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OPENNESS, TECHNOLOGICAL CAPABILITIES AND REGIONAL DISPARITIES IN CHINA

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OPENNESS, TECHNOLOGICAL CAPABILITIES AND REGIONAL DISPARITIES IN CHINA

Abstract

This paper is concerned with analysing of regional disparities in China during the 90's and the main causes behind the increased regional disparities. It has identified regional openness, along with the nature of property right, as a critical influencing factor to the regional disparities, while found that the technological capabilities have complex association with economic growth. In particular, the empirical evidence has shown that non-firm R & D activities are highly concentrated in the major urban cities in China to such an extent that these resources appear to be negatively associated with income level when the major cities are excluded out of the analysis. Moreover, the coastal provinces have a very low level of non-firm R & D activities despite their high level of regional openness. However, firm R & D activities are relatively high. This reflects the significant difference in terms of development pattern between inland and coastal provinces. These findings have profound policy implications in the nature and potential economic reform in China.

INTRODUCTION

There have been a large number of studies examining the convergence hypothesis on both international and intra-national scales. How could the low per capita income countries can catch up with the higher per capita income countries is a prominent theme in the recent macroeconomic literature (Rey & Montouri, 1999). No evidence has shown convergence across most countries as a whole, but convergence does hold among groups with certain characteristics in common and among the regions within a country (Zhang et al., 2001). For the convergence studies on intra-nation scale, there have been many studies that focus on the US experience and show that income convergence in the US has been very strong (Calino & Mills, 1993, 1996a, 1996b; Rey & Montouri, 1999). The parallel to inter-national convergence studies is the disparity studies on intra-national scales for developing economies. The regional disparities has become a dominant issue most concerned with Chinese government since 1990s because this is the most disturbing factor affecting contemporary China in the sense of social stability (Zhao & Tong, 2000).

There are two streams of studies on regional disparities in China. One stream has mainly focused on the measurement of regional disparities (Zhang et al, 2001; Fujita & Hu, 2001;

Sun H. 2000; Dèmurger, 2000). Despite their different observation periods, all of these studies have confirmed the presence of increasing disparities since its adoption of economic reform and open policy. Nevertheless, as Fujita & Hu argue, these studies have not sufficiently explored the reasons behind the increasing disparities. Another stream has focused on explanation of the increasing regional disparities in China (Yao, et al, 1998, 2001; Jian et al, 1996; Tian, 1999; Dèmurger, 2001). Most of these studies found that export and foreign direct investment (FDI) have a positive impact on the growth of the coastal regions, but not on the inland regions (Fu & Balasubramany, 2002). This stream of studies assumes the presence of regional disparities and focuses on the FDI and export performance in relation to regional disparities.

This paper attempts to explore the role of regional openness, the nature of property right and technological capabilities in explaining the increasing regional disparities in China in the 1990s. The questions concerned are as follows:

- Are there nation-wide disparities and how can they be measured?
- What factors can explain such disparities?
- How far can these disparities be explained?

The rest of this paper is organised as follows. Section 2 addresses the relevant concepts, measurements, and then explains the data and methods adopted. Section 3 reports the empirical findings in relation to regional disparities. Section 4 explains the influencing factors and their interactions, and the paper concludes in Section 5.

CONCEPTS, MEASUREMENTS, DATA AND METHODS

The concept of openness originated in the international trade literature and broadly refers to market accessibility. It is linked to non-tariff, non-border barriers such as domestic laws and regulations on competition policy, investment, labour and environment. In this paper, regional openness is explained as the ability of a region to attract foreign goods, capital embodied with technologies, and the inflow of human capital into the region. These indicators such as FDI intensity, FDI stock intensity and international trade intensity have been used in this study to measure the extent of regional globalisation in China.

Technological capability is clearly defined at firm level as the ability to acquire, assimilate, adapt and innovate new technologies (Bee & Geeta, 1998). Lall (1987) regarded firm technological capability as the mastery over each element in technological activity process. However, technological capability at macro level have not been defined and understood yet. Since firm technological capability is always measured in qualitative ways (Lall, 1998), it is difficult to define the technological capability at regional level. Despite this, different regions or nations do have different abilities in response to new technical changes. It therefore makes sense to differentiate the technological capabilities at regional level. The technological capability could enhance the regional disparities between those who can benefit from the new technologies and those who cannot (Zhao & Tong, 2000).

The key point is how to capture regional technological capability. Malecki (1997) argues that regional technological capability is closely assigned to the innovation input intensity and suggests using R & D activities as a proxy for regional technological capability. The R & D spending and the number of scientist and technicians involved in R & D activities are two critical indicators used to capture regional technological capabilities.

The empirical studies have shown the positive association of R & D activities with economic growth in developed economies (Gittleman & Wolff, 1999). However, most studies on this issue are concerned with OECD countries, and few are concerned with developing countries (Coe & Helpman, 1993; Fagerber, 1988; Verspagen, 1994; Pianta, 1998). These empirical exercises have confirmed the positive relationship between R & D activities and growth in developed countries, although the results are very sensitive to sample selection (Levine & Renelt, 1992). There is no simple relationship between R & D and growth in developing countries (Malecki, 1997). This is because of the fact that developing countries have suffered from the problems of low R & D efficiency, mis-allocation and separation from economic activities which have affected the regional technological capabilities to a great extent (Zhao & Xv, 2000; Peng, 2000).

Technological capability in a region consists of two basic components - non-firm R & D activities and firm R & D activities. Non-firm R & D and firm R & D activities have a different focus: the former is mainly devoted to basic research while the latter is heavily concentrated in product development. Non-firm (or public) R & D activities determine the technological capability to generate new technologies because more basic R & D inputs will lead to more innovative outcomes on the basis of theory of linear model of innovation. To measure the non-firm R & D activities, this study uses three indicators: (1) public R & D spending per head; (2) number of scientists and technicians involved in R & D activities in 10,000 persons; and (3) technology transaction value per head.

Tab. 1 The Key to variables

Names of Variables	Measurements	Expected correlation/sign with dependent variable
GDPPC	GDP per capita in region	
INNOV1	Ratio of in-house R & D spending to sales income at firm level	Positive
INNOV2	Ratio of new product sales income to total sales income	Positive
INNOV3	Ratio of technical upgrading & innovation investment to basic capital investment	Positive
FDIS	Per capita amount of accumulated investment by foreign funded enterprises in region	Positive
FDI	Per capita amount of FDI actually used in a calendar year in region	Positive
ITR	Per capita amount of the international trade in region	Positive
RD	Formal R & D spending divided by population in region	Positive
ST	Number of scientists and technicians divided by population in region	Positive
TTV	Technology transaction value divided by population in region	Positive
SOEs	Share of industrial output created by SOEs	Negative
FFES	Share of industrial output created by FFEs	Positive

The second is the firm R & D capability reflecting the degree by which firms utilise new technologies. This study uses the following indicators to measure the firm R & D capability: (1) investment in the technical change as a percentage of capital construction investment; (2) new product development spending as a percentage of total sales; and (3) sales from new products as a percentage of total sales.

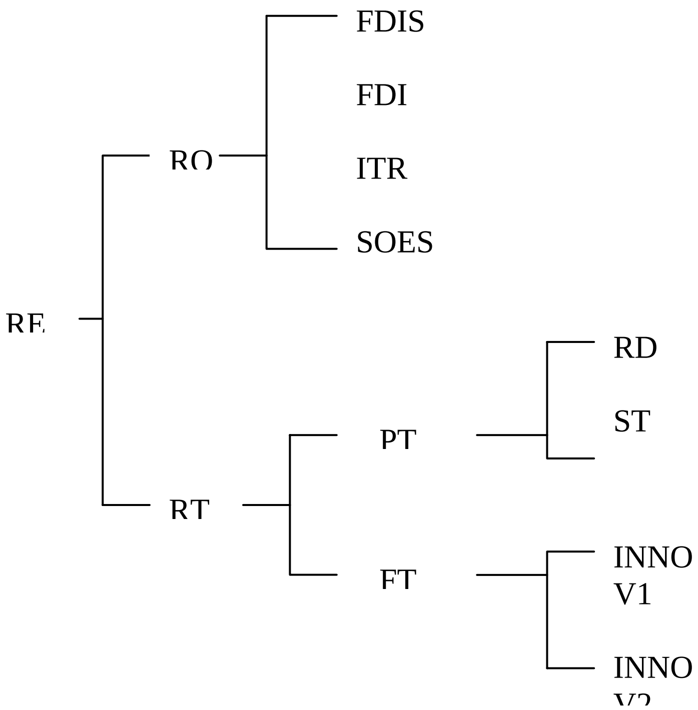


Fig. 1 A diagram showing the interaction between variables

Fig.1 shows the interactions between variables, and REP stands for regional economic performance, measured by per capita GDP. RO stands for regional openness, measured by the indicators denoted as FDIS, FDI, ITR, SOES and FFES. It represents the degree of regional globalisation and the nature of property right. RTC stands for regional technological capability, perceived as two elements: Non-firm (or Public) Technological Capability and Firm Technological Capability. Non-firm TC is measured by three indicators denoted as RD, ST and TTV, while firm TC is measured by INNOV1, INNOV2 and INNOV3.

The studies on regional disparities in China have been lively since 1990 (Zhang et al, 2001; Dèmurger, 2000; Fujita & Hu, 2001). The methods of measuring disparities differ depending upon the researchers' priorities. Suppose $I(X)$ is a function being used to measure the disparity of a variable $X=\{x_i\}$, then $I(X)$ must satisfy the following condition:

$I(X) >= 0$, and $I(X)=0$ if only if x_i =constant for $i=1,2,\ldots,n$

Although many mathematical functions can meet this condition, the most commonly used methods in measuring income disparities are: (1) The Weighted Coefficient of Variation (CV_w); (2) The Theil Index; (3) Gini Coefficient; and (4) Generalised Entropy (GE) Measures. The formula for these indices may be found in Appendix 1.

A factor, denoted as $f=\{f_i\}$, has contributed to the regional disparities *I(Y),* if and only if *y* has significantly positive correlation with *f*, where $i=1, 2, \ldots, n$, $y=\{y_i\}$, y_i is the GDP per capita for the i^{th} province. Thus the quest for questions set out in the introduction can be represented as exploring associations between influencing factors and income level[1]. The overall objectives in this paper are to identify the association of regional income level with market openness factor and technological capabilities.

As this paper uses a set of indicators to measure a single variable, there is multicollinearity among them when all variables in question are used as independent ones. To avoid such multicollinearity this paper applies factor analysis to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables (Norusis, 1988)[2]. The meaning of these factors can be interpreted from the factor loadings that are in essence the correlations of the original variables with the extracted factors. Out of the selected 11 variables, three extracted factors with eigenvalue higher than one are usually used as independent variables for further analysis. These factors are denoted as market openness factor, Non-firm TC factor and firm TC factor (the detailed explanations are given in the next section). The factor analysis should be used with caution when some extreme cases exist in the original data since these outliers could cause different components (Sun Y. F., 2000). This paper therefore uses different approaches to self-contained test.

First, this paper classifies 31 provinces into four clusters, and then compares the factor scores between these clusters. Secondly, regression analysis is conducted on basis of an extensive productive function with integration of technical progress as an indigenous factor. This not only informs how strongly related a pair of variables is, via a measure of correlation, but also it can actually measure the extent of the effect that a change in the independent variable has on the dependent variable. To fully capture the macro data, this paper also explores the varying extent to which the income level (measured by $ln(y)$, y is the logarithm of per capita GDP) associates with influencing factors.

Traditional growth model does not explain long term growth, and neoclassical growth models fail to explain the Asian economic miracle. Growth of per capita income in the long term can only exist if there is an exogenous trend due to technical progress (Freeman & Soette, 1997, p325). Freeman & Soette (1997) further suggest that one must consider an external factor that increases the productivity of inputs over time in order to obtain "unceasing" growth[3]. Let *T* denote exogenous technical progress. *T* can then be integrated into the production function as follows:

$$Y = f(K, L, T) \qquad (1)$$

where *T* is not a production factor like *K* or *L*.

To examine the evolution of aggregate output in 31 provinces, four major components discussed above are integrated into equation *(1)*. The general model is therefore given by

$$Y = f(L, K, H, RD, FRD, FDI) \qquad (2)$$

Where *Y* is aggregate output, *L* labour, *K* fixed capital, *H* human capital, *RD* public (or non-firm) R & D activities, *FRD* firm R & D activities. *FDI* stands for inflow of foreign direct investment that represents a major channel for technology transfer and is therefore regarded as one source of growth. To explain the productivity, the dependent variable is transformed into per capita output. Suppose that

y = *Y/L*

k = *K/L*

h = *H/L*, number of educated people/total population.

rd = Non-firm TC Factor Scores[4].

frd = Firm TC Factor Scores.

fdi = Market Openness Factor Scores.

This study specifies *(2)* as follows:

$$y = g(k, h, rd, frd, fdi) \qquad (3)$$

Thus, following the conventional methods (Zhao & Zhu, 2000; Wei et al, 1998; Zhao, 1995; Madden & Savage, 1998), the regression model can be rewritten as follows:

Where *C* is a constant; *a, b, c, d, e, f* are parameters to be estimated, ε_i is the residual

$$\log(y_i) = C + a \times \log(k_i) + b \times \log(h_i) + c \times \log(rd_i) + d \times \log(frd_i) + e \times \log(fdi_i) + \varepsilon_i$$

$$i = 1,2,...n. \qquad (4)$$

variance. The coefficients: *a, b, c, d, e, f* in this model are expected to be significantly positive. ε_i denotes an unobservable error variable that is assumed to be normally distributed with mean zero. Based on this model, this study poses the following hypotheses:

H1: a>0 (p<0.10)*, i. e. technical equipment level is positively associated with income level.

H2: b>0 (p<0.10), i. e. human capital is positively associated with income level.
H3: c>0 (p<0.10), i. e. non-firm R & D activities are positively associated with income level.
H4: d>0 (p<0.10, i. e. firm R & D activities are positively associated with income level.
H5: e>0 (p<0.10, i. e. regional openness representing regional globalisation and the nature of property right (or economic liberalisation level) is positively associated with income level.
(* p is T-test value, as this is an explanatory study, p<0.10 is acceptable (Zhao & Zhu, 2000))

The primary source of data comprises of the China statistical yearbooks, regional statistical yearbooks and the documents from relevant ministries such as Ministry of Foreign Trade and Co-operation, State Science & Technology Department during the study period.

REGIONAL DISPARITIES IN THE 1990S: A MACRO SCENARIO

China's regional policy has been aimed at reducing disparities across provinces, and has deliberately adopted a balanced development strategy by encouraging the transfer of both physical and human capital, and productive capacity from coastal to inland provinces. An example is the Western & Central Development Strategy launched in 1998 which has put great efforts to encourage investment in the Central and Western areas.

Tab. 2 Estimates of trends in per capita GDP (1980 prices yuan, 1990-1999)

Year	Gaps between regions in terms of per capita GDP		
	Ratio of average per capita GDP in coastal area to the central area	Ratio of average per capita GDP in coastal area to the western area	Ratio of the richest region to the poorest region in terms of per capita GDP
1990	*1.7*	*2.1*	*7.1*
1991	*1.8*	*2.1*	*7.3*
1992	*1.9*	*2.2*	*8.1*
1993	*2.0*	*2.4*	*8.6*
1994	*2.0*	*2.5*	*9.2*
1995	*1.9*	*2.3*	*9.7*
1996	*1.9*	*2.5*	*10.2*
1997	*1.9*	*2.6*	*10.4*

1998	*2.0*	*2.6*	*10.9*
1999	*2.2*	*2.7*	*11.1*
2000	*2.3*	*2.8*	*11.3*

Note: * The unit for total GDP is 0.1 billion yuan, and per capita GDP is yuan.
Sources: Author's calculation based on China Statistic Yearbooks, various issues

It should be noted that before 1980s the income gap, measured by per capita GDP, between provinces was relatively small. Although the income levels of Shanghai, Beijing and Tianjin were substantially higher than any other provinces, the provincial levels per capita GDP are all of comparable size levels: around an average of 332 yuan (equivalent to USD 130) in the 1978's price (Dèmurger, 2000). Regional growth in the 1990s has led to an unexpected growing income gaps between regions. Fig. 2 shows the relevant income gaps cross regions tended to grow. On basis of a series of data analysis in the period 1990 - 2000 (Tab. 2), the ratio of GDP per capita between coastal and western areas rose steadily from 1: 2.1 in 1990 to 1:2.8 in 2000; while the ratio between coastal and central areas increased from 1:1.7 in 1990 to 1:2.3 in 2000. The absolute gap between the poorest province and the richest province enlarged further, rising from 1:7.1 in 1990 to 1:11.3 in 2000.

Fig. 2 Trends of nationwide disparities in terms of per capita GDP 1990-2000

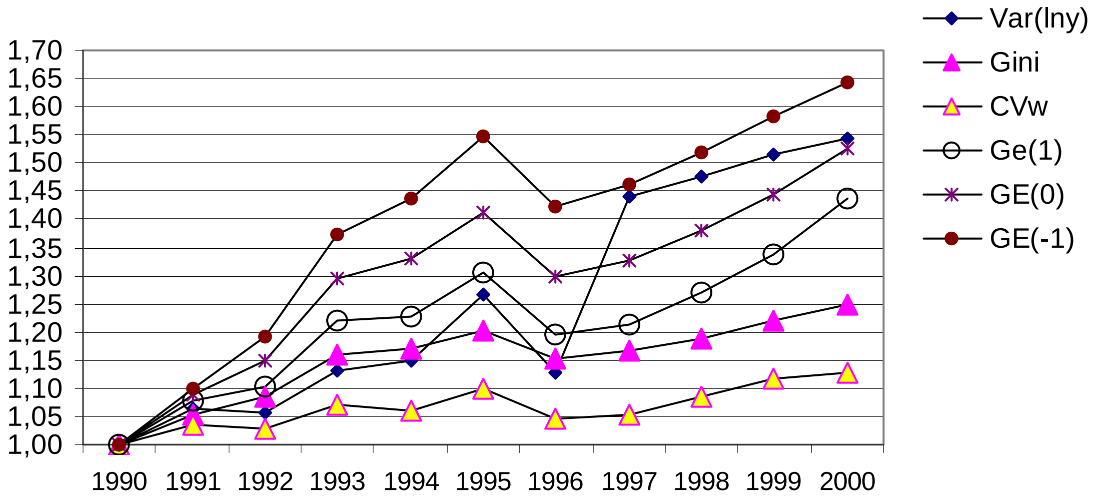
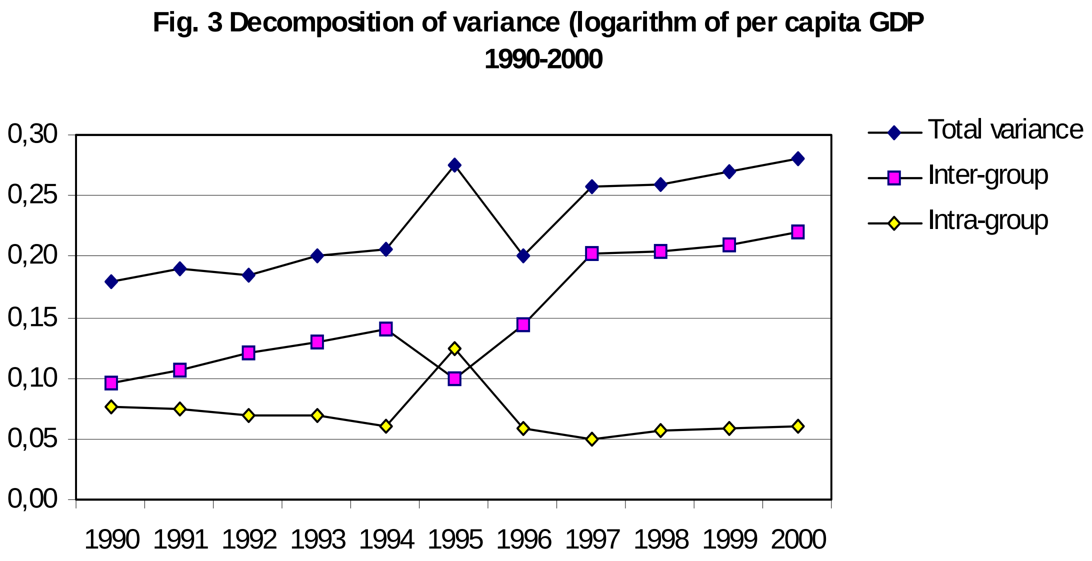
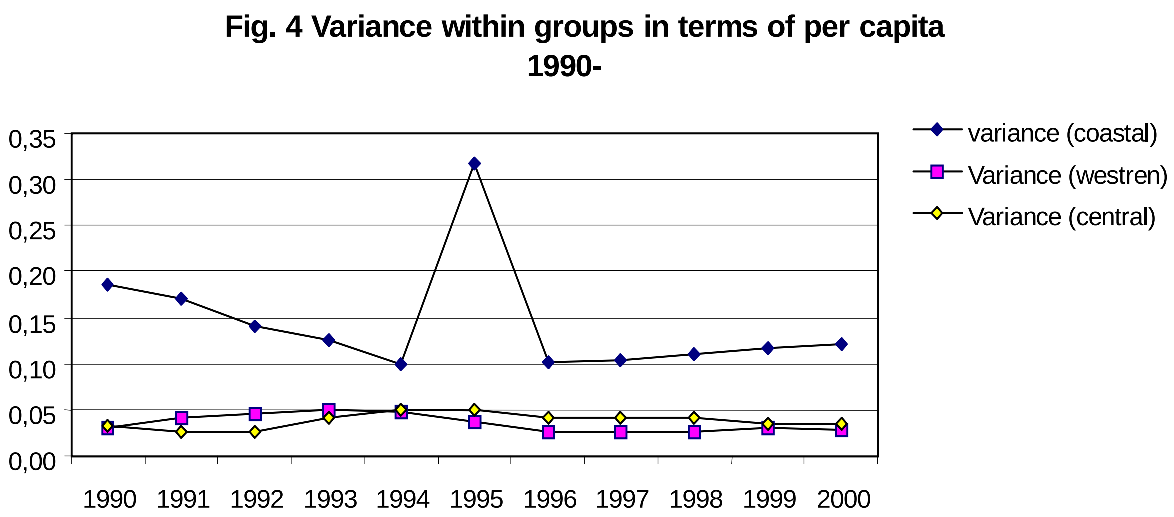


Fig. 2 shows that the nation-wide disparities in China’s 31 provinces appear to be further diversified or increased throughout the whole of the 1990s. Tab. 2 and Fig. 3 report the steady upward trends of inter-provincial disparities with respect to different methods. To facilitate comparison, the value of the indices at the initial year is normalised as unit one (Tsui, 1996). Without exception, all the indices reflect that the nation-wide disparities tend to grow through the 1990s with a sudden drop in 1996. This result supports Démurger's (2000,p18) conclusion, which confirms that "an increase in dispersion in subsequent years" follows the 1990[5].

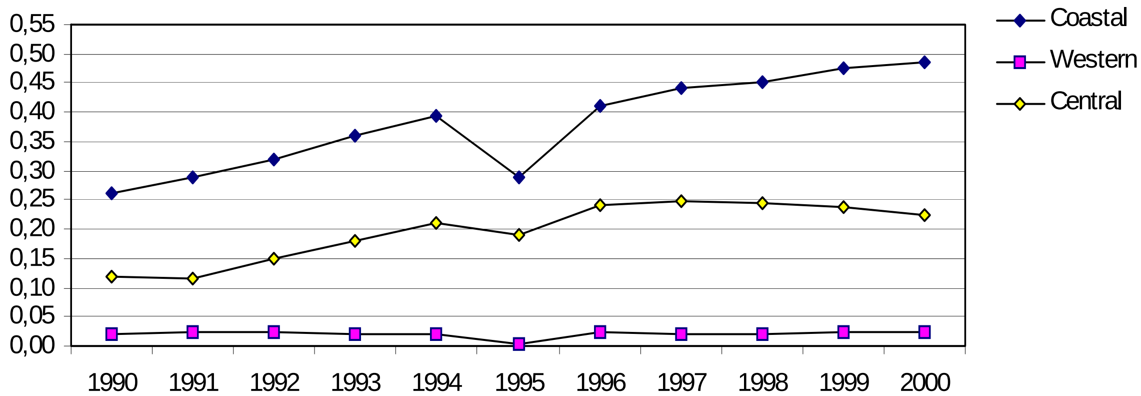




In Fig. 3, using variance decomposition technique[6], the total variances are split into two components: inter-group and intra-group variance. There is an upward trend for the variance between groups with only a slight drop in 1996. Fig. 4 shows the variance caused in different groups of provinces. The variance within the coastal group (i. e. Group 1) decreased in the first part of the 1990s, but increased during during the second part of the 1990s. the outlier point in 1995 may be due to the causes of the severe flood. However, the variances within the other two groups (i. e. the central and western groups) appear to be more controlled as both groups remained stable through the 1990s.

Fig. 5 illustrates the differences between the average income level in each group and national average of the income level. The western group had an average income level through the 1990s. However, the average income levels for both the coastal and western groups departed further away the national average level. This indicates the increased gaps between different regions, particularly between the coastal and western areas. The central group has little difference with the national average income level throughout the 1990s while the differences for both coastal and western groups increased significantly. This clearly illustrates that the main disparities come from the difference between the coastal and the western areas.

Fig. 5 Extent of departure from the national average income level in terms of per capita GDP, 1990-2000



In summary, although the Chinese economy as a whole has grown at a sustained rate over the recent years, its regional economic development is unbalanced. Particularly in 1990s, despite great efforts being put into inland provinces in order to reduce income difference by the government, the nation-wide disparities continue to grow even further. The gaps between different groups remain large, and appear to diversify further against time although intra-group disparities seemed stable.

EMPIRICAL RESULTS: INTERACTION BETWEEN FACTORS

The results of factor analysis by principal component method are shown in Tab. 3 and 4. Three factors are extracted out of the independent variables, which explain up to 81.3 to 85.7 per cent of the total variance in each exercise. Factor 1 is related to all the original variables of regional openness, explaining 35.7 to 41.1 per cent of variance. Factor 1 has the largest loadings on two types of original variables: (1) the variables related to regional globalisation (i. e. FDIS, FDI and ITR), and (2) those related to the nature of property right or economic liberalisation (i. e. SOES and FFES). This is in line with the meaning of regional openness since the inflow of FDI ultimately changes industrial ownership by an increase in the share of foreign-funded enterprises and at the same time a decrease in the share of state-owned enterprises. The loading on INNOV3 captures this phenomenon and reflects the association between market openness and new product promotion.

Tab. 3 Factor loadings, 1996-1999

Variables	1996[a]			1998[b]		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
INNOV1	*0.136*	*0.050*	***0.869***	*0.080*	*0.045*	***0.738***
INNOV2	***0.604***	*0.053*	***0.585***	***0.496***	*0.035*	***0.647***
INNOV3	*-0.058*	*0.175*	***0.865***	*-0.031*	*0.175*	***0.702***
SFDI	***0.877***	*0.378*	*0.020*	***0.908***	*0.315*	*0.072*
FDI	***0.895***	*0.350*	*0.087*	***0.886***	*0.277*	*0.241*
ITR	***0.826***	*0.454*	*0.117*	*0.855*	*0.368*	*0.178*
RD	*0.186*	***0.958***	*0.108*	*0.204*	***0.963***	*0.050*
ST	*0.166*	***0.965***	*0.106*	*0.210*	***0.966***	*0.079*
TTV	*0.337*	***0.910***	*0.072*	*0.364*	***0.913***	*0.091*
SOES	***-0.635***	*0.268*	*-0.353*	***-0.507***	*0.253*	*-0.558*
FFES	***0.930***	*0.209*	*-0.048*	***0.929***	*0.187*	*0.040*

Tab. 3 (cont'd)

Variables	1999[c]			2000[d]		
	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
INNOV1	*0.089*	*0.000*	***0.901***	*0.156*	*0.302*	***0.555***
INNOV2	***0.541***	*0.027*	***0.612***	***0.764***	*0.233*	***0.302***
INNOV3	*0.037*	*0.122*	***0.788***	*0.002*	*0.027*	***0.887***
SFDI	***0.831***	*0.338*	*0.106*	***0.864***	*0.387*	*-0.152*
FDI	***0.891***	*0.371*	*0.138*	***0.913***	*0.345*	*0.046*
ITR	***0.742***	*0.620*	*0.117*	***0.877***	*0.356*	*-0.043*
RD	*0.185*	***0.966***	*0.062*	*0.200*	***0.948***	*0.153*
ST	*0.211*	***0.960***	*0.101*	*0.244*	***0.952***	*0.132*

TTV	*0.194*	***0.965***	*0.001*	*0.350*	***0.899***	*0.109*
SOES	***-0.663***	*0.485*	*0.163*	***-0.736***	*0.338*	*-0.364*
FFES	***0.902***	*0.171*	*0.259*	***0.898***	*0.243*	*0.200*

Notes: Extraction method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
(a)Rotation converged in 6 iteractions; (b) Rotation converged in 6 iteractions
(c)Rotation converged in 5 iteractions; (d) Rotation converged in 4 iteractions

Factor 2 is correlated with the original factors related to R & D level, explaining 28.5-33.6 per cent of the variance. In essence, it represents the level in non-firm technological capabilities since the three largest loadings concentrate on the public R & D related variables: RD, ST and TTV. This also fits the definition of non-firm (or public) technological capabilities. Factor 3 is related to the original variables of firm innovation activities, explaining 13.1-18.4 per cent of variance. It is closely related to three innovation-related variables: INNOV1, INNOV2, and INNOV3; and represents the level of in-house R & D at enterprises and new product development. It also indicates the amount of money spent on technical upgrading and innovation compared to capital investment in a particular province.

Tab. 4 The variance explained by extracted factors in different exercises

Unit: percentage

Years	Total variance explained	Market openness	Public TC	Firm TC
1996	85.7	37.1	30.2	18.4
1998	81.3	35.7	28.5	17.1
1999	85.1	33.7	33.6	17.8
2000	84.5	41.1	30.3	13.1

The factor scores can be interpreted in two ways. In the first instance, the 31 provinces have to be classified into 4 clusters in terms of their GDP per capita, ranging from Cluster 1 to Cluster 4 (Tab. 5). Cluster 1 represents the three urban economies: Beijing, Shanghai and Tianjin. Cluster 2 represents other coastal economies excluding the three urban cities. Cluster 3 incorporates the central regions and cluster 4 consists of the Western regions. Based on each cluster, the factor score is calculated and their differences are analysed.

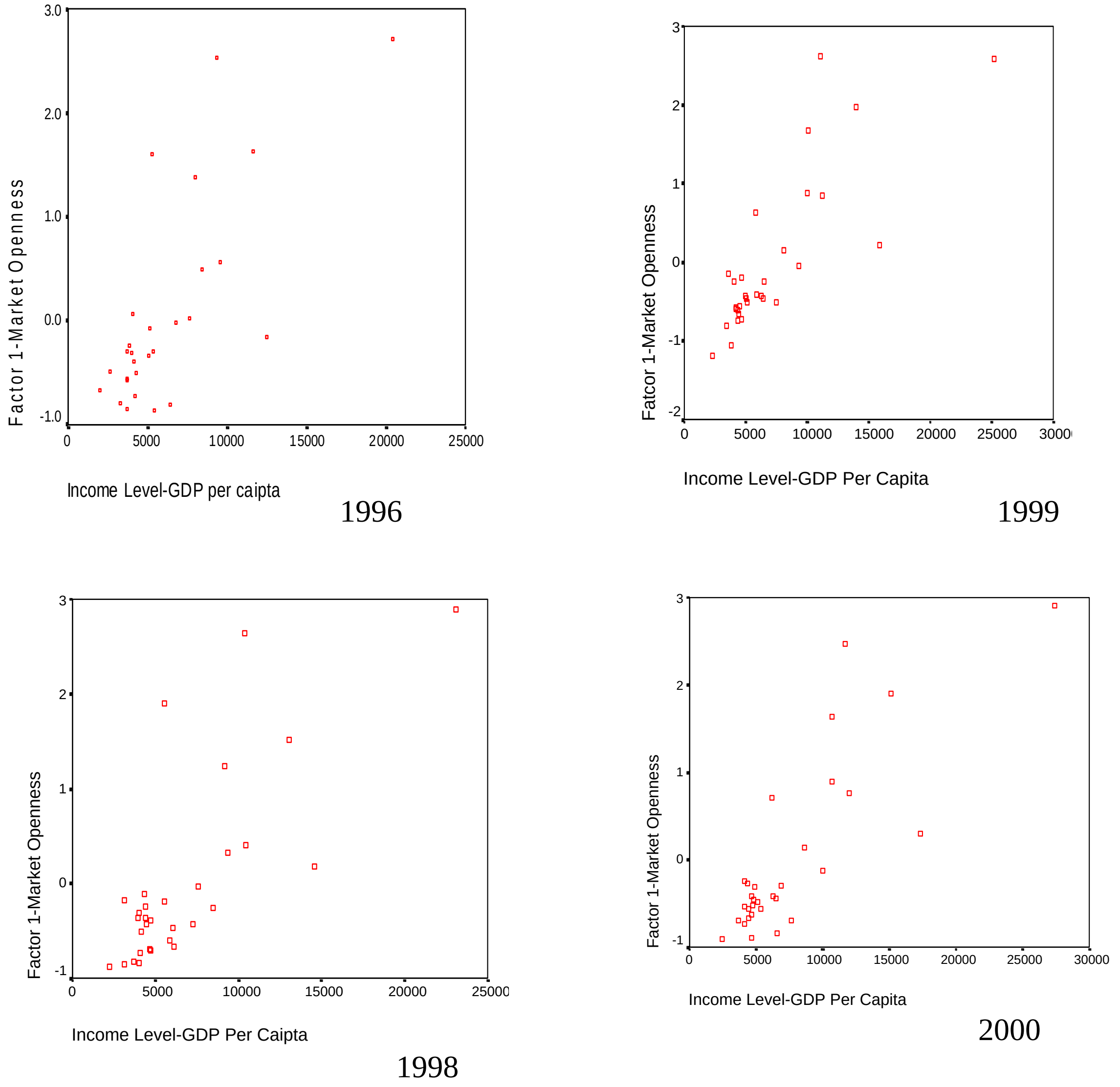
Tab. 5 The cluster analysis on factor scores*

Name of Cluster	GDP Per Capita	Regional R & D	Regional Openness	Firm Innovation	Remarks
Cluster 1	18,356 (1) **	2.14 (1)	1.46 (1)	0.44 (1)	Urban large economies
Cluster 2	9,973 (2)	-0.53 (4)	1.06 (2)	0.20 (2)	Other coastal economies
Cluster 3	5,518 (3)	-0.21 (3)	-0.38 (3)	-0.22 (4)	Central economies
Cluster 4	3,826 (4)	-0.06 (2)	-0.65 (4)	0.04 (3)	Western economies

Notes:
* Based on 1999 data, but can be extended to 1996, 1998 and 2000.
** Number in brackets is rank.

Tab. 5 shows that the urban economies have absolutely high regional non-firm R & D level, regional openness level and firm R & D levels. The coastal economies have a high score for regional openness, but its regional non-firm R & D level is lower than both the western & central economies, while its firm R & D level is higher than the other two clusters. This finding implies that the coastal economies are more dependent upon their regional openness and firm innovation activities than regional R & D activities.

Fig. 6 Regional openness scores versus income level, 1996-2000



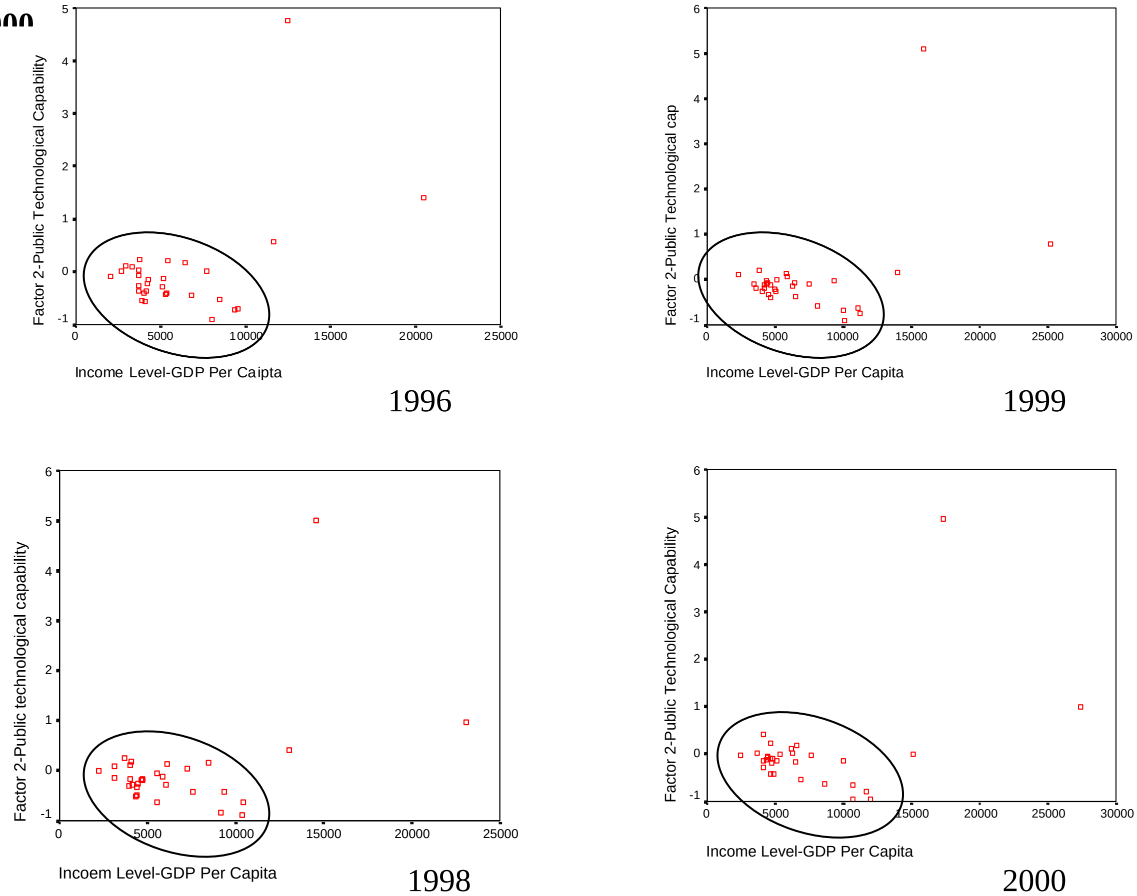
Note: The Person's correlation coefficients are as follows:

1996: r=0.752 with p=0.00 (r=0.700 with p=0.00 in the case excluding three urban cities)
1998: r=0.750 with p=0.00 (r=0.750 with p=0.00 in the case excluding three urban cities)
1999: r=0.808 with p=0.00 (r=0.824 with p=0.00 in the case excluding three urban cities)
2000: r=0.824 with p=0.00 (r=0.792 with p=0.00 in the case excluding three urban cities)

(1) Regional openness factor scores versus income level.

Fig. 6 shows the relationship between the market openness factor and the income level. The Person's correlation coefficient *r* between these two variables is between 0.750 to 0.824,

Fig. 7 Non-firm TC factor scores versus income level, 1996-2000



Note: By excluding three extreme cases (Beijing, Shanghai and Tianjin), the Person's correlation coefficients are calculated as follows:

1996: r=-0.527 with p=0.01
1998: r=-0.530 with p=0.00
1999: r=-0.705 with p=0.00
2000: r=-0.710 with p=0.00

which is significant at $p<0.001$. The highly significant association of regional openness factor with regional economic performance indicates that the provinces with higher level of regional openness have better economic performance in terms of GDP per capita, and support H_5 of this paper.

(2) Non-firm technological capability versus income level.

Fig. 7 shows the relationship between the income levels and the non-firm TC factors. The three extreme cases belong to urban cities are Beijing, Shanghai and Tianjin in Cluster 1. It is reasonable for these urban cities to possess extremely high scores in non-firm R & D activities. Following Fox's (1991) suggestion, outlying these three extreme cases is necessary before conducting any regression analysis. After excluding these three cases, this study obtains a negative relationship between the income level and the non-firm R & D activities. This study supports the earlier findings about the complex relationship between R & D and economic growth in developing countries (MALECKI, 1997). Consequently, H_3 of this paper is not supported. The negative association between non-firm TC and economic growth in China can be seen as a counter example in developing countries[7].

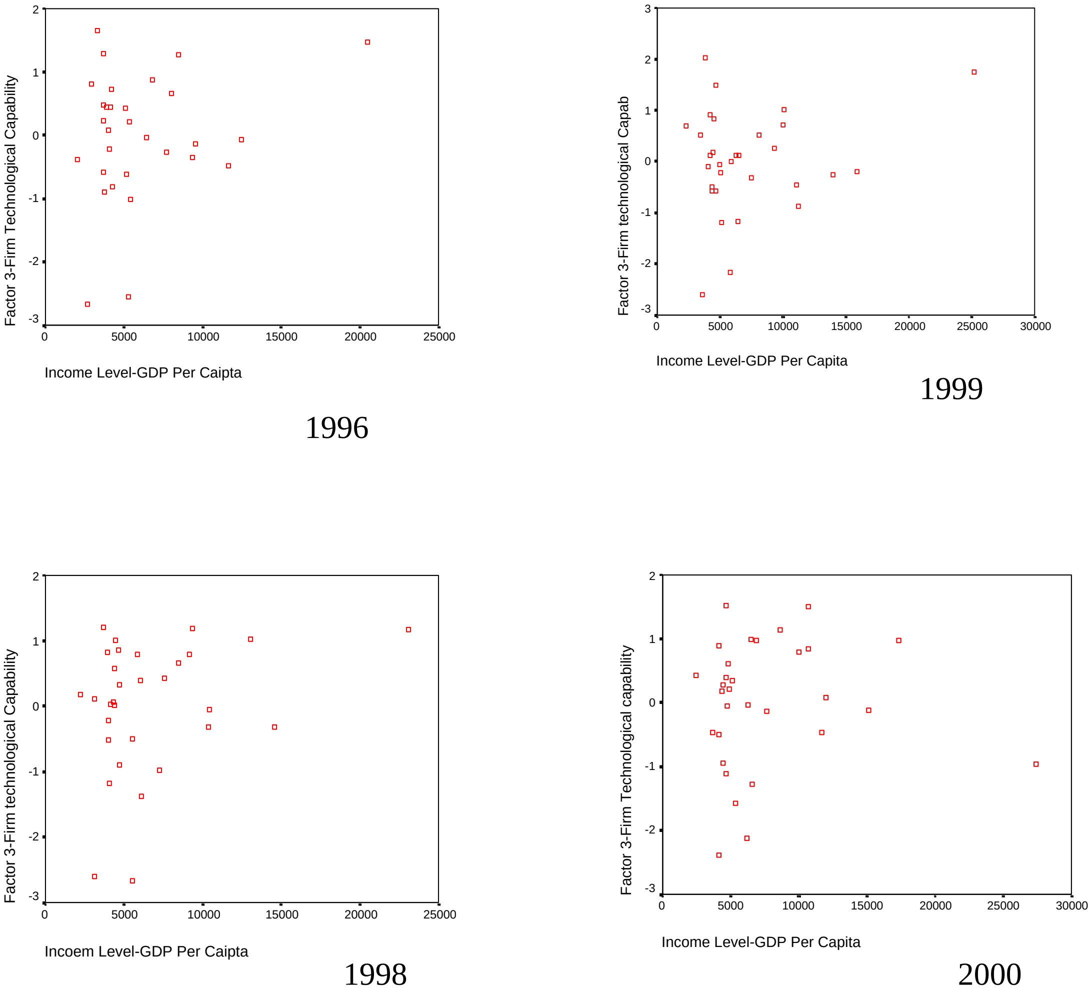


Fig. 8 Firm TC factor scores versus income level, 1996-2000

(3) Firm technological capability versus income level.

Fig. 8 shows the relationship between income level and firm TC factor scores, with no confirmed association as expected. To understand the firm level technological capability, it is critical to re-examine the original variables. The expenditure on allocation of in-house R & D is more in the coastal provinces, compared to the other two groups (except for two coastal provinces such as Zhejiang and Tianjin). Zhejiang is a coastal province with a focus on developing collective ownership enterprises and town-village enterprises. These type of enterprises have weak financial resources to conduct in-house R & D activities (SUN Z., 2000). Thus it is natural to expect a low level of in-house R & D level in a province such as Zhejiang.

The second variable INNOV2 represents the regional level in new product promotion. The coastal provinces have extremely high levels of new product sales than any other group, except for Liaoning province. The coastal provinces usually adopt the out-sourcing strategies for new technologies. The new product sales income takes up a higher proportion in coastal area than the other two areas. The third variable INNOV3 represents the level of technical change. It seems clear that technical change is driven either by abundant capital inflows (for example the coastal provinces) or by the state-owned enterprises that create huge demand for technical upgrading.

This study, therefore, does not establish any confirmatory relationship between firm TC and provincial economic performance and, hence, can not confirm H_4 of this paper.

(4) Regional openness versus non-firm technological capability.

There is a positive relationship of factor scores between the regional openness and the income level irrespective of whether the analysis includes the three urban economies or not. However, the exclusion of the three urban cities results in a negative association between R & D level and regional openness (or the income level as well). If both market openness and non-firm TC are differentiated with two categories of high and low performances, then the four clusters can be placed in a matrix shown in Fig. 9.

To explain the relationship between regional openness and public R & D, the factor analysis is extended to two sets of independent variables relevant to market openness (Variables: FDI, FDIS and ITR) and public technological capability (Variables: RD, ST and TTV) respectively. Thus, two factors are extracted with very high variances being explained.

According to the factor scores, there are ten high performance provinces and twenty-one low performance provinces. A matrix is produced as shown
in Fig. 9.

Fig. 9 Regional openness versus non-firm technological capability

Non-firm Technology Capability	High performance	Beijing, Shanghai, Tianjin, Liaoning, Jiangsu	Sichuan, Hubei, Jilin, Shaaxi
	Low performance	Guangdong, Fujian, Zhejiang, Shandong Hainan	Guizhou, Qinghai, Gansu, Tibet, Yunan, Inner Mongolia, Ningxia, Xinjiang, Henan, Anhui, Shanxi, Hunan, Chongqin, Guanxi, Hebei, Heilongjiang
		High performance	Low performance
		Regional openness	

Beijing, Shanghai, and Tianjin are the three major largest urban economies in China. They have enjoyed reasonably high performances both in terms of market openness and public technological capability. Liaoning and Jiangsu are the two relatively developed provinces in China much before the reform process started. Liaoning is an

area with a high concentration of SOEs, while Jiangsu has a high concentration of township enterprises. Both have historically contributed to the national economic growth, and have high performances in public R & D resources which may be due to the allocation of science and technology resources which had been dependent on the distribution of national industrial productive forces.

The majority of the provinces (in the Central and the Western areas) had low performances both in public technology capability and regional openness. However, some particular regions in the areas, such as Sichuan, Hubei, Jilin, shaaxi and Guizhou, have high performance in technology capabilities because they have had a very high priority in developing the national principal industrial or military bases. However, other coastal provinces, such as Guangdong, Fujian, Zhejiang, Shangdong and Hainan, have rather low performance in public technology capabilities.

To further explore the extent of the association of income level and its determinants, this study has used a regression analysis. It is critical to detect outliers in the sample cases, i. e. the unusual data. The unusual data are problematic in a least-square regression because they can unduly influence the results of the analysis and their presence may be a signal that the regression model fails to capture important characteristics (FOX, 1991, p21). Therefore such cases must be ruled out before any regression analysis takes place.

Tab.6 The detected outliers

Models	Outliers detected
Model-1 (1996 data)	Beijing, Shanghai, Guangdong, Hainan, Tibet
Model-2 (1998 data)	Beijing, Shanghai, Guangdong, Hainan, Tibet
Model-3 (1999 data)	Beijing, Shanghai, Guangdong, Tibet
Model-4 (2000 data)	Beijing, Shanghai, Guangdong, Tibet

Four regression exercises have been conducted depending on different data sets. In each model (Model-1, 2, 3, and 4), the data of an individual year was taken as sample with the exclusion of detected outliers (see Tab. 6). The regression results are summarised in Tab.7.

Tab. 7 Estimated parameters for different data sets

Variables	Model-1 (1996)	Model-2 (1998)	Model-3 (1999)	Model-4 (2000)
Intercept	*10.105*	9.489	8.201	7.612
	*(9.294)*****	(14.644)**	(9.157)**	(8.443)**
k	*0.694*	0.660	0.310	0.330
	*(3.739)*****	(4.325)**	(1.897)#	(1.884)#
h	*0.006*	0.122	0.219	0.368
	(0.036)	(1.112)	(1.604)	(2.669)*
rd	*-0.179*	-0.196	-0.269	-0.434
	(-1.106)	(-1.959)#	(-2.533)*	(-3.037)**
frd	*0.156*	0.374	0.070	0.121
	(1.228)	(4.019)**	(0.769)	(0.914)
fdi	*0.386*	0.248	0.491	0.300
	*(2.740)**	(1.973)#	(3.760)**	(2.079)*
Adjusted R-square	0.770	0.827	0.821	0.800

F-Statistics	16.951	28.807	24.864	21.666
Number of observation	25	26	27	27

Notes: All variables are in natural logarithms and *T*-statistical test is in parentheses.
* * $p<0.01$, * $p<0.05$, # $p<0.10$. Dependent variable *Y/L = GDP* per capital.

Following Fox (1991)[8], five provinces are detected as major outliers in this study (see Table 5): Beijing, Shanghai, Guangdong, Hainnan and Tibet. Both the big cities such as Beijing and Shanghai have highly aggregate public R & D resources. Guangdong is the one region with extremely high FDI inflow and international trade flows. Hainan is a particular province which had enjoyed extremely high market openness in terms of FDI inflow which had ceased to grow after the Asian crisis, and Tibet has suffered from the lack of quality survey data.

Tab. 7 contains the OLS regression estimates using four different data sets. Several points should be noted. The fit of models is fairly good, and the F-statistic (the minimum F value is 16.951) is significant at the one per cent level, indicating at least a ninety-nine per cent probability that coefficients of the explanatory variables are not zero. The adjusted R-square also indicates the high explanatory power of the models, accounting for around eighty per cent of total variance in *ln (y)*.

The physical capital intensity *k* turns out to be positive influencing factor to *ln(y)* at an acceptable significant level (in 1996 and 1998, the significance level is at p<0.01, while in 1999 and 2000, p<0.10). Since *k* represents the technical equipment level, it is obvious that enhancing the technical equipment level could lead to productivity gain. However, *h* turns out to have no strong association with *ln(y)* although only in 2000 with an acceptable significant level of p=0.05. The estimated coefficients are positive in the observation period and increasing against time, suggesting that quality improvement in human capital seems to be an influencing factor contributing to *ln(y)*. H_1 is supported, while H_2 is not confirmed.

The public TC factor, which represents the provincial non-firm R & D activities, is negatively associated with *ln(y).* In other words, this confirms further previous results: (1) non-firm R & D resources seem highly concentrated in the urban economies, such as Beijing, Shanghai and Tianjin; and (2) some provinces, mainly those in coastal areas, have suffered from low level of public R & D activities. The negative association does not mean that new technologies and technological innovation have played less important roles in developing countries such as China. The coastal provinces merely exerted their preferential advantages to out-source new technologies both from home and abroad. It is justifiable to infer that public R & D activities in developing economies do not contribute to economic growth as much as in the developed economies. As the case stands, the public R & D activities have suffered from many problems such as low level of R & D input, low efficiency due to institutional impediments and separation from economic activities. Thus, H_3 is negatively supported.

The firm technological capability has proven no convinced significant relation to *ln(y).* This accords with the findings in previous section although in 1998 the association is significant at a level of $p=0.01$. This appears to be due to unstable break in 1998 when Asian crisis had shed a great impact on the Chinese economy. H_4 is negatively supported. Finally, regional openness factor is positive associated with *ln(y)* with an acceptable significant level (only in 1998, the significant level is at $p<0.10$, while in other cases $p<0.05$). This is consistent with the finding in previous section. H_5 is supported.

CONCLUSION

Using different approaches, this study has detected the existence of regional disparities in China throughout the 1990s. Without exception, all these methods have confirmed that such disparities have increased during the decade. In particular, with the value of c decreasing from 2 to -1, the sharp increase in GE measure indices indicates that the convergence occurs within the provinces with top income level of GDP per capita. Additionally, with the decomposition techniques, this paper has confirmed that the inter-group variance is the main component responsible for regional disparities.

The main cause behind the increased regional disparities is the varying degree of regional openness, which is perceived as the combination of regional globalisation and the nature of property right (or economic liberalisation). Furthermore, the linkage between regional openness and income level seems increasingly dependent on each other, suggesting that regional openness is a critical influencing factor to regional disparities. The empirical results have also shown that non-firm (or public) R & D activities (in terms of R & D spending, R & D personnel and technology transfer activities) are highly concentrated on the urban cities to such an extent that these resources appear to be negatively associated with income level when the major urban cities (Beijing, Shanghai and Tianjin) are excluded out of the analysis. It is surprising that most coastal provinces have a very low level of non-firm R & D activities, although their income level and regional openness are high. These findings provide a counter example of negative relationship between R & D and growth, and have profound implications for deepening the economic reform in China.

The entry into WTO will promote a new wave of economic reform which intensify the regional globalisation processes, and in consequent to this, regional economies will become more open and compete each other to attract more foreign investment. Since regional openness factor is a critical factor in terms of income level, the coastal provinces may continually take advantage from the entry of WTO. Since the assimilation of increasingly sophisticated technologies requires indigenous R & D efforts, the coastal provinces need to address their disadvantages such as low R & D resources. Furthermore, the increasing technological competition between regions may cause extra cost for out-sourcing strategies. Therefore, to achieve long term benefits from market openness, the coastal provinces should promote the indigenous R & D efforts to a large extent.

On the contrary, provinces with higher public R & D resources but lower market openness in the Western and Central areas, may recognise their disadvantages in firm level innovation activities and low efficiency in R & D efforts. These provinces usually have a large portion of state-owned enterprises; most of them are large and medium-sized enterprises. They may face the strategic choice of investing in technical up-grading of old factories or implementing new constructions. They may need to integrate in-house R & D activities into market-oriented business activities. They also need to improve the macro environment to improve their technology-generated mechanism and to create preferential climate to incubate new-generated technologies.

Managing technological diffusion and market expansion are the two critical issues in the urban cities. This category of provinces has absolute competitive advantages in the new technology generation, and has overtaken other regions in terms of regional openness. However, the entry into WTO may unify China's domestic market, and integrate the domestic market into an international one. Also, the urban economies should be able to compete with the challenge from international business, and expand the nation-wide market boundaries. For less developed provinces, where both regional openness and non-firm technological capability are low, the strategic focus is to encourage the inflow of both domestic and international investment and technology inflows.

Appendix 1 Formulae for measuring disparity

(1) Coeffiecient of variation (CV_w) Following Williamson's (1965) method, Fujita & Hu (2001) defines the provincial disparity CV or CV_w for a particular variable $X = \{x_1, x_2, \ldots, x_n\}$ as

$$CV = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \frac{1}{n}\sum_{i=1}^{n}x_i\right)^2}}{\frac{1}{n}\sum_{i=1}^{n}x_i}$$

or

$$CV_w = \frac{\sqrt{\sum_{i=1}^{n}\frac{P_i}{P}\left(x_i - \mu\right)^2}}{\mu}, \qquad \mu = \sum_i \frac{P_i}{P}\times x_i$$

where, x_i is the variable X of the i^{th} province, n is the number of provinces, P_i is the population of the i^{th} province, and P is the total population. The weighted coefficient of variation CV_w, which weights the deviation of each province by its population, can be viewed as an estimator of the disparity among persons nationwide.

(2) *The Theil Index* The Theil Index is essentially is the measurement of the curvature description of Lorenz Curves. Therefore, the observation from Lorenz curves is equivalent to The Theil Index. The measuring formula can be found in Fujita & Hu (2001). As Lorenz curves seem more virtualised, this study therefore adopts Lorenz curves as measurement of the disparities among provinces.

(3)*Lorenz Curves* A useful way of presenting data about income distribution is through a Lorenz curves (Borooah et al., 1990, p49). It can be used to visualise provincial disparities across China (see Demurger, 2000). In order to construct such a curve, the income units are ordered in ascending order of income level. The population in that province is expressed as a proportion of the total population. The GDP in the province is then expressed as a percentage of total GDP. Two variables, cummulative proportions of proportion and GDP, then plotted on X-Y Cartensian coordinate axes.

Suppose that there are m provinces under study, and $GDPPC_i$ stands for the per capita GDP in the i^{th} province, thus for each province,

$$GDPPC_i \geq GDPPC_j \qquad \text{for } i \geq j,\ i, j = 1, 2, \ldots, n.$$

If P_i stands for the population of the i^{th} province ($i = 1, 2, \ldots, m$); P stands for the national total population; GDP_i stands for the GDP value created by the i^{th} province; GDP is the national total GDP value. The Lorenz curve in this case can be represented as:

$$Y_j = L(X_j) = L(100 \times \sum_{i=1}^{j} x_i) = 100 \times \sum_{i=1}^{j} y_i$$

$$(j = 1, 2, \ldots, n.)$$

$$P = \sum_{i=1}^{n} P_i \qquad GDP = \sum_{i=1}^{n} GDP_i$$

$$x_i = \frac{P_i}{P} \qquad y_i = \frac{GDP_i}{GDP}$$

The Lorenz curve provides a very natural means of comparing two or more income distribution (Fig. 8). The extent to which the Lorenz curves depart from the line *Y=X* represents the degree of disparity across provinces.

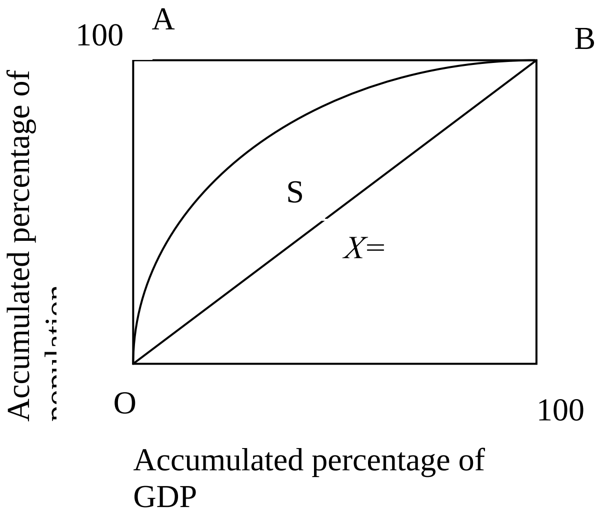


Fig. 8 Typical Lorenz Curve

(4) *Gini Coefficients* As shown in Fig. 8, *S* stands for the area formed by the Lorenz curve and the diagonal line. The Gini coefficient is defined as the ratio of the Area *S* to the Triangle OAB (the area OAB is equal to half unit). Thus Gini coefficient can be written as (see Borooah et al., 1990):

$$Gini = \frac{S}{\frac{1}{2}} = 2S$$

Tsui (1996) gives a concrete expression for Gini coefficient:

$$Gini = \sum_{i=1}^{n}\sum_{j=1}^{n} f_i \times f_j \times \left| y_i - y_j \right| / 2\mu$$

$$\mu = \sum_{i=1}^{n} f_i \times y_i$$

Where y_i is the per capita GDP of the i^{th} province, n is the number of provinces considered, f_i $=Pi/P$ *(Pi* is the population of the i^{th} provinces, and P is the total population of China).

(5) Generalised Entropy (GE) Measures GE measures are less popular. They can be found in Tsui (1996), Sun H. (2000). The class of GE measures depends on a parameter *c*. Following Tsui (1996), this study assigns the value of *c* to -1, 0, and 1 consecutively, and the GE measures are denoted by GE(-1), GE(0) respectively. When *c* is assigned to 2, GE(2) $=CV_{w}$. *GE(-1), GE(0) and GE(1)* are calculated as follows:

The GE measures have a special property: when *c* is less than 2, the ii-sensitive in the sense that the index is more sensitive to income transfer at the bottom end of the income

$$GE(-1) = \sum_{i=1}^{n} f_i \left[\left(y_i / \mu \right)^{-1} - 1 \right]$$

$$GE(0) = \sum_{i=1}^{n} f_i \log\left(\frac{\mu}{y_i} \right)$$

$$GE(1) = \sum_{i=1}^{n} f_i \left(y_i / \mu \right) \log\left(\frac{y_i}{\mu} \right)$$

distribution. Therefore, As the value of c decrease from 2 (i. e. the case of the CVw) to -1, more weight is attached to income transfer at the bottom end of the income distribution. If egalitarian transfers concentrate at the lower end of the income distribution, one expects that decreasing the value of c results in a steeper declining trend (Tsui, 1996, p357).

Notes

[1] A factor, denoted as $f=\{f_i\}$, has contributed to the provincial disparity $I(y)$, if y has significantly positive correlation with f. By taking CV_w as a example, it is easy to proof the following formulae:

$$I(y) = \alpha \left| \frac{\breve{\mu}}{\mu} \right| I(f)$$

$$if \qquad y_i = \alpha f_i + \beta$$

[2] The primary objective of factor analysis is data reduction and summarisation with a minimum loss of information (Kim & Meuller, 1978; Hair, et al, 1987). Hence, the results of a factor analysis simply set out a number of factors (Kline, 1994).

[3] According to growth model, capital accumulation becomes more and more difficult, eventually leading to zero growth in the long run (see Freeman & Soette, 1997, p324).

[4] For convenience in mathematical expression, this paper transfer $rd=e^{\text{Factor score}}$. The same transformation applies to *frd* and *fdi*.

[5] Démurger's (2000) results (data from 1978 to 1996) indicate that the inter-regional variance increased at a faster rate from 1990; while intra-regional variance decreased.

[6] The intra-group variance represents the disparities within groups, while the inter-group variance represents the disparities between groups. To be comparable to previous researches, this study uses the variance decomposition approach which is adopted by Démurger's (2000):

$$V = Var(y_i) = \sum_{j=1}^{k} n_j Var(y_j) + \sum_{j=1}^{k} n_j (\tilde{y}_j - \tilde{y})^2$$

$$\tilde{y}_j = \sum_{l \in Groupj} \frac{y_l}{m_j} \qquad \tilde{y} = \sum_{l} \frac{y_l}{n}$$

Where y_i is the log of GDP per capita of each province i, n_j the number of provinces in Group j as a proportion of the total number of provinces, $Var(y_j)$ the variance of the y_j values for Group j, m_j the number of provinces belonging to group j, n the total number of provinces concerned and k the total groups divided.

[7] Such a negative relationship had ever found in 22 OECD countries, Korea and Yuguslava in a specific period of 1970 - 1985 (Verspagen, 1994). When distinguishing between business and non-business R & D activities, Verspagen (1994) found that economic growth is positive to business R & D activity at statistical significant level, but negative to non-business R & D activity in the period of 1970 -1985.

[8] See Fox (1991, p25), the average hat-value

$$\tilde{h} = (k+1)/n$$

where $k=5$, $n=31$, thus the average hat-value is 0.194.
Hat value measure for each variable is as follows:

$$h_i = \frac{1}{n} + \frac{(x_i - \tilde{x})^2}{\sum_j (x_j - \tilde{x})^2}$$

All the cases which have $h_i > 0.194$ are detected as outliers.

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