"Lock-in Effect" to Be Blamed for Regional Development Imbalances

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Editorial note China's regional development has long remained in disparity. Despite various discussions on the causes of this disparity, it is not common to take a look at the "lock-in effect" as being one of the root causes. Based on some statistics, the authors find that the existence of the lock-in effect" should be blamed for the disparity between east, central and west China, and that the reform and opening up since 1978 has escalated this effect.

I. Introduction

Starting from the late 1980s, the disparity in economic development between east, central and west China escalated as the nation gradually opened up to the outside world and embarked on a course of robust economic growth. The Chinese government was confronted with the arduous task of boosting national economic growth while reigning in regional disparity. A country seeking high-speed growth in its early stage of economic development tends to allocate its scarce resources into regions possessing better infrastructure, so that when they develop, they can bring along the less developed regions. The regional disparity caused by this practice is not uncommon in the course of a country's development, and cannot disappear anytime soon because of its path dependency and "lock-in" characteristics.

As Arthur (1988) put it, the "lock-in" effect is the reason why in reality an economy is often chronically bogged down in a startup mode of development, being unable to break free. On the basis of previous research, this thesis applies the "lock-in" concept to suggest that regional disparity in China is mainly caused by lock-in effects from the reform and opening-up process. In other words, the gradual promotion of this process enabled east China to amass such factors

as manpower, materials and technology in the early stages of development by relying on its favorable location and government policy support. In this way, east China accumulated advanced production know-how, consolidated its advantage in national economic development, and further locked in the allocation of quality resources. Handicapped by inferior factor allocation and unable to attract talent and funds, both central and west China landed in a primary-factor lock-in pattern that could not be changed in a short period of time. Moreover, with the opening-up process picking up speed, regional disparity caused by the lock-in effect has shown further widening tendencies. Based on theories pertaining to the lock-in effect in an open economy, this thesis explores a series of issues related to this effect in the opening-up process of China, and explains the mechanisms behind the occurrence of regional disparity from the perspective of the lock-in effect.

Section II of this thesis takes a brief look back on previous studies of regional disparity in China and the origin of the lock-in effect. Section III dwells on regional disparity from the viewpoint of factor input levels. Section IV establishes a factor lock-in model and combines it with a quantitative analysis to clarify the mechanisms leading to Chinese regional disparity. Section V presents the conclusion reached by the authors of this thesis.

II. A review on previous studies

Much has been written and spoken over the years about regional disparity in the Chinese economy. Scholars have studied the issue from multiple perspectives. Some of them (such as Jian et al, 1996; Fleisher and Chen, 1997) attribute the nation's yawning regional economic gap mainly to the location of coastal regions and favorable government policies. For his part, Young (2000) believes that protectionism holds the key to the widening regional disparity because protectionism can rob a region's resource allocation of its local strength. Cai Fang and Du Yang (2000) assert that disparity in human capital is the principal factor behind the development gap between east, central and west China.

As China steps up its opening-up efforts, the connection between these efforts and regional disparity has drawn the attention of some scholars. Based on analysis of data from 1978-1997, Dayal-Gulati and Husain (2000) conclude that the FDI inflow resulting from opening-up polices has spurred on Chinese economic growth, but at the same time it has aggravated regional disparity. Wei Hekai's (2002) empirical analysis of the impact of FDI on China's regional economic growth on the basis of 1985 to 1999 panel data indicates that approximately 90% of the GDP growth rate differentials between the developed

east China and underdeveloped west China during that period was precipitated by foreign investment. Wei went on to assert that thanks to its ideal location, fine infrastructure and solid economic and technological foundation, east China will continue to receive the lion's share of the FDI inflow, which will have a causal effect between FDI and regional economic growth. Lu Ming (2007) points out that disparity in economic openness is the foremost factor behind regional disparity, adding that regional disparity has been directly intensified by economic activities since the adoption of the opening-up policy, and, in particular, by the gradual gravitation of the manufacturing industry to the coastal regions of east China.

Previous research on the issue has either interpreted regional disparity from the angle of the Chinese economic system, while a number of external problems rendered their arguments irrelevant, or ascribed regional disparity to a single changing factor, while ignoring the effect of structural changes of allocation factors in an open economy. Previous research has rarely looked into the issue from the perspective of the "lock-in effect".

The term "lock-in" originated in Arthur's (1988) study of the issue of technical innovation. He established a "random walk" model with an absorbing screen centered around a self-strengthening (i.e., progressive reward increase) mechanism for an interpretation of the term "lock-in". He believed that the lock-in effect tended to cause technological stagnation and hurt the industrialization process of developing countries. Paul R. Krugman (1987)came to realize the existence of the lock-in effect in open economies. As he saw it, because countries' positions in the global division of industry in the initial mode of trade are determined by their startup stocks of production capacities and industrial know-how, the formation of a long-term trade mode is determined by historical factors. By adding human capital to his analysis of the model of economic growth, Locus (1988) suggested that bilateral trade may bring a lock-in effect on the modes of economic growth of the two countries involved. He states that a country that starts with an endowment of human capital tends to have a relative advantage in the production of certain high-tech commodities and steadily accumulates its experience in this field of production through specialized production and bilateral trade so as to consolidate its monopoly in production and achieve a sustained high growth rate. On the other hand, a country that starts with inferior human capital can only enter into the production of low-tech commodities and maintain a low growth rate. Under an open economy, therefore, a country's startup capability determines what kind of commodities it can produce, and the accumulation of know-how through a "learning while doing" process can strengthen a country's startup capability. Thus countries end up locked in the original mode of international division of labor. In this way Lucas theoretically questioned economic growth retrenchment, and his opinion has been further substantiated by what has happened in both developed and developing countries. However, when Redding (2002) goes further to dissect the lock-in effect in open economies, he points out that developing countries are susceptible to the lock-in effect, whether in the division of labor of an open economic system, in technological development, or in capital formation, which makes it hard for them to catch up with better developed countries in the long run.

At a time when reform and opening up to the outside world efforts are deepening in China, the thoughts of Lucas, Redding and others have inspired us to switch to a new point of view in our study of regional disparity in the Chinese economy. In this thesis, we will proceed from the reality of China and the lock-in effect to analyze the impact of the drain of capital, human resources and technology on regional

disparity in the opening-up process.

III. Lock-in effect on regional disparity in China

(I) Regional disparity and lock-in effect model

1) Lock-in effect model for regional economic development

Regional disparity is worsening as China begins the process of further opening-up and reform. According to the lock-in effect theory, this lopsided mode of development will be locked in when the country's reliance upon it grows to a certain extent, that is, when regional disparity becomes an unchangeable scenario. This thesis will begin with a quantitative examination of the path of regional economic development in China (including east, central and west China) in light of the lock-in effect concept, so as to judge if the lock-in phenomenon has occurred in the development modes of these regions. By drawing on Andersen's (1998) research approach, we have selected the GDP data of each and every province in this country since 1952. To clarify the characteristics of these provinces' reliance on the development path, we have also divided the Chinese economic development before and after the adoption of the opening-up policy into four time sections: 1952-1965 (t-3), 1966-1978 (t-2), 1979-1989 (t-1), and 1990-2005 (t). During the 1952-1978 period, the Chinese economy was under central planning, and thus t-3 and t-2 represent the economic situation prior to the adoption of the reform and opening-up policy. Of this, t-3 was the post-liberation period in which a national system was under construction, the central government centralized price controls and resource allocation through central planning and administrative decrees, and regional growth differentials were under the sway of unified national policies; t-2 encompassed the decade-long "cultural revolution" and two years of political rectification and economic restoration. The 1979-2005 period saw the nation follow the reform and opening-up policy and gradually build up a market economic system. During this period, t-1 was an opening-up time section in which central planning was increasingly weakened, the regional resource allocation process began to come under market impact, and east China took the lead in national development with the support of the opening-up policy. During t (1990-2005), reform and opening-up policies deepened while the market assumed the leading role in the national economy, the provinces' import and export volumes grew steadily, foreign investment began its massive influx into China, and regional disparity surfaced gradually.

On the basis of the division of time sections, we have adopted natural logarithms for the regional GNPs since 1952, derived the natural growth rates from them, calculated each region's average natural growth rates, and regressed these statistics according to Formulas (1), (2) and (3). If a1, a3 and a5 are positive, it means that a given region's economic growth is dependent on their developmental path. If the coefficient indicates a positive increase, this gives us reason to say that China's mode of economic development has shown lock-in characteristics, and that the startup regional disparity has become hard to change because of the lock-in mode of development.

$$[LnY]_{i(t-2)} = a_0 + a_1[LnY]_{i(t-3)} + V_{(t-2)} \quad (1)$$

$$[LnY]_{i(t-1)} = a_2 + a_3[LnY]_{i(t-2)} + V_{(t-1)} \quad (2)$$

$$[LnY]_{i(t)} = a_4 + a_5[LnY]_{i(t-1)} + V_{(t)} \quad (3)$$

Of these, $[LnY]_{i(t-3)}$, $[LnY]_{i(t-2)}$, $[LnY]_{i(t-1)}$, and $[LnY]_{it}$ represent the average natural GDP growth rates of each province during the t-3, t-2, t-1 and t.

2) The factor input lock-in model

The regional disparity in national economic growth is a result of regional differentials in factor allocation. We hereby establish a factor input lock-in model under an open economy to indicate that, on the one hand, regional disparity stems from disparity in

factor allocation, and on the other, factor input lock-in has led to the lock-in effect on the mode of economic growth.

Firstly, according to new economic growth theories, economic growth not only comes from the input of startup factors such as materials and manpower, but also is impacted by internal technological progress. The channels by which technological progress effects economic growth include both the technological progress resulting from domestic research-and-development input and the international spillover of knowledge products and foreign technology brought about by human capital accumulation. Thus we establish the following economic growth model:

$$Ln\left(\frac{y_{it}}{\bar{y}_t}\right) = a_0 + \beta_0 Ln(k)_{it} + \beta_1 Ln(hr)_{it} + \beta_2 Ln(rd)_{it} + \beta_3 Ln(fdi)_{it} + \beta_4 Ln(im)_{it} + \beta_5 Ln(x)_{it} + \beta_6 Ln(fdi)_{it} \times Ln(hr)_{it} + \beta_7 Ln(im)_{it} \times Ln(hr)_{it} + \varepsilon_{it} \quad (4)$$

Of this, $y_{it}/\bar{y}$,k_{it}, hr_{it}, rd_{it}, fdi_{it}, im_{it}, and x_{it} represent respectively the ratios of the per-worker GDP of Region i to the nation's per-worker GDP, per-worker capital, per-worker number of researchers, per-worker research-and-development capital, FDI/GDP ratio, import/GDP ratio, and export/GDP ratio. Ln is natural logarithm; $Ln(fdi)_{it} \cdot Ln(hr)_{it}$, the spillover effect of FDI; $Ln(im)_{it} \cdot Ln(hr)_{it}$, the spillover effect of imports, and ε_{it}, the error term. In this formula, $y_{it}/\bar{y}$ is the index for the gap between each province's economic development and the nation's average level. When $y_{it}/\bar{y}$ is larger than 1, a given province's economic growth surpasses the national average. Otherwise, the province's economic growth is below the national average.

From our analysis of the factors in the economic development in each region, we can more accurately judge what the mode of regional economic growth or the major factor input a region depends upon for economic growth. From an input-output point of view, the lock-in characteristics of economic growth can be traced back to their root through the input of factors. For this reason we have established a lock-in effect model for factor input that is akin to the model for regional economic growth. Samples are also selected from the 1952-2005 period, which are divided into the aforementioned four time sections, and the same regression methodology is employed. What merits attention is that the use of Andersen's (1998) model gets us nowhere when analyzing the data for time sections that are too short in duration. For example, in the case of the input of such factors as number of researchers and research-and-development expenses, statistics are available only for the recent decade, which is too short a time section to be meaningful for our analysis. That is why our analysis of the lock-in effect by using Formula (4) is limited to those capital factors that play a leading role in a region's economic development.

$$[LnK]_{i(t-2)} = b_0 + b_1[LnK]_{i(t-3)} + v_{(t-2)} \quad (5)$$

$$[LnK]_{i(t-1)} = b_2 + b_3[LnK]_{i(t-2)} + v_{(t-1)} \quad (6)$$

$$[LnK]_{i(t)} = b_4 + b_5[LnK]_{i(t-1)} + v_{(t)} \quad (7)$$

Of these, $[LnK]_{i(t-3)}$, $[LnK]_{i(t-2)}$, $[LnK]_{i(t-1)}$, and $[LnK]_{it}$ denote average natural growth rates of the capital stock of various provinces during t-3, t-2, t-1 and t respectively.

The lock-in effect in regional factor allocation is one of the root causes for regional disparity. Even though no essential changes have occurred to the allocation of those capital factors that play a leading role in economic growth, this does not prevent the mode of the lock-in effect in capital factors from experiencing periodic changes in different time sections, particularly the period around the adoption of the reform and opening-up policy. To probe further into the role of the opening-up effort in the lock-in process of factor input, we have set up Formula (8)[iv] for an analysis of the relationship between the degree

of economic openness and factor accumulation, and for a close look into the mode of the lock-in effect on factor input in east, central and west China during the four time sections:

$$[LnK]_{it} = \gamma_0 + \gamma_1[LnXM]_{it} + \gamma_2[LnFDI]_{it} + \mu_{it} \quad (8)$$

Because FDI inflow did not happen in China during t-3 and t-2, and because most provinces did not begin to bring in foreign investment until the middle and later stages of t-1, the $[LnFDI]_{it}$ is deleted from our calculations concerning these three time sections. Moreover, because our study is focused on the time section t, in which the opening-up effort was accelerated, what happened in the previous three time sections is used merely for comparative and interpretative purposes.

(II) Establishing data sources and indexes

Considerable changes have taken place in the Chinese economy and economic system following the adoption of the reform and opening-up policy. In particular, starting from the early 1990s, a market-oriented economic system has taken shape, and the Chinese mode of economic development has taken on more market features than never before. Therefore, the samples chosen in this thesis are focused on time section t for a close examination of the mechanisms that have an impact on economic growth differentials in this country. The following is a detailed presentation of the indexes and statistics to be employed in this thesis. (Where unnoted, the statistics cited in this thesis come from the China Statistical Yearbook for the periods concerned; and our quantitative analysis is conducted by applying the Eviews5.1 software.)

Because the terms "per-worker" and "per-capita" are extensively used in our quantitative analysis, we deem it necessary to explain our choice of relevant indexes beforehand. In our opinion, the use of manpower or population simply as "per-capita" indicators risks neglecting the "learning while doing" effect of manpower in the production process. We thereby unify high-level manpower (i.e., human capital in the common sense of the term) with low-level manpower (i.e., ordinary manpower in the common sense of the term) in the realm of human capital in the broad sense of the term, and replace the number of employees in the common sense of the term with the human capital index as the divisor needed in the "per-worker" concept. This necessitates our calculation of the number of employees as the human capital stock.

In this thesis we employ the average number of years people spend in receiving a certain level of education for our calculations of human capital stocks. Firstly, we assume that the percentages of people with different levels of education in the total number of employees in a given region are close to the percentages of people of various education levels in that region's total population. Secondly, based on the China Population Census Yearbook's sample survey statistics on the population's education structure, we calculate the percentage of people at every education level in the total number of educated people(L_i/L'), and multiply it with a certain education time limit (t_i) to obtain per-capita education level (h_i). The formula is $h_{ij} = \sum (Lij/Lj') \cdot t_{ij}$. In this way, we derive the index for the human capital stock in every region: $H_j = h_{ij} \cdot L_j$. Of this, the time limits we have set up for different levels of education are 0 years for the illiterate, 6 years for primary school, 9 years for junior middle school, 12 years for senior middle school, and 16 years for college; Lj represents the number of employees in a given region. Because 1991, 1992, and 1994 statistics are unavailable in the China Population Census Yearbook, we draw on the 1990-2001 statistics derived by Chen Zhao, Lu Ming and Jin Yu (2004) on the average per-capita number of years spent in receiving education in various regions. Using the same method, we calculate the per-capita number of years of education received, and index H for the human

capital stocks of different regions. The formula sets the average number of years spent for education at 17 as the variable for the R&D human capital stock. The China Science and Technology Statistical Yearbook' s list of the numbers of people engaged in science and technology in different regions will be cited as the R&D human capital stock, to be used to derive HR, the high-level manpower stock index. Therefore HR and per-worker R&D human capital is indicated with HR/H.

In estimating China's material capital stock (such as Chow, 1993; Young, 2000; Zhang Jun and Zhang Yuan, 2003; Gong Liutang and Xie Danyang, 2004; Zhang Jun et al, 2004), Zhang Jun, Wu Guiying and Zhang Jipeng (2004) have chosen and constructed the investment implicit deflator, the investment-item depreciation rate, and the base-year capital stock, and processed the unavailable statistics in a scientific and comprehensive fashion. In this thesis we use their calculation results as our reference indexes [vi]. By converting the fixed-asset investment price indexes into 1990 base-year prices, we have obtained K, the actual capital stock indexes for different regions with 1990 as the base year. The per-worker capital stock, k, is expressed with K/H.

The per-worker output value, y, is expressed with GDP/H, the ratio between the GDP of a given region and its human capital stock. In this thesis, regional retail price indexes are converted into 1990 base-year figures, and these regions' GDP are deflated into 1990 base-year prices. The 1952-2005 GDP statistics are quoted from A Collection of 55 Years of Statistical Data on New China; and $y_{it}/\bar{y}$, the ratio of per-worker GDP of Region i to the national per-work GDP during Period t, is employed as an indicator of the regional disparity.

The R&D index is not only an indirect reflection of technological progress, but also a benchmark for input. The statistics concerning R&D expenses are cited from the category of internal expenses for the scientific and technological undertakings of various regions in the 1991-2006 editions of the "China Science and Technological Statistical Yearbook." Where the R&D input stock is concerned, we have adopted Li Xiaoping and Zhu Zhongdi's (2006) research method, referred to the ideas of Helpman (1995) and Coe, Helpman and Hoffmaister (1997), and adopted the following formula for our calculations:

$$K_{i0} = I_{i0} / {}_1(g + \delta) \quad (9)$$

$$K_{it} = I_{i(t-1)} + (1 - \delta) K_{i(t-1)} \quad (10)$$

I_{i0} is the startup volume of R&D input for 1990; g represents the average growth rate of the R&D expenses during the time section t; and δ, represents the depreciation rate set at 5%. K_{i0} and K_{it} represent the R&D capital stock Region i acquired respectively in the beginning and during t, and $I_{i(t-1)}$ is the volume of R&D expenses of Region i during t-1. We derive the actual volumes of R&D expenses by using the 1990 base-year fixed asset investment price indexes of various regions to deflate their nominal R&D expenses. Then we employ Formulas (9) and (10) to calculate the 1990 R&D capital stocks and 1991-2005 R&D capital stocks of different regions. RD/H represents rd, the per-capita research-and-development capital.

When choosing the index on the degree of openness, we adopt FDI, IM and the ratio between export volume X and GDP, indicated as fdi, im, and x. The primary statistics on FDI and the volumes of imports and exports are indicated in US dollars. These statistics are converted into RMB prices according to RMB's average annual exchange rate to the US dollar and compared with GDP to derive the ratio index. Because both statistics are relative indexes, they are immune from the influence of the price factor. In addition, the interaction factor between fdi, im and hr (high-level human resource) is chosen to account for the technology spillover effect brought on by the opening-up effort on various regions.

(III) Mechanisms for lock-in effect on regional disparity

1) The lock-in characteristics of regional disparity

The lock-in effect figures prominently in the mode of regional economic development. Our quantitative study indicates that in national and west China samples, all the coefficients relevant to intervening periods are positive and rising progressively. This indicates a certain degree of path dependency in the development between two connected periods, and, with the passage of time, a self-strengthening tendency. Particularly in time section t, in which China stepped up its reform and opening-up efforts, the lock-in effect of the latter period's mode of development becomes particularly obvious on the former stage. In east China, despite a marginal readjustment (with the relevant coefficient dropping slightly from 0.9519 to 0.9496) prior to the adoption of this policy, this lock-in effect became stronger after the policy was adopted (with the relevant coefficient rising to 1.0479). Similar changes also occurred in central China. It is thus clear that reform and opening-up has strengthened the path dependency of the original Chinese mode of development to some extent, and took on obvious lock-in characteristics with the passing of time. Because of differences in the favorable government policies granted respectively to east, central and west China, east China was able to outperform central and west China at the startup stage, while the lock-in effect, which played the same role as the Matthew effect, made it difficult to eradicate the disparity between the three regions.

Whether or not this mode of development is the "extensive" mode of development using accumulation as a major motive force we are accustomed to, is a question we must ask ourselves. In this thesis, we use Formula (4) for a quantitative study of the panel data concerning east, central and west China, so that we can further explore the leading factors in the economic development of each region and find out how the factor allocation in an open economy leads to a lock-in mode of economic development. When deflating this panel data, we employ the "Hausman" inspection method using "Eviews5.1" to determine which model should be chosen: FE (fixed effect) or RE (random effect). We use a likelihood irrelevant regression analysis to revise the dishomogeneity-test variances and the correspondence period relativity of the cross-section units. (See Table 1 for the calculation results.)

2) The factor lock-in effect on regional disparity

Firstly, per-worker capital plays a leading role in regional economic development. Table 1 shows that for every 1% increase in per-worker capital (material capital/ordinary productive labor), the ratio between east China's per-worker GDP (abbreviation: y_E) and national per-worker GDP (abbreviation:$\bar{y}$) rises by 0.52%. Because of this, the economy of east China goes a step further above the national per-worker GDP, and the disparity of east China with central and west China is widened as a result. In the same token, when the ratio between central China's per-worker GDP (abbreviation: y_C) $\bar{y}$and goes up by 0.37%, the accumulated capital is conducive to reducing central China's disparity with the national level of development, but is not enough to help the region to catch up with east China. By contrast, west China's pre-Ln(k) coefficient is negative, but this does not mean that capital is not boosting the local economy. It means that west China's gap with east and central China is further widened for the single reason that capital accumulation does not contribute as much to west China as it does to east and central China. When per-worker capital plays a remarkable role in all three regions (that is, with the coefficient at the 1% level), the per-worker capital coefficient becomes higher than the other coefficients before variances were put in, indicating that high-speed regional economic growth is predicated on massive input of primary factors (that

is, low-priced labor and capital accumulation), and that local production is still in the mode of extensive economic growth.

In so far as the capital factor is concerned, the other factors can only play an ancillary role. Human capital and R&D input serve to exacerbate regional disparity. Our empirical study indicates that high-level human capital has cut into east China's lead over the entire country, and reduced the specific value of $y_E/\bar{y}$, but west China's long-standing high-level manpower shortage resulting from its relatively slow pace of opening-up has caused the ratio of its per-capita GDP (abbreviation: y_W) to $\bar{y}$ to drop further, its margin of 0.1597% being far greater than east China's 0.0629%. Thus the east-west disparity is deepened in terms of the degree of the hr effect, but in this regard, high-level human capital is having a smaller impact than the capital factor. In Table 1, the statistics for the R&D capital are positive in our analysis of east, central and west China: for every 1% of increase in the R&D expenses, the GDP/ $\bar{y}$ ratio goes up by 0.36%, 0.13%, and 0.09% respectively for east, central and west China. However, differences in the degree of the R&D input's impact have served to aggravate regional disparity.

Table 1. Results of a quantitative analysis of Formula (4) for economic development in east, central and west China (1990-2005)

Region		Interpreted variable $Ln(y_i/\bar{y})$		
Interpretive variable		East	Central	West
Ln(k)		0.5164*** (15.5278)	0.3709*** (9.3625)	-0.2582*** (-8.2368)
Ln(hr)		-0.0629*** (-3.9488)	-0.0283 (-0.4130)	-0.1597*** (-3.7147)
Ln(rd)		0.3600*** (10.5255)	0.1265*** (3.0516)	0.0917*** (2.9310)
Ln(fdi)		-0.1046*** (-3.5798)	-0.1590*** (-3.2780)	-0.0911*** (-5.3122)
Ln(im)		-0.0092 (-0.4915)	0.0227 (0.2480)	-0.3134*** (-8.2808)
Ln(x)		0.0080* (1.8591)	-0.0252*** (-3.1885)	0.0115 (1.5129)
Ln(fdi)·Ln(hr)		-0.0130* (-1.8867)	-0.0335*** (-3.4332)	0.0015 (0.4144)
Ln(im)·Ln(hr)		-0.0039 (-1.0175)	0.0105 (0.5729)	-0.0622*** (-8.1626)
C		-3.7524*** (6.8893)	-10.9852 (-0.9695)	-0.1543 (-0.6377)
Hausman Test	X^2value	237.2896	139.2993	185.0643
	P	0.0000	0.0000	0.0000
Model		FE	FE	FE
Ad-R^2		0.9953	0.9963	0.9944
F		1879.179	1727.293	1223.219
D-W		2.1071	1.9073	1.9402
Observed number		180	126	117

Note: The statistics in parentheses indicate the checking value t, and ***, **, and * show that this checking value is outstanding at 1%, 5% and 10% respectively; Ln($y_i/\bar{y}$) Ln(k), Ln(hr), Ln(rd), Ln(fdi), Ln(im), Ln(x), Ln(fdi)·Ln(hr), and Ln(im)·Ln(hr) are the natural logarithm of the value of the ratio between each province's per-worker GDP and the national per-worker GDP, the natural logarithm of per-worker capital, the natural logarithm of per-worker number of researches and developers, the natural logarithm of per-worker research-and-development capital, the natural logarithm of the FDI/GDP ratio, the natural logarithm of the import-GDP ratio, and the natural logarithm of the export-GDP ratio; Ln(fdi)·Ln(hr) and Ln(im)·Ln(hr) represent the respective natural logarithm of technological spillover brought about respectively by FDI and import under the opening-up policy. The Hausman test indicates that the panel data pertaining to each province should be analyzed by choosing the fixed effect (EF) model. Because auto-regression may exist in the data, in the process of the test, the models for the eastern central and west China are FE models that may contain AR perturbation. Thus the AR statistics are deleted from the table.

Firstly, opening up to the outside world does not directly cause regional disparity in economic development, nor does the international spillover of technology alleviate such a disparity. The FDI in the economic development of all three regions has shown negative effects. East China obtains more FDI than central and west China, but because of the effect of massive FDI inflow on domestic capital, these additional funds have contributed little to the added value of manufactured goods. The relatively small amount of foreign investment west China acquires is not enough to effectively boost local economic growth. For this reason, the effect of FDI inflow on regional disparity in China is insignificant. Our empirical study shows that for each 1% increase in the export indicator, economic growth in east China rises by a meager 0.008%, which serves only to slightly widen the region's gap with the central and west China. In central China, however, the effect is negative [vii], causing a 0.025% drop in the $y_C/\bar{y}$ ratio, and the region's gap with east China becomes slightly wider as a result. Generally speaking, increases in exports in

east China have only slightly pulled the region away from central and west China. This is mainly because such increases are still locked in primary products and thus fail to yield high volumes of direct profit, whereas east China's robust growth is attributed mainly to a market economic environment cultivated in the opening-up process, an environment in which liberal factor allocation becomes a fountainhead for economic growth.

With this factor's leading role in regional economic development on the one hand, and the high availability of the data pertaining to it on the other, we are able to analyze the capital factor by Formulas (5), (6) and (7). The results suggest that the capital factor has a significant lock-in effect on China in general and east China in particular, with the coefficient related to east China standing at 0.8339, 1.0095, and 1.0508 respectively. The fact that the opening-up process in east China is earlier and broader than in central and west China is convincing proof that lock-in mechanisms are having an effect on factor allocation in the progress of deepening reform and opening-up. Central and west China's degree of openness is lower than that of east China and thus their intervening period coefficient shows no significant increase, but we are aware of the fact that central China's coefficient in Formula (3) is markedly higher than what it is in Formula (1), which means the lock-in effect of factor resources has been enhanced to a certain degree as compared with the pre-reform years.

Thirdly, the mode of the capital lock-in effect is periodic in nature. For a more direct observation of the effect of the variable pertaining to economic openness on the capital factor, we have employed Formula (8) for a quantitative analysis of the three regions. The result reveals a difference in the mode of capital factor accumulation. Because of a lack of experience, China adopted the Soviet Union's highly centralized planned economy model in the early post-liberation years, and supplemented it with a government-mandated foreign trade system. In the period prior to the adoption of the reform and opening-up policy in 1978, the capital lock-in effect caused by this foreign trade system was relatively low (due to the influence of the "cultural revolution", foreign trade's action coefficient on the capital factor fell below 0.07% for all the three regions during the time section t-1). This means that during this period the capital factor circulated by way of planned allocation, and the developmental gap between the regions stemmed for the most part from the national industrial policy's prescribed goals.

In the post-1978 period, the action coefficient concerning the effect of the degree of economic openness on the capital factor has been markedly increased with the gradual transformation of the economic system and the expansion of foreign trade. During the time section t-1, each 1% of increase in the volume of foreign trade meant a 0.20%, 0.19% and 0.09% rise in capital accumulation for east, central and west China respectively, as against 0.33%, 0.39% and 0.45% during the 1990-2005 period; an increase that indicates that the lock-in effect caused by foreign trade was stronger in the latter period than in the former period. This conclusion tallies with the findings in our analyses with Formulas (5), (6) and (7). With central planning gradually giving way to the market force, the lock-in model for capital allocation has come under the increasing effect of the degree of economic openness in the post-1978 period. If capital allocation was still influenced by the opening mode of commodity imports and exports during t-1, then FDI emerged to be another major mode to influence capital allocation during the time section t, in which central and west China trailed behind east China in attracting FDI owing to their lower degree of economic openness. Therefore, imports and exports played a larger part than anything

else in this capital accumulation process. By contrast, east China's higher degree of economic openness turned FDI into an increasingly important factor in the local capital factor flow. Therefore, in the years under the reform and opening-up policy, regional disparity not only stemmed from the national industrial policy, but also as a result of the liberal regulation by the nation's open market.

From an economic growth point of view, the lock-in effect on the capital factor makes it hard for China to quit its position as a commodity manufacturing and processing country in the international division of industry anytime soon. Because of the lack of advanced technology in the processing industry, workers find it hard to develop the skill of "learning while doing" and build up on their knowledge, while low profits rob companies of their drive for research and development. The processing and trade industries may boost regional economic growth, but it is depriving us of what only the upper reaches of the global industrial chain can offer: enormous profits and the opportunity to upgrade technology step by step. If this situation is allowed to go unchecked, our opening-up effort could only lock our country in an extensive mode of economic growth. Judging from the degree of regional disparity in this country, even though none of the regions have freed themselves from the extensive mode of development, the degree of economic openness does make a difference in a region's position in the global division of industry. In east China, the degree of specialization in production is already higher than in central and west China, and it is still rising with the region's ever-growing productivity caused by intensive use of capital factors. Regional disparity will continue to grow as a result. Finally, it is our belief that because the capital factor has a lock-in effect despite its foremost role in the production process, lopsided development in various regions of China is likewise characterized by its lock-in nature.

IV. Conclusion

By establishing formulas for the lock-in effect on regional economic development and factor input and using them for a quantitative study of the panel data on east, central and west China, we find that the Chinese economy remains in an extensive mode of development, a mode that has an intensifying tendency during the period in which the reform and opening-up drive is deepening. Our comparisons and analysis of the paths by which the lock-in effect works on the economic development of the three regions have led to the following conclusion:

The lock-in effect is obvious in the imbalanced regional development of the Chinese economy, and its root cause lies in the fact that economic growth in this country is still predicated on an extensive mode of development. This mode cannot be easily changed, not only because of its path dependency but also because the reform and opening-up drive has aggravated the lock-in effect on factor inputs and eventually exacerbated regional disparity.

To reduce regional disparity, the strategy of the Chinese government is to push, one stage at a time, development in the less developed regions. After carrying out strategies to develop west China in a big way and rejuvenate the old industrial base areas in the northeast and other regions, another high-profile strategy was set in motion last year for the takeoff of central China. The government is obviously doing what it can to set regional economic growth on an even keel.

On the basis of our research and analyses as presented in this thesis, and proceeding from our aforementioned conclusion, we believe that the problem of regional disparity cannot be addressed by merely stepping up the opening-up effort. Only when all the provinces start improving the quality of their factor input and gradually transforming their

resource input methods can the problem be really tackled. Because of the ambiguous lock-in effect of the international technology spillover, proper attention must be paid to integrating the cultivation of R&D personnel with the research into frontier sciences. Only then can advanced foreign technology be better absorbed, and only then can the Chinese economy eradicate the lock-in effect on factor inputs and truly embark on the road of development by relying on scientific and technological progress.

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Abstract:

Reform and opening up has made China's economy develop faster than ever. But it has not succeeded in changing the regional disparity in China. In this article, we establish a model factor input called the "lock-in effect" and analyze the channel of the lock-in effect and how it influences the regional economy. On the analyses of thirty provinces' panel data in China from 1990 to 2005, we find that the lock-in effect of factor inputs further exacerbates the developmental imbalance among regions.

Key words:

Lock-in effect; Regional disparity; Factor input; Openness.