Growth dynamics and conditional convergence among Chinese provinces: a panel data investigation using system GMM estimator

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Dynamiques de croissance et convergence conditionnelle des provinces chinoises: une analyse empirique sur données de panel à partir de l'estimateur GMM en système

Résumé

L'objectif de cet article est de contribuer au débat sur la convergence conditionnelle des provinces chinoises en utilisant les techniques les plus récentes des modèles de panel dynamique. L'analyse économétrique porte sur vingt-neuf provinces chinoises de 1995 à 2009 et est effectuée à partir de l'estimateur GMM en système. Trois résultats principaux sont à souligner. Premièrement, l'investissement en capital physique et l'éducation ont joué un rôle important dans la promotion de la croissance économique, et constituent par conséquent des vecteurs potentiels de réduction des inégalités régionales. Deuxièmement, l'hypothèse de convergence conditionnelle est vérifiée sur la période 1995-2009. Troisièmement, la vitesse de convergence estimée est plus rapide sur la période 2004-2009, ce qui implique que les provinces chinoises ont convergé plus rapidement sur la période la plus récente. Nous suggérons que ce résultat peut s'interpréter comme une conséquence de la mise en place de politiques de rééquilibrage régional au cours des années 2000, et qu'il peut également refléter l'existence d'effets de diffusion de la croissance entre provinces.

Mots-clés : Chine, inégalités régionales, croissance, convergence conditionnelle, modèles de panel dynamique, GMM système.

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Abstract

The paper aims at contributing to the debate on conditional convergence across Chinese provinces by using the most recent techniques of dynamics panel data models. The analysis covers twenty nine Chinese provinces from 1995 to 2009 and is based on the estimation of growth equations using system GMM estimator. Three main results can be drawn from the empirical investigations conducted as part of this study. First, investment in physical capital and education have played an important role in promoting economic growth and may be considered as mean of reducing regional disparities. Second, the hypothesis of conditional convergence is verified over the period 1995-2009. Third, the speed of convergence is found to be faster during the period 2004-2009, which indicates that Chinese provinces have converged more quickly over the most recent period. We suggest that this result may be a consequence of the implementation of regional development programs during the 2000s, and that it may also reflect the existence of growth spillover effects.

Keywords: China, regional disparities, growth, conditional convergence, dynamic panel data, system GMM.

JEL: C33, 040, 053, P25, R11.

1. Introduction

Since the early 1980s, China has made a spectacular economic catch-up. Over the past thirty years, China has recorded an annual average growth rate of 8.5 %, enabling it to become the world's second economic power[1] behind the United States. China may therefore be viewed as a model for other countries since it has been able to take off and to compete with industrialized countries despite the fact that it was still part of the Third World in the 1960s. The rapid emergence of China is closely linked to the shift toward an export-led growth model in the late 1970s. One of the most drastic changes involved integrating global value chains, while the economy was a near-autarky during the Mao era. However, Deng Xiaoping opted to 'let some people get rich first'. The first stage of economic reforms was therefore limited mostly to coastal provinces and cities (Fan, 2006). The model of unbalanced growth has exacerbated regional disparities in China, with coastal provinces becoming richer and more prosperous and inland provinces remaining poorer and less dynamic (Naughton, 2002).

The growing trend in regional disparities since the beginning of economic reforms in the late 1970s has led many scholars to examine the various aspects and changes affecting regional disparities. Most scholars in the field agree that regional disparities first declined between 1978 and the end of the 1980s (Jian et al., 1996; Dayal-Gulati and Husain, 2000; Zheng et al., 2000; Démurger, 2001; Lin and Liu, 2006; Li and Xu, 2008). This decrease is mainly explained by the rural reform implemented in the first stage of economic reforms, in the early 1980s. The rural reform promoted the growth of agricultural production and created job opportunities in township and village enterprises, which resulted in an increase in rural incomes (Yang, 2002; Knight et al., 2004). Subsequently, during the period 1990-2000, regional disparities increased continuously (Zhao and Tong, 2000; Zheng et al., 2000; Démurger, 2001; Cai et al., 2002; Lu and Wang, 2002; Kanbur and Zhang, 2005), mainly as a result of increasing disparities between coastal and inland provinces. By decomposing inequality indexes (Gini or Theil index), Zhang and Yao (2001), and Li and Xu (2008) show that inequalities among eastern, central and western regions account for a significant share of the disparity, and have increased continuously since the 1990s. In fact, throughout the 1990s, the coastal-inland income gap increased faster than the rural-urban gap, and became the major component of overall inequality (Kanbur and Zhang, 1999; Zhang and Yao, 2001). Nevertheless, recent studies (Li and Xu, 2008; Villaverde et al., 2010; Hao and Wei, 2010) show that the rate of increase in regional disparities has declined since the beginning of the 2000s. In a recent survey, the OECD (2010) also suggests that household income inequality may have started to decline in recent years.

In this paper, we propose to test whether the recent reduction in regional disparities has been accompanied by a process of economic convergence across Chinese provinces. The issue of conditional convergence in post-reform China is still not clear-cut, in so far as empirical studies produced mixed results (e.g. Chen and Fleisher, 1996; Pedroni and Yao, 2006; Li and Xu, 2008). We intend to contribute to this debate by estimating economic growth models using the most recent techniques of dynamics panel data models. Our econometric analysis involves twenty nine Chinese provinces from 1995 to 2009. Estimation results are based on system GMM estimator in order to deal with endogeneity issues which are frequently seen in growth regressions (Bond et al., 2001).

The paper is organized as follows. Section 2 reviews the economic literature on regional convergence in post-reform China. Section 3 describes the data and the variables included in the growth model. Section 4 develops the econometric strategy which is implemented to estimate the

[1] Its Gross Domestic Product at Purchasing Power Parity amounted to 10,085.708 billion dollars in 2010 (IMF).

determinants of regional growth using system GMM estimator. Finally, section 5 discusses the results and proposes a more thorough analysis of conditional convergence over the study period.

2. Regional convergence across Chinese provinces: a review

Since the pioneering work of Solow (1956), many empirical studies have focused on the convergence hypothesis. A distinction can be drawn between two types of convergence. Firstly, absolute convergence assumes that all provinces (or countries) are intrinsically the same apart from their initial capital/labour ratio. Provinces with a lower initial income have a lower capital/labour ratio than the long-run value and therefore have higher rates of return. This means that poorer provinces will grow faster and eventually catch-up with richer provinces. Secondly, conditional convergence recognizes differences between provinces in various aspects, and assumes that each province will converge toward its own steady-state level. The test of the hypothesis of conditional convergence requires that a set of variables – which differentiate the provinces – is isolated and remains constant. According to economic literature on growth and convergence (e.g. Barro and Sala-i-Martin, 1995), this set of variables includes : (i) a number of state variables, such as the stocks of physical capital and human capital; and (ii) environmental variables, such as public consumption to GDP ratio, national investment to GDP ratio, fertility rate, and changes in terms of trade.

The question of convergence across Chinese provinces since the reform era has been addressed in a number of papers, but a comparative analysis of the findings of these studies suggests that there is little consensus. Studies focusing on the immediate post-reform period (from 1978 to the mid-1990s) provide mixed and even contradictory results. Some authors validate the hypothesis of conditional convergence (Chen and Fleisher, 1996; Cai et al., 2002), while others give evidence of provincial divergence (Pedroni and Yao, 2006). Besides, some studies that reject the hypothesis of conditional convergence still find evidence of convergence club. The concept of « convergence club » is based on the idea that even if convergence is not verified at the global level, regions belonging to the same group can converge provided they share the same structural characteristics (Berthélemy, 2006). In this line, Yao and Zhang (2001) find evidence of provincial convergence within three clubs of growth during the period 1978-1995: coastal provinces, central provinces and western provinces. Weeks and Yao (2003) also find that coastal and inland provinces are converging toward their own steady-state level during the period 1978-1997. Finally, analyses based on more recent data (until the mid-2000s) tend to validate the hypothesis of conditional convergence across Chinese provinces (Zou and Zhou, 2007; Li and Xu, 2008).

The lack of consensus over the convergence issue may be linked to a number of factors. First, the studies referred to above are not based on the same data sets and do not cover exactly the same periods. Second, official data on China are controversial. In particular, data covering the period that immediately has followed the beginning of economic reforms may suffer from consistency and reliability issues (Maddison, 1998; Rawski, 2001). Third, as emphasized by Knight, "evidence of absolute divergence might be an artefact" (2013: 11), because official data exclude rural-urban migrants to calculate provincial population. As a consequence, "this approach overstates the GDP per capita in the richer provinces that attract migrants" resulting in an exaggerated GDP per capita growth rate in these provinces (Knight, 2013: 11). Fourth, the choice of control variables often depends on data availability. The differences in economic growth between Chinese provinces may be the result of a wide range of factors. Therefore, if variables accounting for the specific characteristics of provinces are missing, the hypothesis of conditional convergence may be invalidated. Fifth, if some explanatory variables are endogenous with respect to economic growth, the results may be biased (Nickell, 1981). To address these concerns, this paper proposes to analyze the hypothesis of conditional convergence using the system GMM estimator (Blundel and Bond, 1998) so as to obtain results that are adjusted for endogeneity. Besides, the econometric estimation will be useful not only

for testing the hypothesis of conditional convergence but also for identifying the driving forces of regional economic growth in China.

3. Data and growth model

Data used in this study are drawn from various editions of the *China Statistical Yearbook* published by the National Bureau of Statistics of China (1995-2009).[2] The econometric analysis is implemented using panel data that cover twenty nine Chinese provinces[3] over five three-year average periods (1995-1997, 1998-2000, 2001-2003, 2004-2006 and 2007-2009).[4] The use of three-year averages has several advantages, thought there is no consensus on the determination of the appropriate time intervals (Temple, 1999). First, the use of averages over several years decreases the influence of short-term shocks and business cycles on economic activity, and reveals long-run relationships. Therefore, it is a way to avoid the problem of non-stationarity which could have produced biased results (regression fallacy). Second, compared to five-year or fifteen-year intervals, the use of three-year intervals allows to keep a sufficient number of observations to use the time dimension of panel data.

The dependant variable is the growth rate of per capita GDP of region *i* over period *t* ($y_{i,t}$). In accordance with Durlauf et al. (2005), the growth equation to be estimated can be written as follows:

$$y_{i,t} = \beta \ln Y_{i,0} + \psi X_{i,t} + \pi Z_{i,t} + \varepsilon_{i,t} \qquad (1.1)$$

where X variables stand for traditional determinants of growth in accordance with models of conditional convergence (Solow, 1956; Mankiw et al., 1992), and Z variables account for additional determinants from endogenous growth models (Romer, 1986; Barro, 1991).

The initial stock of capital is proxied by the logarithm of per capita GDP of province *i* at the beginning of each period (*Initial per capita GDP*). Under the hypothesis of conditional convergence, the associated $\hat{\beta}$ coefficient is predicted to be significant and negative (Solow, 1956; Barro and Sala-I-Martin, 1995). All other things being equal, provinces with a lower per capita GDP are predicted to grow at a faster rate than the richest provinces.[5] The convergence analysis can be completed by calculating two additional parameters. The first one is the "speed on convergence" ($b = - \ln(1 + T\hat{\beta})/T$), which represents the rate at which an economy is getting closer to its steady-state level of income every year. The second one is the "half-life" [$\tau = - \ln(2) / \ln(1 + \hat{\beta})$], accounting for the time required for an economy to cover half the distance from its steady-state level.

Physical capital accumulation is an important determinant of growth in both Solow and endogenous growth models (Romer, 1986).[6] Firms can accumulate know-how through capital accumulation and the free flow of information. Consequently, some investments can produce growing returns and promote economic growth. Physical capital accumulation is integrated to our analysis via the investment rate, calculated as the share of gross fixed capital formation in GDP.

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[2] All nominal values are adjusted for inflation based on provincial consumer price indexes (at 1994 prices) to take account of price changes in each Chinese province.

[3] Tibet is excluded from the analysis because of data unavailability.. Data concerning Chongqing, a province created in 1997, were incorporated in the data for Sichuan.

[4] Three-year average periods have also been used in empirical studies by Brun et al. (2002), Madariaga and Poncet (2007) and Li and Xu (2008).

[5] Due to the law of diminishing marginal returns on capital.

[6] Romer (1990) also emphasized the role of innovation in endogenous growth. Unfortunately, research-and-development expenditures were not taken into account since the relevant data were not available.

The impact of population growth is taken into account via lnPOP variable, which is equal to $n+g+\delta$. n variable accounts for the natural growth rate of each province. g and δ variables represent, respectively, the rate of technical progress and the rate of depreciation of physical and human capital. In accordance with Mankiw et al. (1992), we assume that $g+\delta =0.05$. A rise in fertility rate (proxied by the natural growth rate) may be perceived as an opportunity cost of productive activities. If population increases, a part of national investment will be used to provide capital for new workers instead of raising the level of capital per worker (Barro, 1998). As a consequence, this variable is assumed to have a negative impact on economic growth.

The augmented Solow model (Mankiw et al., 1992) shows that human capital can favourably influence growth. According to Lucas (1988), human capital refers to the stock of skills, knowledge, personality and physical health that can be used by a worker to be more efficient and more productive. In this study, human capital[7] is proxied by the variable *education* which represents the share of students in regular institutions of higher education in the total population of each province.[8]

Public spending plays an unclear role in economic growth. Barro (1990) showed that public spending can promote growth by improving corporate productivity through public infrastructures and human capital. However, the increase in taxation resulting from the funding of public expenditures may have a negative impact on growth. Therefore, the coefficient of the variable is expected to be either positive or negative, depending on which effect is stronger. The variable used in the regression is the share of public expenditures in the total GDP of each province*.*

Another potential determinant of economic growth is the existence of adequate infrastructures (Aschauer, 1990; Démurger, 2001; Egert et al., 2009). Infrastructures can provide positive externalities by promoting labour mobility, exchange of goods and services, and information flow. The development level of infrastructures is proxied by railway density, which represents the ratio of the number of railway kilometres to provincial population. [9]

All explanatory variables are expressed as logarithms so as to facilitate the interpretation of the associated coefficients.

4. Econometric strategy

The panel estimation can be first implemented using a fixed-effects model (FEM) which incorporates individual-specific (time-invariant) effect (δ_i) and time-specific (individual-invariant) effect (λ_t):

$$y_{i,t} = \alpha_1 + \alpha_2 x_{i,t} + \delta_i + \lambda_t + \varepsilon_{i,t} \quad (1.2)$$

where the dependent variable *y* for province *i* in year *t*, is explained by a set of independent variables $x_{i,t}$ and by unobservable characteristics: province-specific (δ_i) and time-specific (λ_t).

The fixed-effects estimator (also called within estimator) is obtained by ordinary least squares (OLS) on the deviations from the means of each individual. However, this estimator can provide biased estimations if the number of time periods is small, and if the lagged value of the dependent

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[7] We also attempted to take into account health conditions through the ratio of the number of hospital beds to provincial population. This choice was conditioned by the lack of health data in the long term. For instance, data relating to life expectancy or public spending on health are not available for each province over the period of study. This variable was removed from the analysis due to multicolinearity problem.
[8] Since primary education is mandatory in China, an indicator of higher education was used (Brun et al., 2002).
[9] We also tried to capture the influence of commercial openness, via the ratio of exportations to GDP (in line with Wu, 2004). However, this variable was removed from the analysis due to its strong correlation with other control variables.

variable $y_{i,t-1}$ is correlated with the individual effects δ_i (Matyas and Sevestre, 2008). In particular, the estimation of growth regression may raise several problems (Bond et al., 2001). First, explanatory variables may be endogenous because of reverse causality or measurement errors. The within estimator has been shown to produce estimations of parameters that are inconsistent and biased downward in presence of endogeneity (Nickell, 1981). Second, omitted variables can bias the estimation. In our case, the omission of characteristic variables may lead to invalidate the conditional convergence hypothesis.

To address these issues, Holtz-Eakin et al.(1988) and Arellano and Bond (1991) suggest to estimate dynamic panel data models using the generalized method of moments (GMM). GMM includes the lagged endogenous variable as an explanatory variable:

$$y_{i,t} = \alpha_1 + \alpha_2 y_{i,t-1} + \alpha_3 x_{i,t} + \delta_i + \lambda_t + \varepsilon_{i,t} \ (1.3)$$

Those authors propose to estimate the regression equation with a first-differentiated GMM estimator. For each period, it is necessary to first-differentiate the equation in order to eliminate individual specific effects:

$$y_{i,t} - y_{i,t-1} = \alpha_1(y_{i,t-1} - y_{i,t-2}) + \alpha_2(x_{i,t} - x_{i,t-1}) + (\lambda_t - \lambda_{t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \ (1.4)$$

By construction, ($y_{i,t-1}$ - $y_{i,t-2}$) is correlated with the error term ($\varepsilon_{i,t}$ - $\varepsilon_{i,t-1}$). As a consequence, it is necessary to resort to instrumental variables techniques (for $t \geq 2$). Arellano and Bond (1991) suggest to use the lagged levels of the lagged endogenous variable $y_{i,t-1}$ as instruments for ($y_{i,t-1}$ - $y_{i,t-2}$), and the lagged levels of the explanatory variables $x_{i,t}$ as instruments for ($x_{i,t}$ - $x_{i,t-1}$). Nevertheless, there are limitations to this approach. For instance, Blundell and Bond (1998) point out that the first-differentiated GMM estimator may provide biased results in the case of finite sample size, and that the lagged levels of the variables cannot be considered as reliable instruments when the dependent and the independent variables are continuous.

To obviate the weak instrument problem, Arellano and Bover (1995) and Blundell and Bond (1998) suggest a second method based on the system GMM estimator. This estimator combines : (i) the standard set of equations in first-differences, ($y_{i,t-1}$ - $y_{i,t-2}$) and ($x_{i,t}$ - $x_{i,t-1}$) variables, with suitably lagged levels as instruments, (ii) with an additional set of equations in levels, $y_{i,t-1}$ and $x_{i,t}$ variables, with suitably lagged first-differences as instruments. Blundell and Bond (1998) have also developed a two-step GMM estimator to address the problem of heteroscedasticity. First, they suggest to get the residuals from the first-step estimation. Second, they recommend to use them in order to perform a robust estimation of the variance-covariance matrix. Using Monte Carlo simulations, Blundell and Bond (1998) show that the two-step estimation method is asymptotically more efficient than the first step method. However, they also underline that the two-step estimation may produce downward biased results when using finite samples. To eliminate this potential bias, Windmeijer (2005) proposes a finite sample correction for the variance-covariance matrix when using the two-step GMM estimator.

The consistency of the system GMM estimator relies on two hypotheses. First, the set of instrumental variables must be valid, i.e. not correlated with the error terms. This hypothesis is tested using Sargan/Hansen test of overidentifying restrictions.[10] Second, the absence of second-order autocorrelation (AR2) in residuals must be verified, while a negative first-order autocorrelation (AR1) may be detected. This second hypothesis is tested using Arellano-Bond tests for AR1 and AR2.

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[10] The Hansen test is implemented instead of the Sargan test when the estimations are adjusted for heteroscedasticity.

Roodman (2009) shows that using too many instruments can produce biased results in GMM estimation.[11] Although the empirical literature provides little evidence on the maximum number of instruments to use, the minimum standard is to have less instruments than individuals (Roodman, 2009). Arellano and Bover (1995) also suggest to use only the most recent difference as an instrument for the level specification of explanatory variables, because other lagged first-differences would result in redundant moment conditions. In this line, we limit the number of lags for both the dependent and explanatory variables to one.[12] In the following section, we estimate our growth equation using two-step GMM estimator with Windmeijer's correction method for the variance-covariance matrix.[13]

5. Results

Explanatory variables are progressively introduced into the growth regression in order to check the robustness of our results. Model 1 follows Solow's specification (1956) and explains the growth rate of per capita GDP by the initial per capita GDP, the accumulation of physical capital and the population growth. Model 2 represents the augmented Solow model proposed by Mankiw et al. (1992), which includes a variable accounting for human capital. The impact of public expenditures on growth is integrated into the analysis in model 3. Finally, model 4 also includes a variable accounting for the infrastructure level. Estimations results of the four growth models using system GMM estimator are presented in table 1.

5.1. Determinants of provincial economic growth

The Hansen test shows that we cannot reject the null hypothesis that the error term is uncorrelated with the instruments for models 1 and 3. For both these models, the validity of the instrumental variables of the regression is therefore confirmed. In each of the four models, Arellano-Bond tests indicate the presence of a negative first-order autocorrelation, while we cannot reject the null hypothesis that there is no autocorrelation of order 2. In view of the results of both Hansen and Arellano-Bond tests, we will only focus on the parameter estimates resulting from models 1 and 3, for which the validity is confirmed.

Table 1. Determinants of the growth rate of regional per capita GDP in China (1995-2009) using system GMM estimator.[1]

Variables	SYS-GMM[2] Model 1	SYS-GMM[2] Model 2	SYS-GMM[2] Model 3	SYS-GMM[2] Model 4
GDP_{t-1}	0.0526	0.3390	0.1462	0.1572
	(0.1860)	(0.2070)	(0.1978)	(0.1933)
Initial per capita GDP	-0.0295**	-0.0597**	-0.0803**	-0.0772**
	(0.0108)	(0.0242)	(0.0300)	(0.0317)
Population	-0.9494***	-0.3783	0.0410	0.1612
	(0.2423)	(0.3284)	(0.3281)	(0.2994)
Investment	0.1416***	-0.01680	0.1349*	0.0853
	(0.0455)	(0.06832)	(0.803)	(0.0652)
Education	-	0.0552*	0.0820***	0.0930***
		(0.0319)	(0.0289)	(0.0297)
Public expenditures	-	-	-0.1210**	-0.1199
			(0.0481)	(0.0772)
Infrastructures	-	-	-	0.0090
				(0.0301)

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[11] In particular, Sargan and Hansen tests can be weakened by the use of too many instruments (Roodman, 2009).
[12] These restrictions enable us to keep the number of instruments for below that of regions, as recommended by Roodman (2009).
[13] Results are obtained using STATA 11 software.

Intercept	-2.2515***	-0.231	1.2063	1.6268
	(0.6858)	(1.1574)	(1.0390)	(1.0730)
Nb of observations	116	116	116	116
Nb of individuals	29	29	29	29
Nb of instruments	9	11	13	15
Hansen test of overidentifying restrictions	2.77	1.07	10.29	13.91
	(0.596)	(0.05)	(0.113)	(0.053)
Arellano-Bond test for AR(1)	-2.14	-2.74	-1.78	-2.02
	(0.032)	(0.006)	(0.075)	(0.044)
Arellano-Bond test for AR(2)	-0.18	0.24	-0.57	-0.34
	(0.86)	(0.807)	(0.569)	(0.732)

Source: Author's calculation, based on *China Statistical Yearbook* (1996-2010).

Notes: (1) Two-step system GMM estimations with Windmeijer's (2005) finite-sample correction for the variance-covariance matrix. (2) Robust standard errors into brackets for GMM estimates, p-value into brackets for Hansen and Arellano-Bond tests. Level of statistical significance: 1 % ***, 5 % **, et 10 % *. Time dummies are not reported.

Barriers to regional growth

First, estimation of model 1 shows that population growth has a significant negative impact on the growth of per capita GDP, in line with Solow's theory (1956). Nevertheless, the coefficient associated to this variable is no longer significant in model 3.

Second, results of model 3 underline that public expenditures have a detrimental effect on the dependant variable. This result may be explained by the fact that public intervention can generate a crowding-out effect and inhibit private investment. In the case of China, Gipouloux (1998) and Catin et al. (2005) show that a strong government intervention acts as a deterrent on foreign direct investments. This result suggests that reducing state intervention and improving the degree of marketization may have a positive impact on growth and regional disparities. To deepen the analysis, it could be interesting to exclude certain items of public expenditures (such as military expenditures) in order to see whether government expenditures on human capital and infrastructures, for their part, have a positive impact on growth.

Engines of regional growth

In both models 1 and 3, the coefficient associated to the share of investment in GDP is significantly positive, respectively at 1 and 10%. The accumulation of physical capital has constituted an engine of regional growth over the period 1995-2009. For instance, according to model 3, a 1% increase in the investment rate is associated with a 0.14% rise in the growth rate of per capita GDP. This figure is higher than that of 0.073% estimated by Cai et al.(2002) for the 1978-1998 period, and of 0.072% found by Li and Xu (2008) between 1991-2005. In the short and medium term, the crucial role of physical capital accumulation in the Chinese growth is largely acknowledged (Wu, 2004). However, some scholars raise doubts about the sustainability of this economic growth model in the long run (Gaulard, 2009).

Moreover, after controlling, the share of students in higher education has a significant positive impact on regional economic growth (at 1% level). According to model 3, a 1% increase in the share of students in higher education increases by 0.082% the growth rate of per capita GDP. This result is consistent with the findings of Fleisher and Chen (1996), Cai et al. (2002), and Li and Xu (2008), and suggests that the improvement of education standards is a key factor in promoting the reduction of regional disparities.

Conditional convergence of the Chinese provinces

Last but not least, the coefficient of the initial level of per capita GDP is negative and significant at the 5% level. The negative association indicates that provinces that were initially richer have recorded a slower growth rate, whereas the growth rate of poorer provinces has been higher. In other words, when we control for the previous set of variables, the hypothesis of conditional convergence is validated during the period 1995-2008. This result means that each province is converging toward its steady-state level.

Moreover, based on $\hat{\beta}$ coefficients estimated in models 1 and 3, the speed of convergence varies between 3.19 and 10.27% a year.[14] This speed of convergence is higher than the one calculated by Zou and Zhou (2007), amounting to 1.64% between 1981 and 2004. However, it is consistent with the 8% speed of convergence estimated by Poncet and Madariaga (2007) using spatial system GMM estimator over the period 1990-2002. The correction of endogeneity problems using system GMM method leads to better estimate the speed of convergence of Chinese provinces, with a higher speed than the one obtained using FEM (between 1.82 and 3.68%, see table A1 in appendix). As for the half-life, it amounts to 22.15 years in model 1, and 8.28 years in model 3. It means that Chinese provinces take approximately 23 years (respectively 8 years) to close half the gap between their current level of income and their steady-state level.

5.2. A more thorough analysis of conditional convergence

In an attempt to refine the analysis of conditional convergence, the variable accounting for the initial per capita GDP is decomposed into two variables. The first variable (*Initial per capita GDP$_1$*) is obtained by multiplying the initial per capita GDP by a dummy variable which takes the value of 1 if the period under study lies between 1995 to 2003, and 0 otherwise. In the same way, the second variable (*Initial per capita GDP$_2$*) is obtained by multiplying the initial per capita GDP by a dummy variable equal to 1 if the period under study is comprised between 2004 to 2009, and 0 otherwise. The division of the variable accounting for initial income will allow us to determine whether the hypothesis of conditional convergence is validated for the entire period, or only for one sub-period. If appropriate, it will also allow us to see if the speed of convergence is higher during either of the two sub-periods. Estimation results for models 1 and 3 with a focus on conditional convergence are reported in table 2. Both the Hansen and Arellano-Bond tests confirm the validity of our estimates.

Table 2. Determinants of the growth rate of regional per capita GDP in China (1995-2009) using system GMM estimator[1], with a focus on conditional convergence.

Variables	SYS-GMM[2] Model 1	SYS-GMM[2] Model 3
GDP$_{t-1}$	-0.1896	0.0040
	(0.2275)	(0.2056)
Initial per capita GDP$_1$	-0.0346**	-0.0631**
	(0.0152)	(0.0292)
Initial per capita GDP$_2$	-0.0395**	-0.0658**
	(0.0161)	(0.0293)
Population	-0.8269***	-0.2456
	(0.2612)	(0.2652)
Investment	0.1067*	0.0569
	(0.0561)	(0.1105)
Education	-	0.0582*

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[14] As a comparison, this speed of convergence is far more higher than the 2 to 3% usually found in cross-section studies (e.g. Barro and Sala-i-Martin, 1991, 1992). However, it is consistent with the rates estimated using panel data (Caselli et al., 1996).

		(0.0305)
Public expenditures	-	-0.0516
		(0.0501)
Intercept	-1.8343**	0.2056
	(0.6998)	(0.8335)
Nb of observations	116	116
Nb of individuals	29	29
Nb of instruments	11	15
Hansen test of overidentifying restrictions	5.36	8.53
	(0.374)	(0.288)
Arellano-Bond test for AR(1)	-2.62	-2.01
	(0.009)	(0.044)
Arellano-Bond test for AR(2)	0.97	0.64
	(0.334)	(0.523)

Source: Author's calculation, based on *China Statistical Yearbook* (1996-2010).
Notes: (1) Two-step system GMM estimations with Windmeijer's (2005) finite-sample correction for the variance-covariance matrix. (2) Robust standard errors into brackets, p-value into brackets for Hansen and Arellano-Bond tests. Level of statistical significance: 1 % ***, 5 % **, et 10 % *. Time dummies are not reported.

Regardless of the model applied, the coefficients of both initial income variables are negative and significant at 5% level. The hypothesis of conditional convergence is therefore validated for both sub-periods. It is worth noting that the coefficient for the second sub-period (2004 to 2009) is higher than that of the first sub-period (1995-2003). This result indicates that Chinese provinces have converged more quickly over the most recent period. Indeed, on the basis of Solow model (model 1), the speed of convergence is 3.65% in the first sub-period, and 4.11% in the second sub-period. Estimations of model 3 lead to a higher speed of convergence: 7% from 1995 to 2003, and 7.06% from 2004 to 2009.

The increase in the speed of convergence over the most recent period may be related to the recent efforts of Chinese authorities to rebalance development between provinces. Since the beginning of the 2000s, Chinese government is increasingly concerned about the explosion of inequalities, which represents a potential threat to social cohesion, political stability and sustainable development (Renard, 2002). In an attempt to reduce the regional gap, several development programs have been created. First, the "Great Western Development" strategy (*xibu da kaifa*) has been launched in 2000. The objective is to promote the regional development of western provinces, primarily by creating transport infrastructures. Although performances have been mixed due to the great socioeconomic diversity of provinces in this group (Goodman, 2004), some western provinces have benefited from this program. At the end of the 2000s, Inner Mongolia has become one of the most prosperous provinces of China, and the « west triangle economic zone » between the cities of Chongqing, Chengdu (in Sichuan province) and Xi'an (in Shaanxi province) is one of the most dynamic centres of growth. Second, the program for « revitalizing old industrial bases in northeast China » (*zhenxing dongbei lao gongye jidi*) has been implemented in 2003. It aims at creating new industrial centres in the three provinces of old Manchuria. In particular, Liaoning and Jilin have been able to move toward sectors with high future potential (such as automobile, aerospace, hi-tech and chemical and pharmaceutical industries). Third, since 2006 the "rise of central China" plan (*zongbu jueqi jihu*) has led to an important increase in per capita GDP of central provinces. In particular, Hubei and Hunan have recorded growth rates above the national average. All in all, changes in the spatial polarization of growth appear to be on the way since the beginning of the 21st century. While the open-door policy implemented in 1978 contributed to increase the gap between prosperous coastal provinces and poorer inland provinces (Naughton, 2002), today coastal provinces are no longer the only Chinese growth poles. Certain inland provinces are rapidly growing, which may explain the acceleration of the convergence process during the late 2000s.

6. Conclusion

The objective of this paper was to contribute to the debate on conditional convergence across Chinese provinces by taking into account the problems of measurement errors, omitted variables and reverse causality, which represent potential sources of endogeneity. The existence of these problems may produce biased results and lead to invalidate the convergence hypothesis (Nickell, 1981; Bond et al., 2001). In order to address the endogeneity issue, we propose to test the conditional convergence hypothesis using the most recent techniques of dynamics panel data models. Our econometric analysis is based on various editions of *China Statistical Yearbook* and considers panel data covering twenty nine Chinese provinces during five three-year periods from 1995 to 2009. We estimate growth equations derived from Durlauf et al. (2005) using two-step system GMM estimator (Blundell and Bond, 1998) with Windmeijer's (2005) finite-sample correction for the variance-covariance matrix.

The empirical investigations conducted as part of this research bring two main results as regard the determinants of provincial economic growth in China: (i) population growth and the share of public expenditures in GDP have a negative impact on economic growth; (ii) investment in physical capital and education have played an important role in promoting economic growth and may be considered as a means of reducing regional disparities. The econometric analysis also allows us to bring interesting results on the convergence issue : (i) the hypothesis of conditional convergence is verified during the period 1995-2009, which means that each Chinese province is converging toward its steady-state level of income; (ii) the speed of convergence is relatively high (between 3.19 and 10.27% depending on the model adopted) but consistent with the rate estimated by Poncet and Madariaga (2007); (iii) the speed of convergence is found to be faster during the period 2004-2009 (compared to the period 1995-2003), which indicates that Chinese provinces have converged more quickly over the most recent period. All in all, the recent reduction in regional disparities together with the existence of a convergence process suggest that growth spillover effects between Chinese provinces might exist since recently.

Deng Xiaoping's strategy of "let some people get rich first" is based on the idea that economic growth will spread from prosperous eastern provinces to inland provinces through the implementation of spillover effects (in line with the theory of unbalanced growth developed by Perroux, 1955; and Hirschman, 1958). These spillover effects may be generated by three kinds of externalities: demand side externalities, suply side externalities and trade externalities (Brun et al., 2002). Since the beginning of the 2000s, Chinese authorities have attempted to strengthen regional externalities with the implementation of regional development programs (e.g. "great western development", "revitalizing old industrial bases in northeast China", "rise of central China"). Moreover, the recent Twelfth Five-Year Plan (2012-2017) emphasizes the need to tackle the issue of unbalanced regional development, widely recognized as a significant threat to the sustainability of economic development. To achieve this aim, the plan proposes guidelines to advance regional integration and promote urbanization. The eastern region is still expected to lead economic development. In addition, support will be given to industries and ecologically-oriented projects in western provinces, such as Sichuan, Yunnan, Gansu, Qinghai and Xinjiang. In north-east China, industries will be revitalized and the modern industrial system improved. The development of central provinces will be energized, while the role of city clusters within the region will be strengthened. China also plans to stimulate the growth of development priority zones (DPZs) by implementing policies with specific guidance for each of the four regions. This set of policies may serve to boost and rebalance growth across the country, particularly in late-developing provinces. However, it is likely that China will also need to implement institutional reforms (such as reforming the *hukou* system) to enhance regional spillovers and to move toward a more balanced and sustainable economic development.

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Appendix

Table A1. Determinants of the growth rate of regional per capita GDP in China (1995-2009) using fixed-effect estimator.[1]

Variables	Fixed-effects Model 1	Fixed-effects Model 2	Fixed-effects Model 3	Fixed-effects Model 4
Initial GDP	**-0,0174***	**-0,0353***	-0,0304	**-0,0336***
	(0,0101)	(0,0187)	(0,0204)	(0,0187)
Population	**-0,4359*****	**-0,2335****	**-0,3055****	**-0,2964****
	(0,1142)	(0,1078)	(0,1163)	(0,1122)
Investment	**0,0548***	0,0438	0,0483	0,0462
	(0,0280)	(0,0301)	(0,0293)	(0,0283)
Education	-	**0,0429*****	**0,0625*****	**0,0699*****
		(0,0112)	(0,0137)	(0,0147)
Public expenditures	-	-	**-0,0856****	**-0,0885*****
			(0,0317)	(0,0302)
Infrastructures	-	-	-	-0,0220
				(0.0233)
Intercept	**-1,2567*****	-0,0001	-0,3175	-0,4485
	(0,3501)	(0,4265)	(0,4520)	(0,4871)
Within R^2	0,4908	0,5361	0,5757	0,5791

<u>Source</u>: Author's calculation, based on *China Statistical Yearbook* (1996-2010).

Notes: (1) Robust standard errors into brackets. Level of statistical significance: 1 % ***, 5 % **, et 10 % *. Time dummies are not reported.

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