Gansu and Qinghai) and one municipality (Chongqing).

[37] Presenting an extended overview of the spillovers channels through FDI is clearly beyond the scope of this paper. Interested reader could refer to Blomström and Kokko (2001) for an excellent discussion on spillovers channels.

integration into international production networks and exposure to foreign competition is expected to bring about technological upgrade and increases in overall productivity.

3.3 Data Issues and Methodology

In this section, we present a brief discussion of the underlying data set followed by the description of our methodological approach.

3.3.1 Data

The empirical analysis presented in this study covers 30 Chinese provinces over the period 1994-2006. The underlying data set is collected from various issues of the China Statistical Yearbook published by the National Bureau of Statistics (NBS). GDP and investment series are expressed in constant prices and deflated by *Regional Retail Price Indexes*.

- *Output Data*

China's official GDP statistics are far from being flawless and might represent some inconsistencies. In the literature, it is generally asserted that China's official statistics underestimate real inflation rates, therefore, overstate real output growth (Maddison, 1998; Young, 2000). [38] Official statistics in China are essentially based on the reports of local officials. It is generally suspected that that political pressure to meet central policy growth targets might push local governments into exaggerating the output performances (Chow and Li, 2002). However, according to Chow (2006) and Holz (2006b) despite some accuracy problems which are pretty common in developing and transitional countries, the Chinese official statistics remain mostly reliable and useful for drawing economic conclusions.

- *Capital stock*

China's official statistics do not report capital stock estimates which satisfy international national accounting standards. As a result, most researchers are brought to derivate their own capital stock series following different methodologies. Özyurt (2009) highlights that capital stock estimates are extremely sensitive to the functional form of depreciation, price deflators,

[38] Maddison (1998) proceeds to a downward adjustment of GDP and reduces China's (official) average growth rate from 9.88 percent to 7.49 percent.

aggregation level, capacity utilisation adjustments and contents of the investment data (i.e. inclusion of land, inventories, residential buildings). In this study, regional capital stock series are computed following the conventional Perpetual Inventory Method[39] (PIM) introduced by Goldsmith (1951). Investment is quantified by regional *Total Investment in Fixed Assets* series. In accordance with the literature (e.g. Wu, 2004; Bosworth and Collins, 2007), we assume a geometric depreciation pattern and set the depreciation rate to 7 per cent.

3.3.2 Methodology

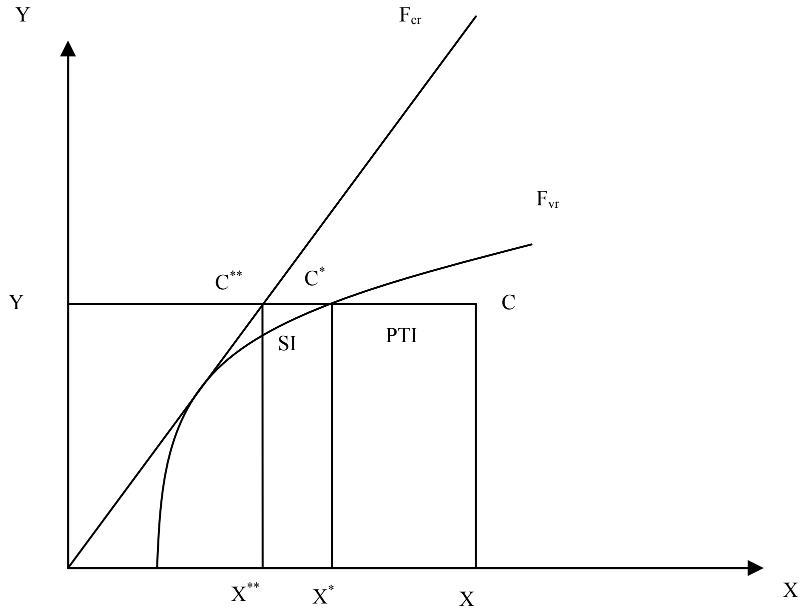
In the literature, empirical analyses on China's recent economic growth generally rely on the conventional growth accounting perspective through the TFP index approach (Solow, 1957). Furthermore, in the recent literature, we distinguish the frontier approach which evaluates the partial productivity of a unit (say a firm, sector or region) against a measure of best practice. The production frontier analysis takes two main forms, namely deterministic and stochastic. The Data Envelopment Analysis (DEA) constitutes an example of the non parametric (programming) approach based on a deterministic production function (e.g. Guironnet and Peypoch, 2007). In the DEA, the production frontier of an economy is built empirically from the observed level of inputs and outputs. Thus, the DEA do not require any prior assumption on the functional form of the production. However, its major shortcoming is that it gives no provision for statistical noise and measurement errors. That is to say, in the deterministic approach, any deviation from the expected output level (i.e. frontier) is recognised as inefficiency.

In this study, we adopt the Stochastic Production Frontier (SPF) approach due to its statistical rigueur. The production frontier refers to the maximum set of output(s) that can be produced with a given set of inputs. One should keep in mind that the efficiency estimates represent a relative measurement, based on the performances of the most efficient province (by comparing the ratio of the weighted sum of outputs and inputs). Our parametric approach introduces a random error term in the production function. Thereby it enables to distinguish inefficiency from the statistical noise and measurement errors.

[39] In sum, the PIM consist of adding the net investment data of the current year to an assumed base year of capital stock.

In this study we follow Wu (2000)'s methodology to identify changes in technical efficiency over time. In addition, we extend Wu's seminal work by including changes in returns to scale in the efficiency analysis. Our technology scores are presented under both variable returns to scale (VRS) and constant returns to scale (CRS) hypothesis.

Figure 3.2: Efficiency in constant returns vs. efficiency in variable returns



To start with, we consider the SPF with variable returns to scale (SPF_{vr}). We assume that a province C_1 can reduce its input level from X to X^* for an unchanged level of output Y (see figure 3.2). We attribute the input reduction to the improvement of technical efficiency (TE), $1\text{-}e_1$ (with X*/X=e). We therefore decompose the disturbance term into two components: random error and technical efficiency.

$$\ln Y_{it} = \alpha + \beta_{it} \ln X + v_{it} - u_{it} \qquad (1)$$

In Equation 1, *Y* corresponds to the level of output and α represent the constant term. All variables are expressed in the logarithmic form. The indexes *i* and *t* denote respectively the time and cross-sectional dimension. *X* designates the set of the following control variables: volume of foreign trade (*Trade*), tertiary education (*Edu*), population growth rate (*Pop*), physical capital (*Phy*), inflation (*Inf*), and foreign direct investment (*FDI*) (Quah, 1997, Baldacci, et al. 2004). v_{it} is the fixed effect and $u_{it} = |U_{it}|$ where Y_{it} follows N(0;σ_u^2).

The maximum output is achieved when U_{it} = 0. We follow the methodology introduced by Fried et al. (2008) and relax the hypothesis of time-invariance of efficiency. We consider that, the time-variant specification is more consistent with economic theory. Thus, our econometric model allows for changes in the most efficient province over time. We, therefore use Battese and Coelli's (1992) formulation in which the random error component is expressed as $u_{it} = u_i(\exp[-\eta(t-T)]$, with *t-T* referring to the difference between the current and the previous period in each panel and η is the decay parameter.

It should be highlighted that in this model the measured efficiency would be absorbing a large amount of cross-country heterogeneity (Greene, 2004). That is to say, it would be more relevant to comment the efficiency scores by taking the provincial heterogeneity into account. Thereby, our results would be unbiased by province-specific structural effects.

In order to take regional fixed effects[40] (FE_i) into account, we include several dummy variables into the model (Equation 2). The inclusion of time-invariant region specific characteristics is expected to reduce the bias in the estimation of the output elasticities. We retain the following most significant dummies: Tianjin, Shanxi, Inner Mongolia, Liaoning, Jilin, Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Shandong, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi and Xinjiang.

$$\ln(y_{it}) = \alpha + \beta X + \gamma FE_i + v_{it} - u_i(\exp[-\eta(t-T)] \tag{2}$$

We set the other provinces as a "base-case" for purpose of comparison and in order to avoid a potential multicolinearity problem. At this point, some caution is needed: The specific effects of provinces without dummy variables are estimated on the mean of the group. It should be noted that in stochastic frontier models, the error component is estimated as $\varepsilon_{it} = v_{it} - u_{it}$ and not as u_{it} as usual. That is to say, inefficiencies could be estimated indirectly by the conditional mean function. By assuming a half-normal model (Jondrow *et al.,* 1982), we obtain:

$$E[u_{it}|\varepsilon_{it}] = \left[\frac{\sigma\lambda}{1+\lambda^2}\right]\left[\tilde{\mu}_{it} + \frac{\phi(\tilde{\mu}_{it})}{\Phi(\tilde{\mu}_{it})}\right] \tag{3}$$

[40] It should be noted that in that case, v_{it} do not vary randomly across countries.

where $\widetilde{\mu}_{it} = \frac{-\lambda\varepsilon_{it}}{\sigma}$, $\phi(.)$ is the density and $\Phi(.)$ is the cumulative distribution function of the standard normal distribution.

To measure the maximum level of productivity, we use the stochastic frontier with constant returns (SPF_{cr}) (see Figure 3.2) (Blancard and Boussemart, 2006). Thus, we observe that the input amount of C^*_1 is too large to reach the maximum level of productivity. In other words, the province should reduce its input to X^{**}_1 level. In stochastic terms, we put:

$$\frac{X_0^{**}}{X_0} = E[u_{it}^{***} | \varepsilon_{it}^{***}], \frac{X_0^{*}}{X_0} = E[u_{it}^{**} | \varepsilon_{it}^{**}] \text{and} \frac{X_0^{**}}{X_0^{*}} = E[u_{it}^{*} | \varepsilon_{it}^{*}] \quad (4)$$

where $1 - E[u_{it}^{***} | \varepsilon_{it}^{***}]$ are assumed to account for Total Technical Inefficiency (TTI) in production which can be decomposed in "Pure Technical Inefficiency" (PTI), measured by $1 - E[u_{it}^{**} | \varepsilon_{it}^{**}]$, and "Scale Inefficiency" (SI), measured by $1 - E[u_{it}^{*} | \varepsilon_{it}^{*}]$.

3.3.3 Convergence Model

The catching-up process refers to the movement of the least efficient economies towards the frontier (Boussemart *et al.,* 2006). According to the catch-up hypothesis, we assume that the productivity growth rate (q^i_t) of a region depends negatively on the level of its productivity in the previous period (*t-1)*. λ is a parameter which captures the productivity adjustment between the periods *t* and *t-1*(i.e. Beta convergence). We therefore obtain the following log-linear adjustment:

$$\ln(q_t^i) - \ln(q_{t-1}^i) = \lambda \ln(q_{t-1}^i) + \alpha^i + \mu_t^i \quad (5)$$

Since we have already taken into account the cross-country heterogeneity, the FE should not influence the catching-up process. However, the residual of the cross-sectional units must differ across countries and across time. Consequently, we utilise the random effects estimator as a weighted average of the "within" and "between" effect estimators. By averaging Equation 5 over time, we obtain:

$$\ln(\overline{q}_t^i) - \ln(\overline{q}_{t-1}^i) = \lambda \ln(\overline{q}_{t-1}^i) + \alpha^i + \overline{\mu}_t^i \quad (6)$$

Subtracting Equation 6 from Equation 5 and introducing the random effect estimator as a weighted average (θ) of the "within" and "between" effects estimator give the following equation:

$$\ln(q_t^i) - \ln(q_{t-1}^i) - \theta[\ln(\overline{q}_t^i) - \ln(\overline{q}_{t-1}^i)] = \lambda[\ln(q_{t-1}^i) - \theta\ln(\overline{q}_{t-1}^i)] + \mu_t^i - \theta\overline{\mu}_t^i \qquad (7)$$

θ is a function of σ_α^2 and σ_μ^2 . Following the assumption adopted on returns to scale, $q^i{}_t$ measures efficiency scores of total technical efficiency (TTI), partial technical efficiency (PTI) and scale effect (SE).

3.4 Results

In this section, we present and discuss the efficiency scores of Chinese provinces. Afterwards, the focus is directed to the regional convergence and catching-up process.

3.4.1 Efficiency Results

The time-varying technical efficiency estimates for Chinese provinces are presented in Table 3.1. Technical efficiency scores are obtained through the estimation of the production frontier for each period (see Appendix 1). According to these estimations, some stylized facts are revealed: First of all, in line with previous research, physical capital accumulation can be recognised as the major engine of economic growth in Chinese provinces. Second, we detect positive and significant effect of international trade and human capital on economic growth. In addition, FDI exerts a positive effect on growth under the CRS technology hypothesis. Concerning inflation, a strong positive effect appears in variable returns to scale, whereas in constant returns to scale the magnitude of the coefficient diminishes significantly. One can consider that the progressive removal of price controls during the reform period represents an encouraging factor to economic growth. In accordance with neoclassical growth framework, our empirical results reveal that population growth has also an enhancing effect on production. It should be noted that this variable also captures the positive contribution of labour force accumulation to growth.

In the early years of the study period, we detect very large differences in technical efficiency among Chinese provinces. Since the late 1990s, the efficiency gap between Chinese provinces has exhibited a decreasing trend; suggesting a gradual convergence pattern (see Appendix 3). One can attribute the wide regional disparities in 1994 to a number of political and macroeconomic factors such as differences in opening-up paces, infrastructure and natural resource endowments, restricted factor mobility, and so on. In the neoclassical theory, the mobility of production factors is expected to reduce regional disparities by equalizing rates of return among regions.

Our empirical analysis detects positive fixed effects for the following provinces: Tianjin, Shanghai and the group of Beijing, Hebei, Fujian, Henan, Hainan, Gansu, Qinghai and Ningxia[41]. That is to say, in 1994, these regions were enjoying some region-specific advantages in the form of a better endowment with natural resources, advanced technology, better infrastructure development, availability of a more skilled workforce, and so on. We can also observe that most of these regions are located on the east coast which benefited from preferential policies in the early years of economic reforms. In addition, a favourable business environment, geographic proximity to overseas China (Hong Kong, Taiwan, Macao) and to other international hubs, superior entrepreneurship culture and higher technological and managerial know-how have also encouraged economic development of these regions.

The efficiency scores presented in Table 3.1 do not include the region-specific fixed effects. Consequently, without the fixed effects, Qinghai and Guizhou become the best practice in the "benchmark" of their inputs. However, if the positive structural effect (i.e. fixed effects) of social capabilities (Abramovitz, 1986) is taken into account, Qinghai, Beijing and the Ningxia become the most efficient regions. The economic development of Qinghai province in the 1990s deserves a closer look: the region is characterized by low population density and abundance in natural resources. It is one of China's major petroleum and gas production bases. During the 1980s, Qinghai exhibited the worst economic performances in all of China. Afterwards, by the implementation of the Western Development Strategy in 1999, both domestic and overseas investment surged to Qinghai. Consequently, since the late 1990s, Qinghai's annual growth exceeded national average.

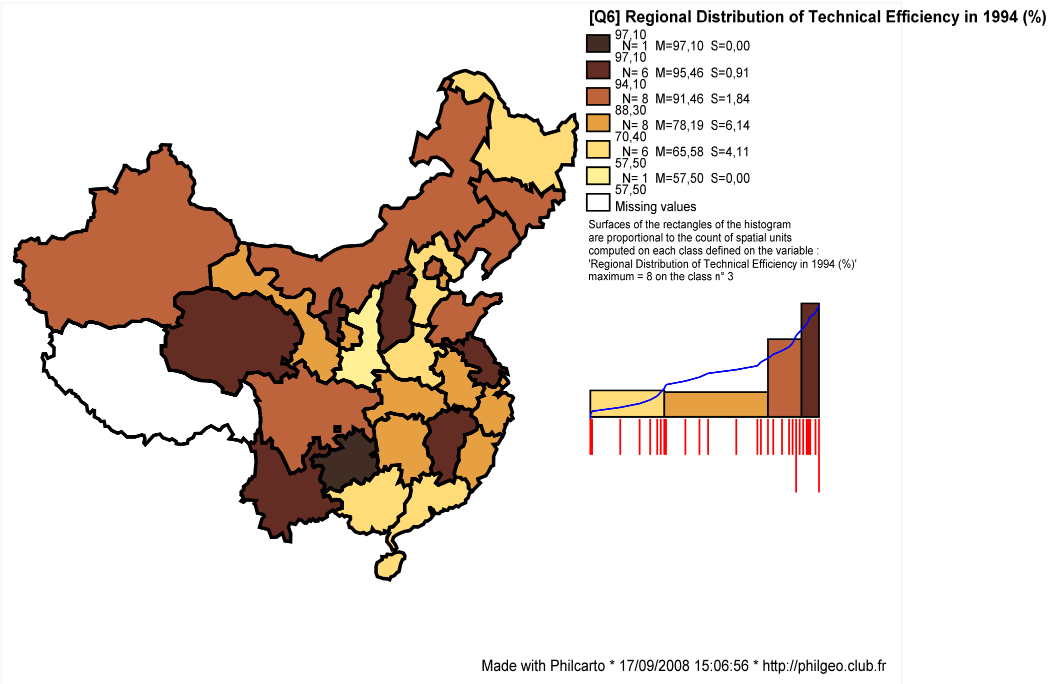
[41] See Appendix 2, for the map of Chinese provinces.

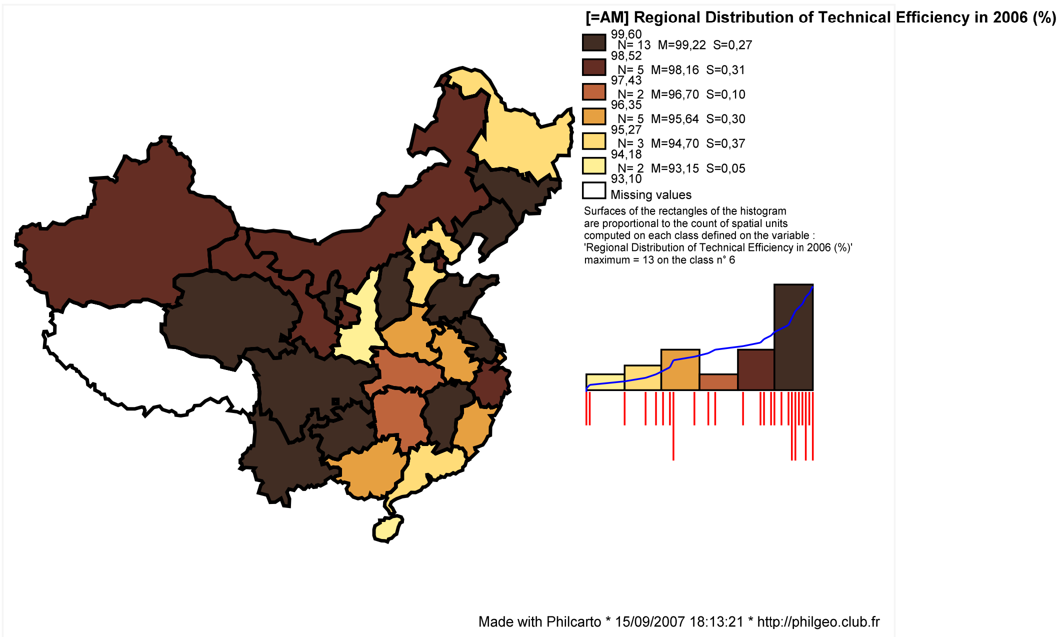
Table 3.1: Efficiency (%) in variable returns

Province	94	95	96	97	98	99	00	01	02	03	04	05	06
Beijing	92.9	94.0	94.9	95.7	96.4	96.9	97.4	97.8	98.1	98.4	98.7	98.9	99.0
Tianjin	82.7	85.2	87.4	89.3	90.9	92.2	93.4	94.4	95.3	96.0	96.6	97.1	97.6
Hebei	66.0	70.5	74.4	78.0	81.1	83.8	86.1	88.2	89.9	91.4	92.7	93.8	94.8
Shanxi	95.5	96.2	96.7	97.2	97.7	98.0	98.3	98.6	98.8	99.0	99.2	99.3	99.4
Inner. M.	89.0	90.7	92.1	93.3	94.3	95.2	95.9	96.5	97.1	97.5	97.9	98.2	98.5
Liaoning	92.3	93.4	94.4	95.3	96.0	96.6	97.1	97.6	98.0	98.3	98.5	98.8	99.0
Jilin	90.7	92.1	93.3	94.3	95.2	95.9	96.5	97.1	97.5	97.9	98.2	98.5	98.7
Heilong.	68.0	72.2	76.0	79.3	82.3	84.8	87.0	89.0	90.6	92.0	93.2	94.3	95.1
Shanghai	73.9	77.5	80.7	83.4	85.8	87.9	89.7	91.3	92.6	93.7	94.7	95.5	96.2
Jiangsu	94.1	95.0	95.8	96.4	97.0	97.4	97.8	98.2	98.5	98.7	98.9	99.1	99.2
Zhejiang	86.9	88.8	90.5	91.9	93.1	94.2	95.1	95.8	96.5	97.0	97.5	97.9	98.2
Anhui	70.4	74.3	77.9	81.0	83.7	86.1	88.1	89.9	91.4	92.7	93.8	94.8	95.6
Fujian	70.8	74.8	78.3	81.3	84.0	86.3	88.3	90.1	91.6	92.8	93.9	94.9	95.6
Jiangxi	96.4	96.9	97.4	97.8	98.2	98.4	98.7	98.9	99.1	99.2	99.3	99.4	99.5
Shandong	93.1	94.1	95.0	95.8	96.4	97.0	97.4	97.8	98.2	98.5	98.7	98.9	99.1
Henan	69.8	73.9	77.5	80.6	83.4	85.8	87.9	89.7	91.2	92.6	93.7	94.6	95.5
Hubei	76.5	79.8	82.7	85.2	87.4	89.2	90.8	92.2	93.4	94.4	95.3	96.0	96.6
Hunan	77.8	80.9	83.7	86.0	88.1	89.9	91.4	92.7	93.8	94.7	95.5	96.2	96.8
Guangdong	62.7	67.5	71.8	75.6	79.0	82.0	84.6	86.8	88.8	90.4	91.9	93.1	94.2
Guangxi	69.0	73.1	76.8	80.1	82.9	85.4	87.5	89.4	91.0	92.3	93.5	94.5	95.3
Hainan	58.0	63.2	67.9	72.1	75.9	79.3	82.2	84.8	87.0	88.9	90.6	92.0	93.2
Chonqing	93.7	94.6	95.4	96.1	96.7	97.2	97.7	98.0	98.3	98.6	98.8	99.0	99.1
Sichuan	91.7	92.9	94.0	94.9	95.7	96.4	96.9	97.4	97.8	98.1	98.4	98.7	98.9
Guizhou	97.1	97.5	97.9	98.2	98.5	98.7	98.9	99.1	99.2	99.4	99.5	99.5	99.6
Yunnan	94.9	95.6	96.3	96.9	97.4	97.8	98.1	98.4	98.6	98.9	99.0	99.2	99.3
Shaanxi	57.5	62.7	67.4	71.7	75.6	79.0	81.9	84.5	86.8	88.8	90.4	91.9	93.1
Gansu	86.5	88.5	90.2	91.6	92.9	94.0	94.9	95.7	96.3	96.9	97.4	97.8	98.1
Qinghai	96.8	97.3	97.7	98.1	98.4	98.6	98.8	99.0	99.2	99.3	99.4	99.5	99.6
Ningxia	95.6	96.3	96.9	97.3	97.7	98.1	98.4	98.6	98.9	99.0	99.2	99.3	99.4
Xinjiang	88.3	90.0	91.5	92.8	93.9	94.8	95.6	96.3	96.9	97.3	97.8	98.1	98.4

Table 3.1 highlights that between 1994-2006, Chongqing, Shandong, Jiangsu, Liaoning, Beijing upgraded to the most efficient group, whereas Heilongjiang, Henan, Guangdong, Guangxi, Hainan remained in the less efficient group over the entire study period. The table above also reveals that technological upgrade process occurred faster in the East coast. While we breakdown the sample into two sub-groups, we obtain an average efficiency gain rate of 18.25 percentage points for coastal regions, while the same rate is only of 12.5 percentage points for inland regions. That is to say, coastal regions moved faster towards the production frontier. Contrary to Young (2000) who argues that the development of coastal regions relied solely on scale effect, our findings give evidence that Coastal regions in China benefited substantially from technological upgrade.

Figure 3.3: Regional distribution of technical efficiency (1994, 2006)





The choropleth maps above display the distribution of technical efficiency across Chinese provinces in 1994 and 2006 (Figure 3.3). In the maps, Chinese provinces are divided into quartiles based on the technical efficiency scores they achieved. It is obvious from Figure 3.3 that in China, some coastal regions in the East, namely, Jilin, Liaoning, Beijing, Tianjin, Shandong, Jiangsu, Zhajiang gained substantially in technical efficiency over the study period.

The maps also reveal that some central regions such as Qinghai, Sichuan, Guizhou, Yunnan also upgraded to the most efficient group between 1994 and 2006.

3.4.2 Catch-up Results

In the catching-up analysis we are not able to detect any fixed effects given that they are already taken into account in the estimation of the production function. We therefore consider that the random effect specification with "within" and "between" effects is more suitable for analysing catch-up process in China.

Table 3. 2. Catch-up Results (1996-2006)

Variables	TE	SE	TTE
Λ	0.157*** (9.90e-06)	-0.032*** (0.008)	0.063*** (3.42e-07)
Intercept	3.12e-06 (3.20e-06)	0.006 (0.009)	8.00e-06*** (7.34e-07)

Table 3.2 reveals a significant catch-up pattern across Chinese provinces, at a rate of 15.7 per cent over 1994-2006 (i.e. an annual mean of 1.3 per cent). Furthermore, as suggested by the theoretical framework, Chinese provinces exhibit decreasing returns to scale production technology. In other words, Chinese regions represent an unoptimal productive structure which reduced the catch-up effect by 3.2 percentage points over twelve years. Besides, the negative scale effect seems to be compensated by technology diffusion (Kumar and Russel, 2002), with a TTE growth of 6.3 per cent over the same period. From the results above one can draw the following conclusion: Chinese provinces tend to increase their productivity by adopting more efficient technologies rather than optimising their production scale.

By comparing the decomposition of TTE (i.e. TE and SE), we can observe that TE and SE seems to offset each other. That is to say, the sum of the estimated coefficients of TE and SE is not equal to the estimated coefficient of TTE and the impact of SE effect is stronger than the impact of TE effect. One possible explanation for that is the following: some Chinese regions - with higher decreasing returns – exert a stronger influence than the mean of the all provinces (i.e. "between effects"). For instance, some large provinces such as Yunnan and Guizhou were already enjoying high levels of productivity at the start period. Thereby, the convergence speed of those regions remained below the average convergence rate of the entire sample.

Conclusion

In this study, we bring fresh empirical evidence to improve our understanding of China's recent economic performances. Consistent with previous research, our analysis shows that physical capital accumulation could be recognised as the main driving force behind China's rapid growth performances. In addition, openness to trade and FDI, human capital development, population growth and the removal of price controls exert a positive effect on economic growth.

In China, regional economic development is unevenly distributed across space and exhibits a strong clustering pattern. Accordingly, provinces with higher or lower efficiency levels are generally neighbours or proximate. Besides, due to the region-specific advantages and preferential opening up policies, Eastern regions in China enjoy higher productivity and technological progress rate while some inland and western regions are seriously lagging behind.

In 1994 (which is our starting period), strong disparities in economic performances among Chinese regions are detected. However, alongside the study period, a significant catch-up process has emerged. One can conclude that new regional development policies introduced in the late 1990s have substantially promoted the economies of inland and western regions. Our results suggest that in order to encourage the catch-up process, higher outward orientation, additional investment in physical and human capital construction in backward provinces are needed.

Furthermore, from a macroeconomic point of view, the strong trend of economic convergence among regions gives evidence on the sustainability of Chinese rapid economic growth in the near future. That is to say, policy-makers should pursue their initiative to promote backward regions in western and inland China and encourage their economic integration through the free movement of production factors across regional borders.

After 30 years of successful reforms, insuring the sustainability of growth in the future particularly relies on technological upgrade. Our empirical findings show that Chinese provinces are expected to compensate negative scale effects by rising productive efficiency through technological progress. However, some further investigation is needed on this topic. For instance, a possible improvement could be the investigation of the non-neutrality of technological component (Chambers and Färe, 1994). To date, such framework still remains a challenging task ahead.

Appendices

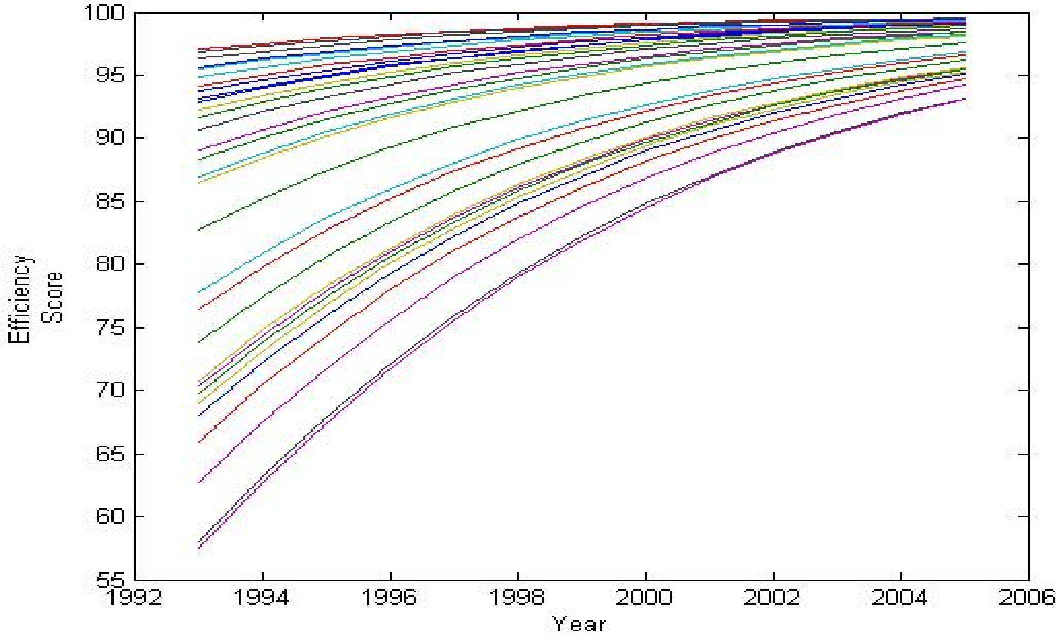
Appendix 1: Stochastic production frontier estimation

Variables	**Variable returns**	**Constant returns**
LogPhy	0.406*** (0.023)	0.328*** (0.025)
LogTrade	0.151*** (0.009)	0.169*** (0.013)
LogInf	0.436*** (0.054)	0.158*** (0.024)
LogEdu	0.093*** (0.019)	0.0003 (0.025)
LogPop	0.309*** (0.015)	0.324*** (0.034)
IDE	0.005 (0.008)	0.021** (0.008)
Tianjin	0.307*** (0.044)	0.462*** (0.100)
Shanxi	-0.305 *** (0.033)	-0.375*** (0.078)
Innermong	-0.275*** (0.039)	-0.216** (0.073)
Liaoning	-0.225*** (0.039)	-0.326*** (0.084)
Jilin	-0.246*** (0.037)	-0.232** (0.073)
Shanghai	0.343*** (0.042)	0.467*** (0.080)
Jiangsu	-0.341*** (0.044)	-0.472*** (0.092)
Zhejiang	-0.117** (0.044)	-0.161* (0.079)
Anhui	-0.328*** (0.040)	-0.414*** (0.077)
Jiangxi	-0.364***	-0.520***

	(0.038)	(0.091)
Shandong	-0.259*** (0.046)	-0.387*** (0.090)
Hubei	-0.369*** (0.042)	-0.348*** (0.078)
Hunan	-0.474*** (0.048)	-0.470*** (0.083)
Guangdong	-0.413*** (0.046)	-0.409*** (0.084)
Guangxi	-0.373*** (0.040)	-0.390*** (0.075)
Chonqing	-0.341*** (0.035)	-0.376*** (0.076)
Sichuan	-0.641*** (0.046)	-0.732*** (0.088)
Guizhou	-0.638*** (0.038)	-0.845*** (0.101)
Yunnan	-0.409*** (0.039)	-0.611*** (0.106)
Shaanxi	-0.797 *** (0.045)	-0.623*** (0.103)
Xinjiang	-0.777*** (0.051)	-0.748*** (0.082)

Appendix 2: Map of Chinese regions

Appendix 3: Efficiency scores of Chinese provinces



PART II

OPENNESS SPILLOVERS TO CHINESE ECONOMY: A SPATIAL ECONOMETRIC PERSPECTIVE

Chapter 4

Regional Assessment of Openness and Productivity Spillovers in China from 1979 to 2006: a Space-Time Model[42]

Abstract

Since the introduction of the "open door" policy in 1978, China has been attracting a growing share of FDI flows and its international trade has been expanding considerably. In addition, China's accession into the World Trade Organisation (WTO) in 2001 started a new era for the country's integration into the world economy.

This study investigates the impact of inward foreign direct investment (FDI) and international trade on labour productivity in 30 Chinese provinces over the period 1979-2006. We model labour productivity as dependent on FDI, foreign trade and other traditional variables such as capital intensity, infrastructure and human capital development. Our empirical analysis improves considerably the existing abundant literature by the explicit consideration of spatial effects and potential econometric issues they imply. We utilise the recently developed spatial data analysis tools to explore the pattern and the extent of spatial interaction of labour productivity between regions. In addition, we extend previous research by testing the explanatory power of additional variables such as spatially lagged independent and dependent variables.

Our results indicate a general trend of spatial autocorrelation in labour productivity during the study period. Put differently, in China, the productivity level of a given region is jointly

[42] I would like to thank Luc Anselin and his assistants Julia and Nancy for their suggestions and constructive remarks on this research. I am also grateful to Rosina Moreno, Cécile Batisse, Sylvie Démurger, Xiaolan Fu and the participants of the ERSA/PREPARE 2008 summer institute in Spatial Eonometrics and Computable General Equilibrium Models, in Pécs/Hungary, for their insightful comments. Any errors or omissions remain my responsibility.

determined by those of surrounding regions. In addition, our empirical outcomes yield support for positive and significant impact of FDI and foreign trade on labour productivity. These findings are robust to a number of alternative spatial weighting matrix specifications.

Keywords: Foreign direct investment; Spillovers; China; Spatial autocorrelation; Labour productivity.

JEL classification: O11; O18; P20; R10.

Résumé

Depuis l'introduction des politiques d'ouverture sur l'extérieur en 1978, la Chine a attiré une part croissante des flux d'investissements directs étrangers (IDE) dans le monde. Suite à l'initiative d'ouverture, les échanges internationaux de la Chines ont progressé de manière considérable. De plus, l'accession de la Chine dans l'Organisation Mondiale de Commerce (OMC) en 2001, a amorcé une nouvelle ère pour l'intégration du pays dans d'économie mondiale.

Cette étude analyse l'impact des IDE entrants et des échanges internationaux sur la productivité de travail dans 30 provinces chinoises, entre 1979 et 2006. La productivité de travail est modélisée à travers les variables explicatives traditionnelles comme l'intensité capitalistique, le développement de capital humain et des infrastructures. Notre analyse empirique améliore la littérature de manière considérable par la prise en compte des effets spatiaux et des problèmes économétriques qu'ils impliquent. Nous analysons ainsi la distribution spatiale de la productivité et les interactions spatiales entre les provinces chinoises. Pour ce faire, nous appliquons les outils récemment développés d'analyse de données et de régression spatiales.

Nos résultats empiriques révèlent une forte dépendance spatiale de productivité de travail parmi les régions chinoises. Autrement dit, le niveau de la productivité d'une région est aussi déterminé par la productivité des régions voisines ou à proximité. De plus, nos résultats révèlent l'impact positif de l'ouverture à l'IDE et au commerce international sur la productivité. Ces résultats sont robustes aux spécifications alternatives de la matrice de poids de distance.

Mots Clés: Investissement direct étranger; Chine; Autocorrélation spatiale; Productivité de travail.

JEL classification: O11; O18; P20; R10.

4.1 Introduction

Since the introduction of the economic reform policy in the early 1980s, China has undergone a continuous and spectacular economic growth. Along with the impressive economic take off, China has observed a rapid expansion of its foreign trade and attracted increasing amounts of foreign capital. Thereby, over the last decade, China became the largest recipient of foreign direct investment (FDI) flows among developing countries (DCs), after the United States, and the largest host country among developing countries. Furthermore, ranked 32nd in 1978, China outpaced major trading countries in 2006 and emerged as the world's 3rd largest trading economy.

In developing countries, the nexus between outward orientation and economic development has been an issue of considerable interest. Policy makers and scholars generally perceive FDI and foreign trade as key vehicles of economic growth and technology diffusion. Compared to portfolio investments and international loans, FDI projects involve longer term commitments and constitute less volatile and safer forms of financing (Baharumshah *and al.,* 2006). In host economies, FDI and trade are expected to create employment opportunities and enhance capital formation. In addition, advanced technologies possessed by multi-national companies (MNCs) might leak to host economies through various channels such as imitation-demonstration and contagion effects, competition of foreign firms, training of local employees, backward and forward linkages. Thus, since the last few decades, developing countries have been racing with each other through incentive policies to attract FDI flows to their territory.

Despite the general belief in the benefits of openness, in developing countries, recent empirical literature generates mixed evidence on the existence of positive spillovers via FDI and foreign trade (Aitken and Harrison, 1999; Haddad and Harrison, 1993; Kokko, 1996). These studies emphasise that such spillovers are not automatic and their existence depends substantially on host country's competitiveness and technological absorptive capabilities.

The empirical analysis conducted in this article covers 30 Chinese provinces over the period 1979-2006. Prior to 1979, foreign trade and FDI were virtually nonexistent in China. After 1979, the country has progressively moved away from being an autarchic economy towards a market oriented economy. Besides that, China's opening up to the world came along with an impressive economic development and technological upgrade. On that account, we consider that China provides capital statistical information and portrays a unique observation field to explore the long-term relationship between openness to the world and productivity spillovers to host developing countries.

China is a very big country characterised by heterogeneous development over space. The opening up paces and the implementation of economic reform show important disparities among Chinese regions. However, empirical studies based on regional data generally fails to consider the distinctive characteristics of geographical data. By considering each region as an isolated and independent identity, they overlook regional dynamics, agglomeration and proximity effects. Moreover, ignoring spatial effects in empirical analysis could bring about serious misspecification problems and generate dubious measures of parameter estimates and statistical inferences (Abreu *et al*., 2005).

Over the last few decades, the explicit consideration of spatial dependence[43] raised increasing interest in applied econometrics. The explanatory spatial data analysis (ESDA) and spatial

[43] Spatial dependence refers to the correlation of observations across space.

regression techniques have been in particular applied to "economic convergence" studies between regions or countries (e.g. Baumont *et al.,* 2000; Badinger *et al.*, 2004; Lall and Yilmaz, 2000).

The application of the ESDA and spatial regression methods has recently been extended to various research fields. For instance, some recent studies on geographical targeting of foreign direct investment have started to rely on spatial data analysis. To name only a few, Coughlin and Segev (2000), Blonigen *et al.* (2004) conduct spatial econometric analysis and show the importance of the agglomerations economies in FDI location decisions, respectively in China and in the OECD countries. Keller and Shuie (2007) study the expansion of interregional trade networks in China trough spatial explanatory data analysis. Madariaga and Poncet (2007) utilise spatial regression methods to inquire into the impact of FDI on per capita income growth in Chinese cities. Fingleton (1999) explore productivity spillovers in manufacturing sector among 178 E.U. regions while Conley and Ligon (2002) study cross-country economic growth spillovers through the world. Ying (2003) conducts a spatial analysis on Chinese output growth and reveals that previous studies which ignore spatial dependence present serious misspecification issues and generate unreliable results. It should be outlined that up to now, the applied literature on spatial econometrics is confined to the cross-section dimension. The extension of the ESDA and spatial regression to panel data structure remain a challenge for ongoing research.

To the best of our best knowledge, this study represents the first analysis of the impact of openness to foreign trade and investment on productivity from a spatial econometric perspective. The theoretical model we use is mainly linked to the "endogenous growth" framework (Lucas, 1988; Grossman and Helpman, 1991) and to the "economic geography" literature (Krugman and Venables, 1995). The objectives of the study are threefold: The first objective is to examine the main determinants of regional labour productivity performances in Chinese provinces. The second objective is to give empirical evidence on the existence of openness spillovers via FDI and foreign trade. The third objective is to address the specification problems arising from spatial effects through the use of the ESDA and spatial regression techniques. We consider that, the simultaneous inclusion of the space-time dimension into the modelling scheme generates capital information which enables to draw important policy recommendations.

The remainder of the paper proceeds as follows. The second section provides a literature review and a brief overview of China's opening up process. Section 3 discusses the underlying data and presents the empirical model. Section 4 introduces a methodological discussion on the ESDA methods and their application on panel data sets. The empirical findings are presented and interpreted in Section 5.

4.2 Openness and Productivity Spillovers in China: Theoretical and Historical Background

4.2.1 Main characteristics of China's opening up to the world

China started to receive foreign capital in 1979 along with the implementation of economic reform policies. As Table 4.1 displays the economic transition of China has been a gradual and spatially uneven process. During the early stage of the economic reform, inward FDI amounts to China remained fairly low and the opening up policies were only confined to a few selected regions. Then, in the early 1980s, the bulk of the FDI projects were highly concentrated on the southern provinces of Guangdong and Fujian where four Special Economic Zones (SEZ) were established[44] to offer preferential treatments to foreign investors. In 1984, the SEZ were extended to further 14 coastal cities[45] and to Hainan Island.

[44] Shenzhen, Zhguhai, Shantou in Guandong province and Xiamen in Fujian province.
[45] Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Fuzhou, Guangzhou, Zhanjiang and Baihai.

Table 4. 1 : FDI flows to China by province (1990 constant USD 10000) (1/2)

Province	1980	1985	1990	1995	2000	2005
*Beijing	0	10404	276955	124304	137398	320084
*Tianjin	410	5165	8315	134749	95153	290470
*Hebei	0	460	3935	69172	55429	141340
Shanxi	0	50	340	5656	18339	33190
Inner Mong.	0	0	13	9397	8624	N/A
*Liaoning	0	1838	24831	124417	166840	421208
Jilin	0	295	1694	35335	27502	53512
Heilongjiang	0	265	2534	39759	24552	120105
*Shanghai	0	7312	17719	287989	257886	499754
*Jiangsu	0	1395	14110	423623	524359	1225751
*Zhejiang	0	1914	4844	111453	131603	625086
Anhui	0	191	961	42761	25989	97992
*Fujian	549	13801	29002	357892	280064	226459
Jiangxi	0	606	621	25537	18544	197354
*Shandong	0	655	15084	231031	242467	703234
Henan	0	662	1049	42518	46028	129738
Hubei	0	0	2900	55164	77010	172210
Hunan	0	2063	1116	43245	55641	182336
*Guangdong	18619	60360	145984	902107	920590	1020392
*Guangxi	0	1465	3025	59328	42815	31432
*Hainan	15	2454	10055	93488	35156	52669
Chonqing	0	500	332	33607	19941	48942
Sichuan	0	0	1029	25038	35657	N/A

Source: Various Issues of China Statistical Yearbook, author's calculations, * denotes coastal regions.

Table 4. 1 : FDI flows to China by province (1990 constant USD 10000) (2/2)

Province	1980	1985	1990	1995	2000	2005
Sichuan	0	0	1029	25038	35657	N/A
Guizhou	0	173	468	5054	2041	6599
Yunnan	0	183	260	19938	10455	21236
Shaanxi	0	1609	4191	28717	23537	N/A
Gansu	234	346	472	5664	5088	2077
Qinghai	0	0	0	6129	8993	19338
Ningxia	0	29	103	2840	1421	N/A
Xinjiang	0	184	713	5918	1559	7289

Source: Various Issues of China Statistical Yearbook, author's calculations, * denotes coastal regions.

In 1992, the historical tour of the Chinese leader Deng Xiaoping to coastal southern cities emphasised the commitment to open door policy and started a new era for China's integration into the world economy. After 1992, a progressive switch from special regimes to nationwide opening up policies emerged. New policies to ensure a more even distribution of foreign capital among Chinese provinces were introduced. Consequently, between 1992 and 1994, FDI flows reached a peak and China became the largest host of FDI among developing countries. In 1999, FDI flows to China slowed down due to the Asian Financial crises and picked up their growing trend in the 2000s.

Along with the market oriented economic reforms, Chinese government also implemented preferential policies to encourage foreign trade (e.g. duty exemptions for intermediate goods used in export-oriented production). Then, since the 1980s, China's foreign trade expanded very rapidly and in 2006 China outpaced major trading countries and became the world's third largest trading economy (Table 4.2). Furthermore, China's accession into the WTO on the 1st January 2001 contributed to reduce trade distortions and reinforced its integration into the world economy.

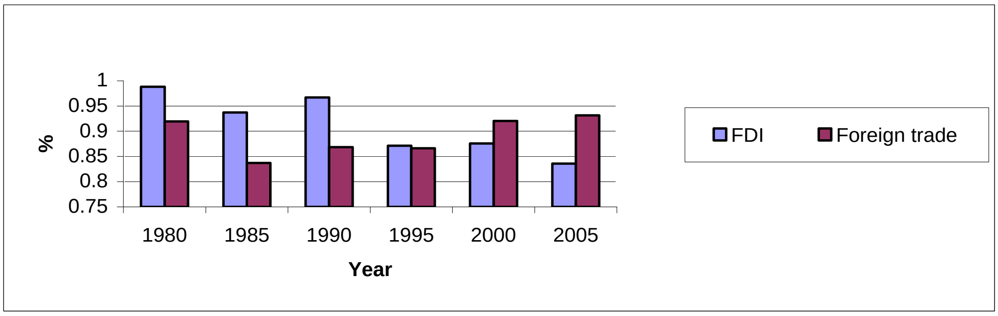
Table 4.2 : World's top 10 trade partners in 2006 (billion USD)

Rank	Exporters	Value	Share	Rank	Importers	Value	Share
1	Germany	1112	9.2	1	United States	1920	15.5
2	United States	1037	8.6	2	Germany	910	7.4
3	China	969	8.0	3	China	792	6.4
4	Japan	647	5.4	4	United Kingdom	601	4.9
5	France	490	4.1	5	Japan	577	4.7
6	Netherlands	462	3.8	6	France	533	4.3
7	United Kingdom	443	3.7	7	Italy	436	3.5
8	Italy	410	3.4	8	Netherlands	416	3.4
9	Canada	388	3.2	9	Canada	357	2.9
10	Belgium	372	3.1	10	Belgium	356	2.9

Source: WTO.

In China, FDI patterns show a great disparity regarding the distribution between regions and sectors. Until the last decade, China's economic reforms and open door policy have essentially focused on the development of coastal regions. That is to say, preferential treatment of coastal regions brought about uneven opening up paths and serious regional disparities. Aside from preferential policies, coastal regions in China also enjoy a number of growth-enhancing structural advantages such as geographical proximity to international markets, low information costs, better infrastructural development, superior access to sea-routes and a relatively well educated human capital stock. Accordingly, today, (despite the growing share of the inland regions) the bulk of FDI are still directed to coastal regions (Figure 4.1).

Figure 4. 1: The share of inward FDI and foreign trade in coastal regions in China : 1979-2005 (%)



Source: China Statistical Yearbook (2006).

FDI flows to China are largely dominated by overseas Chinese firms from Hong Kong, Taiwan and Macao. Nevertheless, an appropriate estimation of the overstatement of FDI flows due to "round tripping[46]" is very hard. According to the World Bank, the share of the round tripping accounts up to one quarter of total inward FDI flows to China.

As for the sectorial distribution, the major part of onward FDI to China is drawn to labour-intensive manufacturing industries. Next fallows the real estate sector. In addition, over the last few years, the share of service sector has been increasing considerably[47]. Sectorial distribution of inward FDI to China exhibits different patterns regarding source countries. On one hand, FDI from developed source countries is generally concentrated in capital and technology intensive industries (e.g. electronic, machinery and automobile industries, construction, raw-chemical materials etc.). It is essentially oriented towards the Chinese domestic market. Therefore, FDI decisions from the OECD countries are above all motivated by the large size of the population (around 1.2 billion) and rapid economic growth. On the other hand, the major part of FDI from

[46] Round-tripping designates reinvestment of Chinese capital from abroad due to some bureaucratic and political barriers (e.g. issues between Taiwan and China) or in order to benefit from preferential regimes.

[47] Providing a detailed discussion on the determinants of inward FDI to China is clearly beyond the scope of this paper. For an extensive discussion on FDI patterns in China, the interested reader should refer to Lemoine (2000), Liu (2002).

overseas China is attracted by cheap labour costs and directed towards labour-intensive and export-oriented manufacturing industries. In the literature, it is generally asserted that, FDI from the Greater China Area does not necessarily represent a genuine source of advanced technology (Hu and Tong, 2003; Lemoine, 2000). Even so, one cannot disregard that over the last few decades, overseas inward FDI contributed to expand China's foreign trade. Today, labour-intensive, processing trade activities of foreign affiliates represent by far the most dynamic component of China's foreign trade.

4.2.2 Theoretical framework on openness spillovers

Over the last decades, the nexus between openness to the world and the host country's economic development became a popular subject of interest. The existence of spillovers to developing countries (DCs) via foreign trade and FDI was debated extensively by scholars and policy makers. In time, a general belief on the positive effect of openness has been established progressively.

In developing countries which are generally scarce in capital, FDI and foreign trade represent an effective way to alleviate capital shortage and create employment opportunities. Furthermore, multinational companies (MNCs) which set up affiliates in developing countries generally enjoy higher productivity rates than domestic counterparts. Thereby, when MNCs invest in a foreign country, they transfer to their subsidiaries a "package" composed of capital, advanced technologies and managerial-organisational know-how[48] (Hymer, 1960; Balasubramanyam *et al.*, 1996). The "firm-specific assets" of MNCs enable them to compete with their local counterparts who benefit from a superior knowledge of consumer preferences and business practices on local market (Blomström and Sjöholm, 1999). The advanced technologies brought by MNCs might later leak out to local firms through various channels outlined below.

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[48] Mansfield and Romeo (1980) reveal that in developing countries, technologies transferred from parent firms to their subsidiaries are newer than those sold by licensing agreements.

Imitation-demonstration and contagion effects: (Findlay, 1978; Caves, 1974). Foreign invested firms enjoy higher technological intensity and are expected to bring in new products and technologies. In addition, geographic proximity to foreign firms stimulates close observation of technologies and imitation of high-technology products (Blomström and Wang, 1992). That is to say, in host countries, local firms could upgrade their technology by observing (learning by watching) and by imitating (learning by doing) the MNCs operating on the market. In the literature, it is argued that transmission of technical innovations would be more effective between agents located in the same area (Arrow, 1971; Findlay, 1978). In other words, face-to-face contacts and personal relationships ease diffusion of advanced technologies. Consequently, in the literature, FDI is generally recognised as the major source of technological upgrade in host countries.

Competition: The presence of foreign owned enterprises (FOEs) generally exerts a competitive pressure which might push local firms to improve their technological efficiency (Kokko, 1996). In addition, in host countries where competition is fierce, MNCs are expected to be more inclined to transfer their most advanced technologies to their subsidiary companies.

Labour turnover: In developing countries, MNCs carry most of the R&D and training activities. Knowledge created in MNCs is likely to diffuse to local economy in various ways, for instance through labour turnover and when skilled workers trained in the MNCs establish businesses of their own (Blomström and Sjöholm, 1999).

Backward and forward linkages: In the presence of quality linkages between foreign firms and their local suppliers or customers, spillovers can take place in the form of labour training and technological know-how transfer (Blomström and Kokko, 2001; see the literature review).

Trade: The expansion of foreign trade could increase technical efficiency in various ways. The expansion of exports is expected to enlarge market size and generate scale economies. Generally speaking, in host countries, MNCs tend to be more export oriented than local counterparts. The export activity of MNCs could stimulate the integration of local firms into international markets.

The export-oriented FDI firms could reduce information costs in foreign markets and ease the establishment of adequate transport and communication infrastructure facilities. The competition on foreign markets and integration into the international production networks could bring about some efficiency gains for local firms (Blomström and Kokko, 2001). Furthermore, foreign currency brought by exports could finance the import of sophisticated equipment and machinery.

Despite little theoretical controversy on the subject, empirical studies generate conflicting evidence on the existence of spillovers via openness to the world. Some recent studies, namely Aitken and Harrison (1999) for Venezuela, Haddad and Harrison (1993) for Morocco; and Aslanoglu (2000) for Turkey reveal negative impacts of FDI on host countries' economic performances. These studies report that following the entry of MNCs into the local market, host economies could suffer from fierce competition (Kokko *et al.*, 1996). In that case, the presence of foreign firms is expected to draw demand from local firms and "crowd out" less competitive firms of the market (especially in large-scale industries). Moreover, in DCs, purchasing advanced technology from abroad, setting up joint-ventures and buying licences might also constitute a substitute for local innovation activities (Aitken and Harrison, 1999).

The aforementioned empirical studies emphasise the fact that spillovers from openness to FDI do not arise automatically. Their existence and strength are strongly conditioned to host country's innovation and absorptive capabilities. Cohen and Levinthal (1989) define "absorptive capability" as the ability of a region or an organisation to identify, assimilate and exploit external knowledge. In the same way, Abramovitz (1986) argues that the ability to absorb more advanced technologies depend on the « social capabilities » of host countries. The notion of social capability refers to a number of factors such as technological and organisational skills, development of human capital and adequate infrastructure facilities, macroeconomic stability and quality of institutions.

In the empirical literature, absorption capabilities are generally proxied by the technological gap between foreign investors and host country. True, a large technology gap between local and foreign firms could hint at a big "catch-up" potential; but, it can also indicate poor absorptive capabilities of host economies (Blomström and Sjöholm, 1999). Therefore, technology diffusion is expected to be more effective when the gap is small and host and home countries compete directly in comparable activities (Kokko, 1992). Xu (2000) and Borensztein and al. (1998) highlight the role of human capital development in spillovers process. They show that host countries should reach a threshold level of minimum human capital development in order to benefit from technology spillovers. In the same way, Blomström and Wolff (1994) conclude that in host countries, basic infrastructure facilities have to be in place for the technology transfer to take place.

4.3 Data Description and Theoretical Model

4.3.1 Data

In this study, we explore labour productivity in 30 Chinese provinces over the period 1979-2006. Tibet is excluded from the panel data set due to data unavailability. The underlying series are originated from various issues of China Statistical Yearbook. All nominal values are deflated by region-specific retail price indexes and expressed in 1978 constant RMB. Missing observations are completed by linear interpolation.

4.3.2 Description of main variables

A detailed description of the main variables used in the empirical specifications is provided below:

- **Dependent Variable: *Labour Productivity***: We proxy technological efficiency of a region by its labour productivity, which is a partial measure of productive efficiency (OECD, 2001). Due to the scarcity of data, the labour productivity series are based on average value added per employee (instead of hours worked).

- **Control Variables:** ***FDI*** is measured in terms of flows instead of stock. In the literature, it is generally asserted that positive effects of inward FDI on the host economy take some time to manifest themselves. In order to detect any delayed effects[49], we construct the FDI series, based on one-year lagged values. ***International trade*** series correspond to the sum of total exports and imports. Given the mixed empirical literature outlined in section 2, we remain *a priori* agnostic on the expected signs of coefficients associated with FDI and trade variables. ***Capital intensity*** refers to the average level of capital assets per employee. In accordance with the neoclassical framework, we consider that workers equipped with better capital are expected to achieve higher productivity. ***Human capital*** is used as a proxy for the host region's absorptive capabilities. Since the data series on the composition of employed persons by educational level are unavailable, the human capital series are based on the share of the population studying at the institutions of higher education. We expect that a well-trained and more qualified workforce would achieve higher productivity. There are various ways to quantify the ***infrastructure adequacy*** of the host region. In this study, we rely on data in the infrastructure development in transportation services. We therefore compute a measure of combined length of highways and railways[50]. Number of phone sets could also be a good measure of infrastructure development, but data are unavailable over our study period. We also built an alternative measure of infrastructure adequacy, which is the interaction term between FDI per habitant and combined length of railways and highways. We consider that a better infrastructure development should generate higher labour productivity. Main descriptive statistics of model variables as well as the expected signs of associated coefficients are outlined below, respectively in Table 4.3 and Table 4.4.

[49] The amount of FDI to a province is directly affected by the size of the province. Thus, in order to control for the 'size' effect we also tested alternative measures of FDI such as FDI per capita and ratio of FDI over GDP. Nevertheless, these variables turn insignificant and the models exhibit a very bad fit. As a consequence we take into account of heterogeneity across regions by means of cross-sectional dummies.

[50] We consider that if those two measures are not combined together, they might generate biases against regions where railway or road transportation dominates.

Table 4.3: Descriptive statistics

Variable	Labour Productivity	One-year-lagged FDI	Trade	Educ.	Capital Intensity	Infrast.
Mean	-1.66	-1.63	3.93	-5.21	-0.57	1.24
Median	-1.69	0.65	4.53	-5.43	-0.51	1.36
Maximum	0.71	5.15	10.65	-2.56	2.15	3.18
Minimum	-5.04	-13.82	-13.82	-6.88	-13.82	-1.47
Std. Deviation	0.94	6.05	3.70	0.90	1.48	0.78

Note: All of the variables are explained in log linear form.

Table 4.4: Summary of expected signs

Variable	Expected Sign
FDI	+/-
Education	+
Trade	+/-
Capital Intensity	+
Infrastructure	+
Wages	+

4.3.3 Model

In the empirical model, we adopt the log-linear functional form. Thereby, the estimated coefficients could be interpreted as elasticities. The model is set as follows:

$$\ln LP_{i,t} = \alpha_0 \ln FDI_{i,t-1} + \alpha_1 \ln Trade_{i,t} + \alpha_2 \ln Edu_{i,t} + \alpha_3 \ln K/L_{i,t} + \alpha_4 \ln Infra_{i,t} + \eta_i + \gamma_t + \varepsilon_{i,t} \quad (1)$$

In Equation 1 the index i denotes cross-sectional dimension while the index t indicates time dimension. The disturbance term is composed as follows: η_{i} corresponds to the unobservable time variant province specific fixed effect and γ_t designates the unobserved period-specific effect; ε_{it} is the stochastic error term which is assumed to be i.d.d. The inclusion of region specific effects enables to deal with the omitted-variables and misspecification issues. Differences in opening up paces across regions are expected to be captured by time specific fixed effects.

4.4 Introduction of Spatial Effects: Model Background

Tobler's first law of geography (1970) expresses the origins of spatial econometrics as follows « Everything is related to everything else, but near things are more related than distant things ». That is to say, spatial econometrics is dedicated to the study of spatial structure and spatial interactions between observations. It is mainly inspired from the research issues of economic geography and regional science (Anselin, 2001).

In spatial modelling, the pioneering work of Moran (1948), Hordijik and Paelinck (1976), Paelinck and Klaassen (1979), Cliff and Ord (1973), Anselin (1988) introduced an empirical framework and made considerable methodological progress. Over the last decade, with better availability of geo-coded socioeconomic data sets, spatial econometric analysis received an increasing attention of mainstream economists. Furthermore, considerable methodological progress has been made to extend the theoretical framework to applied econometrics. As yet, the usual approach in spatial data essentially consisted of leaving out the time dimension and focusing on a single cross-section interaction equation (Fingleton, 2001).

Over the last few years, the field of spatial econometrics has started to be extended to space-time data specifications. To name only a few, Elhorst (2001, 2003); Anselin (2001); Anselin *et al.* (2008) provide theoretical framework and comprehensive methodological discussion on spatial panel econometrics. However, up to the present time, the dissemination of these methods to empirical practice has been impeded by the lack of adequate econometric packages and softwares.

Our analysis constitutes one of the first attempts to extend the empirical techniques of spatial data analysis to panel data sets. We therefore test a number of panel data specifications, which up to now has remained confined to the theoretical and methodological framework. We expect our estimations to constitute a baseline and give stimulus to further applied research in alternative space-time model specifications.

4.4.1 Main econometric issues introduced by spatial data

The use of spatial data in empirical analysis could bring about two major econometric problems, namely spatial dependence and spatial heterogeneity[51]. Living out these two issues could generate serious misspecification problems and unreliable results (Abreu *et al.*, 2005).

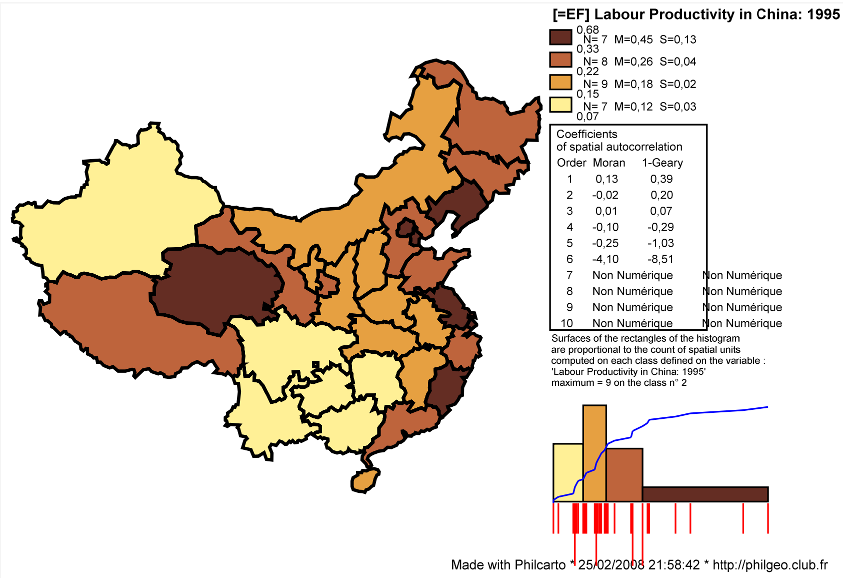
- **Spatial Dependence**

Spatial dependence refers to absence of independence between geographic observations. It is introduced when the correlation across the cross-sectional units follows a certain spatial ordering. In other words, spatial autocorrelation is the coincidence of value similarity and location similarity (Anselin, 2001). In some way, spatial autocorrelation could be viewed as analogous to serial correlation in time series models. Thus, models which rely on geographical data need to be tested systematically for spatial autocorrelation (Cliff and Ord, 1981). It should be noted that, unlike serial autocorrelation, dependence in space is not linear. It implies feedback effects and simultaneity due to the two-directionality of the neighbourhood relation: "I am my neighbours' neighbour" (Anselin and Bera, 1998; Anselin and Rey, 1991).

Spatial dependence could arise from either theoretical or statistical reasons. On one hand, it could be the outcome of the economic integration of geographical units in the form of labour migration, capital mobility and inter-regional trade. It can also stem from institutional and political factors and externalities such as technology and knowledge spillovers (Buettner, 1999; Ying, 2003).

[51] Going into an excessive discussion on spatial econometric methodology is clearly behind the scope of this paper. For a detailed taxonomy of spatial regression models, see Anselin (1988), Anselin and Bera (1998), Baumont *et al.* (2000).

Figure 4.2: Spatial dispersion of labour productivity in China: 1995 and 2005



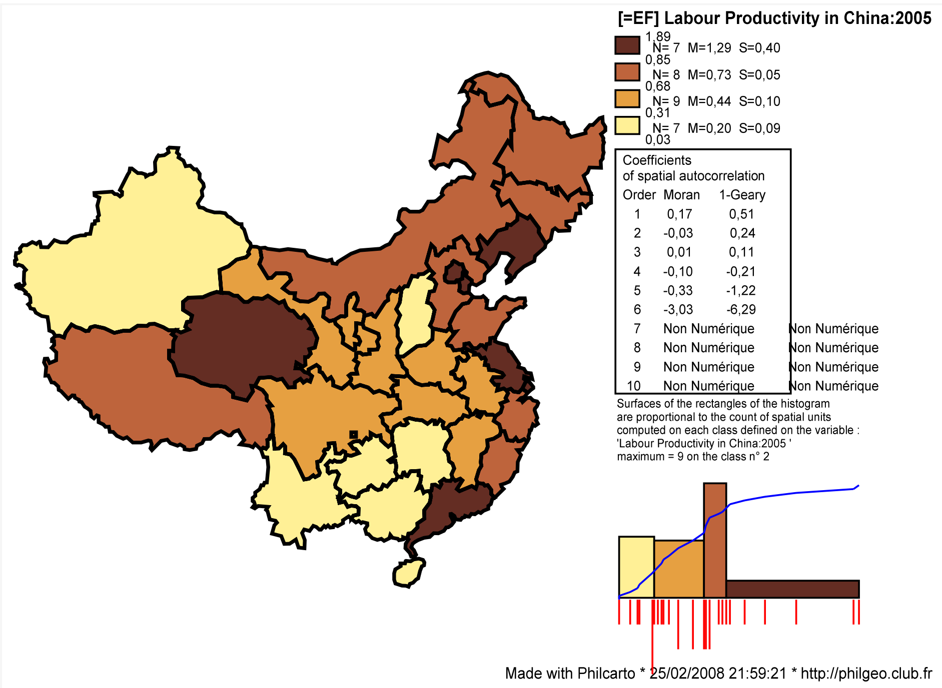
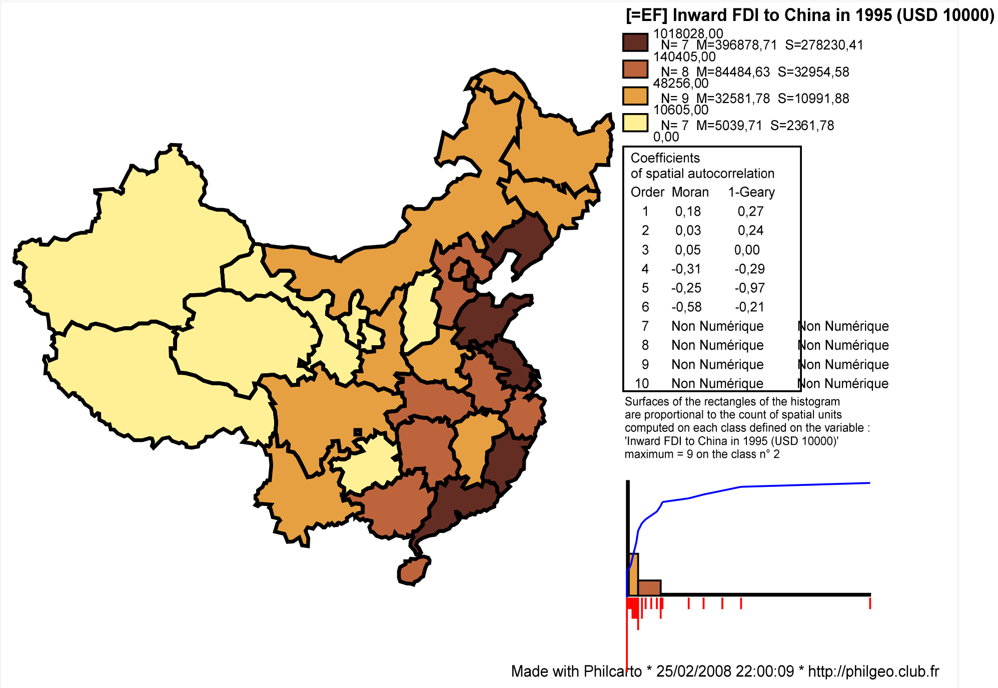


Figure 4.3: Regional distribution of FDI in China: 1995 and 2005



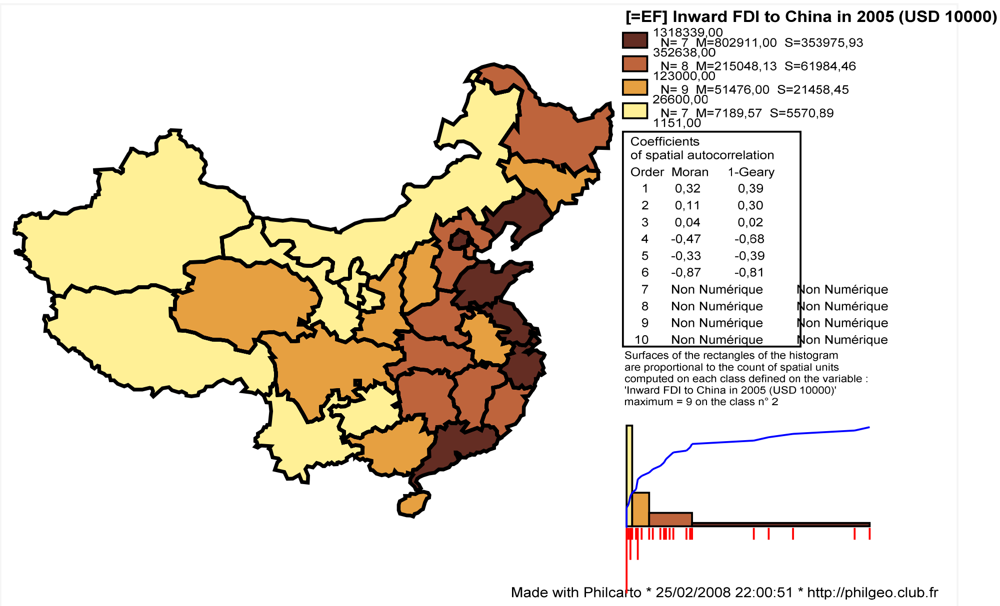
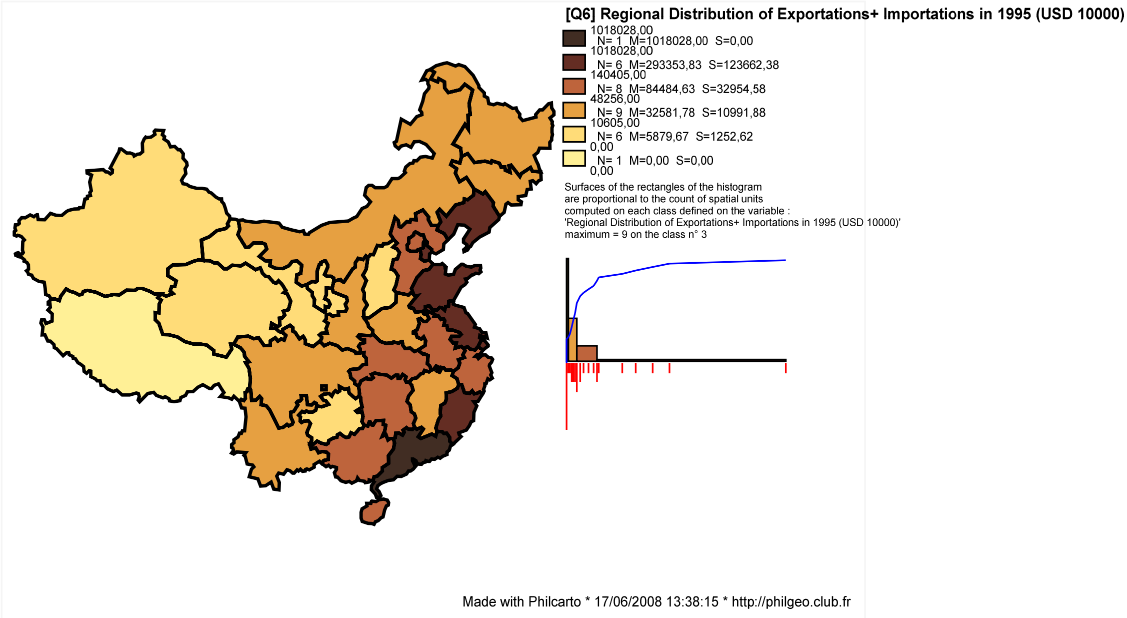
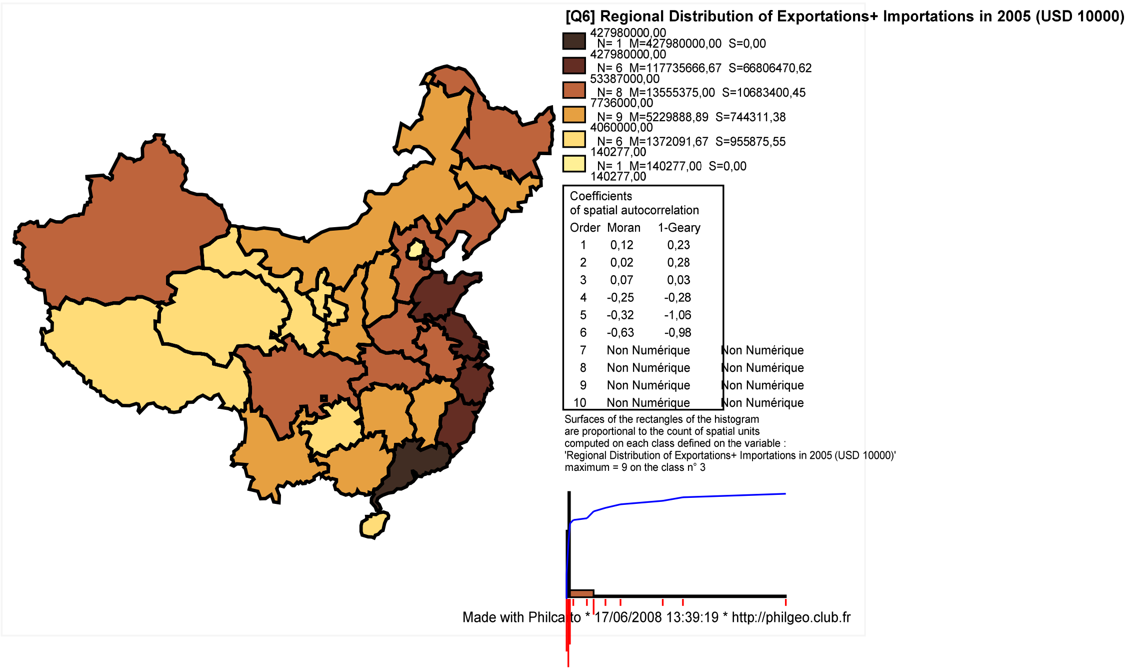


Figure 4.4 : Regional distribution of trade in China: 1995 and 2005





On the other hand, spatial dependence could be related to some statistical issues such as measurement errors, varying aggregation rules, different sample designs and omission of some variables with spatial dimension (such as climate, topology and latitude) (Anselin and Florax, 1995).

The figures below display the choropleth maps of labour productivity, international trade and FDI in China, in 1995 and in 2005. In the maps, Chinese provinces are divided into quartiles based on the amount of FDI flows they have received. It is obvious from Figures 4.2 and 4.3 and 4.4 that in China, the regional distribution of labour productivity, FDI and trade exhibit a clear positive spatial dependence in 1995 and in 2005. In other words, we can clearly observe from the maps that regions with high or low values of FDI, trade and labour productivity are strongly clustered.

- **Spatial Heterogeneity**

The second issue introduced by the use of geographical data is spatial heterogeneity in the econometric relationship. Spatial heterogeneity refers to the structural variability of the estimated parameters across the *i* according to spatial variables such as location, distance, region, etc. (Baumont and al., 2000). The presence of spatial heterogeneity violates the Gauss-Markov assumption of existence of a single linear relationship with constant variance across the entire data sample. In the case of structural instability, alternative estimation procedures are needed to model appropriately this variation and draw reliable inferences. In the literature, spatial variability in the regression coefficients is modelised in various ways such as spatial regimes (Anselin, 1988), spatial expansion (Casetti, 1997), geographically weighted regressions (Fotheringham and al., 1998), and Bayesian hierarchical models (Anselin and Florax, 1995). However, up to now, neither of these specifications has seen application in panel data structure (Anselin *et al.*, 2008). Therefore, we confine our attention to the unobserved heterogeneity which we tackle by means of conventional panel econometrics methods such as cross-sectional and time dummies.

4.4.2 Properties of the spatial weighting matrix

The spatial weighting matrix (W) provides the structure of the assumed spatial relationships and captures the strength of potential spatial interactions between observations. The determination of an accurate spatial weights matrix is a fundamental step in spatial data analysis. The over-specification and under-specification of W can affect the performance of diagnostic tests as well as the reliability of estimated coefficients and statistical inferences (Florax and Rey, 1995).

The spatial weighting matrix is a square matrix of dimension equal to the number of cross sectional units (NxN). Given the elements of the spatial weights matrix have to be non-stochastic and exogenous to the model (otherwise the model would be highly non linear), spatial matrices are generally based on geographic criteria such as distance or contiguity (Anselin and Bera, 1998). In the literature, geographic distance based spatial connexion is defined in a number of ways alternatively:

- **Simple contiguity**: The simple contiguity binary matrix is the most widely used distance weights matrix in the literature due to its simplicity of construction. The binary contiguity matrix is based on the adjacency of location of observations. Put w_{ij} to express the magnitude of the interaction between province *i* and *j*. If two provinces share a common boundary we put $w_{ij}=1$ and $w_{ij}=0$ otherwise.

- **Distance based contiguity:** In distance based contiguity matrices, spatial weights attributed to the observations depend on the geographic or Euclidean distance d_{ij} between locations *i* and *j*. Distance matrices differ in the functional form used, for instance distance function [$w_{ij}=d_{ij}$], inverse function of distance [$w_{ij}=1/d_{ij}$], inverse distance raised to some power [$w_{ij}=1/d_{ij}^N$], negative exponential function [$w_{ij}=\exp(-\theta d_{ij})$], and so on.

> In distance decay functions, it is considered that the strength of spatial dependence declines with distance. In addition, it is generally assumed that beyond a certain critical bilateral geographic distance, interactions between provinces become negligible (Abreu *et al.*, 2005). In the literature, distance cut-off points are generally set up according to some statistical or arbitrary criterions based on the minimum or median distance between regions, significance of spatial diagnostic statistics, and goodness of fit of regressions.

The weighting matrix is generally row standardised by dividing each weight of an observation by the corresponding row sum $w_{ij} / \Sigma_j w_{ij}$. In this way, the elements of each row sum to unity. Whereas the original spatial weighting matrix is usually symmetric; the row-standardised one is not (Anselin *et al.*, 2008). It should be noted that the non-symmetry of W implies unusual complication and brings about significant computational consequences. An asymmetric spatial weighting matrix implies that, region *i* could exert a larger influence on the random variable of interest in region *j* and *vice-versa.* By convention, the distance matrix has zeros on the main diagonal, thus no observation predicts itself.

In the distance-based spatial matrix, each weight w_{ij} could be interpreted as the province's share in the weighted average of the neighbouring observations. In this way, $w_{ij}=0$ indicates the lack of spatial interactions among observations. By convention, the distance matrix has zeros on the main diagonal, thus no observation predicts itself.

It was recently argued that the spatial interdependence between observations could be a function of other factors than geographic distance, namely differences in factor prices, cultural distance, travel time, similarities in per capita income, etc. In some studies (e.g. Conley and Ligon, 2002) economic distance was used to construct weighting matrixes. However, given that the economic distance based weights are not exogenous to the model, their utilisation could imply serious identification problems (see the "reflexion problem" in Manski, 1993). The "block weights" constitute an alternative form of economic weights where all observations in the same region are considered to be neighbours. For instance, if there are N_g units in a block (say counties in a city) they are all considered to be neighbours. Each unit in the same block is attributed the spatial weight $1/(N_g-1)$ (Lee, 2002).

In this study, in order to test the robustness of our results with respect to various spatial structures, a row-standardised simple binary contiguity and five inverse distance matrices are computed. The characteristics of the great circle distance matrix (based on the coordinates of centroids of Chinese provinces) are listed below in Table 4.5.

Table 4. 5: Characteristics of great circle distance matrix based on capital cities of Chinese provinces (km)

Arc Distance matrix	
Dimension:	30
Average distance between points:	603.208
Distance range:	1714.61
Minimum distance between points:	21.0473
Quartiles:	
First:	329.798
Median:	535.332
Third:	823.098
Maximum distance between points:	1735.66
Min. allowable distance cut-off:	201.639

Note: The matrix is computed by using Anselin's SpaceStat 1.91 version software package (2001).

4.4.3 Diagnostic tests for spatial dependence

In the applied literature, the most widely used diagnostic tests for spatial association are based on the seminal work of Moran (1948), Geary (1954), and Cliff and Ord (1973). Spatial autocorrelation diagnostic tests capture whether the value of an observation in one location is similar to those of proximate regions. Moran's I is by far the most widely used univariate test to determine whether a process is spatially non-stationary. Moran's I[52] statistic could be interpreted as the statistic measure of the covariance of the observations in nearby provinces relative to the variance of the observations across regions. It gives statistical evidence about spatial autocorrelation in the variable of interest for a given year t.

Moran's I spatial diagnostic test is conducted under the null hypothesis of lack of model misspesification due to spatial dependency (in the form of an omitted spatially lagged dependent variable) and uncorrelated homoscedastic error terms. The significance of the coefficients is based on the z-values. Given that the variables are standardised, the Moran's I values range from -1 to 1. In the absence of spatial autocorrelation, the expected value of Moran's I statistic is zero.

If Z (I) = 0 we consider that the observed values are randomly and independently distributed over space (Goodchild, 1986). To be more precise, Moran's I statistic could be interpreted in the following way: If Z (I)>0 with (p<0.05) nearby regions have similar values. That is to say, the random variable tends to cluster in space. In contrast, Z (I)<0 with (p<0.05) reveals negative spatial autocorrelation with dissimilar values of proximate regions. Negative spatial dependence implies a checkerboard pattern of values and does not always have a theoretically meaningful interpretation. Anselin (1995) has also developed a local indicator of spatial correlation (LISA) which provides a spatial association measure for a particular locality and identifies local clusters.

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52 $I_y = \frac{N}{S_0} \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{ij}^{(y)} z_i z_j}{\sum_{i=1}^{N} z_i^2}$, $\forall$ all $t=1,2,...,T$ Where, for a given year t and spatial lag y: i≠j, n is the number of regions, z_i and z_i are normalised vectors of observed values of the variable at locations *i* and *j*, w_{ij} is the element of spatially weighting matrix W(N x N) corresponding to the observation pair *i* and *j* and S_0 is a scaling constant. Moran's I statistic could be interpreted as the statistic measure of covariance of observations in nearby provinces relative to the variance of the observations across regions.

Cliff and Ord (1988) adopted Moran's I test to spatial autocorrelation to regression residuals (see chapter 5).

Table 4. 6: Moran's I and Geary's c test results for labour productivity, trade and FDI in China, 1979-2006.

Variable	Moran's I Statistic	Moran's I p-values	Geary's c Statistic	Geary's c p-values
Labour Productivity				
1979-1985	0.041	0.22	0.875	0.07
1986-1990	0.062	0.12	0.864	0.05
1991-1996	0.074	0.08	0.869	0.05
1997-2001	0.106	0.02	0.854	0.03
2002-2006	0.144	0.00	0.840	0.02
FDI				
1979-1985	0.009	0.47	0.866	0.05
1986-1990	0.031	0.28	0.861	0.04
1991-1996	0.098	0.03	0.803	0.00
1997-2001	0.069	0.09	0.841	0.02
2002-2006	0.131	0.00	0.824	0.01
Trade				
1979-1985	0.087	0.03	0.833	0.01
1986-1990	-0.004	0.29	0.883	0.09
1991-1996	0.009	0.07	0.868	0.05
1997-2001	0.022	0.10	0.863	0.04
2002-2006	0.055	0.06	0.856	0.03

Notes: Results are based on the inverse distance weighting matrix with a critical band of 0-800 km. The diagnostic tests are estimated by using Anselin's SpaceStat 1.91 version software package (2001).

The Geary's c test for spatial dependence is also based on the null hypothesis of the lack of spatial dependence between observations. In the absence of autocorrelation, the expected value of Geary's c statistic is 1. That is to say, $c<1$ with ($p<0.05$) indicates positive autocorrelation, while $c>1$ with ($p<0.05$) indicates negative autocorrelation between observations.

Table 4.6 displays the results of Moran's I and Geary's c statistics and related p-values for labour productivity, FDI and trade. We can observe from Table 4.6 that Moran's I and Geary's c statistics hint at positive and mostly significant spatial autocorrelation between 1979 and 2006. That is to say, we reject the null hypothesis that, in China, labour productivity, FDI and trade were randomly distributed over space between 1979 and 2006.

4.4. Spatial model specifications

In the empirical literature, the spatial component is generally incorporated into the regressive structure in three major forms, namely in the form of a lag operator to the dependent variables, to the explanatory variables or to the error term (Anselin *et al*,. 2008; Anselin, 2006).

- **Spatial Lag Model:**

The spatial lag model combines the standard regression model with a spatially lagged dependent variable introduced into the right hand side as an explanatory variable. To be more precise, for location *i,* the spatial lag operator corresponds to the weighted average of random observations in nearby regions. In a spatial system, the values of the dependent variables in different locations are jointly determined. They are a function of the explanatory variables and error terms at all locations in the system (i.e. the spatial multiplier process). Spatial lag operators imply a shift over space and can be viewed as analogous to the back shift operator in the first order autoregressive time series. The spatial lag model is expressed as follows:

$$y = \rho W y + X\beta + \varepsilon \qquad (2)$$

Using traditional notation, *y* is a (N x 1) vector of observations of dependent variable, *X*, a (N x K) matrix of K exogenous variables, *β*, a (K x 1) vector of explanatory variable coefficients and *ε*, a (N x 1) vector of stochastic disturbance terms. *W* corresponds to the (N x N) spatial weighting matrix which identifies the geographic relationship among spatial units. *ρ* refers to the spatial autoregressive parameter which captures spatial interactions between observations. It measures the impact of surrounding regions (positive or negative) on the dependent variable in a reference region *i*. *ρ* is assumed to lie between -1 and 1. One should note that, if $\rho \neq 0$, ignoring *ρ* has similar consequences to omitting a significant control variable from the model specification.

In spatial lag models, including a spatially lagged dependent variable to the right hand side introduces a simultaneity problem. By construction, the lagged dependent variable is correlated with the individual fixed effects in the error term. Consequently, the OLS estimator becomes inconsistent and biased. In spatial models, the endogeneity problem is usually solved by the application of the instrumental variables approach, the Maximum Likelihood (ML) estimator and the Generalised Method of Moments (GMM) estimator suggested by Kelejian and Prucha (1999).

It should be outlined that in spatial lag models, additional information derived from the explicit incorporation of spatial effects improves the explanatory power of the model. On one hand, adding a spatially lagged depending variable enables to capture the pattern and the extent of spatial effects. On the other hand, controlling for spatial dependence enables to isolate the effect of the explanatory variables on the dependent variable (Anselin, 1996).

In conventional econometric specifications (without spatial effects), the β coefficients capture the total marginal effect which includes both direct effects of control variables as well as indirect and induced effects arising from spatial dependence. In contrast, in the spatial lag model the associated β coefficients only capture direct marginal effects of control variables. As a consequence, the comparison of β coefficients between the traditional regression and spatial lag models would be irreverent.

- **Spatial Error Model:**

In spatial error models, spatial autoregressive process is confined to the error term. Unlike the spatial lag model, the spatial error specification does not require any underlying theoretical model for spatial and social interactions. Thereby, spatial lag introduced to the error term works through data issues, omitted variables, measurement errors, aggregation biases, the mismatch of administrative boundaries, and so on. In the spatial error model, the spatial autocorrelation gives a parsimonious covariance structure of disturbance terms and generates a non-spherical error covariance matrix (Baumont *and al.*, 2000). Spatial error models can be represented in the following form:

$$y = X\beta + \varepsilon \tag{3}$$

$$\varepsilon = \lambda W \varepsilon + \mu \text{ then } \varepsilon = (I - \lambda W)^{-1} \tag{4}$$

Where ε is an (Nx1) element vector of error terms and λ is the spatial autocorrelation coefficient which is assumed to lie between -1 and 1. The parameter λ captures how a random shock in a specific region is propagated to surrounding regions. By definition, the spatial lag term $W\varepsilon$ is clearly endogenous and correlated with the error term. Living out spatial correlation between error terms has similar consequences to ignoring heteroscedasticity. That is to say, the OLS estimator remains consistent but no longer efficient (it leads to biased and inconsistent statistical inferences).

- **Spatial Cross-Regressive Model:**

In cross-regressive models, spatial correlation is included to the right hand side in the form of one or more spatially lagged explanatory variables.

$$y = \rho WX + X\beta + \varepsilon \tag{5}$$

For instance in our model, the inclusion of spatially lagged FDI will be capturing the impact of the FDI directed to surrounding regions on labour productivity at location *i*. This type of spatial specification does not imply endogeneity issue; that is to say, it does not require any particular estimator such as IV, ML or GMM (Anselin, 1999; Baumont and al., 2000; Lall and Yilmaz, 2002).

To summarise, the spatial model specifications presented above place additional structure on the unobserved determinants of the endogenous variable which would otherwise be captured by the traditional error term.

Spatial structures can also be combined in order to include multiple orders of contiguity (i.e. higher degrees of neighbourhood). In addition, over the last few years, spatial specifications have been extended to higher order models. To name only a few, the seasonal autoregressive-moving average (SARMA; p,q) models , the mixed regressive models which simultaneously include space and time dependence, the models with joint spatial lag and error structures, and the specifications with spatial heterogeneity jointly with spatial dependence have recently been developed.

In the literature, the estimation of spatial panel models is based on methods and theory developed for cross-sectional models. Accordingly, it is considered that the equilibrium process is stable over time with constant spatial lag parameter *ρ* and the distance matrix *W*. With W_N as the matrix dimension of weights for cross-sectional dimension, for panel data, we obtain the weights matrix $W_{NT}=I_T \otimes W_N$, where I_T is an identity matrix of dimension T (Anselin *et al.*, 2008). In our sample, the time-invariant spatial structure implies that $w_{ij,1979}=w_{ij,1980}=\ldots=w_{ij,2006}$. In the next section we empirically test the application of some of the aforementioned model specifications in panel data structure.

5. Model Estimation and Results

4.5.1 Inclusion of spatial structure

- **Spatial Lag Model**

In this section, we augment the basic regression model (Equation 1) by introducing spatial interactions through spatially lagged endogenous and exogenous variables. By including a spatially lagged dependent variable, we test the hypothesis that the productivity level of a province is jointly determined by the productivity of nearby provinces via spatial and social interactions (i.e. integration of economies through trade, capital-labour movements, agglomeration effects and technology spillovers). The spatial model we estimate takes the following form:

$$\ln LP_{i,t} = \alpha_0 W \ln LP_{i,t} + \alpha_1 \ln FDI_{i,t-1} + \alpha_2 \ln Trade_{i,t} + \alpha_3 \ln Edu_{i,t} + \alpha_4 \ln K/L_{i,t} + \alpha_5 \ln Infra_{i,t} + \eta_i + \gamma_t + \varepsilon_{i,t} \quad (6)$$

The other notation is as before, $WLP_{i,t}$ designates spatially lagged labour productivity. To be more precise, a spatially lagged variable for province *i* in year *t* corresponds to the row-sums of spatially weighted values of variable of interest in year *t* in surrounding provinces.

- **Spatial lag model with spatially lagged dependent and independent variables**

$$\ln LP_{i,t} = \alpha_0 W \ln LP_{i,t} + \alpha_1 W \ln FDI_{i,t-1} + \alpha_2 W \ln Trade_{i,t} + \alpha_3 \ln FDI_{i,t-1} + \alpha_4 \ln Trade_{i,t} + \alpha_5 \ln Edu_{i,t} + \alpha_6 \ln K/L_{i,t} + \alpha_7 \ln Infra_{i,t} + \eta_i + \gamma_t + \varepsilon_{i,t} \quad (7)$$

In Equation 7, spatially lagged control variables are included; $WFDI_{i,t-1}$ and $WTrade_{i,t}$ designate respectively spatially lagged FDI and trade. In the estimation of this model some caution is needed: the joint introduction of spatially lagged dependent and independent variables into the same regression could generate some inconsistencies. Indeed, given that $WY_{i,t}$ already includes $WX_{i,t}$ their simultaneous introduction into the model could bring about identification problems (Anselin *et al.* 2008). However, this issue is often overlooked in the literature. For instance, in his seminal study on spatial panel specifications, Elhorst (2001, pp. 121) introduces simultaneously spatially lagged dependent and control variables in the same regression model.

In this study, we estimate Equation 7 in order to test the empirical consequences of a possible identification problem. Our major objective is to give an empirical baseline for further research in the estimation of alternative spatial panel data specifications.

- ***Time recursive spatial lag model***

Equation 8 includes a time recursive component in the form of serial (time) autoregressive parameter. The spatio-temporal model defines jointly two different kinds of neighbourhood: neighbours in space, through the spatial weights matrix and neighbours in time, by the inclusion of the time lagged (autoregressive) dependent variable.

$$\begin{aligned}\ln LP_{i,t} &= \alpha_0 \ln LP_{i,t-T} + \alpha_1 W \ln LP_{i,t} + \alpha_2 W \ln FDI_{i,t-1} + \alpha_3 W \ln Trade_{i,t} + \alpha_4 \ln FDI_{i,t-1} + \alpha_5 \ln Trade_{i,t} \\ &+ \alpha_6 \ln Edu_{i,t} + \alpha_7 \ln K/L_{i,t} + \alpha_8 \ln Infra_{i,t} + \eta_i + \gamma_t + \varepsilon_{i,t}\end{aligned} \quad (8)$$

$LP_{i,t-T}$ corresponds to one-year serially lagged dependent variable. However, Anselin *et al.* (2008) argue that the spatial lag model with a time recursive term implies some additional complications of estimation. Thus, in the same way as Equation 7, the estimation of Equation 8 is expected to induce some inconsistencies arising from the identification problem.

4.5.2 Results

The OLS and ML estimation results of Equations 5, 6 and 7 are presented respectively in Tables 4.7 and 4.8. As mentioned above, in the presence of spatial autocorrelation, the OLS estimator is no longer expected to achieve consistency. That is to say, the OLS results are only reported as a baseline. They should not be the basis of any substantive interpretation.

Table 4.7 outlines that over the period 1979-2006, besides capital deepening; human capital and infrastructure[53]development could be recognised as the main determinants of labour productivity. In addition, the OLS results show negative effects of FDI and international trade on labour productivity, though the values of associated coefficients remain very low. One can observe that, the spatial autocorrelation coefficient ρ has a positive sign and is always significant at the 1 per cent confidence level. This outcome highlights that in China, labour productivity spills over province borders. In addition, the LR [54] test results reveal that the incorporation of the spatially lagged variables improves the overall explanatory power of the model. The auto-regressive form of the model is presented in Column 5. Accordingly, *one-year-lagged labour productivity* variable turns to be significant at the 1 per cent confidence level. Yet, given the presence of the spatial autocorrelation, we strongly suspect the OLS results to be fallacious. Recent theoretical (Abreu *et al.,* 2005) and empirical (Ying, 2002) literature demonstrated that in the presence of spatial interactions, the OLS estimator is no longer reliable.

[53] As for the *infrastructure* variable, we refer to the combined length of highways and railways. We also ran regressions with alternative infrastructure measures such as the interaction term between combined length of highways and railways and alternative measures of FDI. However, all of those variables turn to be insignificant or introduce serious multicollinearity issues.

[54] The LR test corresponds to twice the difference between the log likelihood in the spatial lag model and the log likelihood in a standard regression model with the same set of explanatory variables (Anselin 1996).

The ML[55] estimations presented in Table 4.8 correct for the endogeneity issue in the regression due to spatial dependence. Column 1 displays that all of the explanatory variables exhibit a significantly positive effect on the dependent variable at the 1 per cent confidence level. Consistent with the endogenous growth theory, one can observe that conventional variables such as human capital, capital intensity and infrastructure development exert the greatest impact on labour productivity performances of Chinese regions.

In addition, Table 4.8 reveals a positive effect of FDI and trade on labour productivity. The coefficients associated with *FDI* and *trade* variables exhibit similar values and are positively significant at the 1 per cent level. Accordingly, in a given region, a 10 per cent increase in either FDI or trade increases labour productivity of 1.2 per cent.

[55] The Maximum Likelihood (ML) estimation consists of applying a non-linear optimisation to a log-linear function. It should be borne in mind that the ML estimator relies on normally distributed variables with constant variance assumptions. The term *quasi* ML estimator is used in the specifications where the actual distribution differs from the normal distribution of error terms (Anselin et al. 2008).

Table 4.7: OLS estimates with time-specific and cross-section fixed effects (1979-2006)

Dep. Variable: LP	(1)	(2)	(3)	(4)	(5)
Constant	-2.420 (-29.072)***	-1.284 (-9.819)***	-1.281 (-9.735)***	-1.287 (-9.869)***	-0.903 (-7.653)***
FDI	-0.008 (-4.347)***	-0.006 (-3.481)***	-0.006 (-3.485)***	-0.005 (-3.255)***	-0.004 (-3.227)***
Education	0.309 (8.700)***	0.303 (9.138)***	0.304 (9.083)***	0.286 (8.549)***	0.189 (6.581)***
Trade	-0.003 (-1.995)**	-0.001 (-0.903)	-0.001 (-0.912)	0.022 (3.966)***	0.017 (3.434)***
KL	0.022 (4.596)***	0.023 (5.326)***	0.023 (5.253)***	0.025 (5.768)***	0.019 (4.880)***
Infrastructure	0.108 (3.443)***	0.054 (1.821)*	0.054 (1.829)*	0.059 (1.994)**	0.022 (0.881)
Spatially Lagged LP	-	0.613 (10.782)***	0.615 (10.606)***	0.650 (11.270)***	0.411 (7.701)***
Spatially Lagged FDI	-	-	0.000 (0.219)	-0.001 (-0.394)	-0.006 (-1.499)
Spatially Lagged Trade	-		-	0.001 (0.411)	0.002 (0.881)
LP serially lagged (one year)	-	-	-	-	0.311 (17.050)***
Adjusted R^2	0.98	0.98	0.98	0.98	0.98
Log Likelihood	561	619	619	628	762
AIC	-1.18	-1.32	-1.32	-1.34	-1.70
Log Ratio Test	-	116***	116***	134***	402***
Number of observations	840	840	840	840	840

Source: see table 4.8

Table 4. 8: ML estimates with time specific and cross-section fixed effects (1979-2006)

Dependent Variable: LP	(1)	(2)	(3)	(4)
FDI	0.012*** (9.668)	-0.001 (-0.916)	-0.003 (-2.857)***	-0.001 (-1.438)
Education	0.444 (29.018)***	0.448 (30.563)***	0.158 (13.663)***	0.155 (12.914)***
Trade	0.012 (4.813)***	0.007 (2.653)***	0.004 (2.600)***	0.004 (2.771)***
KL	0.036 (6.306)***	0.0263 (4.595)***	0.016 (4.596)***	0.017 (4.837)***
Infrastructure	0.198 (6.619)***	0.186 (6.521)***	0.003 (0.182)	0.017 (4.837)***
Spatially Lagged LP	0.103 (6.474)***	0.106 (6.932)***	0.104 (10.462)***	0.101 (10.140)***
Spatially Lagged FDI	-	0.019 (8.536)***	-	-0.002 (-1.539)
Spatially Lagged Trade	-	-	0.021 (6.632)***	0.025 (6.336)***
LP serially lagged (one year)		-	0.598 (31.268)***	0.601 (31.313)***
Adjusted R^2	0.967	0.969	0.98	0.98
Log Likelihood	301	337	662	666
Number of observations	840	840	840	840

Notes: The numbers in parentheses are t-statistics. (*), (**), (***) denote respectively significance at the 10%, 5% and 1% level. The spatial weighting matrix used is a binary contiguity matrix computed by MATLAB, the spatial econometrics toolbox of Lesage (www.spatial-econometrics.com).

From Table 4.8 we can observe that the coefficients associated with spatially lagged labour productivity are positive and significant at the 1 per cent level. This confirms the positive pattern of spatial clustering of labour productivity among Chinese regions. The value of ρ lies around 0.1. The elasticity estimates suggest that a 10 percent increase in average productivity of surrounding regions increases by 1 per cent the labour productivity of the reference region. It should be outlined that, even after allowing for spatially lagged dependent variables, we are still able to identify productivity spillovers from inward FDI and foreign trade. This outcome strongly supports the argument that openness to FDI and trade gave rise to substantial productivity spillovers to Chinese economy.

In Columns 2 and 3 we estimate Model 7 which includes both spatially lagged dependent and control variables. Unexpectedly, after including spatially lagged FDI, *FDI* variable itself looses significance. In addition, spatially lagged FDI appears to be positive and significant at the 1 per cent level. This finding could be interpreted as an evidence for interregional FDI spillovers. In that case, it would imply that Chinese regions reaped more benefit from FDI directed to surrounded regions rather than their own inward FDI flows. However, this outcome is very puzzling and not consistent with the economic literature.

After the inclusion of the spatially lagged FDI, the loose of significance of the *FDI* variable is fairly deceptive but not inconsistent with the methodological framework developed by Anselin *et al.* (2008). Accordingly, we strongly suspect the identification problem, arising from the simultaneous introduction of spatially lagged dependent and independent variables into the model, to be at the origin of this counter-intuitive result. This finding also motivates our sensitivity analysis with respect to alternative specifications of the distance weighting matrix.

Column 3 introduces spatially lagged *trade* variable. We can observe that the associated coefficients to spatially lagged *trade* are positive and highly significant. This outcome points at the existence of positive trade spillovers between Chinese regions. Whereas, after including spatially lagged trade, in the same way as in Column 2, trade variable itself turns to be negative and significant at the 1 per cent level.

The time-recursive spatial-lag model estimations are presented in Column 4. The coefficient associated with the auto-regressive term is positive and significant at the 1 per cent level. However, when we introduce one-year serially lagged dependent variable, spatially lagged FDI loses its significance. Yet, the time-recursive spatial-lag model is very difficult to estimate due to the additional endogeneity and identification problems it implies. Thus, the estimation results of

Equation 8 are only reported for the purpose of demonstration of its complexity. They should not be the basis of any substantive interpretation.

Table 4.9: ML estimates with time-specific and cross-section fixed effects

	Distance Band (0,5)	Distance Band (0,6)	Distance Band (0,7)	Distance Band (0,8)	Distance Band (0,9)	Distance Band (0,10)
FDI	0.012 (9.447)***	0.011 (9.069)***	0.011 (8.843)***	0.010 (8.600)***	0.010 (8.444)***	0.010 (8.399)***
Education	0.465 (30.663)***	0.446 (29.862)***	0.435 (29.075)***	0.421 (28.561)***	0.410 (28.061)***	0.406 (27.892)***
Trade	0.0144 (5.171)***	0.014 (5.138)***	0.013 (5.050)***	0.013 (4.969)***	0.013 (4.923)***	0.012 (4.830)***
KL	0.041 (6.738)***	0.042 (7.044)***	0.049 (7.200)***	0.041 (7.067)***	0.040 (6.929)***	0.012 (4.830)***
Infra	0.209 (6.724)***	0.204 (6.679)***	0.205 (6.774)***	0.200 (6.687)***	0.200 (6.773)***	0.198 (6.707)***
Spatially Lagged LP	0.054 (4.460)***	0.089 (7.030)***	0.106 (8.134)***	0.134 (10.079)***	0.154 (11.402)***	0.164 (12.103)***
Adjusted R^2	0.964	0.965	0.966	0.966	0.969	0.967
Log Likelihood	273	260	247	222	199	184
Number of observations	840	840	840	840	840	184

Notes: The numbers in parentheses are asymptot t-statistics. (*), (**), (***) denote respectively significance at the 10%, 5% and 1% level. All of the inverse distance matrices are computed by using Anselin's SpaceStat 1.91 version software package (2001). In the distance matrixes weights are defined as w i,j = 1/d i,j □i≠j. The distance band of 0-600 km is denoted by d= (0,6] and so on.

Table 4. 10: ML estimates with time specific and cross-section fixed effects

	Distance Band (0,5)	Distance Band (0,6)	Distance Band (0,7)	Distance Band (0,8)	Distance Band (0,9)	Distance Band (0,10)
FDI	-0.002 (-1.094)	-0.002 (-1.319)	-0.002 (-1.315)	-0.002 (-1.407)	-0.002 (-1.407)	-0.002 (-1.429)
Education	0.473 (32.534)***	0.450 (31.482)***	0.442 (30.753)***	0.433 (30.439)***	0.420 (29.811)***	0.413 (29.477)***
Trade	0.008 (2.993)***	0.008 (2.975)***	0.007 (2.922)***	0.007 (2.858)***	0.007 (2.841)***	0.007 (2.752)***
KL	0.029 (4.958)***	0.031 (5.353)***	0.032 (5.483)***	0.030 (5.305)***	0.029 (5.218)***	0.029 (5.172)***
Infra	0.200 (6.691)***	0.193 (6.589)***	0.195 (6.707)***	0.192 (6.651)***	0.192 (6.718)***	0.188 (6.634)***
Spatially Lagged LP	0.048 (4.139)***	0.090 (7.420)***	0.102 (8.166)***	0.122 (9.545)***	0.144 (11.075)***	0.159 (12.201)***
Spatially Lagged FDI	0.020 (8.686)***	0.020 (8.584)***	0.019 (8.459)***	0.019 (8.470)***	0.019 (8.470)***	0.018 (8.248)***
Adjusted R^2	0.966	0.968	0.968	0.969	0.969	0.970
Log Likelihood	313	296	286	270	244	222
Number of Observations	840	840	840	840	840	840

Notes: The numbers in parentheses are asymptot t-statistics. (*), (**), (***) denote respectively significance at the 10%, 5% and 1% level. All of the inverse distance matrices are computed by using Anselin's SpaceStat 1.91 version software package (2001). In the distance matrixes weights are defined as $w_{i,j} = 1/d_{i,j}\ \forall i \neq j$. The distance band of 0-600 km is denoted by d= (0,6] and so on.

4.5.3 Robustness Check

In this section, we explore the robustness of the empirical results to alternative specifications of the distance weights matrix. On this purpose, five simple inverse distance matrixes are computed with the upper distance bands ranging from 500 to 1000 km. Given the theoretical framework of spillovers, one could consider that a distance-based matrix would be more appropriate to analyse spillovers and technological diffusion processes (*Abreu et al., 2005*).

Table 4.9 displays the estimation results of the basic spatial lag model (Table 4.8 Column 1) with respect to various spatial weight matrices. We can observe from Table 4.9 that all of the coefficients have expected signs and are highly significant at the 1 per cent confidence level. In terms of likelihood, those models exhibit slightly lower performances than the ones based on the simple binary contiguity matrix (Table 4.8). In table 4.9, the magnitude of spatial lag coefficient ρ ranges from 0.05 to 0.16 with respect to different cut-off points. This finding is fairly in line with our previous results.

In Table 4.10 we also test the robustness of the puzzling finding relative to the inclusion of spatially-lagged control variables. We introduce spatially lagged *FDI* to the regression with respect to various specifications of W. Consequently, we obtain similar results as before: after including spatially lagged FDI, *FDI* variable itself looses significance. We strongly suspect the identification problem to be at the origin of these results.

In sum, on the outcome of various specifications of distance weighting matrix, the overall picture we obtain is quite similar to our previous results based on the simple contiguity matrix. That is to say, our results are not really sensitive to alternative specifications of the spatial weighting matrix[56].

[56] We also tested the robustness of the models with spatially lagged *trade* variable and the auto-regressive form. We eventually obtained similar results to those presented in Table 4.8.

4.5.4 Time Breakdown

China's integration into the world economy was a gradual and spatially uneven process. In order to capture different productivity patterns over time, we split our sample into two sub-periods, namely 1979-1991 and 1992-2006. We therefore estimate separately equations 6 to 8 for each sub-period.

The first stage of China's integration to the world economy is above all characterised by special regimes and large disparities in opening up paces between regions. Table 4.11 shows the estimation results for the period 1979-1991.
From Table 4.11 we can observe that over the sub-period of 1979-1991 labour productivity of Chinese regions was mainly determined by human capital and infrastructure development. In addition, capital deepening and FDI also exerted a positive (but relatively low) effect on productivity performances. However, during this period, we are not able to detect any significant effect of foreign trade on productivity.

Over the period 1979-1991, we observe that the spatial autocorrelation coefficients ρ have a positive sign and are always significant at the 1 per cent confidence level. In Table 4.11, the values of ρ lie around 0.2 which is twice higher than our previous estimations for the whole period of 1979-2006. Accordingly, one can presume that regional interactions in labour productivity were stronger during the first stage of China's opening up process.

Table 4.11: ML estimates with time-specific and cross-section fixed effects (1979-1991)

Dependent Variable: LP	(1)	(2)	(3)	(4)
FDI	0.004 (3.688)***	-0.000 (-0.916)	-0.005 (0.877)	-0.000 (-0.371)
Education	0.312 (8.610)***	0.197 (5.342)***	0.176 (4.744)***	0.136 (3.941)***
Trade	-0.000 (-0.001)	0.001 (-0.972)	-0.003 (-0.087)*	-0.001 (-0.917)
KL	0.016 (3.784)***	0.011 (2.849)***	0.014 (3.585)***	0.012 (3.331)***
Infrastructure	0.696 (8.459)***	0.488 (5.904)***	0.421 (5.119)***	0.345 (4.401)***
Spatially Lagged LP	0.228 (6.176)***	0.201 (7.661)***	0.201 (5.782)***	0.203 (6.055)***
Spatially Lagged FDI	-	0.014 (7.661)***	0.009 (4.524)***	0.006 (3.103)***
Spatially Lagged Trade	-	-	1.018 (4.288)***	0.016 (3.838)***
LP serially lagged (one year)		-	-	1.171 (6.669)***
Adjusted R^2	0.983	0.983	0.984	0.985
Log Likelihood	340	340	348	361
Number of observations	390	390	390	390

Notes: The numbers in parentheses are asymptot t-statistics. (*), (**), (***) denote respectively significance at the 10%, 5% and 1% level. Spatially weighting matrix used is a binary contiguity matrix computed by MATLAB, the spatial econometrics toolbox of Lesage (www.spatial-econometrics.com).

Table 4.12: ML estimates with time-specific and cross-section fixed effects 1992-2006

Dependent Variable: LP	(1)	(2)	(5)	(6)
FDI	-0.006 (-1.126)	-0.007 (-1.055)	-0.007 (-0.999)	-0.008 (-1.989)**
Education	0.205 (11.243)***	0.208 (11.179)***	0.210 (10.730)***	0.059 (4.555)***
Trade	0.111 (10.723)***	0.111 (9.441)***	0.119 (7.348)***	0.037 (3.723)***
KL	0.229 (9.914)***	0.230 (9.868)***	0.231 (9.891)***	0.100 (6.781)***
Infrastructure	-0.029 (-1.427)	0.028 (-1.402)	-0.027 (-1.334)***	-0.065 (-5.228)***
Spatially Lagged LP	0.175 (11.896)***	0.169 (11.464)***	0.175 (11.884)***	0.096 (11.042)***
Spatially Lagged FDI	-	0.001 (0.178)	0.005 (0.451)	0.006 (0.850)
Spatially Lagged Trade	-	-	-0.017 (-0.740)	-0.005 (-3.799)***
LP serially lagged (one year)		-	-	0.761 (29.885)***
Adjusted R^2	0.988	0.988	0.988	0.995
Log Likelihood	305	313	304	567
Number of observations	450	450	450	450

Notes: The numbers in parentheses are asymptot *t*-statistics. (*), (**), (***) denote respectively significance at the 10%, 5% and 1% level. Spatially weighting matrix used is a binary contiguity matrix computed by MATLAB, the spatial econometrics toolbox of Lesage (www.spatial-econometrics.com).

The second stage of China's integration to the world economy is above all marked by a progressive shift from preferential to a nationwide opening-up strategy (see Chapter 3). Table 4.12 reveals that over the period 1992-2006 human capital, capital deepening and international trade were the main determinants of labour productivity in China. In addition, Table 4.12 illustrates that the coefficients associated with *capital intensity* variable are strongly higher than our previous results. This finding outlines the fact that during the second stage of China, physical capital accumulation was the main engine of productivity gains. Furthermore, we can observe from Table 4.12 that *FDI* variable is not significant in none of the equations. Accordingly, over this period 1992-2006, the positive impact of openness was exclusively captured by foreign trade.

In Table 4.12, spatial autocorrelation variable ρ appear with a positive sign and is always significant at the 1 percent confidence level. However ρ exhibit lower values than those of the sub-period 1979-1991. That is to say, during the second era of China's opening up, inter-regional dynamics of labour productivity were relatively low.

Concluding Remarks

In this study, we focus on a panel of Chinese provinces and investigate the influence of several key economic and policy factors on labour productivity. By introducing spatial effects to the model, we attempt to draw a clearer picture of regional productivity spillovers and agglomeration effects. It should be outlined that, as yet, the growing literature on spatial panel econometrics has been essentially confined to theoretical framework (due to software limitations). Today, developing alternative approaches and adequate spatial econometrics softwares for panel data structure remains a challenge for ongoing research. This study represents one of the first attempts to apply spatial econometric techniques in panel data structure. Our main objective is to give stimulus to further applied research in the field of spatial panel specification.

Our empirical outcomes report that, consistent with economic theory, human capital, infrastructure development and capital intensity could be recognised as the main determinants of labour productivity. In addition, FDI and trade also exert a positive impact on productivity performances of Chinese regions.

The spatial analysis shows that the geographical environment has a subsequent influence on the level of labour productivity. That is to say, the more a region is surrounded by high-productive regions, the more its productivity is expected to be high. This finding has serious policy implications: Preferential policies that solely consist of opening up some selected regions are not optimal. In order to reap more benefits from foreign presence, coordinated industrial policies which reinforce regional complementarities are needed. In addition, the removal of restrictions to the free movement of labour across regional borders is also crucial to improve productivity.

Chapter 5

A Fresh Scrutiny of Openness and Per Capita Income Spillovers in Chinese Cities: a Spatial Econometric Perspective[57]

Abstract

This paper investigates openness and per capita income spillovers over 367 Chinese cities in the year 2004. Per capita income is modelled as dependent on investment, physical and social infrastructure, human capital, governmental policies and openness to the world.

Our empirical analysis improves substantially the previous research in several respects: Firstly, by extending the data set to prefecture-level, it tackles the aggregation bias. Secondly, the introduction of the recently developed explanatory spatial data analysis (ESDA) and spatial regression techniques enables to address misspecification issues due to spatial dependence. Thirdly, the endogeneity problem in the regression is taken into consideration by means of the Generalised Method of Moments (GMM) estimator.

Our study confirms the positive pattern of spatial clustering among Chinese cities. That is to say, the more a city is surrounded by high income cities, the more its level of economic development is expected to be high. This finding has serious policy implications: Policies that solely consist of opening up and developing some specific regions are not optimal. Economic development policies should rather focus on reinforcing complementarities and interactions across regions.

[57] I would like to thank Harry X. Wu, Ligang Song, the participants of the International Forum for Contemporary Chinese Studies 2008, in Nottingham; and the participants of the Western Economic Association International Pacific Rim Conference 2009, in Kyoto, for their constructive comments and suggestions. Any errors or omissions remain my responsibility.

Our major findings are, in Chinese cities, physical and social infrastructure development, human capital and investment could be recognised as major driving forces of per capita income (i), whereas the government expenditure ratio exerts a negative impact on per capita GDP level (ii). Our empirical findings also give evidence on the existence of spillovers via FDI and foreign trade to Chinese economy (iii). These findings are robust to a number of alternative spatial weighting matrix specifications.

Keywords: China; Openness; Spatial regression; Spillovers; Transition economies.

JEL Classification: O11; O18; P24; R10.

Résumé

Cette étude examine les retombées positives liées à l'ouverture sur 367 villes chinoises en 2004. Dans la modélisation économétrique, le revenu par habitant est expliqué à travers l'investissement, le développement des infrastructures physiques et sociales, le capital humain, les politiques gouvernementales et l'ouverture sur l'extérieur.

Notre analyse empirique contribue à la littérature de manière considérable. Tout d'abord, elle corrige le biais d'agrégation par l'extension de la base de données au niveau des préfectures. Ensuite, elle introduit les outils récemment développés en analyse de données et régression spatiales. Ainsi, elle tient compte des problèmes de spécification liés à la dépendance spatiale. Elle prend aussi en considération le problème d'endogénéité par l'utilisation de la Méthode des Moments Généralisés (MMG).

L'étude spatiale confirme l'existence de l'effet d'agglomérations et les interactions entre les villes chinoises. Ainsi, plus une ville est entourée des villes à revenu élevé, plus son niveau de développent économique serait élevé. Ce constat a d'importantes implications politiques : les politiques qui consistent uniquement à ouvrir et à développer certaines régions spécifiques ne sont pas optimales. Les politiques de développement devraient plutôt se concentrer à renforcer les complémentarités et les interactions entre les régions.

Les principaux résultats empiriques de l'étude sont les suivants: dans les villes chinoises, le développement de l'infrastructure sociale et physique ainsi que l'investissement constituent les principaux déterminants du revenu par tête (i) ; le ratio de dépenses gouvernementales sur PIB exerce un effet négatif sur le niveau de GDP par tête (ii) ; il existe des retombées positives liées à l'IDE et aux échanges internationaux (iii). Ces résultats sont robustes aux spécifications alternatives de la matrice de poids de distance.

Mots Clés: Chine; Ouverture; Régression Spatiale; Economies en transition.

JEL Classification: O11; O18; P24; R10.

5.1 Introduction

Since the introduction of economic reform policies in the early 1980s, China has been experiencing a continuous and rapid economic growth. Alongside the implementation of market oriented policies, China has progressively emerged in the world economy as a leading economic partner. In 2002, China overtook the United States and became the world's largest recipient of foreign direct investment (FDI). Moreover, in 2006, it outpaced major trading countries to emerge as the world's third largest trading partner.

The transition of China from an autarchic economy to a market-based one was a gradual and spatially uneven process. Differences in regional resource endowments and preferential opening up policies favoured coastal regions. They led to dramatic income disparities between the coastal and inland regions, and also between the urban and rural areas.

The purpose of this study is to bring new insight into our understanding of China's recent economic performances. Based on a comprehensive data set, this study yields fresh empirical evidence to a number of questions: What are the driving forces behind China's recent economic development? What is the spatial pattern of China's per capita income distribution? To what extent did the opening-up policies contribute to regional economic development in China? Are there any positive spillovers to Chinese economy arising from openness to FDI and international trade?

This study improves the previous literature in various respects: First, in order to address any aggregation biases, we extend the cross-sectional basis to prefecture-level. It should be noted that, due to data scarcity, the empirical literature on China's regional development is generally confined to province-level data. Given the massive size of China, we expect that using smaller scale spatial units would provide a better understanding of regional development patterns (see Yu and Wei, 2008).

Second, the paper addresses spatial effects by the explicit incorporation of spatial information in the modeling scheme. We consider that for a better understanding of regional development, the focus should be put on spatial patterns and interactions among geographical units. Moreover, ignoring spatial autocorrelation might generate serious misspecification issues, inconsistent parameter estimates and statistical inferences (Anselin, 1988).

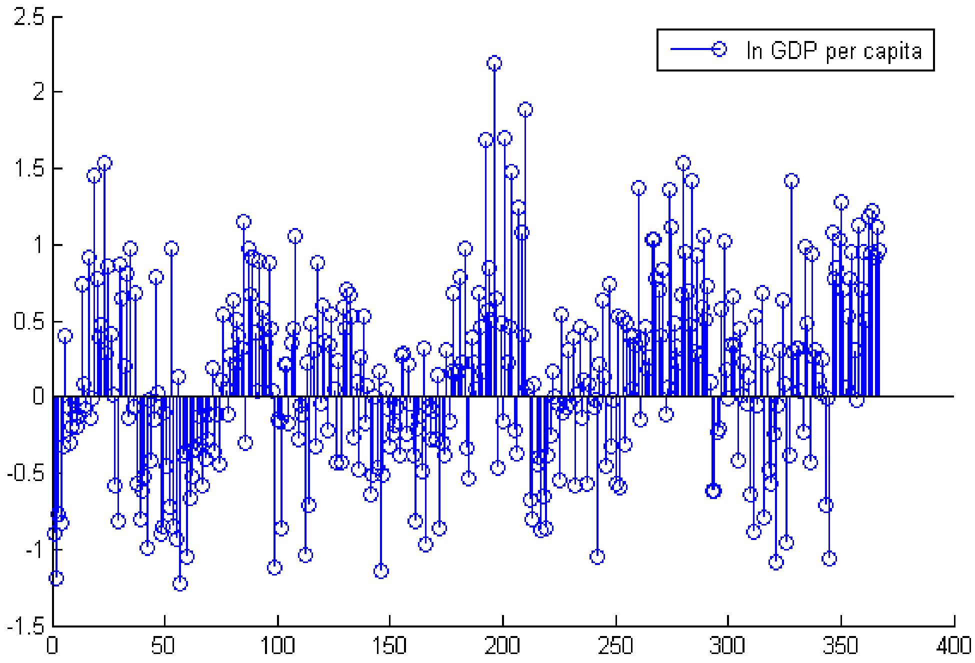
Third, previous studies generally overlook the endogeneity issue. However, in the investigation of the relationship between openness and growth, one should take into account a potential inverse causality. In this study, a possible simultaneity issue is tackled by means of the Generalised Methods of Moments (GMM) estimator.

The remainder of the paper proceeds as follows. The second section presents the underlying data set and methodology. Spatial effects are outlined and discussed in section 3. Section 4 presents the empirical outcomes. The last section concludes the paper.

5.2 Methodology

Our investigation of China's economic development is mainly inspired by the endogenous growth framework (Lucas, 1988; Romer, 1990). Following the empirical literature (Wei, 2000; Yu and Wei, 2008), we chose per capita GDP as the indicator of regional development. It can be clearly observed from Figure 5.1 that the distribution of per capita income exhibits striking disparities among the sample cities.

Figure 5. 1: Distribution of GDP per capita in sample cities (2004)



5.2.1 Data

The underlying data series are collected from the *China Provincial Statistical Yearbook (2005)* from 31 provinces. The data set covers 364 county and prefecture-level cities and 3 super cities (Beijing, Tianjin, Shanghai) spread over the entire Chinese territory[58]. After excluding observations with missing values, our final sample includes 367 cities for the year 2004 (see Appendix 2).

5.2.2 Model

The dependent we use, is the ratio of GDP to population at the year-end. The set of control variables is specified as follows: Physical capital accumulation is proxied by the ratio of completed investment in capital construction to population *(INV),* while the ratio of number of beds in hospitals and sanitation agencies to population *(Bed)* proxies for social infrastructure.

[58] For further information on China's administrative division see Appendix 1.

Physical infrastructure is quantified through the ratio of local telephone subscribers to population *(Phone)*. The ratio of student enrollment in regular secondary schools to population *(HK)* represents absorptive capabilities through human capital development. Openness is measured by the ratio of exports value to GDP (*EXP)* and the ratio of actually realised FDI flows to GDP (*FDI*). Political determinants are controlled by local government expenditure to GDP ratio (*GVT*). A basic description of the series is presented in Appendix 3. After the log linear transformation, the model could be expressed as follows:

$$\ln GDP_i = \alpha_0 + \alpha_{1i} \ln Inv_i + \alpha_2 \ln Bed_i + \alpha_3 \ln HK_i + \alpha_4 \ln GVT_i + \alpha_5 \ln FDI_i + \alpha_6 \ln Phone_i + \alpha_7 EXP_i + \varepsilon_i \quad (1)$$

5.3 Spatial effects

Spatial econometrics takes its origin from Tobler's first law of geography: « Everything is related to everything else, but near things are more related than distant things ». To be brief, spatial econometrics is dedicated to the study of spatial structure and spatial interactions between observation units. It is mainly inspired from the research issues of new economic geography and regional science (Anselin, 2001). The main distinguishing characteristic of spatial data analysis from conventional econometric regression analysis lies in taking into account the spatial arrangement of observations. That is to say, in spatial regressions, regions are not treated as isolated economies and the interactions between them are explicitly incorporated into the modelling scheme. Since the last decade, the increasing availability of geo-referenced socio-economic data sets made possible the extension of applied spatial econometric studies to some mainstream fields of economics (e.g. international economics, labour economics, public economics, agricultural and environmental economics). Beside the cross-sectional dimension, the time dimension has recently started to be included in spatial modelling schemes (see Ehorst, 2001; Anselin *et al*., 2008).

5.3.1 Spatial Dependence

Spatial dependence (or spatial autocorrelation) is one of the main issues introduced by the use of geographical data. It refers to the absence of independence between geographic observations. In other words, spatial autocorrelation corresponds to the coincidence of value similarity and the location similarity of an observation (Anselin, 2001).

Spatial dependence is likely to arise from either theoretical or statistical issues. On one hand, it can be the outcome of the increased economic integration of geographical units due to labour migration, capital mobility, transfer payments and inter-regional trade. In addition, it can also arise from some institutional and political factors, or from externalities such as technological diffusion and knowledge spillovers (Buettner, 1999; Ying, 2003). On the other hand,, as pointed out by Anselin and Florax (1995), spatial dependence can be related to statistical issues such as measurement errors, varying aggregation rules, different sample designs and omission of the variables with spatial dimension (e.g. climate, topology and latitude).

5.3.2 Spatial weighting matrix

The spatial weighting matrix provides the structure of assumed spatial relationships and captures the strength of potential spatial interactions between observation units. Thereby, in spatial analysis, construction of an appropriate spatial weighting matrix is a fundamental step: The choice of the spatial matrix affects both the performance of spatial diagnostic tests and parameter estimates. Since the elements of the spatial weights matrix have to be exogenous to the model[59], the weighting matrix is generally based on geographic criteria (i.e. border sharing or distance).

[59] Otherwise, the model is expected to be non-linear.

- **Simple contiguity**

Due to its simplicity of construction, the binary contiguity matrix is the most widely used distance matrix in the literature. The simple contiguity binary matrix is based on the adjacency of locations of observations. Put w_{ij} to express the magnitude of the interaction between provinces i and j. Then, if two provinces share a common boundary we put $w_{ij}=1$ and $w_{ij}=0$ otherwise.

- **Distance based contiguity**

In distance based contiguity matrices, spatial weights attributed to observations depend on geographic distance d_{ij} between locations *i* and *j*. Distance matrices differ in functional form used, for instance distance function [$w_{ij}=d_{ij}$], inverse function of distance [$w_{ij} =1/d_{ij}$], inverse distance raised to some power [$w_{ij} =1/d_{ij}^N$] and negative exponential function [$w_{ij} =\exp(-\theta d_{ij})$] are frequently used in the literature. In distance decay functions, the strength of spatial interactions declines with geographic distance. d_{ij} corresponds to the cut-off point which maximizes the spatial association and beyond which spatial interactions between units are assumed to be nonexistent. In the literature, the cut-off points are generally set up following some statistical or arbitrary criterions such as minimum or median distance between regions, significance of spatial diagnostic statistics, and goodness of fit of the regression.

The weighting matrix is generally row standardised by dividing each weight of an observation by the corresponding row sum $w_{ij} / \Sigma_j w_{ij}$. Thereby, the elements of each row sum to unity[60] and each weight w_{ij} could be interpreted as the province's share in the weighted average of neighbouring observations. $w_{ij}=0$ indicates the lack of spatial interactions between observations. By convention, the distance matrix has zeros on the main diagonal, thus no observation predicts itself.

[60] Whereas the original spatial weighting matrix is usually symmetric, the row-standardised one is not (Anselin et al. 2008). An asymmetric spatial weighting matrix implies that, region *i* could have a larger influence on the random variable of interest in region *j* and *vice-versa.*

Given the complexity of interactions among geographic units, in this study, we explore the robustness of our results with respect to various specifications of the distance weighting matrix. On this purpose, six spatial weights matrices are computed based on either border sharing or distance based contiguity. The main characteristics of the Euclidian distance matrix of our sample are summarised in Appendix 4. We set the minimum upper distance band to 10 kilometres regarding the minimum allowable distance cut-off point (9.33 kilometers).

Empirical studies in spatial econometric literature rely essentially on two major methods: explanatory spatial data analysis (ESDA) and spatial regression techniques. The ESDA methods are generally used in univariate analysis while the spatial regression techniques enable to explore spatial patterns at multivariate level. Recent literature (Anselin, 2001) provides an extended taxonomy of spatial econometric models (see chapter 4). In this study, our focus is limited to two major classes of specifications for spatial dependence, namely spatial lag and spatial error models.

5.3.3 Spatial Regressions

- **Spatial Lag:**

The spatial lag model combines the standard regression model with a spatially lagged dependent variable introduced as an explanatory variable. Spatial lag operators refer to the weighting average of the random variables in proximate regions. Spatial lag model could be expressed as below:

$$y = \rho W y + X\beta + \varepsilon \qquad (2)$$

Using traditional notation, y is a (N x 1) vector of observations of dependent variable, X, a (N x K) matrix of K exogenous variables, β, a (K x 1) vector of explanatory variable coefficients and ε, a (N x 1) vector of stochastic disturbance terms. W corresponds to the (N x N) spatial weighting matrix which identifies the geographic relationship among spatial units. ρ refers to the spatial autoregressive parameter that captures spatial interactions between observations. It measures the impact of surrounding regions (positive or negative) on the dependent variable in a reference region *i*. ρ is assumed to lie between -1 and 1. If $\rho \neq 0$, ignoring ρ has similar consequences to omitting a significant independent variable from the regression model. That is to say, the statistical inferences and estimated parameters would be questionable.

In the spatial lag model, including a spatially lagged dependent variable to the right hand side introduces a simultaneity problem. By construction, the lagged dependent variable is correlated with the individual fixed effects in the error term. Consequently, the OLS estimator becomes inconsistent and biased. In the literature the endogeneity problem is generally solved by the means of the Instrumental Variables approach, the Maximum Likelihood (ML) estimator and the Generalised Method of Moments (GMM) estimator (see Kelejian and Prucha, 1999).

- **Spatial Error Model:**

In spatial error models, spatial autoregressive process is only confined to the error term. Spatial error models can be represented in the following form:

$$y = X\beta + \varepsilon \tag{3}$$

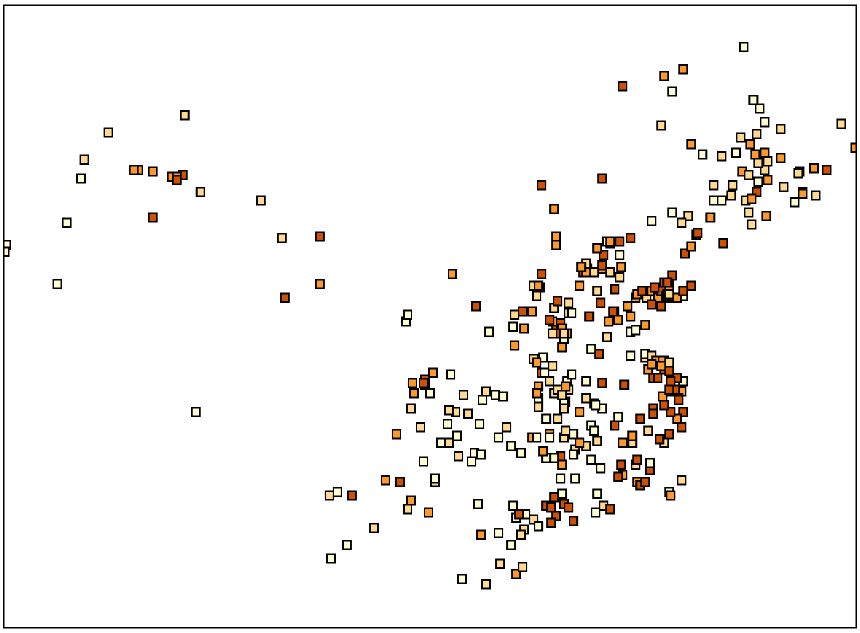
$$\varepsilon = \lambda W \varepsilon + \mu \text{ then } \varepsilon = (I - \lambda W)^{-1} \tag{4}$$

Where ε is a (Nx1) element vector of error terms and λ is the spatial autocorrelation coefficient. The parameter λ captures how a random shock in a specific region is propagated to surrounding regions. It is assumed to lie between -1 and 1. By definition, the spatial lag term $W\varepsilon$ is clearly endogenous and correlated with the error term. Living out spatial correlation between the error terms has similar consequences to ignoring heteroscedasticity. That is to say, the OLS estimator remains consistent but no longer efficient (it might generate biased and inconsistent statistical inferences).

5.3.4 The diagnostic of spatial dependence

The distribution of GDP per capita among Chinese cities in 2004 is presented in the map below. The sample of Chinese cities is divided into quartiles with respect to their level of GDP per capita. Each of the four classes is represented by a different colour[61]. One can observe from the map a clear spatial clustering pattern among Chinese cities. In other words, Chinese cities with high (low) level of per capita income are neighbours or proximate. The map also displays that high-income cities are particularly located on the east coast. According to this visual information, we strongly suspect the presence of spatial autocorrelation in our data sample. That is to say, the per capita income in China is not randomly distributed across space. Thus, Chinese cities should not be treated as isolated economies; they are highly expected to interact with each other.

Figure 5.2: Distribution of per capita income among Chinese cities (2004)



Note: The choropleth map is computed using Geoda 0.9.5-i software created by Luc Anselin.

[61] Due to data limitation our sample might represent some selection bias: it can be observed from Figure 5.2 that the western cities are underrepresented.

- **Spatial Diagnostic tests**

In the literature, spatial autocorrelation diagnostic tests are mainly based on the pioneering work of Moran (1948) and Geary (1954). Tests for spatial association investigate whether the value of an observation in one location is similar to those in proximate regions. Moran’s I is by far the most widely used test by regional scientists (due to its simplicity of construction). To be more precise, Moran’s I is an univariate test which provides information on the degree of linear association between proximate observations. Generally speaking, the spatial diagnostic tests are conducted under the null hypothesis of lack of model misspesification due to spatial dependency. The significance of the coefficients are based on z-values. Anselin (1995) also developed a local indicator of spatial correlation (LISA) which provides a spatial association measure for a particular locality and enables to identify local clusters. Cliff and Ord (1981) adopted Moran’s I test to regression residuals in order to detect spatial autocorrelation at the multivariate level.

In this study, we investigate a possible spatial dependence through Moran’s I test for regression residuals. Table 5.1 reports the Moran’s I statistics and associated probabilities with respect to six weighting matrices. The spatial diagnostic results presented below reveal a clear pattern of positive spatial autocorrelation in the regression residuals. Consequently, we reject the null hypothesis of random distribution of the economic development across the Chinese cities.

After identifying the presence of spatial dependence, we need to specify the adequate underlying modelling structure of spatial dependence. On this purpose, we perform the Lagrange Multiplier (LM) test which enables to distinguish between two alternative specifications of spatial models, namely spatial error (LMERR) and spatial lag (LMLAG). The Lagrange Multiplier (LM) test only requires estimation of the model under the null hypothesis of no spatial dependence. The choice of the most adequate model is operated by the joint use of the LMERR[62] and LMLAG[63] statistics. The LM error and lag statistics are asymptotically distributed as χ^2 (1).

Table 5.1: Diagnostic tests for spatial dependence

	Binary	D10	D25	D50	D75	D100
Moran's I	6.023 [0.000]	4.116 [0.000]	4.618 [0.000]	4.548 [0.000]	4.586 [0.000]	6.070 [0.000]
LMSAR	79.420 [0.000]	49.239 [0.000]	49.263 [0.000]	48.111 [0.000]	48.768 [0.000]	82.579 [0.000]
LMERR	32.536 [0.000]	14.978 [0.000]	18.730 [0.000]	18.054 [0.000]	18.328 [0.000]	32.514 [0.000]
LMSAR Robust	6.972 [0.008]	9.543 [0.002]	9.139 [0.002]	8.894 [0.002]	7.837 [0.005]	8.808 [0.002]
LMERR Robust	5.760 [0.016]	0.317 [0.573]	0.882 [0.347]	0.815 [0.366]	1.114 [0.291]	3.766 [0.052]

Notes: Figures in brackets are probabilities. All spatial weights matrices are row-standardized: Binary is the first order contiguity; D10 refers to distance-based contiguity for a distance band of 0-10 km and so on. The distance-based inverse matrices are manually computed by the author. The tests are performed by using MATLAB, the spatial econometrics toolbox of Lesage (www.spatial-econometrics.com).

According to the decision rule proposed by Anselin and Florax (1995), the model with the highest value (or lowest probability) exhibits the best fit. In our analysis, the results of the LM and robust LM tests (see Table 5.1) indicate that spatial effects in the form of spatially lagged

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[62] The LM ERR statistic can be expressed as follows: $LM_\lambda = \frac{[\mathrm{e'We}/(\mathrm{e'e}/N)]^2}{tr[\mathrm{W'W}+\mathrm{WW}]}$ where e is a Nx1 vector of OLS residuals, and tr is sum of the diogonal elements (i.e. the trace operator). Apart from the scaling factor in the denominator, this statistics corresponds to the square of Moran's I.

[63] Using the previous notation, the LM LAG statistic can be represented as $LM_\rho = [\mathrm{e'Wy}/(\mathrm{e'e}/N)]^2/D$.

Where e corresponds to the OLS residuals and the denemonator terms follows as: $D = [(\mathrm{WX}\hat{\beta})'[\mathrm{I}-\mathrm{X}(\mathrm{X'X})^{-1}\mathrm{X'}](\mathrm{WX}\hat{\beta})/\hat{\sigma}^2] + tr(\mathrm{W'W}+\mathrm{WW})$ where ˆβ and σ^2 are from OLS (Anselin 2006).

dependent variable (the SAR model) fit better the underlying spatial structure. In addition, this outcome is also consistent with economic theory (see the literature review). Accordingly, the value of the dependent variable of one city is jointly determined by that of the nearby cities through spatial and social interactions. One can expect that the increasing regional integration (through capital and labour movements and international trade) as well as positive openness spillovers have significant impact on a city's level of per capita income.

5.4 Results

In this section, we allow for spatial interactions in Equation 1 by introducing to the right hand side a spatial lag component $WlnGDP_i$. In this way, we consider that per capita income of a given city is likely to be affected by the level of per capita income in the neighbouring or proximate cities. The spatial model we specify takes the following form:

$$\ln GDP_i = \alpha_0 + \alpha_1 W \ln GDP_i + \alpha_2 \ln Inv_i + \alpha_3 \ln Bed_i + \alpha_4 \ln HK_i + \alpha_5 \ln GVT_i + \alpha_6 \ln FDI_i + \alpha_7 \ln Phone_i + \alpha_8 EXP_i + \varepsilon_i \quad (5)$$

Before proceeding to the regressions, we first investigate a potential multicollinearity issue which might arise from the presence of a linear relationship between some of the explanatory variables. From the coefficients of correlations presented in Appendix 5, one can observe that all of the explanatory variables are highly correlated with the dependent variable. This outcome hints at the good explanatory power of the model. However we also detect linear relationships between some of the explanatory variables. For instance, the variables *FDI*, *EXP* and *GVT* are highly correlated with each other. Moreover, the coefficient of correlation between the infrastructure variables *Bed* and *Phone* are also relatively high. The simultaneous inclusion of the highly-correlated variables to the right hand side could potentially bias the empirical results. We therefore run several regressions to explore separately the specific effects of *FDI* and *EXP* on per capita income.

Table 5.2 displays the estimation results of various specifications of Equation 4 by the OLS, ML and GMM estimators. As mentioned before, in the presence of spatial dependence, the OLS estimator is no longer consistent. Thereby, the OLS results are only reported as a baseline for comparison [64]. They should not constitute the basis of any substantive interpretation.

Table 5.2 outlines that in 2004, infrastructure development, human capital[65] and physical investment could be recognized as the driving forces of economic development in the Chinese cites. The table also displays that while introduced separately to the model, FDI and foreign trade also exert a significant and positive effect on GDP per capita. From all of the specifications we can observe a significantly negative impact (at the 1 per cent level) of the government expenditure ratio on per capita income. This outcome is in accordance with the previous empirical studies. We consider that the negative sign of the coefficient captures the economic inefficiencies related to the predominance of the state sector.

Table 5.2 also reveals that the coefficients associated with the spatial autocorrelation variable ρ have a positive sign and are always significant at the 1 percent confidence level. This outcome confirms the positive pattern of spatial clustering among the Chinese cities. That is to say, the more a city is surrounded by high-income cities the more its level of GDP is expected to be high. The magnitude of the coefficient associated with ρ ranges about 0.3. Accordingly, a 1 per cent increase of per capita income in the proximate cities increases the GDP per capita of a given city by 0.3 per cent. It should be outlined that, even after the introduction of the spatially lagged dependent variable, we are still able to identify growth enhancing effects of FDI and trade. This outcome strongly supports the argument that in China openness has substantially contributed to promote the economic development.

[64] It should be noted that in the OLS estimation without spatial effects, the β coefficients capture the total marginal effect which includes direct, indirect and induced effects of the explanatory variables. In contrast, in the spatial lag models the associated β coefficients only capture the direct marginal effects. Thus, the comparison of the β coefficients between the traditional OLS estimates and spatial lag models would be irreverent.

[65] In order to test any potential threshold level effect of human capital development, we divided our sample into two sub-groups according to their ratio of student enrolment in secondary schools. We ran separate regressions for the two sub groups with high and low level of human capital. Yet, we were unable to detect any conclusive results on the existence of the threshold level effect of absorptive capabilities.

Table 5. 2 : OLS, ML, GMM estimation results (1/2)

Dependent variable : GDP/habitant	(1.1)	1.OLS (1.2)	(1.3)	(1.4)	(2.1)	2.ML (2.2)	(2.3)	(2.4)	(3.1)	3.GMM (3.2)	(3.3)	(3.4)
Constant	1.903 [0.000]	3.757 [0.000]	1.698 [0.000]	1.972 [0.000]	1.905 [0.000]	3.589 [0.000]	1.746 [0.000]	1.955 [0.000]	1.905 [0.000]	3.499 [0.000]	1.745 [0.000]	1.955 [0.000]
Investment Ratio	0.030 [0.000]	0.044 [0.000]	0.030 [0.000]	0.030 [0.000]	0.025 [0.002]	0.036 [0.000]	0.025 [0.002]	0.025 [0.002]	0.025 [0.003]	0.032 [0.001]	0.025 [0.003]	0.025 [0.002]
Number of beds ratio	0.416 [0.000]	0.260 [0.000]	0.402 [0.000]	0.427 [0.000]	0.397 [0.000]	0.249 [0.000]	0.385 [0.000]	0.404 [0.000]	0.397 [0.000]	0.243 [0.000]	0.386 [0.000]	0.404 [0.000]
Human capital	0.256 [0.000]	0.528 [0.000]	0.246 [0.000]	0.263 [0.000]	0.290 [0.000]	0.548 [0.000]	0.283 [0.000]	0.296 [0.000]	0.289 [0.000]	0.558 [0.000]	0.282 [0.000]	0.297 [0.000]
Gvt expenditure	-0.687 [0.000]	-	-0.709 [0.000]	-0.692 [0.000]	-0.639 [0.000]	-	-0.655 [0.000]	-0.642 [0.000]	-0.641 [0.000]	-	-0.656 [0.000]	-0.641 [0.000]
FDI	0.007 [0.084]	0.023 [0.000]	-	0.008 [0.031]	0.005 [0.151]	0.019 [0.000]	-	0.006 [0.000]	0.005 [0.153]	0.018 [0.000]	-	0.113 [0.000]
Number of phones	0.136 [0.000]	0.196 [0.000]	0.146 [0.000]	0.134 [0.000]	0.115 [0.000]	0.163 [0.000]	0.122 [0.000]	0.113 [0.000]	0.116 [0.000]	0.145 [0.000]	0.123 [0.000]	0.006 [0.000]
Exportations	0.016 [0.000]	0.021 [0.023]	0.018 [0.013]	-	0.011 [0.100]	0.015 [0.076]	0.013 0.054	-	0.012 [0.099]	0.012 [0.163]	0.013 [0.005]	-
Rho	-	-	-		0.293 [0.000]	0.383 [0.000]	0.300 [0.000]	0.299 [0.000]	0.282 [0.000]	0.589 [0.000]	0.292 [0.000]	0.303 [0.084]

Note: Figures in brackets are probabilities.

Table 5. 2 : OLS, ML, GMM estimation results (2/2).

Dependent variable : GDP/habitant	(1.1)	1.OLS (1.2)	(1.3)	(1.4)	(2.1)	2.ML (2.2)	(2.3)	(2.4)	(3.1)	3.GMM (3.2)	(3.3)	(3.4)
Adjusted R^2	0.579	0.331	0.577	0.575	0.578	0.358	0.576	0.577	0.618	0.42	0.617	0.617
Log Likelihood	-	-	-	-	-32.038	-113.03	-33.068	-33.408	-	-	-	-
Number of observations	367	367	367	367	367	367	367	367	367	367	367	367

Note: Figures in brackets are probabilities.

Table 5. 3 : ML and GMM estimates with respect to various distance weighting matrix (1/2)

Dependent variable : GDP/habitant	ML D10	D25	D50	D75	D100	GMM D10	D25	D50	D75	D100
Constant	2.133 [0.000]	2.149 [0.000]	2.214 [0.000]	2.141 [0.000]	2.166 [0.000]	2.185 [0.000]	2.212 [0.000]	2.216 [0.000]	2.204 [0.000]	2.195 [0.000]
Investment Ratio	0.027 [0.001]	0.027 [0.001]	0.026 [0.001]	0.026 [0.002]	0.025 [0.002]	0.025 [0.003]	0.025 [0.003]	0.023 [0.005]	0.023 [0.006]	0.024 [0.004]
Number of beds ratio	0.423 [0.000]	0.425 [0.000]	0.427 [0.000]	0.428 [0.000]	0.419 [0.000]	0.417 [0.000]	0.418 [0.000]	0.421 [0.000]	0.423 [0.000]	0.415 [0.000]
Human capital	0.309 [0.000]	0.309 [0.000]	0.307 [0.000]	0.306 [0.000]	0.319 [0.000]	0.329 [0.000]	0.330 [0.000]	0.330 [0.000]	0.328 [0.000]	0.330 [0.000]
Gvt expenditure	-0.637 [0.000]	-0.631 [0.000]	-0.634 [0.000]	-0.636 [0.000]	-0.626 [0.000]	-0.606 [0.000]	-0.595 [0.000]	-0.596 [0.000]	-0.601 [0.000]	-0.611 [0.000]
FDI	0.003 [0.596]	0.003 [0.465]	0.003 [0.478]	0.003 [0.478]	0.002 [0.558]	0.003 [0.455]	0.002 [0.538]	0.002 [0.487]	0.002 [0.581]	0.002 [0.615]

Notes: Figures in brackets are probabilities. All spatial weights matrices are row-standardized: Binary is the first order contiguity; D10 refers to distance-based contiguity for a distance band of 0-10 km and so on.

Table 5. 3 : ML and GMM estimates with respect to various distance weighting matrix (2/2)

Dependent variable : GDP/habitant	ML					GMM				
	D10	D25	D50	D75	D100	D10	D25	D50	D75	D100
Number of phones	0.106 [0.000]	0.104 [0.000]	0.104 [0.000]	0.104 [0.000]	0.125 [0.000]	0.096 [0.000]	0.093 [0.000]	0.092 [0.000]	0.092 [0.000]	0.125 [0.000]
Exportations	0.008 [0.037]	0.009 [0.049]	0.009 [0.051]	0.009 [0.050]	0.008 [0.057]	0.008 [0.092]	0.008 [0.078]	0.008 [0.086]	0.008 [0.080]	0.008 [0.073]
Rho	0.246 [0.000]	0.279 [0.000]	0.283 [0.000]	0.287 [0.000]	0.332 [0.000]	0.373 [0.000]	0.418 [0.000]	0.453 [0.000]	0.454 [0.000]	0.402 [0.000]
Adjusted R^2	0.586	0.587	0.586	0.585	0.585	0.613	0.613	0.612	0.611	0.624
Log Likelihood	-35.031	-34.565	-34.854	-35.342	-30.578	-	-	-	-	-
Number of observations	367	367	367	367	367	367	367	367	367	367

Notes: Figures in brackets are probabilities. All spatial weights matrices are row-standardized: Binary is the first order contiguity; D10 refers to distance-based contiguity for a distance band of 0-10 km and so on.

Robustness Check

In this section, we explore the robustness of the empirical results to alternative specifications of the distance weighting matrix. On that account, five row standardised simple inverse distance matrices were computed with the upper distance bands ranging from 10 to 100 km. Table 5.3 displays the estimations of Equation 5 with respect to alternative specifications of the spatial weighting matrix.

From Table 5.3, one can clearly recognize that the ML and GMM estimations provide similar parameters to those based on the simple binary contiguity matrix (Table 5.2 Columns 2.1 and 3.1). In all of the specifications, the spatial autoregressive parameter ρ is positive and significant at the 1 per cent level. That is to say, on the outcome of various specifications of W, the overall picture we obtain with respect to various cut-off points is quite similar to those based on the simple contiguity matrix. Our results are not really sensitive to alternative specifications of the spatial weights matrix[66].

Conclusion

In this study we explore the local patterns of regional development in China. We direct our attention to city level and investigate the influence of several key economic and policy factors on regional development. By introducing spatial effects to the modelling scheme, we focus on regional dynamics and attempt to draw a clearer picture of per capita income distribution in China. Our empirical outcomes show that, consistent with theoretical framework, human capital, physical and social infrastructure development and investment could be recognised as the major driving forces of per capita income. We also detect the existence of positive spillovers from foreign trade and FDI to Chinese economy.

[66] We also tested the robustness of the spatial auto-regressive models which introduce separately *FDI* and *EXP*. We eventually obtained similar results to those presented in Table 5.2.

Our study gives strong evidence on the agglomeration effects and clustering pattern among Chinese cities. That is to say, the more a city is surrounded by high income cities, the more its level of economic development is expected to be high. This finding has serious policy implications: Policies which solely consist of opening up and developing some specific regions are not optimal. Development policies should rather follow a coordinated nationwide perspective and focus on reinforcing complementarities and interactions across regions .In addition the removal of restrictions to labour movements across regional borders and between the urban and coastal areas is crucial to enhance economic development.

Appendices

Appendix 1: China's Administrative Division System

The People's Republic of China is divided into 22 provinces, 5 autonomous regions, 4 centrally-administered municipalities and 2 special administrative regions listed below:

Provinces: 安徽 Anhui, 福建 Fujian, 甘肃 Gansu, 广东 Guangdong, 贵州 Guizhou, 海南 Hainan, 河北 Hebei, 河南 Henan, 黑龙江 Heilongjiang, 湖北 Hubei, 湖南 Hunan, 吉林 Jilin, 江苏 Jiangsu, 江西 Jiangxi, 辽宁 Liaoning, 青海 Qinghai, 山东 Shandong, 山西 Shangxi, 陕西 Shaangxi, 四川 Sichuan, 云南 Yunnan, 浙江 Zhejiang

Autonomous Regions (Zizhiqu): 广西 Guangxi, 内蒙古 Inner Mongolia, 宁夏 Ningxia, 西藏 Xizang (Tibet), 新疆 Xinjiang

Municipalities: 北京 Beijing, 重庆 Chongqing, 上海 Shanghai, 天津 Tianjin

Special Administrative Regions: 香港 Hong Kong, 澳门 Macau

Provinces and municipalities are self governing districts which are under direct jurisdiction of the central government. In autonomous regions, the minority (Chinese Han) constitute the majority in the local government and congress. In Special Administrative Regions, the policy of "one country two systems" is pursued.

China's administrative units are currently based on a three-tier system which divides the nation into provinces, counties and townships. A province or an autonomous region is subdivided into autonomous prefectures, counties, autonomous counties and/or cities. A county or an autonomous county is subdivided into townships, and ethnic townships and/or town.

Appendix 2 : List of sample cities (1/3)

Province	City	Province	City	Province	City	Province	City
Beijing	Beijing	Inner Mongolia	Feng Zhen	Jilin	Shuangliao	Jiangsu	Pizhou
Tianjin	Tianjin	Inner Mongolia	Gen He	Jilin	Shulan	Jiangsu	Qidong
Hebei	Anguo	Inner Mongolia	Man Zhou Li	Jilin	Taonan	Jiangsu	Rugao
Hebei	Bazhou	Inner Mongolia	Ulanhot	Jilin	Tumen	Jiangsu	Taicang
Hebei	Botou	Inner Mongolia	Xilinhot	Jilin	Yanji	Jiangsu	Taixing
Hebei	Dingzhou	Inner Mongolia	Ya Ke Shi	Jilin	Yushu	Jiangsu	Tongzhou
Hebei	Gaobeidian	Inner Mongolia	Zha Lan Tun	Heilongjiang	Acheng	Jiangsu	Wujiang
Hebei	Gaocheng	Liaoning	Beining	Heilongjiang	Anda	Jiangsu	Xinghua
Hebei	Hejian	Liaoning	Beipiao	Heilongjiang	Beian	Jiangsu	Xinyi
Hebei	Huanghua	Liaoning	Dengta	Heilongjiang	Fujin	Jiangsu	Yangzhong
Hebei	Jinzhou	Liaoning	Donggang	Heilongjiang	Hailin	Jiangsu	Yixing
Hebei	Jizhou	Liaoning	Fengcheng	Heilongjiang	Hailun	Jiangsu	Yizheng
Hebei	Luquan	Liaoning	Gaizhou	Heilongjiang	Hulin	Jiangsu	Zhangjiagang
Hebei	Nangong	Liaoning	Haicheng	Heilongjiang	Muleng	Zhejiang	Cixi
Hebei	Qian\'an	Liaoning	Kaiyuan	Heilongjiang	Ning\'an	Zhejiang	Dongyang
Hebei	Renqiu	Liaoning	Linghai	Heilongjiang	Shangzhi	Zhejiang	Fenghua
Hebei	Sanhe	Liaoning	Lingyuan	Heilongjiang	Shuangcheng	Zhejiang	Fuyang
Hebei	Shahe	Liaoning	Pulandian	Heilongjiang	Suifenhe	Zhejiang	Haining
Hebei	Shenzhou	Liaoning	Tiefa	Heilongjiang	Tieli	Zhejiang	Jiande
Hebei	Wu\'an	Liaoning	Wafangdian	Heilongjiang	Tongjiang	Zhejiang	Jiangshan
Hebei	Xinji	Liaoning	Xingcheng	Heilongjiang	Wuchang	Zhejiang	Lanxi
Hebei	Xinle	Liaoning	Xinmin	Heilongjiang	Wudalianchi	Zhejiang	Leqing
Hebei	Zhuozhou	Liaoning	Zhuanghe	Heilongjiang	Zhaodong	Zhejiang	Lin\'an
Hebei	Zunhua	Jilin	Daan	Heilongjiang	Zhaoyuan	Zhejiang	Linhai
Shanxi	Fenyang	Jilin	Dehui	Shanghai	Shanghai	Zhejiang	Longquan
Shanxi	Gaoping	Jilin	Dunhua	Jiangsu	Dafeng	Zhejiang	Pinghu
Shanxi	Gujiao	Jilin	Gongzhuling	Jiangsu	Dongtai	Zhejiang	Ruian
Shanxi	Hejin	Jilin	Helong	Jiangsu	Gaoyou	Zhejiang	Shangyu
Shanxi	Houma	Jilin	Huadian	Jiangsu	Haimen	Zhejiang	Shengzhou
Shanxi	Huozhou	Jilin	Huichun	Jiangsu	Jiangdu	Zhejiang	Tongxiang
Shanxi	Jiexiu	Jilin	Ji\'an	Jiangsu	Jiangyan	Zhejiang	Wenling
Shanxi	Lucheng	Jilin	Jiaohe	Jiangsu	Jiangyin	Zhejiang	Yiwu
Shanxi	Xiaoyi	Jilin	Jiutai	Jiangsu	Jingjiang	Zhejiang	Yongkang
Shanxi	Yongji	Jilin	Linjiang	Jiangsu	Jintan	Zhejiang	Yuyao
Inner Mongolia	Aershan	Jilin	Longjing	Jiangsu	Jurong	Zhejiang	Zhuji
Inner Mongolia	E Er Gu Na	Jilin	Meihekou	Jiangsu	Kunshan	Anhui	Jieshou
Inner Mongolia	Erenhot	Jilin	Panshi	Jiangsu	Liyang	Anhui	Mingguang

Appendix 2 : List of sample cities (2/3)

Province	City	Province	City	Province	City	Province	City
Anhui	Ningguo	Shandong	Laizhou	He'nan	Xinzheng	Hu'nan	Linxiang
Anhui	Tianchang	Shandong	Leling	He'nan	Yanshi	Hu'nan	Liuyang
Anhui	Tongcheng	Shandong	Linqing	He'nan	Yima	Hu'nan	Miluo
Fujian	Changle	Shandong	Longkou	He'nan	Yongcheng	Hu'nan	Shaoshan
Fujian	Fuan	Shandong	Penglai	He'nan	Yuzhou	Hu'nan	Wugang
Fujian	Fuding	Shandong	Pingdu	Hubei	Anlu	Hu'nan	Xiangxiang
Fujian	Fuqing	Shandong	Qingzhou	Hubei	Chibi	Hu'nan	Yuanjiang
Fujian	Jian\'ou	Shandong	Qixia	Hubei	Dangyang	Hu'nan	Zixing
Fujian	Jianyang	Shandong	Qufu	Hubei	Danjiangkou	Guangdong	Conghua
Fujian	Jinjiang	Shandong	Rongcheng	Hubei	Daye	Guangdong	Enping
Fujian	Longhai	Shandong	Rushan	Hubei	Enshi	Guangdong	Gaoyao
Fujian	Nan\'an	Shandong	Shouguang	Hubei	Guangshui	Guangdong	Gaozhou
Fujian	Shaowu	Shandong	Tengzhou	Hubei	Hanchuan	Guangdong	Heshan
Fujian	Shishi	Shandong	Wendeng	Hubei	Honghu	Guangdong	Huazhou
Fujian	Wuyishan	Shandong	Xintai	Hubei	Laohekou	Guangdong	Kaiping
Fujian	Yongan	Shandong	Yanzhou	Hubei	Lichuan	Guangdong	Lechang
Fujian	Zhangping	Shandong	Yucheng	Hubei	Macheng	Guangdong	Leizhou
Jiangxi	Dexing	Shandong	Zhangqiu	Hubei	Qianjiang	Guangdong	Lianjiang
Jiangxi	Fengcheng	Shandong	Zhaoyuan	Hubei	Shishou	Guangdong	Lianzhou
Jiangxi	Gaoan	Shandong	Zhucheng	Hubei	Songzi	Guangdong	Lufeng
Jiangxi	Guixi	Shandong	Zoucheng	Hubei	Tianmen	Guangdong	Luoding
Jiangxi	Jinggangshan	He'nan	Changge	Hubei	Wuxue	Guangdong	Nanxiong
Jiangxi	Leping	He'nan	Dengfeng	Hubei	Xiantao	Guangdong	Puning
Jiangxi	Nankang	He'nan	Dengzhou	Hubei	Yicheng	Guangdong	Sihui
Jiangxi	Ruichang	He'nan	Gongyi	Hubei	Yidu	Guangdong	Taishan
Jiangxi	Ruijin	He'nan	Huixian	Hubei	Yingcheng	Guangdong	Wuchuan
Jiangxi	Zhangshu	He'nan	Jiyuan	Hubei	Zaoyang	Guangdong	Xingning
Shandong	Anqiu	He'nan	Lingbao	Hubei	Zhijiang	Guangdong	Xinyi
Shandong	Changyi	He'nan	Linzhou	Hubei	Zhongxiang	Guangdong	Yangchun
Shandong	Feicheng	He'nan	Mengzhou	Hu'nan	Changning	Guangdong	Yingde
Shandong	Gaomi	He'nan	Qinyang	Hu'nan	Hongjiang	Guangdong	Zengcheng
Shandong	Haiyang	He'nan	Ruzhou	Hu'nan	Jinshi	Guangxi	Beiliu
Shandong	Jiaonan	He'nan	Weihui	Hu'nan	Jishou	Guangxi	Cenxi
Shandong	Jiaozhou	He'nan	Wugang	Hu'nan	Leiyang	Guangxi	Dongxing
Shandong	Jimo	He'nan	Xiangcheng	Hu'nan	Lengshuijiang	Guangxi	Guiping
Shandong	Laixi	He'nan	Xingyang	Hu'nan	Lianyuan	Guangxi	He Shan
Shandong	Laiyang	He'nan	Xinmi	Hu'nan	Liling	Guangxi	Ping Xiang

Appendix 2 : List of sample cities (3/3)

Province	City	Province	City	Province	City	Province	City
Hainan	Dan Zhou	Sichuan	Pengzhou	Yun'nan	Jinghong	Xinjiang	Atush
Hainan	Dong Fang	Sichuan	Qionglai	Yun'nan	Kaiyuan	Xinjiang	Bole
Hainan	Qiong Hai	Sichuan	Shifang	Yun'nan	Luxi	Xinjiang	Changji
Hainan	Wan Ning	Sichuan	Wanyuan	Yun'nan	Ruili	Xinjiang	Fukang
Hainan	Wen Chang	Sichuan	Xichang	Yun'nan	Xuanwei	Xinjiang	Hami
Hainan	Wu Zhi Shan	Guizhou	Bijie	Shannxi	Hancheng	Xinjiang	Hotan
Chongqing	Hechuan	Guizhou	Chishui	Shannxi	Huayin	Xinjiang	Kashi
Chongqing	Jiangjin	Guizhou	Duyun	Shannxi	Xingping	Xinjiang	Korla
Chongqing	Nanchuan	Guizhou	Fuquan	Gansu	Dun Huang	Xinjiang	Kui Tun
Chongqing	Yongchuan	Guizhou	Kaili	Gansu	Hezuo	Xinjiang	Miquan
Sichuan	Dujiangyan	Guizhou	Qingzhen	Gansu	Linxia	Xinjiang	Shihezi
Sichuan	Emeishan	Guizhou	Renhuai	Gansu	Yu Men	Xinjiang	Tacheng
Sichuan	Guanghan	Guizhou	Tongren	Qinghai	Delingha	Xinjiang	Turpan
Sichuan	Huaying	Guizhou	Xingyi	Qinghai	Golmud	Xinjiang	Urumqi
Sichuan	Jiangyou	Yun'nan	Anning	Ningxia	Ling Wu	Xinjiang	Usu
Sichuan	Jianyang	Yun'nan	Chuxiong	Ningxia	Qingtongxia	Xinjiang	Yi Ning
Sichuan	Langzhong	Yun'nan	Dali	Xinjiang	Aksu	Tibet	Xigaze
Sichuan	Mianzhu	Yun'nan	Gejiu	Xinjiang	Aletai		

Appendix 4: Descriptive statistics

	BED	EDU	EX	FDI	GDPH	GVT	INV	PHONE
Mean	-6.094	-2.721	-4.825	-6.859	0.142	-2.653	-2.322	-1.534
Median	-6.136	-2.704	-3.302	-4.656	0.133	-2.723	-1.965	-1.507
Maximum	-4.269	-1.944	1.799	-0.613	2.194	-0.136	0.892	0.557
Minimum	-7.804	-4.993	-19.984	-19.984	-1.225	-3.729	-13.816	-5.066
Std. Dev.	0.513	0.299	4.930	5.513	0.606	0.499	2.372	0.561
Skewness	0.241	-3.135	-1.888	-1.226	0.202	1.088	-3.650	-0.597
Kurtosis	3.548	24.026	5.296	2.820	2.927	5.332	18.347	7.279
Jarque-Bera	8.128	7341.588	297.862	92.225	2.568	155.195	4404.705	300.984
Probability	0.017	0.000000	0.000	0.000	0.277	0.000	0.000	0.000
Sum	-2230.355	-995.932	-1765.990	-2510.431	52.170	-971.110	-850.023	-561.512
Sum Sq. Dev.	96.408	32.805	8872.445	11091.890	134.209	90.913	2052.414	114.9175

Note : All variabes are expressed in Ln.

Appendix 5: Euclidian distance matrix

Characteristics of distance matrix	
Dimension	367
Average distance between points:	14.284
Distance range:	57.234
Minimum distance between points:	0.080
<u>Quartiles:</u>	
First:	7.290
Median:	11.929
Third:	19.024
Maximum distance between points:	57.315
Min. allowable distance cut-off:	9.333

Note: The Euclidian distance matrix is computed using Anselin's SpaceStat – 1.8 version software package (1996).

Appendix 6: Correlation matrix

	BED	EDU	EX	FDI	GDPH	GVT	INV	PHONE
BED	1.000	-0.109	-0.124	-0.179	0.269	0.249	0.189	0.323
EDU	-0.109	1.000	-0.050	-0.003	0.212	-0.246	-0.034	-0.172
EX	-0.124	-0.050	1.000	0.519	0.191	-0.153	0.014	0.230
FDI	-0.179	-0.003	0.519	1.000	0.257	-0.342	0.038	0.224
GDPH	0.269	0.212	0.191	0.257	1.000	-0.577	0.258	0.527
GVT	0.249	-0.246	-0.153	-0.342	-0.577	1.000	-0.078	- 0.118
INV	0.189	-0.034	0.014	0.038	0.258	-0.078	1.000	0.169
PHONE	0.323	-0.172	0.230	0.224	0.527	-0.118	0.169	1.000

GENERAL CONCLUSION

China's recent emergence as a major global partner has been one of the most remarkable economic developments in the past decades. Over the last 30 years of reform, Chinese economy exhibited unprecedented sustainable economic growth at an average rate of 9.5 per cent. Since the implementation of reform policies, China has gradually embraced the principles of a market based economic system. It transformed its economic structure from a state dominated, self-reliant economy towards a dynamic private-sector-led open economy.

Since the last few decades, understanding China's robust economic growth has become a growing interest among academics and policy makers. In this thesis, four empirical analyses investigating into China's recent economic performances are presented. Using comprehensive data sets and recently developed econometric tools, we bring fresh evidence on growth and productivity patterns of the Chinese economy.

In the outcome of empirical analysis, we draw the following conclusions: China's rapid economic growth over the last few decades has largely been driven by massive capital accumulation and increased integration into the global economy through FDI and trade. In addition, human capital construction and development of adequate infrastructure facilities have also significantly contributed to raise growth and productivity.

Empirical studies presented in Chapters 2, 3 and 4 reveal that productivity gains have actively contributed to China's economic rise. Alongside the reform period, substantial productivity gains have been reaped from efficiency improvements through sectorial reallocation of resources from farming to industry and from structural transformations through the expansion of private sector. The study presented in Chapter 2 shows that over the reform period (1979-2005), rapid output growth in Chinese industry is linked with growth in Total Factor Productivity (TFP). Furthermore, the TFP estimates exhibit an accelerating growth pattern since the early 1990s; giving consistent evidence on the sustainability of economic growth in the near future.

Chapter 3 detects substantial efficiency improvements in Chinese provinces due to technological progress, over the period 1994-2006. According to economic theory, significant contribution of productivity gains to economic growth indicates the sustainability of growth in the long run. Consequently, in order encourage productivity growth; Chinese authorities should pursue public and private initiatives in terms of innovation, R&D, development of information technologies and human capital construction. In addition, ongoing reforms to restructure the state and banking sectors are also expected to raise productive efficiency.

Over the last three decades, China's economic takeoff has mainly been driven by industrialization through the manufacturing sector. China has followed a resource-intensive and outward-oriented economic development model, in the same way as the East Asian NIEs. It has successfully exploited its comparative advantage in abundant cheap labour and specialised in the production of labour intensive manufacturing goods.

China's WTO accession in 2001 inaugurated a new stage of economic integration through the benefits and challenges it generated. The WTO membership implied the opening up of the service sector to foreign competition in a wide range of areas such as banking, insurance, telecommunication, distribution and many other industries. In other words, the WTO accession gave China the opportunity to attract FDI to new capital intensive, highly productive sectors with a greater potential of growth. For instance, since 2001 one can observe an increasing interest of foreign direct investors in the banking, insurance, finance and distribution sectors in China. In the future, developing the service sector through adequate policies should be a priority for the Chinese authorities. Furthermore, given the superior rates of return on investment that service sector implies, one can expect that FDI in the service sector would induce considerable spillovers to local economy.

China's 30 years of economic reform has brought about a higher per capita income and a substantial reduction in poverty. In 1992, income per capita in China outpaced the average level of low income DCs. Yet, China has more to do in the future in order to catch up with industrialised countries. In 2007, its GDP per capita reached only half of that of middle income DCs.

Despite the substantial part of population which jumped out of poverty; today, the general perception is that reform policies in China resulted in worsening regional disparities. China adopted an unbalanced development model through trickle-down effect. Thus, preferential opening up policies coupled with some other geographical, political and structural factors have manifestly favoured the development of coastal regions. Since the introduction of economic reforms, inland regions have fallen far behind while export and FDI oriented regions have enjoyed higher income growth paces.

In the 1990s unbalanced development, in the form of widening rural-urban and coastal-noncoastal income disparities became a growing concern for the Chinese authorities. The deepening regional income disparities started to be recognised as a threatening factor to social, political and economical harmony. In 1992, the Chinese government manifested its intention of turning away from special regimes towards a nation-wide opening-up strategy. Thus, the government's recent initiatives shifted the focus back to the development of interior regions. In 1999, the government launched the Western Development Strategy in order to establish a favourable business environment in western China (by developing human capital, natural resources, transport and communication infrastructures, and so on). The Western Development Strategy produced immediate results; it drained considerable amounts of both domestic and foreign investment to relatively backward western regions. Since 1999, China's western regions have reported annual growth rates above the national average.

The stochastic frontier analysis conducted in Chapter 3 highlights that since the late 1990s; a significant catch-up trend among Chinese provinces has progressively emerged. The Chinese government should in the future pursue its initiative to promote harmonious economic development. For instance, the establishment of a nation-wide social security system could play a key role to reduce the income imbalances. In addition, active government spending in human capital development, construction of adequate infrastructure facilities and a greater outward orientation are needed to encourage the development of inland regions and to promote innovation-driven growth.

The second part of the thesis investigates labour productivity and per capita income patterns in China through a spatial econometric perspective. The empirical studies conducted in Chapters 4 and 5 highlight the importance of regional dynamics and spatial interactions in the process of economic development. Chapter 4 shows that the geographical environment has a subsequent influence on the level of labour productivity. To be more precise, the more a region is surrounded by highly productive regions, the more its productivity is expected to be high. In the same way, Chapter 5 gives strong evidence on the agglomeration pattern among Chinese cities. It outlines that the per capita income of a given city is jointly determined by the level of per capita income in neighbouring and proximate cities.

The empirical outcomes of these spatial analyses have serious policy implications.

Accordingly, in China, preferential policies which consist of opening up and developing a specific region are not optimal. Economic development policies should follow a coordinated nation-wide perspective by reinforcing complementarities and interactions among regions. In addition, the existence of spatial dynamics highlights that free movement of production factors across regional borders and between urban-rural areas is crucial to promote economic development. Hence, government authorities should pursue their incentives to remove formal restrictions and informal barriers to labour and capital mobility across regions.

Today, China's economic transformation remains unfinished. In order to sustain the pace of economic growth more has to be done in the future. Despite the governments' considerable efforts over the last three decades, Chinese economy still exhibits some structural weaknesses in the agricultural, financial and state sectors. For instance, the banking and financial sector in China is characterised by massive inflows of household funds, very high levels of bank deposits (due to high saving rates) and extensive controls on capital outflows. In addition, despite their higher productivity, private enterprises in China still have more difficult access to financial resources than state-owned firms. Moreover, the financial market remains underdeveloped and largely state-controlled. Yet, the misallocation of capital and inefficient use of financial resources through the banking sector can compromise China's sustainable economic growth in the future. Efficiency improvement, liberalisation and restructuration of the banking system constitute key challenges for China's future reform agenda. Furthermore, establishment of better transparency and rule of law as well as reinforcement of intellectual property rights and property rights in rural areas should be a priority to promote a favourable business environment.

In this thesis, two major phases in China's economic development are distinguished: On one hand, under the command economy, the pre-reform period (1949-1977) is marked by self reliance and isolation from the rest of the world. On the other hand, the reform period (1978 and onwards) is characterised by a progressive instauration of a market based economy and China's emergence as a leading global partner. Today, the Chinese economy is going through a new wave of changes and facing the challenges of the global economy. In the future, China's economic development could potentially be constrained by bottlenecks in the field of energy, natural resources and environment. Rising income inequalities, environmental deterioration, demographic challenge via aging population and external trade frictions due to the ongoing global economic crisis might jeopardise China's robust economic growth.

In the near future, the Chinese policy makers should look forward to meeting the needs and challenges of sustainable economic development and promoting a more harmonious society. China's unprecedented growth since 1978 is largely resource intensive and based on over-reliance upon external markets. From an international perspective, domestic consumption to GDP ratio in China remains relatively small. Moreover, high saving rates of Chinese household are essentially triggered by the lack of a nation-wide social security system. As argued by Wu (2007), the third wave of China's economic development, should be based on new driving forces such as expansion of domestic consumption, enlargement of the service sector; and development of new technologies and innovation activities.

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