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THE CYCLICAL BEHAVIOUR OF REGIONAL GROWTH RATES IN CHINA

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ABSTRACT: Chinese economic growth has been rapid and sustained over the past two decades but has varied significantly across regions. We analyse economic growth disparities at the provincial level using combined time-series and cross-section data within a framework first used by Thirlwall in 1966 for the analysis of unemployment rate disparities in the UK. We find considerable differences in the sensitivity of provincial growth rates to fluctuations in the national growth rate, with the most sensitive provinces generally having the highest average growth rates. Thus continued increases in the national rate will exacerbate disparities. We find that industrial structure has little explanatory power for sensitivities and experiment with various measures of geography and policy. We find that a simple coastal dummy variable has the greatest explanatory power, eclipsing the policy variable. We use our analysis to predict that an increase in the national growth rate to double-digit levels will considerably worsen the dispersion of growth rates across the provinces.

1. INTRODUCTION

China's economic growth over the past half-century has been the subject of world-wide interest and, particularly since the "opening-up" of China in the late 1970s, has been nothing short of spectacular, averaging just under 10 percent per annum over a 20-year period. This is important first of all because, as Wu (2004) points out, it has meant that a fifth of the world's population has largely climbed out of poverty. However, there is concern that this rapid growth has not been evenly spread across the country. Indeed, there is considerable evidence that many of the reforms following the change in direction in 1978 have boosted growth at the expense of widening regional inequalities.

Concern with the spatial distribution of economic activity is not new for China's policy makers. Much of economic policy in the pre-reform period was carried out in the framework of five-year plans which gave explicit attention to the regional distribution of resources. Thus the Third and Fourth Five-Year

Plans (1966-70 and 1971-75) explicitly shifted resources to the central and western provinces although, in contrast to the basis for most modern regional policy, the motivation was heavily influenced by national security considerations.

Subsequent Plans shifted emphasis back to coastal development but even then the regional distribution of activity was still of major concern. Thus the Sixth and Seventh Five-Year Plans (1981-85 and 1986-90) incorporated the notion of unbalanced development, exploiting the natural advantages of the coastal provinces but expecting that, in time, the rest of the country would follow as higher growth spilled over into neighbouring provinces.

More recently, following concern at the apparent failure of the higher coastal growth to spill over into the rest of the country (at least, to a sufficient extent), there has been a shift back to explicit aid for the western provinces in particular – the Great Western Experiment was announced in 1999 during the currency of the Ninth Five-Year Plan (1996-2000) in which there was to be substantial assistance to western provinces. The motivation for this shift was clearly the failure of regional disparities to contract with implications for social stability as well as the growing awareness of the ecological problems arising from heavy industrialisation of the western provinces in earlier years and the importance of western resources to the industrial activity in the east.

In contrast to the long history of policy concern about the spatial distribution of prosperity in China, academic analysis of regional disparities has been a relatively recent phenomenon and has largely awaited the availability of data in the late 1990s. Since then there has been a rapidly expanding empirical literature examining the characteristics of the impressive and sustained growth of the Chinese economy in general and of its regional distribution in particular.

Empirical research has proceeded in various ways. Some papers have been largely descriptive and have focussed on regional disparities as such. They have examined different measures of economic activity and prosperity such as GDP, consumption and income. They have assessed the sensitivity of measured inequality to different measures of the dispersion of economic activity such as the standard deviation, the weighted standard deviation, the coefficient of variation, the Gini coefficient and Theil's measure of inequality. Most importantly, they have addressed the issue of whether disparities have increased or decreased over time. Early papers are by Lyons (1991) and Tsui (1991, 1993) and more recent examples are Kanbur and Zhang (1999), Fujita and Hu (2001) and Lu and Wang (2002).

Not surprisingly, the majority of papers on regional dispersion have been motivated from the point of view that disparities exist and that they are more than transitory and have, therefore, asked what are the factors that determine the disparities and will these factors result in a decrease in the observed disparities over time or otherwise? Much of this analysis has been cast in the framework of the "convergence debate".[1] The overwhelming conclusion of this body of

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[1] The convergence debate was originally concerned with the explanation of the differences in growth rates between countries. See Kuznets (1955) and Williamson

empirical work is that provincial GDP per capita (the most commonly used variable) is converging to a steady state level but the steady state differs across provinces (i.e., conditional rather than absolute convergence).

A large number of different conditioning variables have been found significant in the case of China. They include ones traditionally used in the convergence literature in general such as physical investment, human capital investment, foreign direct investment, employment growth (Chen and Fleisher, 1996), technical progress (Fleisher and Chen, 1997), trade variables (Yao and Zhang, 2001a), infrastructure (Demurger, 2001). Other variables are more specific to China's economy such as the interaction between urban/rural and provincial disparities (Kanbur and Zhang, 1999, Chang, 2002, Lu, 2002), barriers to labour migration which have been particularly strong in China's recent history (Lu, 2002, Cai, Wang and Du, 2002), region-biased policy (Yang, 2002, Demurger, Sachs, Woo, Bao, Chang and Mellinger, 2002, and Demurger, Sachs, Woo, Bao and Chang, 2002) and geography – some form of coastal/non-coastal dummy variable has been used by many authors and geography has received specific attention in such recent papers as Yao and Zhang (2001b), Bao, Chang, Sachs and Woo (2002), Demurger, Sachs, Woo, Bao, Chang and Mellinger (2002) and Demurger, Sachs, Woo, Bao and Chang (2002). In summary, therefore, it appears that the observed disparities are likely to be a long-term feature of the Chinese economy.

The analysis of regional dispersion within the growth convergence literature has, however, all been concerned with the long-run behaviour of disparities which is doubtless an important issue both from a research perspective as well as from a policy point of view. However, there are also short-term fluctuations in relative growth rates as shown in Figure 1 which pictures the dispersion of provincial growth rates of real GDP as measured by a weighted standard deviation over the period 1979-2001.

Whatever might be the implications of Figure 1 for secular trends in disparities, there are clearly also substantial fluctuations about trend which are not the focus of growth models. Moreover, as Figure 2 clearly shows, much of the short-term movement in our measure of dispersion is closely related to the business cycle as measured by the annual rate of national GDP growth – the correlation coefficient between the two series is approximately 0.5.

In contrast to the convergence/growth literature, this paper focuses on the cyclical behaviour of provincial growth rates and does so within a framework originally set out by Thirlwall (1966) in his explanation of the dispersion of regional unemployment rates in the UK. He examined the relationship between unemployment rates at the regional and national levels and found that on average the regions with the highest unemployment rates also had unemployment rates which showed the greatest sensitivity to fluctuations in the national

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(1965) for early work and by Barro and Sala-i-Martin (1992) for the paper which coined the "convergence" term. More recently tests of convergence have been applied to regional data sets, including China. Islam(2003) provides a recent survey of the convergence literature in general and Liu and Wei (2003) contains a review which focuses on Chinese evidence.

unemployment rate. Thus the unemployment rate disparities fluctuated systematically with the cycle as measured by changes in the national rate. He went on to investigate whether regions had sensitive unemployment rates because they were over-endowed with industries which were sensitive to national fluctuations.

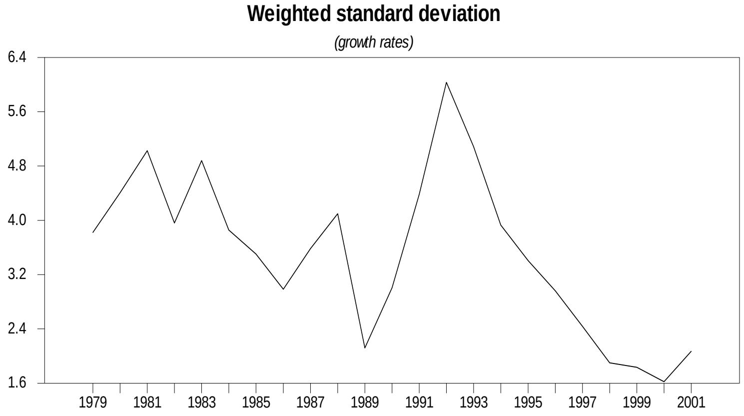

Figure 1. Dispersion of provincial growth rates.

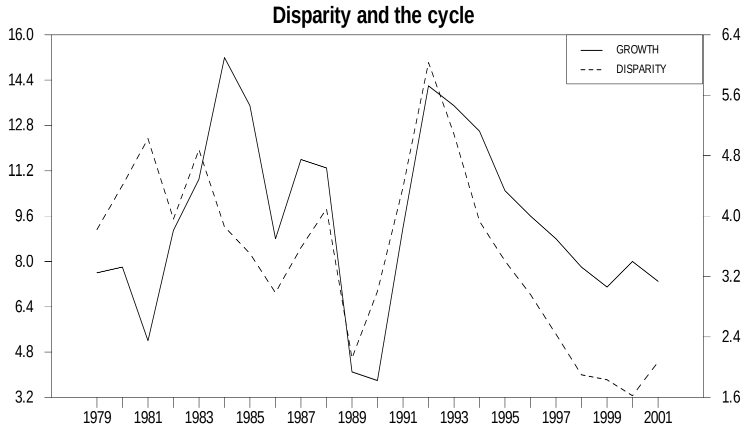

Figure 2. Dispersion of provincial growth rates and the national growth rate.

We apply his framework to regional (provincial) growth rates and also find systematic differences in the sensitivity of different regions to fluctuations in the national growth rate with the high-growth provinces being the most sensitive to fluctuations in the national growth rate. We find we can explain a substantial part of the variation in the dispersion of growth rates over the sample period. We also go on to investigate industry structure, geography and policy as possible explanations of regional sensitivity and find, like many of the convergence studies, that a coastal/non-coastal dummy variable is the dominant factor, eclipsing the policy variable in contrast to the results of Demurger *et al.* (2002). In an application of our regression results we predict the effect on dispersion of various rates of national economic growth.

The structure of the remainder of this paper is as follows. In the next section we set out the framework for our empirical work, followed in section 3 by a description of the data used. Our results are reported in section 4 and conclusions are drawn in section 5.

2. EMPIRICAL FRAMEWORK

The framework that we use for the examination of regional growth disparities is one proposed by Thirlwall (1966) and originally applied to the question of regional unemployment rate disparities. He addressed the policy issue of why it was that the dispersion of regional unemployment rates in the UK had failed to narrow even in the face of concerted government policies to reduce disparities. He analysed the issue by estimating the sensitivity of each region's unemployment rate to fluctuations in the national unemployment rate. The sensitivity for each region was estimated as the slope coefficient in a regression of the regional unemployment rate on the national unemployment rate.

He found that the regions with the highest rates also had the greatest sensitivities so that a rise in the national rate, as happened over most of his sample period, resulted in the observed widening of disparities, offsetting the possible effects of policy initiatives that the government undertook to reduce the disparities. He went on to attempt an explanation of the differences in regional sensitivities in terms of industry structure; he tested whether regions with highly sensitive unemployment rates also had a greater than average share of industries whose unemployment rate was very sensitive to fluctuations in the national unemployment rate. This attempt was only partly successful.

Subsequent literature extended and refined his analysis but retained his framework – see, e.g., Brechling (1967), Harris and Thirlwall (1968), Elias (1978, 1979, 1980), Gordon (1979, 1980, 1985), Bell (1981), Forrest and Naisbitt (1988), Byers (1990), Chapman (1991), Groenewold (1991), Martin (1997), Debelle and Vickery (1998, 1999), Dixon and Shepherd (2001) and Dixon, Shepherd and Thompson (2001).

We build on this literature and proceed as follows. We begin by investigating the relationship between each province's growth rate and the national growth rate by estimating the following equation for each province:

$$gr_{it} = \alpha_i + \beta_i gr_t + \varepsilon_{it}, \qquad t=1,2,\ldots,T \qquad (1)$$

for each i=1,2,…,N, where T is the length of the time-series data and N is the number of provinces. We find that sensitivities to national growth fluctuations (the estimated β_is) differ across provinces and that these differences are closely related to average growth rates, with the fastest-growing provinces being most sensitive to national fluctuations. An important implication of this is that, *ceteris paribus*, only a slowdown in aggregate growth will result in a narrowing of the regional growth disparities while an acceleration of national growth will exacerbate the dispersion of regional growth rates.

We go on to investigate the source of cross-province differences in sensitivities, starting where Thirlwall also started – by analysing the sensitivity of national industries and combining this with differences in industry structure across provinces. We do this by estimating βs for industries rather than provinces and computing a hypothetical β for each province by weighting industry βs by each province's industry output share. We then compare these hypothetical βs to those estimated from equation (1); they should be strongly correlated if provincial βs differ mainly because of the different shares of industries with different sensitivities. This approach meets with only limited success so that we proceed to consider alternative explanations that are closely related to the conditional convergence literature. In particular, we explore the explanation of the estimated βs using variables capturing geography and policy:

$$\hat{\beta}_i = \gamma_0 + \gamma_1 geog_i + \gamma_2 policy_i + \eta_i, \qquad i=1,2,\ldots,N \qquad (2)$$

where *geog* is the geography variable and *policy* is a dummy variable which captures regional policy.

We examine these relationships both within Thirlwall's two-step framework as well as extending the method to a more satisfactory simultaneous approach which treats the data as a panel and allows for tests of the cross-equation constraints imposed by the model. To derive the simultaneous system we substitute for β_i in equation (1) to obtain:

$$gr_{it} = \alpha_i + \beta_i gr_t + \varepsilon_{it} = \alpha_i + (\gamma_0 + \gamma_1 geog_i + \gamma_2 policy_i) gr_t + \varepsilon_{it}$$

so that:

$$gr_{it} = \alpha_i + \gamma_0 gr_t + \gamma_1 geog_i . gr_t + \gamma_2 policy_i . gr_t + \varepsilon_{it}, \quad i=1,2,\ldots,N \text{ and } t=1,2,\ldots,T \qquad (3)$$

Thus we add to equation (1) interaction terms between aggregate growth and the two variables (*geog* and *policy*) which we use to explain the βs. We need to estimate this system simultaneously so that the cross-equation restrictions that the γ coefficients are the same across all equations can be imposed. The simultaneous approach also has the advantage that the restrictions can be tested using a straightforward likelihood-ratio test.

3. DATA

The data used for growth rates are:

- gr_{it} = the gross real GDP growth rate of province *i* from year *t-1* to year *t*.
- gr_t = the gross real GDP growth rate of the nation from year *t-1* to

year *t*.

The data for 1978-1998 are from *Comprehensive Statistics Data and Materials on 50 Year of New China* (Zhongguo Tongji Chuban She (China's Statistical Press), Beijing, 1999). Data for the period 1999-2001 were taken from *China Statistical Yearbook, 2002* (Zhongguo Tongji Chuban She (China's Statistical Press), Beijing).

The data for industry output disaggregated by province used to compute the hypothetical βs were obtained from the same sources.

We experimented with several measures of geography: distance from the coast (two measures), a simple coast dummy, the length of the coastline and a measure of the population living within 100km of the coast. The variables are as follows:

- Distance1: Samuelon's iceberg transformation of distance = 1/(1+d) where d denotes the railway distance from the capital of each province to the nearest seaport.
- Distance2: as for distance1 but here d is the distance from the geocenter of each province to the nearest coastline.
- Coast: a dummy variable which equals 1 for coastal provinces (Beijing, Tianjin, Hebei, Hainan, Guangdong, Shandong, Fujian, Zhejiang, Jiangsu, Shanghai, Liaoning, Guangxi) and zero otherwise.
- Coastline: the length of the continental coastline, excluding coastline above the winter extent of sea ice, of each province.
- Population: the proportion of the population of a province in 1994 within 100 km of the coastline or ocean-navigable river, excluding coastline above the winter extent of sea ice and the rivers that flow to this coastline.
- Policy: a preferential policy index for each province. The construction of the variable is based on the number of designated open economic zones in a province and the extent of the preferential treatment. The variable is restricted to purely open door preferential policies and does not take into account of other factors. Source: Demurger *et al.* (2002)

The data for distance1 were calculated on the basis of information obtained from *21 Shi Ji Zhong Guo Ditu Ce* (Haerbing Ditu Chu Ban She, Haerbing, 2000). The distance2, coastline and population variables are as defined in Bao *et al.* (2002) and the data for them were kindly provided by Professor Bao.

4. RESULTS

As stated in the second section of the paper, we begin by applying the method which Thirlwall (1966) used to analyse regional unemployment rates to regional growth rates. The framework is very simple and begins by estimating (using OLS) equation (1) using time series data – in our case annual data for the period 1978-2001. The results are reported in Table 1.

The results show that, with some exceptions, the equations achieve a reasonable degree of explanatory power, given that the dependent variable is a growth rate. The intercepts are mostly insignificant but the slope coefficients are generally highly significant – only for two provinces are the t-ratios below 2: for Heilongjiang the slope coefficient is significant only at the 10 percent level while for Tibet it is not significant at any reasonable level of significance. There is a considerable variation in the estimated slope coefficients; ignoring the estimates of low significance they vary from a high of 1.467 for the coastal province of Zhejiang to a low of 0.504 for China's far north-western province of Xinjiang.

Table 1. Growth Rate Sensitivities by Province

Province	$\hat{\alpha}_i$	$\hat{\beta}_i$	R^2	DW	gr$_i$
Beijing	1.932	0.855	0.474	1.9	10.02
	(0.991)	(4.354)			
Tianjin	1.987	0.806	0.367	0.871	9.61
	(0.866)	(3.49)			
Hebei	0.017	1.101	0.632	0.725	10.43
	(0.01)	(6.227)			
Hainan	-0.875	1.293	0.295	1.362	11.35
	(0.179)	(2.54)			
Gangdong	3.178	1.095	0.532	1.057	13.53
	(1.427)	(4.887)			
Shandong	0.531	1.182	0.721	1.395	11.71
	(0.333)	(7.359)			
Fujian	2.881	1.092	0.416	1.325	13.2
	(1.027)	(3.864)			
Zhejiang	-0.682	1.467	0.648	1.178	13.19
	(0.291)	(6.219)			
Jiangsu	-0.889	1.406	0.695	2.627	12.41
	(0.440)	(6.917)			
Shanghai	1.687	0.842	0.516	0.506	9.66
	(0.955)	(4.733)			
Niaoning	-3.029	1.252	0.755	1.542	8.03
	(-1.960)	(8.042)			
Guangxi	2.692	0.683	0.256	0.947	9.15
	(1.066)	(2.685)			
Sichuan	2.586	0.694	0.608	1.493	9.15
	(2.143)	(5.709)			
Guizhou	3.145	0.620	0.299	1.633	9.01
	(1.528)	(2.991)			
Yunnan	2.982	0.684	0.390	1.899	9.45
	(1.609)	(3.662)			
Tibet	8.077	0.133	0.002	1.654	9.33
	(1.367)	(0.223)			
Shaanxi	0.219	0.971	0.519	1.877	9.4
	(0.108)	(4.765)			
Gansu	0.334	0.905	0.347	1.925	8.9
	(0.124)	(3.344)			
Qinghai	0.880	0.708	0.166	2.264	7.57
	(0.256)	(2.042)			

Table 1 (continued)

Province	$\hat{\alpha}_i$	$\hat{\beta}_i$	R^2	DW	gr_i
Ningxia	2.341 (1.245)	0.707 (3.732)	0.399	1.424	9.03
Xinjiang	5.509 (3.296)	0.504 (2.996)	0.299	1.406	10.27
Shanxi	-0.191 (0.75)	0.954 (3.712)	0.396	1.817	8.83
Inner Mongolia	3.510 (1.527)	0.668 (2.887)	0.284	1.982	9.83
Jilin	-0.766 (0.280)	1.106 (4.01)	0.434	2.047	9.69
Heilongjiang	5.136 (3.592)	0.263 (1.825)	0.137	1.543	7.62
Anhui	0.223 (0.0637)	1.107 (3.099)	0.314	1.89	10.69
Jiangxi	1.491 (0.780)	0.925 (4.802)	0.523	1.539	10.24
Henan	1.298 (0.498)	0.950 (3.622)	0.384	2.929	10.28
Hubei	1.173 (0.527)	0.991 (4.422)	0.482	1.652	10.55
Hunan	2.953 (2.563)	0.640 (5.514)	0.591	1.037	9.00

Note: Figures in parentheses are t-ratios (absolute values), gr_i is the average growth rate for province i over the sample period. Chongqing is not included in the table because of the unavailability of consistent data for the entire sample period.

The Durbin-Watson statistics show that for some provinces the error term is autocorrelated which makes inference based on the reported standard errors invalid. We re-estimated the equations with an AR(1) correction but inferences were unaltered; we therefore do not report these adjusted estimates and proceed with the coefficients reported in Table 1. The final column of the table reports each province's average growth rate over the sample.

The provinces in Table 1 are ordered so that, roughly, the first group are coastal and include the three cities of Beijing, Tianjin and Shanghai, followed by the western provinces and finally the central provinces.[2] The first group, the coastal provinces, all have sensitivities greater than 1 with the exception of Guangxi and the striking exception of all three cities which have β estimates well below 1. Thus the coastal provinces (except Guangxi) have growth rates which

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[2] To be precise, the members of the coastal region are: Beijing, Tianjin, Hebei, Hainan, Guangdong, Shandong, Fujian, Zhejiang, Jiangsu, Shanghai, Liaoning and Guangxi; the members of the western region are: Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang; the members of the central region are: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan.

fluctuate more widely than does the national rate while the cities have distinctly smaller fluctuations. The western provinces, on the other hand, have sensitivities all less than 1 indicating that their growth rates fluctuate less than the national rate. Finally, the position of the central provinces is between the other two groups, with only Jilin and Anhui provinces having a growth rate which fluctuates at least as much as the national average.

If we pursue Thirlwall's approach, we can examine the relationship between the average growth rates over the sample and the sensitivities. Casual observation suggests that the coastal provinces have grown the fastest over the period and that they are also the most sensitive to national growth rate fluctuations. This is borne out by the correlation coefficient between the estimated βs and the average growth rates which is 0.67 indicating a strong positive relationship. It is interesting that if we omit the three cities which have low sensitivities but have grown relatively rapidly, the correlation increases to 0.84, as expected. The implication of this for future disparities is that the dispersion will tend to grow if the national growth rate increases while the dispersion will tend to be compressed if the national growth rate falls, a conclusion similar to that reached by Thirlwall for unemployment rates for UK regions and used by him to explain the seeming intractability of regional unemployment disparities over his sample period.

It is therefore of interest to look behind the sensitivities and we start by continuing to follow Thirlwall's lead and examine the hypothesis that a province has a high sensitivity because it has a high concentration of high-sensitivity industries. To test this we estimate sensitivities for industries and then compute a hypothetical β, denoted β^*, for each province that would result if its sensitivity were fully explained by its industry structure. Due to data limitations we consider only three industries – primary, secondary and tertiary; their estimated growth rate sensitivities to national growth rates are reported in Table 2. The results reported in Table 2 clearly show that primary industry has little connection with the aggregate economy but that both secondary and tertiary industries have a close relationship with aggregate fluctuations with secondary industry having by far the higher β.

We proceed to compute a β^* for each province as the output-weighted average of the industry βs with the weight for industry j in province i being the industry j's share of output in province i. If the hypothesis that industry structure is the major source of in-regional variation in the βs is correct there should be a strong correlation between the β^*s and those reported in Table 1. Table 3 has the β^*s as well as the original βs.

Inspection of the results suggests that there is little relationship between the two β measures. This is confirmed in Table 4 which shows the correlation coefficients between the βs as well as between each of the βs and the average provincial growth rate. It shows that the correlation between the two β measures is negligible, that there is a strong correlation between the estimated βs and the average growth rate and that the correlation between the hypothetical βs and the average growth rate is approximately zero.

Table 2. Industry Sensitivities

Industry	$\hat{\alpha}_i$	$\hat{\beta}_i$	AR(1)	R^2	DW
Primary Industry	2.895 (1.332)	0.191 (0.873)		0.035	1.770
	2.804 (1.054)	0.190 (0.710)	0.104 (0.410)	0.05	1.723
Secondary Industry	-2.696 (-1.576)	1.494 (8.675)		0.781	1.217
	-2.958 (-1.394)	1.527 (7.463)	0.394 (1.788)	0.812	1.820
Tertiary Industry	0.678 (0.376)	1.012 (6.583)		0.597	0.564
	1.664 (0.795)	0.910 (5.995)	0.734 (4.686)	0.808	2.175

Note: t-ratios in parentheses. Primary Industry includes agriculture, forestry, logging, fishing and hunting. Secondary Industry includes mining, manufacturing, electricity, gas, water and construction. Tertiary Industry includes the other industries which are not included in the Primary Industry and Secondary Industry.

Thus, there appears to be very little explanatory power in the Thirlwall hypothesis that sensitivities differ across regions mainly because of their different industry structure combined with differences in industry sensitivities. Not only is the relationship between the two β measures weak but it is also rather sensitive to the sample. Thus if we include Tibet province, the correlation becomes 0.36 although the relationship between β and the growth rate is little different. Moreover, the within-region correlations are also variable: that between the βs is negative for the central and coastal regions but 0.53 for the western region while the correlation between β and the average growth rate is 0.54 and 0.79 for the coastal and central region but negative for the western region. Finally, if we inspect the graph of the β measures, we find that the observations for Hainan and Heilongjiang are outliers and if they are excluded the correlation is 0.54. Thus, on the whole the correlation is both low and fragile and we conclude that there is little explanatory power in Thirlwall's hypothesis that the sensitivities are mainly determined by underlying industry sensitivities. We therefore proceed to search for alternative explanations of sensitivities.

In our search for alternative explanations we look to the regional growth literature cited in the first section of the paper but take care to choose only exogenous variables so as to avoid the problem of reverse causation. Thus, it is quite possible to argue that foreign direct investment (FDI), say, affects sensitivity to the national cycle. But it is likely that there is also causation in the opposite direction: the FDI literature shows that high-growth regions are more likely to attract FDI than are stagnant regions. We avoid this problem by experimenting with variables which are based largely on the geography of each of the provinces.

Table 3. Estimated sensitivities ($\hat{\beta}_i$) and hypothetical sensitivities ($\hat{\beta}_i^*$)

	$\hat{\beta}_i$	$\hat{\beta}_i^*$	gr_i
Beijing	0.855	1.142	10.02
Tianjin	0.861	1.188	9.61
Hebei	1.152	1.066	10.43
Hainan	1.293	0.766	11.35
Guangdong	1.153	1.105	13.53
Shandong	1.182	1.062	11.71
Fujian	1.092	1.026	13.20
Zhejiang	1.503	1.120	13.19
Jiangsu	1.406	1.080	12.41
Shanghai	0.984	1.229	9.66
Niaoning	1.252	1.127	8.03
Guangxi	0.628	0.901	9.15
Sichuan	0.694	0.952	9.15
Guizhou	0.620	0.904	9.01
Yunnan	0.684	0.988	9.45
Shaanxi	0.971	1.016	9.40
Gansu	0.905	0.992	8.90
Qinghai	0.708	1.020	7.57
Ningxia	0.707	1.019	9.03
Xinjiang	0.504	0.960	10.27
Shanxi	0.954	1.130	8.83
Inner Mongolia	0.668	0.943	9.83
Jilin	1.106	0.994	9.69
Heilongjiang	0.263	1.125	7.62
Anhui	1.107	0.974	10.69
Jiangxi	0.925	0.929	10.24
Henan	0.950	1.005	10.28
Hubei	0.991	1.030	10.55
Hunan	0.610	0.941	9.00

Note: Tibet has been excluded and estimated βs are based on AR(1)-corrected equations where necessary.

Table 4. Correlation Coefficients.

	$\hat{\beta}_i$	$\hat{\beta}_i^*$	gr_i
$\hat{\beta}_i$	1	0.190274	0.666418
$\hat{\beta}_i^*$	0.190274	1	0.036281
gr_i	0.666418	0.036281	1

In our search for alternative explanations we look to the regional growth literature cited in the first section of the paper but take care to choose only exogenous variables so as to avoid the problem of reverse causation. Thus, it is quite possible to argue that foreign direct investment (FDI), say, affects sensitivity to the national cycle. But it is likely that there is also causation in the opposite direction: the FDI literature shows that high-growth regions are more likely to attract FDI than are stagnant regions. We avoid this problem by experimenting with variables which are based largely on the geography of each of the provinces.

Following the regional growth literature we experimented with two different measures of the distance of a province from the coastline, the extent of a province's coastline, the population living within 100 kilometres of the coast and whether the province was a coastal province or not. Clearly all these measures are variation on a common Chinese theme that the coastal provinces have natural advantages compared especially to the inland western provinces. One possibility is that this effect is not simply a geographical characteristic but largely the result of policy preference and we test this by experimenting with a policy-preference variable in addition to the geographical ones listed above. Thus having estimated the β_is from time-series data in the first stage using equation (1) above, we now estimate a second-stage regression using cross-section data and estimate equation (2) above.

We estimate the relationship between the βs and geography and policy variables in two ways. First we implement the two-stage procedure outlined above where we estimate the βs in the first stage and then regress the estimated βs on the determinants. The estimated βs are subject to sampling errors which reduces the efficiency of the estimation of the parameters in equation (2) as well as possibly inducing heteroskedasticity in the second-stage regression. We overcome these problems by estimating the two equations simultaneously as explained in the previous section.

We report the results for the second-stage regressions in Table 5. We experiment with two alternatives for measuring the distance of a province from the coast as well as a dummy variable for whether a province is a coastal province, a variable measuring a province's coastline and a measure of the population which lives within 100 km of the coast. Finally we use a policy dummy variable which captures whether policy has favoured the economic development of this province.

Table 5. Second Stage Regression Results.

$$\hat{\beta}_i = \gamma_0 + \gamma_1 geog_i + \gamma_2 policy_i + \eta_i , \qquad i=1,2,\ldots,N$$

Variable	γ_0	$t(\gamma_0)$	γ_1	$t(\gamma_1)$	γ_2	$t(\gamma_2)$	R^2	BP
distance1	0.8924	16.1031	0.1461	0.9790			0.0343	0.7518
distance2	0.8646	14.6225	5.2755	1.5338			0.0801	0.8904
coast	0.7881	13.7976	0.3014	3.3951			0.2992	0.7053
coastline	0.8271	16.1810	0.0001	3.3086			0.2885	0.7290
population	0.8194	15.0930	0.3943	3.0709			0.2589	0.2441
policy	0.7425	9.3083			0.1816	2.6306	0.2040	0.5993
distance1	0.7354	8.8392	-0.0616	-0.3783	0.1984	2.3911	0.2084	0.8834
distance2	0.7307	8.5291	-2.0447	-0.4249	0.2142	2.0627	0.2095	0.4263
coast	0.7818	9.8893	0.2870	1.8832	0.0131	0.1176	0.2996	0.8249
coastline	0.8250	9.1616	0.0001	1.7572	0.0035	0.0289	0.2885	0.9048
population	0.7940	9.2367	0.3239	1.4435	0.0449	0.3856	0.2631	0.4306

Note: $t(\gamma_i)$ represent the absolute value of the t-ratio for the corresponding coefficient; the column headed BP contains the p-values for the Breusch-Pagan test for heteroskedasticity.

Clearly the two distance variables have little explanatory power – they are both insignificant and explanatory power of the equation is less than 10 percent in each case. The three coastal variables are more successful – each is clearly significant and has an associated R^2 of between 25 and 30 percent. Of the three, the simple coast dummy performs best. Finally the policy variable is also significant on its own with the expected sign although it has a lower t-ratio than the coast variables and lower explanatory power. The final column of the table reports the p-values for the Breusch-Godfrey test for heteroskedasticity; it is clear that despite the generated dependent variables, there is not evidence of heteroskedasticity in any of the equations reported.

In the second panel of Table 5 we combine the geography and the policy variables. We would expect some multicollinearity since policy has tended to favour the coastal provinces for much of our sample period as explained in section 1 but it is nevertheless interesting to combine them to see whether there is a noticeable independent effect of the policy variable. It is not surprising that the policy variable is significant when combined with the distance variables since neither of these variables is significant on its own. When the policy variable is combined with the coast variables, however, it is far from significant and the coast dummy variable is significant at least at the 10 percent level. The value of R^2 increases only marginally reflecting the multicollinearity between the two variables.

Thus we can conclude that both a measure of the province's location and central government policy have a positive influence on the province's sensitivity to national cycles but that location, best measured by a simple coastal dummy variable, seems to be more important than policy although this conclusion should be tempered by the presence of multicollinearity.

Our second approach to the cross-section explanation of the βs is the simultaneous approach outlined in section 2, the results for which are reported in Table 6. We estimated the set of equations (3) together by treating them as a panel model allowing the intercepts to vary freely across provinces but restricting the slopes to be determined by the geography and policy variables. It is clear that the R^2 values are higher than those reported in Table 5 but they are not strictly comparable since in the case of Table 6 they relate to the system as a whole while in Table 5 they relate to the second-stage regression only.

Table 6. Simultaneous Estimation

$$gr_{it} = \alpha_i + \gamma_0 gr_t + \gamma_1 geog_i . gr_t + \gamma_2 policy_i . gr_t + \varepsilon_{it}, \quad i=1,2,\ldots,N \text{ and } t=1,2,\ldots,T$$

Variable	γ_0	$t(\gamma_0)$	γ_1	$t(\gamma_1)$	γ_2	$t(\gamma_2)$
constant	0.9128	30.3900				
distance1	0.8924	18.4713	0.1461	1.1230		
distance2	0.8646	16.3916	5.2755	1.7193		
coast	0.7881	13.5870	0.3014	3.3432		
coastline	0.8271	16.0500	0.0001	3.2819		
population	0.8194	15.2661			0.3943	3.1061
policy	0.7425	9.7416			0.1816	2.7530
distance1	0.7354	9.3948	-0.0616	-0.4021	0.1984	2.5414
distance2	0.7307	9.0591	-2.0447	-0.4513	0.2142	2.1908
coast	0.7818	9.9135	0.2870	1.8878	0.0131	0.1179
coastline	0.8250	9.2532	0.0001	1.7748	0.0035	0.0292
population	0.7940	9.4872	0.3239	1.4827	0.0449	0.3961

Variable	R^2	LLF	LR	p-value
constant	0.4583	-1765.97	39.6600	0.0709
distance1	0.4593	-1765.31	38.3320	0.0728
distance2	0.4608	-1764.42	36.5600	0.1036
coast	0.4676	-1760.16	28.0320	0.4093
coastline	0.4673	-1760.37	28.4520	0.3880
population	0.4664	-1760.95	29.6100	0.3320
policy	0.4647	-1762.02	31.7500	0.2415
distance1	0.4648	-1761.93	31.5800	0.2074
distance2	0.4648	-1761.91	31.5360	0.2089
coast	0.4676	-1760.15	28.0180	0.3576
coastline	0.4673	-1760.37	28.4500	0.3367
population	0.4665	-1760.86	29.4460	0.2912

Note: $t(\gamma_i)$ represent the absolute value of the t-ratio for the corresponding coefficient; LLF is the log of the likelihood function for the system as a whole, a LR is the value of the likelihood ratio statistic appropriate to the test that the variation in the βs is adequately explained by the geography and policy variables and the p-value relates to the LR test.

In each case the estimated γs are the same as in Table 5 but, as expected, the t-ratios are different although the conclusions reached are similar to those derived from the results in Table 5 – the coast dummy still dominates and there is only a marginal role for the policy dummy once we have accounted for the geography effect. The only difference in conclusion is that the second distance variable is now marginally significant when used alone.

An additional benefit of the simultaneous estimation is that we can carry out a formal test of whether the geography and/or policy variables adequately explain the cross-section variation in the sensitivities by comparing the completely unrestricted system with the system in which the slopes are restricted to vary only with geography and policy. We use the values of the likelihood functions for this purpose. They are reported for each model in Table 6 under “LLF” and the likelihood ratio test statistic is reported in the column headed “LR” with the p-value in the final column.

We conducted a preliminary test of whether there was significant variation in the βs across the provinces by comparing the unrestricted model to a system in which all βs were constrained to be equal. The p-value for the LR test was 0.0709 showing that there was significant variation at the 10 but not at the 5 percent level. We therefore proceeded to test whether the variation could be adequately explained by the geography and/or policy variables. Surprisingly in the light of earlier results, each of the distance and policy variables adequately explains the variation in βs across the provinces although the restrictions can be rejected at the 10 percent level for the first distance variable. Again, the coast dummy produces the strongest improvement in the value of the likelihood function and the highest p-value.

We can conclude, therefore, that there is significant although only modest variation in the betas across provinces and that this variation can best be explained by a simple coast dummy with negligible additional explanatory power from the policy dummy variable.

We proceed finally to an analysis of the implication of our analysis for the relationship between various hypothetical alternative national growth rates and the dispersion of provincial growth rates. To preserve comparability with our earlier graph, we measure dispersion by the weighted standard deviation. We first used the estimated equations in Table 1 to predict the provincial growth rates for various alternative national growth rates ranging from 5 to 15 percent. We also included the actual growth rate for 2001 of 7.3 percent to enable us to compare the results to our earlier graph. The provincial growth rates were then used to compute a weighted standard deviation corresponding to each national growth rate. The results are pictured in Figure 3.

It should be noted that the weighted standard deviations are smaller than the ones pictured in Figures 1 and 2 because those in Figure 3 do not take into account the errors about the regression line which are included in the actual growth rates which underlie Figures 1 and 2 but not in the predicted growth rates used to compute the dispersion measure in Figure 3.

The clear implication of Figure 3 is that for most of the range of national growth rates pictured, the dispersion increases with the growth rate although there is a modest fall for low growth rates. From a policy perspective it is clear that in 2001 with a growth rate of 7.3 percent, dispersion was close to its cyclical minimum and that reasonable increases in the growth rate from this figure to a level around 8-10 percent will increase dispersion by about 10-15 percent while more ambitious increases in the national growth rate to, say, 15 percent will almost double dispersion.

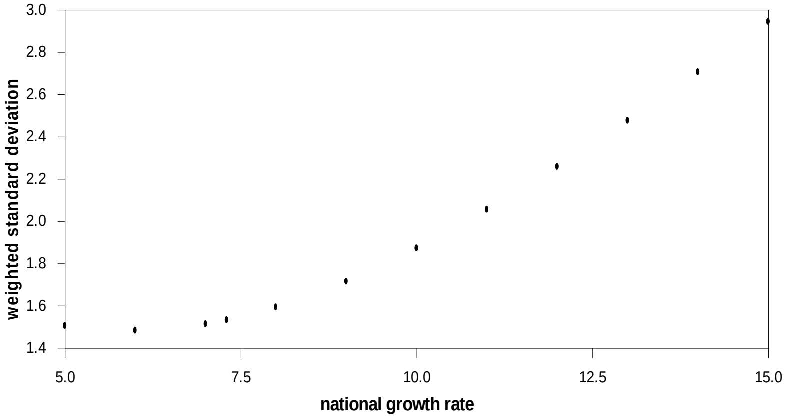

Figure 3. National growth rate and dispersion.

5. CONCLUSION

In this paper we have explored the cyclical fluctuations in regional growth dispersion by examining the sensitivity of regional growth rates in China following the approach of Thirlwall (1966). We argued that an important influence on regional growth disparities is the interaction of changes in the national growth rate with the individual provinces' sensitivities to these changes. The determinants of differences in sensitivities are therefore an important matter for research by regional economists.

We estimated the sensitivities using annual data for the period 1979-2001 and found significant variation across provinces. Thirlwall's explanatory device in which the provincial sensitivities were explained by a combination of industry sensitivities and provincial industry structure was not successful and we proceeded to an examination of factors suggested by the more recent regional growth literature. In particular, we explored the effects of geography and policy and found that a simple dummy variable which indicated whether the province was a coastal one or not best explained the cross-section variation in the sensitivities and that policy made little additional contribution to the explanatory power of the cross-section regression.

We simulated the estimated model to compute a measure of regional dispersion at various possible future national growth rates and show that the higher the aggregate growth rate the more serious is the problem of regional disparities likely to be.

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