環境関連財政支出および企業の環境対策による
マクロ的経済効果に関する日中比較研究

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はじめに

新興工業国は、経済発展の初期段階から一般の公害対策に加えて地球規模での環境問題への対応が迫られている。この点で先進工業国が、当初主として局所的な環境問題（公害）への対応することで経済成長を成し遂げてきた発展過程と大きく異なる。先進工業国は経済成長を成し遂げた後に地球規模の環境問題への対応が迫られるようになったことで、先進工業国の側に、新興工業国が現在抱える環境・経済問題解決のための十分な理解があるとは言えない状況にある。経済成長とともに加速する新興工業国の環境問題解決のためには、先進工業国は、環境汚染の内部化に成功したプロセスにおける政府・企業の役割（対策）を明らかにし、新興工業国がとるべき環境対策の方向を示して行く必要がある。

現代の新興工業国（中国およびアジア NIES）は、国際市場における工業製品の飽和を考慮すれば、いっそう厳しい経済条件下で環境保護を進める必要にさらされている。この現実をふまえ、本研究は、新興工業国側の要請に基づき、環境政策がそのマクロ経済全般にもたらす効果を明確にすることを試みたもので、経済成長の維持と地球規模での環境保全を合わせた持続的経済成長のための政策立案に対し有効な情報提供を通して、新興工業国が自らの環境対策を進めていくため指針の提供を目指してきた。

この報告書は、大きく二つの部分からなっている。第一部の「**Economic Development : Environment Perspective**（経済発展：環境の視点）」は、主としてこの研究に携わった研究者の経済発展と環境保護にかかる研究成果をまとめたものである。ここでは、2000 年にこの科研プロジェクトの一環として開催した国際シンポジウム「**Environment and Our Sustainability in the 21st Century: Understanding and Cooperation between Developed and Developing Countries**」において報告いただいた中国国家環境保護総局司長（部長）の彭 近新氏およびシカゴ大学経済学部のジョージ トーリイ教授の論文をプロシーディングスから再録させて頂いた。

第二部の「**Economic Growth: Regional Perspective**（経済発展：地域の視点）」は 2000 年に寧夏大学と共催した『中国西部経済発展国際シンポジウム』において報告された論文のうち地域開発の視点から経済発展を分析した研究を収録している。地域開発の論文を同時に収録したのは、環境問題の解決にはその地域それぞれの政府と民間の地道な取り組みがわけても重要であると私が考えたことに他ならない。発展途上国の環境問題を解決に導く鍵が、地域の経済発展パターンの厳密に分析を通して得られる可能性が高い。

第二部にも、シカゴ大学経済学部のトーリイ教授が『中国西部経済発展国際シンポジウム』に出された論文を収めさせていただいた。この論文は、寧夏大学の呉教授や私が、シカゴ大学でトーリイ教授の主宰されている中国の西部開発に関する研究会のメンバーに加えて頂いていたことから、このシンポジウムのために書いてくださったものである。また、名古屋大学大学院法学研究科の加藤久和教授、同経済学研究科の塚田弘志教授は、この科

研のメンバーではなかったが、それぞれご専門のお立場から中国の環境問題と地域開発に資するためということで論文を用意してくださるとともに本報告書への掲載を快く了承してくださった。

本報告書の構成にかかる話に加えて、寧夏大学と『中国西部経済発展国際シンポジウム』を共催するに至った経緯、この科研プロジェクトがもたらした思わぬ波及効果およびこの報告書が英語で編集された理由について簡単に触れさせて頂きたい。

現在の中国の重点政策である「西部開発」と「環境保護」の研究を進めるべく寧夏大学西部発展研究センターが2001年10月に設立されたことから、寧夏大学副学長で同センター主任（当時　現寧夏省社会科学院院長）の呉 海鷹教授からの強い研究協力要請があった。この要請に対し、研究分担者の大分大学の薛 進軍教授と相談の上、この科研プロジェクトの最終報告会を寧夏大学の『中国西部経済発展国際シンポジウム』に併せて開催することにした。中国の環境問題への貢献姿勢を明確できかつ我々の研究成果を公開できる絶好の機会ととらえ、積極的な協力を行うこととなった。もともと我々の研究は、先にも述べたとおり、先進国の公害克服の経験を経済学的に明らかとすることで環境問題に直面している新興工業国の環境政策に寄与することを目的としたものであることから、寧夏大学においてこのような形で我々の研究成果を発表する機会が与えられたことは、誠にうれしいことであった。

この研究プロジェクトでは、2002年度に西安市、桂林市、南寧市、2003年度には寧夏省で、政府の環境政策と企業の対応に関する質問票調査を実施した。この調査では、国家環境保護総局の彭 近新司長および北京大学環境科学研究所の楽 胜基教授の研究協力をお願いし、楽先生の大学院生をそれぞれの環境保護局に派遣してもらい、その院生が現地での調査員の指導を行うという形で企業調査を進めることができた。３人の北京大学の院生が協力をしてくれた。寧夏大学でのシンポジウムに楽先生がこの３名の大学院生を伴っていらしたが、驚いたことにはこの院生たちが、集めたデータをもとに自分たちですでに企業の環境対策に関する分析を始めており、その成果をシンポジウムで報告してくれた。寧夏大学の呉先生も、寧夏省での質問票調査のデータをもとにこの報告書の第７章に収録した研究をまとめられていた。

私は、この瞬間まで、中国において、研究者自らがデータを採りそれをもとにして自らが環境政策と企業の対応に関する分析を行い自らが政策提言を行うようになるには今しばらくの時間がかかると考えていた。このゆえに、「公害先進国・環境先進国」の日本が主導する形で、中国の環境をテーマとする研究プロジェクトを進めた。ところが、研究成果の公刊においても、寧夏大学の呉教授に先を越されてしまうというううれしい誤算が生じた。我々の研究チームの報告を含む『中国西部経済発展国際シンポジウム』での報告論文は、中国語に翻訳され《中国西部経済発展理論と実証研究》として一足先に中国経済出版社から出版された。

出版の計画段階から、この科研プロジェクトに対して研究協力をしてくださった多くの方々、さらにはこの科研の研究分担者や研究協力者から、一連の研究成果を英語版として編集してほしいとの希望が出されていた。特に、中国の研究者に、この要望が強かった。この要請に応えるべく、また我々の研究のいっそうの国際化を図るという目的を兼ね、この報告書は英語で編集することとなった。本報告書が、表紙と前書きを除き、英語版となったのはこの事情による。

この文部科学省科学研究費補助金『環境関連財政支出および企業の環境対策によるマクロ的経済効果に関する日中比較研究』を終えるにあたり、このプロジェクトに対しさまざま形でご助力をくださった方々に対して、研究チームを代表しお礼を申し上げたい。わけても、名古屋大学名誉教授飯田経夫先生、中国国家環境保護総局司長彭　近新氏、シカゴ大学経済学部名誉教授ジョージ・トーリイ氏、韓国エネルギー経済研究所所長李 相駿氏、中国寧夏省社会科学院院長呉 海鷹氏からはなにものにも代え難い貴重なご助言と多くの支援を受けた。この方々のご理解なしにはこの研究プロジェクトはけっして成立しなかったといっても過言ではない。

最後に、名古屋大学経済学研究科事務局の効率的にしてかつ心のこもった研究サポートに対して感謝の意を表したい。事務長の鈴木宏治氏（ご退官）、同古田牧夫氏、庶務掛長の中山聖英氏、会計掛長の小林雪子氏（ご退官）、同林 光治氏、会計掛主任の伊藤 誠氏、会計掛事務官大場 亮氏、同小椋友明氏ほか大勢の方々の研究支援に対し感謝申し上げたい。

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Chapter 13

Can Economic Policy Reverse Regional Inequality? Convergence across Provinces in China, 1978 to 2000

Chi AN†

1. Introduction

A major debate concerning the existence of convergence among countries or between regions within a country over time has been going on since Solow(1956) and Swan(1956) developed the neoclassical growth model. Empirical tests of convergence fall into two categories. The first set, basically consisting in the performing cross-section regressions, rejects the no convergence null using the subsequent growth rates for a group of economies during a particular period as a dependent variable and the initial per capita output levels in each of them as an independent variable. Barro(1991), Barro and Sala-I-Martin(1995) and Sala-I-Martin (1996a, 96b) do not indicate that there is convergence in income levels across the whole sample of 118 countries within the period 1960 to 1985, but illustrates the existence of convergence within high-income countries belonging to OCED area. Baumol, Nelson and Wolff(1994) indicates that differences in conditional levels of productivity are decreasing across the same whole sample, after eliminating African countries.

The second set, consisting in time series tests, shows that there is little observable tendency for poorer economies to catch up to richer ones, as well as the failure of per capita output to equalize across developed countries and less developed

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countries. According to Quah's critique (1993, 1996), the existence of beta convergence is compatible with the existence of international inequality that remains constant or even grows especially between developed countries and developing countries. And it is meaning the in-existence of a catching of poorer economies up to richer ones.

Results often have been contradictory when different tests have been applied to output series and this has led to a wide literature which has formally tested the convergence hypothesis and interpreted convergence. Bernard and Durlauf(1996) propose two definitions of convergence which capture some of the implications of the neoclassical growth model related to the difference between the levels of per capita income of different economies. They are 1)*Convergence as catching up* and 2)*Convergence as equality of the long-term forecast at a fixed time.* These definitions characterize convergence between a pair of economies or members of a set of economies in which every pair exhibits convergence. The definition 1) implies that the differences between the economies under analysis tend to decrease, and the definition 2) implies that the long term forecast for these differences tends to zero as the horizon grows larger, which means that there are not any shocks with indefinitely long effects.

Given implications of these definitions, Utrera and Koroch(1998) develop the model for the case of Argentina, following the procedure proposed by Zivot and Andrews(1992), a unit-root testing procedure concerning the dynamic properties of macroeconomic time series, by which the non-convergence hypothesis is rejected if null hypothesis of the existence of unit-root can be rejected, or if the hypothesis of the existence of a deterministic trend can be rejected.

The regions within China show marked disparities in regional income and have registered quite differing growth performances over the past 20 years[1]. Some backward regions realized rapid catching-up to advanced regions, while others stagnated in per capita outputs[2]. This paper is to explore the characteristics of regional disparity and structural change in the process of economic. The analysis contributes to the regional growth literature in three respects. First, a way is developed to distinguish the China's regions(30 provinces) into three different groups with respect to different initial income level and mixed growth performance. Second, the paper applies "Classical" test of convergence hypothesis to show disagreements about the empirical evidence in favor of or against the existence of convergence of regional

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[1] It also seems clear that growth is much more different after the transition to a market economy in 1978 than it was in the "Command Economy" period from 1949 to 1978.

[2] See Arayama (1991) who proposed the dichotomy between "advanced" regions and

output. Third, considering the two definitions of convergence proposed by Bernard and Durlauf(1996) for the unit-root test in time series model, the analysis is to show that the empirical evidence for or against the existence of regional structural changes constitutes evidence for or against the hypothesis of regional convergence. The purpose of this paper is to awaken an interest of those who consider it possible to reverse economic inequalities, through the implementation of different economic policies.

The investigated panel consists of real per capita GPP (gross provincial product) across 30 provinces in mainland of China for the period 1978 to 2000. Section 2 measures the extent of real-income disparities between regions to present how these have changed since 1978. In the third section, the estimation to test "classical" convergence hypothesis is effected through a non-linear Least Squares procedure. In section 4, a unit-root test of time series model is applied to speculate on structural changes in regional growth trends in order to give a possible rationalization for the observed convergence in regional growth. Section 5 contains concluding remarks and hints at some further problems to be investigated.

2. Establishing the Basic Facts about Regional Growth and Its Dispersion

The estimates of Table 1 merge three kinds of information relative to 30-province sample from 1978 to 2000, that is, for the period of "economic reform" in China[3]. These are 1) real GPP p.c (per capita Gross Provincial Product in 2000 prices), 2) the average annual growth rate of GPP p.c., and 3) Regional Disparity Index (RDI), that is, the ratio of real per capita gross product of each province (real GPP p.c.) to that of the whole nation(real GDP p.c.)[4].

In order to facilitate the analysis, 30 provinces within China are here distinguished into three groups. 4 provinces with the highest income level in 1978 and decreasing trend of RDI from 1978 to 2000 are placed in the Traditional Advanced Regions (TARs) group. The rest is grouped by the regional pattern of RDI change, with 5 increasing pattern and 21 decreasing or roughly constant pattern. This produces New Advanced Regions (NARs) group and Less Developed Regions (LDRs) group. Figure 1 gives a representative picture of comparative growth performance among these three regional groups in the term of RDI.

"poor" regions within China.

[3] The sources of data used are presented in the Statistics Resources

[4] It measures the multiple of any provincial average income to national level in the logarithmic scale. See Ohtomo(1992), pp66.

Figure 2 presents the trend of the standard deviation distribution of GPP p.c. for various regions within the whole of the country and within every-two groups from 1978 to 2000. Three kinds of distribution can be observed. First, a decreasing trend of "sigma" from 1978 to 1989, turning to increasing trend in 1990, is shown within the national scale. Almost the same trend pattern is found for regions within "TARs + LDRs" scale. Second, a positive trend of "sigma" is observed at the beginning of 1980, turning stronger after 1991, within the "NARs + LDRs" scale. Last, a strong reduction of "sigma" within "TARs + NARs" scale from 1978 to 2000 indicates that NARs are "catching-up" with TARs by closing the gap.

The following facts emerge from the evidence of Table 1, Figure 1 and Figure 2.

1) There was a substantial increase in real income in all regions during the period 1978 to 2000, by which a high rate of growth in China has been maintained.
2) The 30 provinces can be divided into three groups by some degree of homogeneity with respect to initial income level and growth performance pattern. TARs have had the highest income but lower annual growth rate comparing with the national level over time[5]. NARs have taken the fastest growth and achieved the second-highest level of income at the end of our study period. LDRs still kept the lowest income level at the end of study period, which are not very different from that of TARs 20 years ago.
3) The pace of regional growth over 20 years has not been steady. The annual growth rates in these regions varied considerably, so that the disparity between the highest- and lowest-rate of growth from 1978 to 2000 is above twofold. The acceleration was most marked in NARs and least so in TARs. This growth pattern has tightened in all regional groups in 1990's.
4) There was a good deal of "catch-up" among some regions, within a national framework of "divergence". A weak reduction of the inter-region income spread at the national scale from 1978 to 1987 was observed, but it turned to a "divergence" trend since 1990. The widening in the spread was seemingly due to the disappointing performance of LDRs. The gap between TARs and NARs was significantly reduced over 1978 to 2000.
5) The within-group homogeneity of the performance suggests that the regions in

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[5] Shanghai, Beijing, Tianjin and Liaoning, in real GPP p.c. term, are ranked 1st, 2nd, 3rd, and 4th in 1978 and 1st, 2nd, 3rd, and 8th in 2000 respectively. But the annual growth rates of GPP p.c. between 1978 and 2000 are the 19th, 20th, 21st, and 23rd in 30-province sample respectively. See Table 1.

each group had common institutional and/or policy characteristics that distinguished them from the members of the other groups.

3. "Classic Approach" to Regional Pattern of Convergence

Two measures of convergence are used in this section, and both are members of "Classical" convergence approach(Sala-I-Martin,1996b). The first measure is a simple regression of average growth rate of real gross per capita product in any region of China overtime. A negative coefficient associated with the initial income levels of region indicates that poorer region with lower initial income is "catching up" by higher growth rate with rich region which started by higher initial income. It can be measured in absolute or conditional terms, defined as follows in this paper.

For the fundamental differential equation of the neoclassic model in the neighborhood of the steady state (see Barro and Sala-I-Martin(1995)), Eq.(1) is modified to examine the regional absolute "beta convergence",

$$(y_{i,t} - y_{i,0}) / t = a - [(1 - e^{-\beta t}) / t] y_{i,0} + u_i \qquad (1)$$

where y_{it} and y_{i0} are denoted as in terms of logarithm of real gross per capita product of province i in years t and 0 respectively as the empirical literature has generally focused on, u_{it} is a stochastic error with the usual characteristics, and β is the speed of convergence[6]. The regional "beta convergence" is equated with a positive value of β, treating $\beta \leqq 0$ as the no convergence null hypothesis.

An equation of the form,

$$(y_{i,t} - y_{i,0}) / t = a - [(1 - e^{-\beta t}) / t] y_{i,0} + \phi X_i + u_i \qquad (2)$$

is modified to include a set of control variables X_i for province i. A positive β means regional economies can converge to different long-run equilibria depending on conditions, that holds conditional on two sets of exogenous factors in this paper. When X_i includes regional level of secondary schooling and industrial structure in the initial year, regional dummy variables. that is, to examine the regional "conditional beta convergence" Obeying a version of the Solow growth model where economies can converge to different The other, a set of proxy variables stand for the steady state of province i, includes regional Non-Stated Ownership Enterprises(NSOE) output, foreign direct investment(FDI), export, local fiscal expenditure and inter-regional transfer.

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[6] $\beta = (1 - \alpha)(\delta + n + x)$ with α being the exponent of capital in a Cobb-Douglas function, δ the capital depreciation rate, n the population growth and x the rate of technological change.

The second measure is based on the trend of standard deviation distribution of inter-regional output over time named "sigma convergence". The existence of equality is possible as regions have reached their steady states, and "sigma convergence" is indicated when the coefficient declines over time.

$$\sigma(t) = \alpha + \gamma T_t + \mu_t \qquad (3)$$

T_t is noted respect to time trend. The existence of sigma convergence is shown as $\gamma < 0$[7].

The test to "beta convergence" (1) and (2), is effected with non-linear least square estimation procedure and the test to "sigma convergence" (3) with GLS procedure[8].

In Table 2, it can be observed that beta is significant in Reg.1 without conditioning. But the coefficient of determination is too low (R^2 =0.077) for the regression model to fit the data. In this case, because deviations of y_{i0} from its mean almost do not translate into different estimated values for the average annual growth rate (left side of regression equation (1)), y_{i0} has lower explanatory power in support of the absolute beta convergence hypothesis[9].

When including the regional dummies(R1 and R2), used to distinguish 30 provinces into three regional groups mentioned in section, a positive and significant beta is obtained, as with for coefficients corresponding to dummy variables in Reg.2. Besides, the quality of the regression improves considerably, with R^2 growing from 0.077 to 0.356; the t statistic corresponding to the initial per capita product also increases.

When the rates of enrollment in secondary education to regional population(ER) in 1982 are taken in Reg.3, the R^2 grows to 0.363, the t statistics corresponding to these variables are significant. In order to detect random shocks which may be correlated with the initial income levels, thus biasing the beta estimator,

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[7] Sala-I-Martin(1996a, 96b) proves the beta convergence is a necessary but not sufficient condition for the variance of regional income distribution to show a negative trend. For this reason, sigma convergence is used together with beta convergence in "classical approach". Sigma convergence exists when $\sigma(t+1) < \sigma(t)$, $\sigma(t)$ being the standard deviation of a per capita GPP (Gross Provincial Products) between regions at moment t.

[8] The derivatives of the regression equation (1) or (2) with respect to the parameters depend upon parameters, that is, the model of (1) and (2) is nonlinear in parameters. See Green(1997), pp451

[9] It is also necessary to pay attention to the speed of convergence. It is estimated at about 1% per year that means the gap is closed in 70 years if per capita income of richer region is twice as much as that of poorer region.

the fraction of products originating from agricultural and industry in the initial year every region (NY1 and NY2) is added[10] in Reg.4. Just as in most of the "Classical" convergence literature, the estimated beta in Reg. 2 to Reg.4 is around 0.02, which is consistent with the neoclassical "uniformity" (Barro and Sala-I-Martin, 1991,1992, Sala-I-Martin, 1996a,b).

Further more, the influence on speed of conditional convergence, which can related to Non-State Ownership Enterprises(NSOE) output, foreign direct investment, export, local government expenditure and interregional transfer, is estimated by Reg. 5 to Reg. 10. GPP per capita shows tendency for convergence with high level of significance. The shares of NSOE output in GPP, the rate of FDI to GPP, the level of regional export p.c. and interregional transfer(i.e., difference between labor productivity and real wages) are contributing to raise GPP per capita. It is also observed that the rate of local government expenditure to GPP has been playing different roles in the process of regional growth.

The estimation procedure(3) has been tested through with linear least squares regressions, to find whether sigma convergence is existent within and between regional groups or not, focusing directly on the transience or permanence change of regional output differences. As shown in table 3, the existence of sigma convergence is only observed between TARs and NARs with a higher significant level over sub-period of 1978-89 and 1989-97, and the whole period of 1978-97. It is showing a divergence tendency for regions as a whole in the country, due to the performance of LDRs during 1989 to 1997. The null hypothesis of in-existence of sigma convergence can not be rejected for the whole of country during our study period.

Thus, empirical evidence obtained from estimation is in favor of the conditional beta convergence hypothesis and against the absolute beta convergence hypothesis and the sigma convergence hypothesis. Different from the prediction of the neoclassical growth model, by which Barro(1991), Barro and Sala-I-Martin(1991,1992), Sala-I-Martin(1996a, 1996b) hold that relatively homogeneous economies as regions within a country tend to show all three types of convergence, the evidence shows that regional economies do not present absolute beta convergence nor sigma convergence but present convergence with different structural features considered in this paper. The policies with respect to Non-state Ownership Enterprises, Foreign Direct Investment, Export, local government expenditure and inter-regional transfer, which

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[10] It can be observed that Adjusted R^2 rises by adding variables to the model, that means, the contribution of the new variables adds more to the fit of the regression than it is offsetting the correction for the loss of additional degrees of freedom.

are provided with regionally heterogeneous characteristics, are seemly powerful enough to influence economic structure in regions, so as to influence their growth patterns[11].

In order to give a possible explanation about conditional convergence in regional disparity related to the differential structural features among regions, two definitions of convergence proposed by Bernard and Durlauf (1996, pp165) are employed in the next section.

4. The Time Series Test for the Convergence Hypothesis in Regional Development

The first definition is *Convergence as catching up* [12]. The existence of convergence implies that the differences between the levels of per capita output of different economies are expected to decrease in value. The second definition is *Convergence as equality of the long-term forecast at a fixed time*[13]. The long term forecast for these differences tends to zero, as the horizon grows larger. Continuing their analysis, Bernard and Durlauf hold firstly that the existence of convergence according to the later implies the existence of convergence in the sense of the former, but not the reverse, and secondly that the existence of beta convergence, although it is consistent with the former, is compatible with models which violate the later.

Besides, if any shock with indefinitely long effects occurred in some region/regions in the process of development, the differential of per capita output between this region/these regions and any other regions become to contain either a deterministic or unit-root component. In this case, the second definition of convergence is violated. Hence a test consistent with two definitions appears. The non-convergence hypothesis can be evaluated by the existence of unit-root in the series of the differential between the per capita output of related regions and that of the nation. In particular, applying the Augmented Dickey-Fuller test (ADF) to the differences, the non-convergence hypothesis is rejected if the null hypothesis of the existence of unit

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[11] It is observed that interregional transfer, FDI and export are contributing to raise the per capita output in manufacturer sector, and per capita product in service sector in regions of China over 1978 to 1997(see Arayama and An(2000)).

[12] Economies i and j converge between dates t and t+T if the per capita product disparity at t is expected to decrease in value as following: If $y_{i,t} > y_{j,t}$, then $E(y_{i,t+T}-y_{j,t+T} \mid X_t) < y_{i,t}-y_{j,t}$, where X_t denotes all the information available at moment t. See Bernard and Durlauf (1996), pp165.

[13] As $\lim_{k\to\infty} E(y_{i,t+k}-y_{j,t+k} \mid X_t)=0$, economies i and j converge if the long-term forecasts of per capita product for both economies are equal at a fixed time t. Bernard and Durlauf(1996), pp165.

root can be rejected[14].

It is supposed there is an equilibrium differential for each region between its per capita product and that of the nation (in logs). In this way:

$$(y_{it} - y_{.t}) = (y_i^e - y_.^e) + u_{it} \tag{4}$$

where left-side is the differential of per capita product between region i and that of the nation in moment t, right-side is the equilibrium differential with deviations which are formed by a deterministic linear trend and a stochastic process as following.

$$u_{it} = v_{i0} + \beta_i t + v_{it} \tag{5}$$

where v_{i0} is the original deviation of region i with respect to its equilibrium differential. β_i is the speed of convergence and it is possible that the differential economies present different rates of convergence. v_{it} are the deviations with respect to its deterministic trend at moment t. Replacing in:

$$(y_{it} - y_{.t}) = (y_i^e - y_.^e) + v_{i0} + \beta_i t + v_{it} \tag{6}$$

The hypothesis of the existence of beta convergence in the cross-section test implies that if $v_{i0} > 0$, then $\beta_i < 0$, and vice versa, which means that if a region is initially above its equilibrium differential it must later grow less than the nation to return to it, while the opposite must happen if it is initially below its equilibrium differential.

In order for the existence of convergence, these deviations must constitute a stationary stochastic process. Modeling v_{it} as an ARMA(1,0) process:

$$(1 - \rho_i L)v_{it} = e_{it} \tag{7}$$

where L is the lag operator, ρ_i is the coefficient of the lagged v_{it}, and e_{it} is a random shock without autocorrelation. Substituting (7) in (6), and rearranging terms,

$$dy_{it} = a_i + b_i t + \rho_i dy_{i,t-1} + \sum_{m=1}^{k} d_{im} \Delta dy_{i,t-m} + e_{it} \tag{8}$$

$$\begin{aligned} with \quad & dy_{it} = y_{it} - y_{.t} \quad dy_i^e = y_i^e - y_.^e \\ & \Delta dy_{it} = dy_{it} - dy_{it-1} \\ & a_i = (1 - \rho_i)(dy_i^e + v_{i0}) + \rho_i \beta_i \qquad (9) \\ & b_i = (1 - \rho_i)\beta_i \qquad (10) \end{aligned}$$

where a_i, b_i, ρ_i and d_{im} are parameters. The k extra regressors are added in the

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[14] Including the presumption that, if there is a structural change, its date is not known a priori but rather is gleaned from the data, Zivot and Andrews(1992) developed a unit-root testing procedure concerning the dynamic properties of macroeconomic time series. Accordingly, Utrera and Koroch(1998) develops the model that combines the definition of beta convergence in the cross-section test with the elements of time series. The same analytical methods are applied in this paper to develop the empirical model.

preceding regressions to eliminate possible nuisance-parameter dependencies in the limit distributions of the test statistics caused by temporal dependence in the disturbance. The number k of extra regressors is determined by test of the significance of the estimated coefficients d_{im}. Contemplating ARMA(p, q) processes with p and q values larger than 1 and 0 respectively, equation (8) can be used to real per capita gross product for regions in China.

The existence of *convergence as equality of the long-term forecast at a fixed time* implies that dy_{it} is a stationary series with $\rho_i<1$. Otherwise, if $\rho_i=1$, the variance of dy_{it} increases steadily with time and goes to infinity by which the existence of convergence is rejected, and if $\rho_i>1$, the series is. Therefore, the hypothesis of convergence (in the sense of definition 2) can be evaluated by testing whether the absolute value of ρ_i is strictly less than one. The ADF test takes the unit root as the null hypothesis: $\rho_i=1$. Since explosive series do not make much economic sense, this null hypothesis is tested against the one-sided alternative: $\rho_i<1$. The test is carried out by estimating an equation with dy_{it-1} subtracted from both sides of the equation(8):

$$\Delta dy_{it} = a_i + b_i t + c_i dy_{i,t-1} + \sum_{m=1}^{k} d_{im}\Delta dy_{i,t-m} + e_{it} \tag{11}$$

$$with \quad c_i = -(1-\rho_i) \tag{12}$$

where the null and alternative hypotheses are $c_i=0$ and $c_i<0$. If alternative hypothesis is accepted, $\{dy_{it}\}$ is illustrated as a stationary series, the existence of convergence can not be rejected. If null hypothesis is accepted, $\{dy_{it}\}$ is a nonstationary series. In other words, if the process is started at some point, the variance of $\{dy_{it}\}$ increases steadily with time and goes to infinity.

In table 4, it presents that the unit-root hypothesis can be rejected in ten cases at a significance level of 5% or less, and two cases at 10%. They are Beijing(5%), Tianjin(10%) and Snanghai(1%) belonging to TARs group, Zhejiang(5%), Fujian(5%), Shandong(10%) and Guangdong(1%) belonging to NARs group, and Heilongjiang(5%), Anhui(5%), Guangxi(5%), Sichuan(5%) and Shanxi(1%) belonging to LDRs group. Hence, the non-convergence hypothesis can be rejected for regions mentioned above.

These findings are consistent with the previous results on existence of convergence, including regional dummy variables in which the members of TARs group and NARs group are distinguished from the members of LDRs group in former section. Actually, the existence of unit root in the most regions of TARs and NARs (that is, 3 of 4 regions in TARs, 4 of 5 regions in NARs) is rejected by the Augment

Dickey-Fuller test.

These findings provide one possible explanation for the reason why only the conditional convergence of regional disparity can be observed in China, after her introducing the open-market policies. Although a convergence trend among some regions (most of them belong to TARs and NARs) is observed, for national framework non-convergence can not be rejected, with our unit root in the series of output differences in other 18 regions (in which 16 regions belong to LDRs). It is clear that these regions have contributed to the "divergence" of the regional disparity in economic growth.

5. Conclusions

In this paper, I develop a way to divide 30 sample-provinces into three groups, named Traditional Developed Regions group (TARs), New Developed Regions group (NARs), and Less Developed Regions group (LDRs). This partition is motivated by the fact that regions in each group have some degree of homogeneity, i.e., initial income level, the pace of growth, the regional pattern of convergence, over 1978 to 1997. The TARs group with the highest income levels has shown a lower annual growth rate comparing with the national level over time. The NARs group has registered the fastest growth and achieved the second-highest level of income at the end of study period. LDRs have the lowest income level, which is not very different from that of TARs 20 years ago.

The results of "classical" test to convergence hypothesis across 30 provinces of China show that regions do not present neither absolute beta convergence nor sigma convergence but do present conditional convergence. The empirical evidence illustrated the impact of policies, with respect to Non-state Ownership Enterprises, Foreign Direct Investment, Export, local government expenditure and inter-regional transfer as factors influencing economic performance of regions with regionally heterogeneous characteristics.

The existence of conditional convergence can be explained by the non-convergence trend of the LDRs group. The empirical analysis for the existence of unit-roots in deterministic trend constitutes evidence against the existence of convergence in 18 provinces, of which 16 provinces belong to LDRs group. It is indicated the growth performance of LDRs group contributed to the "divergence" with respect to the country as a whole. In conclusion, we may say there was a good deal of "catch-up" between TARs and NARs within a national framework of "divergence", due

to the growth performance in LDRs over time.

There are some further tasks that should be done in this area of investigation for the case of China. The power of our test in favor of the regional structural change is probably low for the small size of the time series used in this paper.

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Table 1 Economic Growth and Regional Disparity in China from 1978 to 2000

	real GPP p.c.(yuan)		Growth Rate(%)			Regional Disparity Index	
	1978	2000	1978-89	89-2000	78-2000	1978	2000
National level	1258	7063	7.9	9.2	8.2	100	100
Beijing	3564 (2)	17936 (2)	7.3	8.8	7.6 (22)	283	254
Tianjin	3121 (3)	16377 (3)	6.3	10.3	7.8 (19)	248	232
Liaoning	2191 (4)	11017 (8)	7.5	8.5	7.6 (23)	174	156
Shanghai	5545 (1)	27187 (1)	6.4	9.6	7.5 (24)	441	385
Jiangsu	1126 (12)	11539 (5)	10.5	13.1	11.2 (3)	89	163
Zhejiang	1058 (15)	12906 (4)	11.3	14.2	12.0 (1)	84	183
Fujian	1029 (18)	11294 (6)	10.2	14.2	11.5 (2)	82	160
Shandong	1045 (16)	9409 (9)	9.1	13.2	10.5 (5)	83	133
Guangdong	1148 (8)	11181 (7)	11.1	11.8	10.9 (4)	91	158
Hebei	1136 (10)	7546 (11)	7.2	11.9	9.0 (10)	90	107
Shanxi	1072 (14)	4986 (21)	6.9	8.3	7.2 (25)	85	71
Inner Mongoliar	989 (20)	5897 (16)	8.5	9.3	8.5 (12)	79	83
Jilin	1131 (11)	6676 (14)	8.4	9.3	8.4 (13)	90	95
Heilongjiang	2108 (5)	8818 (10)	5.8	8.5	6.7 (28)	168	125
Anhui	701 (29)	5076 (20)	8.4	11.5	9.4 (6)	56	72
Jiangxi	738 (28)	4838 (23)	7.8	11.1	8.9 (11)	59	69
Henan	778 (27)	5551 (18)	8.7	11.0	9.3 (7)	62	79
Hubei	1034 (17)	7094 (12)	8.5	10.9	9.1 (9)	82	100
Hunan	1080 (13)	5733 (17)	6.6	10.2	7.9 (18)	86	81
Guangxi	883 (22)	4567 (26)	5.2	11.4	7.8 (20)	70	65
Hainan	953 (21)	6588 (15)	8.2	11.3	9.2 (8)	76	93
Sichuan	847 (24)	4904 (22)	7.6	10.0	8.3 (14)	67	69
Guizhou	560 (30)	2819 (30)	8.0	8.0	7.6 (21)	44	40
Yunnan	852 (23)	4559 (27)	8.2	8.4	7.9 (17)	68	65
Tibet	1018 (19)	4483 (28)	5.8	9.0	7.0 (27)	81	63
Shannxi	838 (25)	4607 (25)	8.7	8.1	8.1 (16)	67	65
Gansu	828 (26)	3838 (29)	6.9	8.3	7.2 (26)	66	54
Qinghai	1555 (6)	5089 (19)	4.9	6.8	5.5 (30)	124	72
Ningxia	1140 (9)	4725 (24)	7.3	6.7	6.7 (29)	91	67
Xinjiang	1271 (7)	7088 (13)	9.1	7.9	8.1 (15)	101	100

Data source: Statistical Resources

Note: 1. Real GPP p.c. presents the real per capita Gross Provincial Product in 2000 prices.

2. Regional Disparity Index is the ratio of real GPP p.c. to real GDP p.c..

3. The number in high-low order of 30 provinces is provided in paretheses.

Table 2 Results of the Cross-setion Regressions of Beta Convergence

	β	R1	R2	ER	NY1	NY2	SNSOE	SFDI	LEX	SFE	TR	R^2	ADJ. R^2	S. E.
Reg. 1	0.014 ***											0.077	0.076	0.022
	(9.48)													
Reg. 2	0.020 ***	0.020 ***	0.031 ***									0.356	0.352	0.018
	(15.26)	(7.48)	(14.98)											
Reg. 3	0.021 ***	0.014 ***	0.032 ***	0.032 ***								0.363	0.359	0.018
	(15.89)	(3.56)	(15.18)	(2.61)										
Reg. 4	0.019 ***	0.021 ***	0.035 ***	0.102 ***	0.088 ***	−0.006						0.439	0.433	0.017
	(14.38)	(5.72)	(17.25)	(6.82)	(3.86)	(−0.25)								
Reg. 5	0.018 ***						0.002 ***					0.312	0.309	0.019
	(15.52)						(13.98)							
Reg. 6	0.018 ***							0.002 ***				0.188	0.186	0.02
	(13.81)							(8.34)						
Reg. 7	0.023 ***								0.009 ***			0.289	0.286	0.019
	(19.19)								(13.29)					
Reg. 8	0.015 ***									−0.001 ***		0.138	0.135	0.021
	(10.59)									(−6.33)				
Reg. 9	0.022 ***										0.019 ***	0.175	0.172	0.021
	(15.91)										(8.23)			
Reg.10	0.024 ***						0.001 ***	0.001 **	0.001	−0.0002	0.009 ***	0.433	0.427	0.017
	(21.00)						(5.65)	(2.23)	(0.88)	(−1.12)	(3.11)			

Note:

1. The results were obtained estimating, Regression 1 for absolute β convergence and Regressions 2-10 for conditional β convergence,by means of Non-linear Least Squares.
2. R1and R2 are used for differentiating three regional groups from each other as showing as R1=1, R2=0 for TARs, R1=0, R2=1 for NARs, and R1=R2=0 for LDRs.
3. ER is the rate of enrolment in secondary education to regional population in 1982.
4. NY1 and NY2 are the fraction of products originating from Agriculture and Industry respectively in 1978.
5. SNSOE is the anuual average fraction of products originating from Non-state ownership enterprises over 1978 to 1997.
6. SFDI presents the average rate of Foreign Direct Investment to Real Gross Provincial Product annually from 1990 to 1997.
7 LEX is denoted for the annual average of regional exports p. c. in logs from 1992 to 1997.
8. SFE is the annual average rate of local government expenditure to GPP over 1978-1997.
9. TR is the average differential between labor productivity and wage(in logs) of 30 provinces from 78 to 90 in order to present the inter-region income tranfer.
10. Tibet is not included in regression 8 for no available data of SFDI in it.
11. t statistic is provided in parentheses under each estimated parameter. Significant level is indicated by ***=1%,**=5%, and *=10%.

Table 3 Regression of standard variance inter–region to time trend

	78–97			78–89			89–97		
	trend	t st.	R^2	trend	t st.	R^2	trend	t st.	R^2
TARs[1] + NARs[2]	−0.016	−45.0 ***	0.991	−0.016	−24.2 ***	0.983	−0.017	−13.8 ***	0.965
NARs + LDRs[3]	0.008	10.2 ***	0.853	0.003	4.0 ***	0.611	0.014	12.7 ***	0.959
national scale	0.001	1.6	0.124	−0.003	−4.6 ***	0.678	0.006	8.9 ***	0.919

Note:

1. TARs (Traditional Advanced Regions) group inculding Beijing, Tianjin, Liaoning and Shanghai.
2. NARs (New Advanced Regions) group including Jiangsu, Zhejiang, Fujian, Shandong and Guangdong.
3. LDRs (Less Developed Regions) group including Hebei and Hainan in Eastern of China, Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui,Jiangxi, Henan, Hubei, Hunan and Guangxi in central, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang in western.
4. Significant level at: *=10%, **=5%, ***=1%

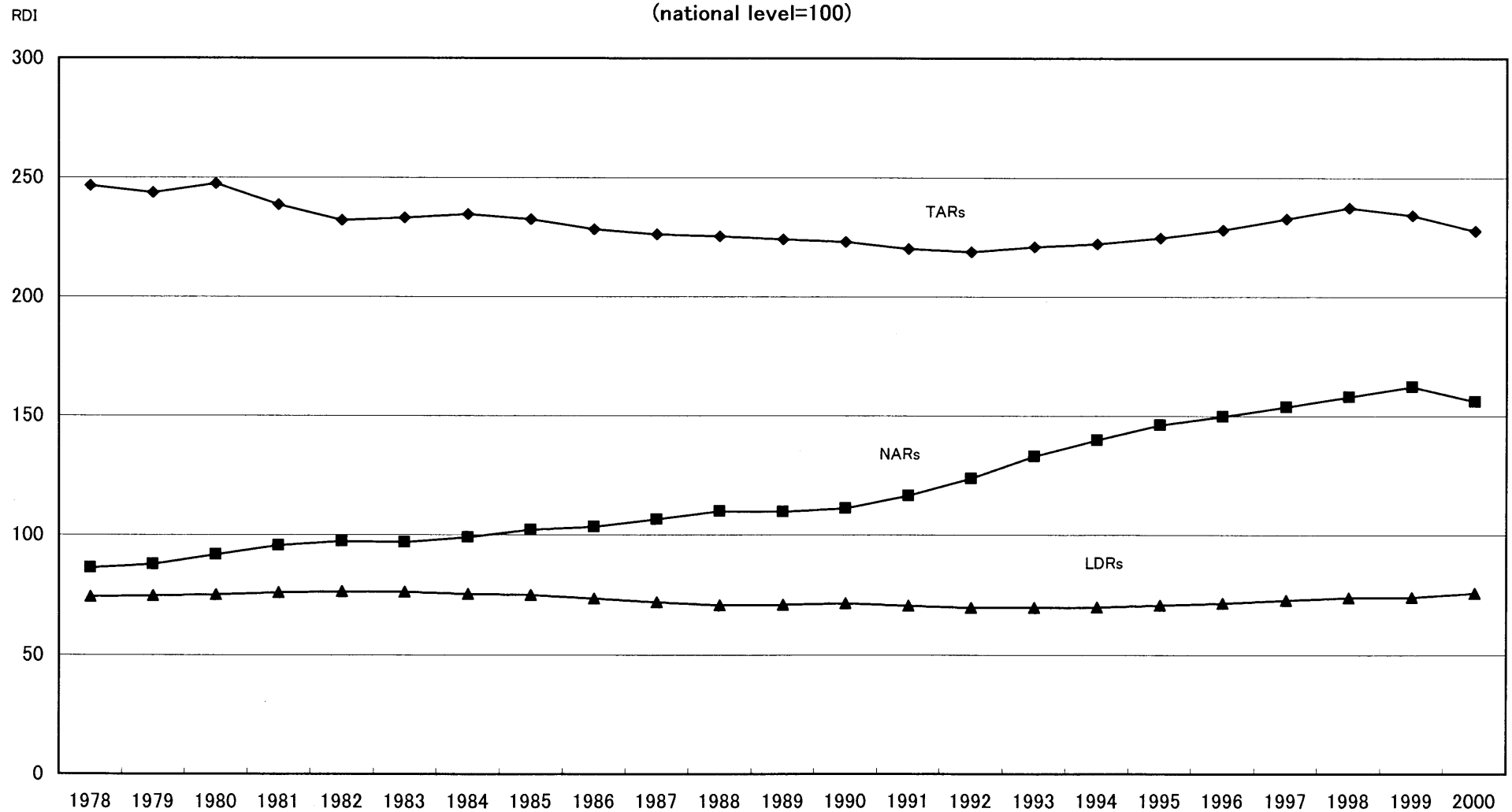
Table 4 Results of the ADF test for regional convergence in China case[1]

Province[2]	k[3]	Constant	t st.	Trend	t st.	$dy_{(i,t-1)}$	t st.
TARs group							
Beijing	1	1.303	3.7	-0.007	-3.1	-1.073	-3.73 **[4]
Tianjin	6	1.153	3.2	-0.01	-1.8	-0.988	-3.47 *
Liaoning	3	0.2	1.8	-0.002	-2.7	-0.346	-1.65
Shanghai	7	5.884	5.14	-0.021	-3.2	-3.123	-5.25 ***
NARs group							
Jiangsu	6	0.046	1.1	-0.059	-0.9	2.746	0.96
Zhejiang	7	-0.727	-4.1	0.115	4.3	-3.786	-4.16 **
Fujian	1	-0.006	-0.35	0.003	2.3	-1	-4.34 **
Shandong	7	-1.04	-3.6	0.062	3.8	-3.85	-3.55 *
Guangdong	7	-0.243	-12	0.035	12.5	-0.967	-20.57 ***
LDRs group							
Hebei	5	-0.101	-3	0.015	3.8	0.468	2.26
Shanxi	0	-0.004	-0.2	-0.005	-1.8	-0.442	-2.12
Inner Mongolia	0	-0.022	-0.9	-0.001	-1	-0.293	-1.8
Jilin	0	0.007	0.4	0.001	0.8	-0.575	-2.54
Heilongjiang	1	0.288	4.1	-0.015	-4.1	-0.677	-4.3 **
Anhui	5	-0.588	-4.9	-0.001	-0.4	-1.557	-4.78 **
Jiangxi	7	-0.04	-0.8	0.026	5.8	0.955	4.08
Henan	4	-0.478	-2.6	0.003	1.3	-1.117	-2.48
Hubei	7	0.098	-5.6	0.004	3	-0.856	-3.26
Hunan	6	-0.066	-0.8	0.005	0.8	0.028	0.07
Guangxi	5	-0.47	-4.7	-0.002	-0.7	-0.761	-4.32 **
Hainan	1	-0.146	-2	-0.11	1.9	-0.486	-2.55
Sichuan	1	-0.382	-4.2	-0.003	-2.4	-1.111	-4.09 **
Guizhou	6	-0.228	-1.5	-0.026	-2.8	-0.641	-2.78
Yunnan	1	-0.297	-2.9	-0.001	-0.8	-0.586	-3.09
Tibet	5	0.167	0.7	-0.022	-0.9	-0.783	-1.32
Shaanxi	7	-1.176	-6.1	-0.007	-3	-4.34	-6.28 ***
Gansu	7	-0.226	-1.9	-0.008	-2.6	-1.454	-2.76
Qinghai	2	0.041	1.4	-0.011	-2.1	-0.374	-2.16
Ningxia	0	-0.013	-0.8	-0.004	-1.5	-0.304	-1.7
Xingjiang	0	-9.1E-05	-0.004	-0.001	-0.5	-0.169	-1.06

Note:

1. The results were obtained by completing Augmented Dickey-Fuller test. The investaged variable is differential of real gross per capita product(in logs) between GPPp.c. and GDPp.c. over 1978-97.
2. Results of the ADF test consist of regional time series for the period 1978-97 and includes 30 provinces.
3. K, the number of lags in the ADF test, was chosen following Perron(1989,1990) and Zivot and Andrews (1992) procedure (I set the number of it starting from a maximum of 7).
4. Mackinnon critical value for rejection of hypothesis of a unit root: *=10%, **=5%, ***=1%

Figure 1 Evolution of RDI in each gourp from 1978 to 2000
(national level=100)



Note: RDI, the Regional Disparity Index, is the ratio of real per capita gross product of each group to that of nation.

Figure 2 Evolution of the Standard Deviation Distribution of GPP p.c. in logs within a two-group scope