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An Empirical Study on the Steady States of Per-Capita Output of Five Latin American Countries and China

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Abstract: This paper uses the econometric method to show, in terms of steady state of per-capita output, the relative positions of five Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico) remained below but not far away the average level of a test sample of 112 countries during the 1970-2019 period, which means, even in terms of steady state of per-capita output, the above five countries were still typical "middle income trap" countries during this period. Combining the theory of convergence with the practical data of the five countries, this paper also makes an analysis of the reasons for such a situation in their steady states of per-capita output. This paper also verifies, in terms of steady state of per-capita output, China's relative position was extremely low in 1970s but kept rising rapidly in the test sample during the 1970-2019 period, and almost caught up with the overall level of the five Latin American countries in 2010s, which means, in terms of steady state of per-capita output, China was not a "middle income trap" country during this period, but China started to face the "middle income trap" in 2010s, and the future changes in China's steady state of per-capita output will determine whether China can cross the "middle income trap".

Keywords: Five Latin American countries; China; steady state of per-capita output; conditional convergence; social infrastructure

1. Introduction

Many scholars have studied the reasons why Latin American countries fell into and have been staying in the "middle-income trap" from different perspectives, and have made many valuable research results. Examples are as follows, Caldentey (2012) indicated that in the late 1990s Chile's performance began to deteriorate due to the limited capacity of the natural resources industry. To promote the extensive upgrading of other industries, the government has formulated industrial policies to promote innovation, but this effort is limited by the low level of R & D expenditure and the lack of innovation culture in the private sector. Paus (2014) argued that many Latin American countries have found that they have been unable to compete in labor-intensive, standardized goods, but their current production capacity has not been widely improved and they cannot compete in high value-added products. Foxley and Stallings (2016) emphasized that Latin America needs greater institutional capacity to promote innovation, which in turn increases productivity. Lustig (2016) found that the effect of fiscal redistribution policy in Latin American countries is not always positive, even negative for some countries. For example, the fiscal redistribution policies in Brazil and Colombia have increased poverty as a result of high consumption taxes on basic products. Dabús, Tohmé, and Caraballo (2016) pointed out that once the world's demand for primary commodities does not increase or even decrease, Latin American countries that are heavily dependent on international prices of primary commodities will fall into the middle-income level. Argentina is a prominent example of this phenomenon. Albuquerque (2019) discussed Brazil's industrial policies that failed to narrow the gap between Brazil and developed countries, as well as the historical roots of Brazil's long stay in the "middle-income trap" with special attention to the role of income inequality. According to their research results, one can draw the following conclusions: after reaching the middle-income level, Latin American countries failed to realize the transformation of economic development strategy and mode, resulting in difficulties in industrial upgrading and insufficient endogenous power for economic growth; on the other hand, the unreasonable fiscal policies of some Latin American countries led to the aggravation of poverty and income inequality, which hindered the efforts to achieve equitable development. Therefore, these countries have stayed in the rank of "middle income trap" countries for a long time.

The above conclusions which are drawn on these scholars' research are generally pertinent, but these scholars' research is not enough. This is reflected in the fact that the explanation of the reasons behind the phenomenon is not convincing enough, and the more convincing quantitative analysis (especially the quantitative analysis of econometrics) is obviously less, which directly affects the academic value of their research results. The future research should try to make up for this deficiency.

This paper attempts to make a study on the "middle income trap" countries from the perspective of steady state of per-capita output. According to the theory of convergence, for a given period, an economy's per-capita output always converges to its steady state of per-capita output in the given period. On the other hand, because of existence of capital accumulation and technological innovation, the steady state of per-capita output also grows over time for most countries, but the growth rate can be different across countries, i.e., the steady state of per-capita output can grow fast for some countries but slowly for some other countries. Obviously, it is an important work to investigate the relative change in the steady state of per-capita output of a country in a broad set of countries. To carry out such a study, this paper establishes an important concept: *the relative steady state of per-capita output,* which is the ratio of the steady state of per-capita output of a country to the average level of a broad set of countries. According to this definition, a change in the relative steady state of per-capita output of a country indicates there happens a relative change in the steady state of per-capita output of the country in a broad set of countries.

This paper will use econometric methods to obtain the estimates of the relative steady states of per-capita output of five Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico), China (i.e., the mainland of China, the same below) and United States (as a representative of developed countries) in the 1970s, 1980s, 1990s, 2000s and 2010s to show the relative changes in the steady states of per-capita output of the above countries in a test sample of 112 countries during the 1970-2019 period. Combining the theory of convergence with the practical data of the above countries, this paper will also make an analysis of the reasons for the relative changes in the steady states of per-capita output of the above countries. Conclusions will be made on a comparison between the five Latin American countries and China.

The paper consists of eight sections. Section 1 is introduction. Section 2 is a brief review of previous studies on convergence. Section 3 gives the brief explanations of several concepts on convergence involved in this paper. In Section 4, the regression equation to test the hypothesis of conditional convergence is described. In Section 5, the data and the empirical methodology used are described, and the details of both results and analyses are also given. After Section 6 showing the paths of the relative steady states of per-capita output of the above countries, Section 7 provides an analysis of the reasons for the relative changes in the steady states of per-capita output of the concerned countries. Conclusions are made in Section 8.

2. A Brief Review of Previous Studies on β-convergence

Most economists make their studies on convergence stemming from Solow's classical growth model. The Solow model presents β-convergence, which consists of absolute convergence and conditional convergence. Conditional convergence is more common in a set of economies, so the previous studies on β-convergence generally focuses on conditional convergence.

In addition, Phillips & Sul (2007) established a new model presenting a new method to investigate convergence, which is regarded as an important contribution in the field of convergence and has been used frequently by some economists. Phillips & Sul (2009) also used their method to study the growths of various countries by displaying the relative transition parameters, which are calculated for per capita income of the countries during a given period. It is necessary to stress that without involving the steady state mentioned in Solow model, they can still show the growths of developed and developing countries will converge to different levels, which means conditional convergence. Therefore, the previous studies using the method of Phillips & Sul did not show any information about the steady state mentioned in Solow model.

This paper provides a study on convergence using the steady state mentioned in Solow model through testing the hypothesis of conditional convergence. It is well known, based on the steady state mentioned in Solow model, many economists have found the evidence of conditional convergence (e.g., Baumol (1986), Barro (1991), Mankiw, Romer, and Weil (1992), Caselli, Esquivel, and Lefort (1996), Lee, Pesaran, and Smith (1997), Panik and Rassekh (2002), Mathur (2005), Mcquinn and Whelan (2007), Karras (2008), Cavenaile and Dubois (2011), Bagci (2012), Rath (2016), Stengos, Yazgan, and Ozkan (2018), etc), the main difference among their regression results focuses on the estimate of the speed of convergence. Now it is necessary to point out their studies on convergence were made using only *one* period rather than *several successive* periods. The reason for that is these economists argue that concept of convergence applies to a long period which usually consists of several decades or even hundreds of years, and they supports two propositions: (1) No matter whether a country is developed or underdeveloped, its steady state of per capita output can remain unchanged for decades or even more than a hundred years; (2) Some developing countries can enjoy the same steady state with developed countries, but the developed countries are close to their steady state while the developing countries are far away from their steady state. But their idea is probably wrong. Let's make a brief analysis in theory and list several reasons for questioning.

Firstly, The Solow model shows that an economy's steady state of per-capita output depends on its economic parameters and effectiveness of labor. In the real world, a country's the economic parameters (such as saving rate, population growth rate, etc.) and the effectiveness of labor will change at times, so the idea that a country's steady state of per-capita output remains unchanged for decades or even more than a hundred years is much possibly wrong, at least for most countries, this idea is not applicable.

Secondly, based on the Solow model, it can still be judged that for most developing countries, their steady states are usually obviously lower than those of developed countries. The reason for that is even if there is no significant difference in economic parameters (saving rate, population growth rate, etc.) between developing and developed countries, the labor efficiency of developing countries is obviously lower than that of developed countries, so the steady states of per-capita output of developing countries are usually obviously lower than those of developed countries.

Thirdly, the economic convergence theory derived from Solow's model does imply that the steady state of per-capita output of an economy exists for a given period, but this theory does not specify the length of the given period. Theoretically, the steady state of per-capita output of an economy can exist in a relatively short period, such as a 10-year period.

All previously mentioned studies did not test the hypothesis of conditional convergence across sub-periods, so they did not assess whether there happened changes in the fixed effect of each selected economy and the speed of convergence across sub-periods. Furthermore, they did not assess whether there happened, across sub-periods, a change in a country's relative steady state of per-capita output, whose definition is given in Section 1. Such a change for a country means, in terms of steady state of per-capita output, a change in its relative position in a broad set of countries, so it is undoubtedly worth to make a study to investigate such a change, especially for some important developing countries.

This paper will make such a study by testing the hypothesis of conditional convergence in a broad set of countries in 1970s, 1980s, 1990s, 2000s and 2010s, and will show the paths of relative steady states of per-capita output of five Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico), China and United States (as a representative of developed countries) by using the obtained estimates of these countries in the above five successive sub-periods. A comparison of the paths will give some valuable information on the growths of the above countries.

3. The Explanations of Several Concepts on Convergence

This paper makes a study on convergence based on the Solow model[1] which is shown in Figure 1[2]. This paper involves several concepts on convergence: the steady state, social infrastructure, the speed of convergence β and β-convergence.

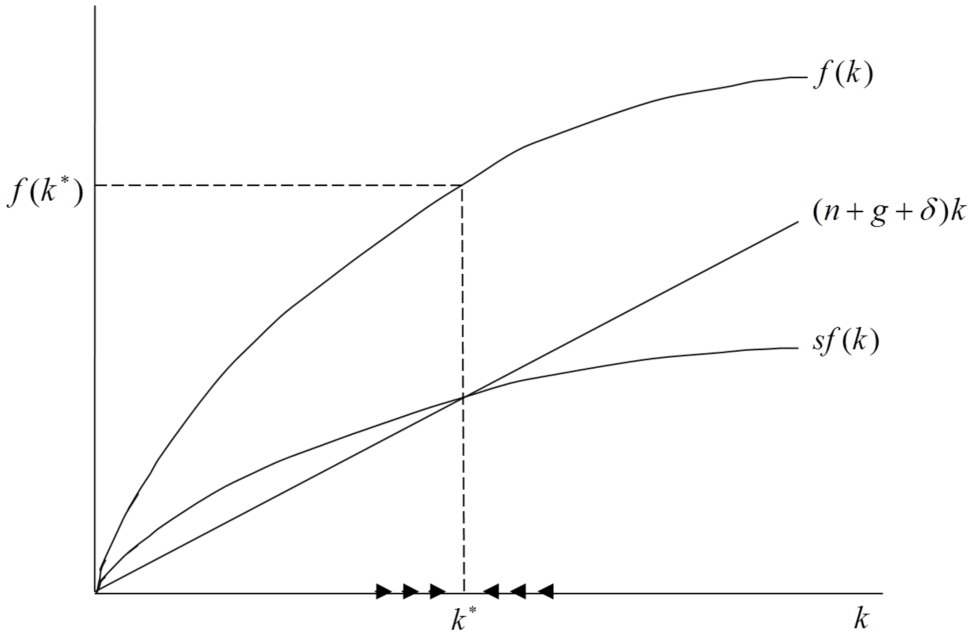

Figure 1: An Economy's Steady State for a given Period

The first is the steady state. Figure 1 shows that for an economy for a given period, the capital per unit of effective labor k converges to its steady state k^*, so the output per unit of effective labor $f(k)$ converges to its steady state $f(k^*)$. Further, the output per unit of labor (i.e., per-capita output) $Af(k)$ converges to its steady state $Af(k^*)$, where A denotes the effectiveness of labor in the given period.

The model focuses on discussing the effects of the changes in some economic parameters on the steady state. For example, for an economy, if the saving rate s rises or the population growth rate n declines, k^* and $f(k^*)$ will increase, resulting in an increase in the steady state of per-capita output $Af(k^*)$ with a given A. In addition, if the effectiveness of labor A improves and k^* is given, $Af(k^*)$ will also increase.

According to what Romer describes[3], social infrastructure refers to those institutions, policies, traditions and cultures, which can influence economic growth. In fact, an economy's social infrastructure can almost determine its steady state of per-capita output through influencing the economic parameters and the effectiveness of labor. The high steady states of per-capita output of developed countries are mainly attributed to their superior social infrastructures, so a less developed country must establish a good social infrastructure in advance if it wants to be a developed one.

The following equation[4] is used to explain the speed of convergence β.

$$k(t)-k^{*}=e^{-\beta t}\left(k(0)-k^{*}\right) \tag{1}$$

Equation (1) shows that only a positive value of β let *k* converge to k^{*}, and a larger value of β means a quicker convergence. β in equation (1) is assumed to be a small constant when *k* is close to k^{*} for an economy for a given period; otherwise, β can be changed.

β-convergence is named after the speed of convergence β. It has two forms: absolute convergence and conditional convergence. Absolute convergence implies the selected economies might have similar social infrastructure, so they can enjoy the similar steady state of per-capita output to converge, while conditional convergence implies the selected economies might have different social infrastructures, so they have different steady states of per-capita output to converge, respectively. There will be either absolute convergence or conditional convergence in a set of economies.

4. The Regression Equation to Test the Hypothesis of β-convergence

The following equation[5] is used to test the hypothesis of β-convergence.

$$(1/T)\log\left(Y_{i,t}/Y_{i,t-T}\right)=\alpha_i-(1/T)\left(1-e^{-\beta T}\right)\log Y_{i,t-T}+u_{i,t}, \tag{2}$$

where the subscript *t* denotes year *t*; the subscript *i* denotes economy *i*; *T* denotes the length of the time interval of observations used; $Y_{i,t}$ denotes per-capita output of economy *i* for all *i* in year *t*, as shown in Section 3, $Y_i = A_i f(k_i)$ holds for economy *i* for all *i*; β denotes the average speed of convergence for all economies in a sample for a given period; $\alpha_i = x_i + (1/T)\left(1-e^{-\beta T}\right)\log Y_i^{*}$, x_i denotes the technological progress rate of economy *i* for all *i* ($x_i = g_i$ holds for all i), Y_i^{*} denotes the steady state of per-capita output of economy *i* for all *i* for a given period, and as shown in Section 3, $Y_i^{*} = A_i f(k_i^{*})$ holds for economy *i* for all *i* for a given period. Equation (2) implies the average annual growth rate (between year *t-T* and year *t*) of per-capita output of economy *i* for all *i* depends positively on Y_i^{*} and negatively on $Y_{i,t-T}$.

In order to remove the time trend associated with the growth of technological progress (x_i), Coulombe (2004) defines $y_{i,t} = \log(Y_{i,t} / \bar{Y}_t)$, where $\bar{Y}_t$ is the cross section mean of $Y_{i,t}$ in year *t* for all *t*. The equation (3) is obtained by transforming the equation (2), the details for the transformation are shown in *Appendix A*.

$$(1/T)\Delta y_{i,t} = c_i - (1/T)(1 - e^{-\beta T})y_{i,t-T} + \varepsilon_{i,t}, \tag{3}$$

where $\Delta y_{i,t} = y_{i,t} - y_{i,t-T} = \log(Y_{i,t} / \bar{Y}_t) - \log(Y_{i,t-T} / \bar{Y}_{t-T})$; $c_i = \alpha_i - \bar{\alpha} = (1/T)(1 - e^{-\beta T})y_i^*$ almost holds because both x_i and $\bar{x}$ are positive and small enough so that the difference $x_i - \bar{x}$ can be neglected, $y_i^* = \log(Y_i^* / \bar{Y}^*)$, which denotes the relative steady state of per-capita output (log version) of economy *i* for all *i*; and $\varepsilon_{i,t} = u_{i,t} - \bar{u}_t$.

In this paper, it is equation (3) that is used to test the hypothesis of β convergence. In equation (3), c_i is the constant term (fixed effect) of economy *i* for all *i*. In the case of conditional convergence, Y_i^* changes with *i*, then Y_i^* does not equal $\bar{Y}^*$ for most *i* and y_i^* does not equal zero for most *i*, thus c_i does not equal zero for most *i*, i.e., c_i is significant for most *i*. In the case of absolute convergence, c_i is not significant for most *i*.

5. The Data, the Empirical Methodology, the Results and Analyses

5.1. The Data

World Bank provides data on per-capita output, i.e., GDP per capita (constant 2015 US$) for countries. The downloaded data on GDP per capita cover the years from 1970 to 2019 and include 112 countries[6] which are listed in *Appendix B* and whose data on GDP per capita are available in each year from 1970 to 2019. The data are balanced panel data.

5.2. The Empirical Methodology

Firstly, the above data is regarded as a joint sample (the 1970-2019 sample), which consists of the five sub-samples: the 1970-1979 sub-sample, the 1980-1989 sub-sample, the 1990-1999 sub-sample, the 2000-2009 sub-sample and the 2010-2019 sub-sample. There are both developed and less developed countries in each sub-sample, so conditional convergence should exist in each one.

Secondly, the regression results from using the data in the five sub-samples can provide, respectively, an estimate of relative steady state of per-capita output of each country in 1970s, 1980s, 1990s, 2000s and 2010s. If the hypothesis of conditional convergence is tested in the five sub-samples separately, the five estimates of each country will be obtained separately. According to econometrics, one cannot simply use two estimates to judge whether the change in a variable or the gap between two variables is significant without doing a Wald test. To make Wald tests for assessments, the five estimates of all countries must be obtained simultaneously, which can make all estimates associated with each other in an econometric software like Eviews. To solve this problem, dummy variables can be introduced into the regression equation.

Because $(1/T)(1-e^{-\beta T}) \cong \beta$ holds when β is a very small positive number[7], the constant term $c_i = \beta y_i^*$ holds for country *i* for all *i*. Take one year as the time interval of observations, i.e., T = 1 year, equation (3) can be rewritten as

$$\Delta y_{i,t} = c_i - \beta y_{i,t-1} + \varepsilon_{i,t} \tag{4}$$

Four dummy variables $D1$, $D2$, $D3$ and $D4$ are introduced into equation (4) to capture, respectively, the changes in constant term c_i of country *i* for all *i* across sub-periods. Another four dummy variables $DT1$, $DT2$, $DT3$ and $DT4$ are introduced to find, respectively, the changes in the average speed of convergence β for all countries in the sample across sub-periods. Such an introduction of dummy variables yields equation (5).

$$\begin{aligned}\Delta y_{i,t} &= c_{i,0} + \gamma_{i,1}D1 + \gamma_{i,2}D2 + \gamma_{i,3}D3 + \gamma_{i,4}D4 \\ &\quad - \beta_0 y_{i,t-1} + \lambda_1 DT1 y_{i,t-1} + \lambda_2 DT2 y_{i,t-1} + \lambda_3 DT3 y_{i,t-1} + \lambda_4 DT4 y_{i,t-1} + \varepsilon_{i,t}\end{aligned} \tag{5}$$

where $D1 = DT1 =$ 1 when data is in the 1980-1989 sub-sample, $D1 = DT1 =$ 0 otherwise; $D2 = DT2 =$ 1 when data is in the 1990-1999 sub-sample, $D2 = DT2 =$ 0 otherwise; $D3 = DT3 =$ 1 when data is in the 2000-2009 sub-sample, $D3 = DT3 =$ 0 otherwise; $D4 = DT4 =$ 1 when data is in the 2010-2019 sub-sample, $D4 = DT4 =$ 0 otherwise; $c_{i,0}$ denotes the constant term (fixed effect) of country *i* for all *i* in 1970s; $\gamma_{i,1}$ denotes the gap between c_i in 1970s and 1980s for all *i*; $\gamma_{i,2}$ denotes the gap between c_i in 1970s and 1990s for all *i*; $\gamma_{i,3}$ denotes the gap between c_i in 1970s and 2000s for all *i*; $\gamma_{i,4}$ denotes the gap between c_i in 1970s and 2010s for all *i*; β_0 denotes the average speed of convergence for all countries in the sample in1970s; λ_1 denotes the gap between β in 1970s and 1980s; λ_2 denotes the gap between β in 1970s and 1990s; λ_3 denotes the gap between β in 1970s and 2000s; and λ_4 denotes the gap between β in 1970s and 2010s. Further, $c_{i,0}$, $(c_{i,0}+\gamma_{i,1})=c_{i,1}$, $(c_{i,0}+\gamma_{i,2})=c_{i,2}$, $(c_{i,0}+\gamma_{i,3})=c_{i,3}$ and $(c_{i,0}+\gamma_{i,4})=c_{i,4}$ denote, respectively, the constant term of country *i* for all *i* in 1970s, 1980s, 1990s, 2000s, 2010s; β_0, $(\beta_0-\lambda_1)=\beta_1$, $(\beta_0-\lambda_2)=\beta_2$, $(\beta_0-\lambda_3)=\beta_3$, $(\beta_0-\lambda_4)=\beta_4$ denote , respectively, the average speed of convergence for all countries in the sample in 1970s, 1980s, 1990s, 2000s and 2010s. After such an introduction of eight dummy variables, data in the five sub-samples can be used jointly to estimate equation (5) to get the estimates of all above coefficients simultaneously, further, get simultaneously the five estimates of relative steady state of per-capita output of all countries in the sample in the above five successive sub-periods.

5.3. The Results and Analyses

According to the definition of conditional convergence, if β_0 in equation (5), β_1, β_2, β_3 and β_4, which are implied in equation (5) , are all positive; $c_{i,0}$ in equation (5), $c_{i,1}$, $c_{i,2}$, $c_{i,3}$ and $c_{i,4}$, which are implied in equation (5), are all significant for most *i*, the hypothesis of conditional convergence cannot be rejected, respectively, in the 1970-1979 sub-sample, the 1980-1989 sub-sample, the 1990-1999 sub-sample, the 2000-2009 sub-sample and the 2010-2019 sub-sample.

Now make the following ten null hypotheses for the above five sub-samples: $H_0:\beta_0=0$, $H_0:c_{i,0}=0$; $H_0:\beta_1=0$, $H_0:c_{i,1}=0$; $H_0:\beta_2=0$, $H_0:c_{i,2}=0$; $H_0:\beta_3=0$, $H_0:c_{i,3}=0$; $H_0:\beta_4=0$, $H_0:c_{i,4}=0$. The regression results from estimating equation (5) by using data in the five sub-samples jointly are shown in *Appendix C*, but the regression results about Argentina, Brazil, Chile, Colombia, Mexico, China and United States are chosen and displayed in Table 1.

Table 1. The selected regression results from estimating equation (5)

Method: GLS (Cross Section Weights)
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments
Number of cross-sections included: 112
Total pool (balanced) observations: 5488

Variable	*Coefficient*	*Estimates*	*Std. Error*	*t-statistic*	*p value*
$y_{i,t-1}$	$-\beta_0$	-0.199982	0.041515	-4.817125	0.0000
$DT1y_{i,t-1}$	λ_1	0.080308	0.051524	1.558653	0.1191
$DT2y_{i,t-1}$		0.006861	0.059827	0.114683	0.9087
$DT3y_{i,t-1}$		0.135475	0.048498	2.793392	0.0052
$DT4y_{i,t-1}$		0.037872	0.049117	0.771069	0.4407
$c_0(ARG)$	$c_0(ARG)$	-0.052648	0.016556	-3.179949	0.0015
$D1(ARG)$	$\gamma_1(ARG)$	-0.026020	0.020796	-1.251209	0.2109
$D2(ARG)$	γ_2 (ARG)	-0.040316	0.023413	-1.721966	0.0851
$D3(ARG)$	γ_3 (ARG)	0.011227	0.026680	0.420782	0.6739
$D4(ARG)$	$\gamma_4(ARG)$	-0.039258	0.025821	-1.520381	0.1285
c_0 (BRA)	c_0 (BRA)	-0.041925	0.012210	-3.433626	0.0006
$D1(BRA)$	$\gamma_1(BRA)$	-0.001682	0.019927	-0.084426	0.9327
$D2$ (BRA)	γ_2 (BRA)	-0.054640	0.019175	-2.849570	0.0044
$D3$ (BRA)	γ_3 (BRA)	0.016393	0.019998	0.819743	0.4124
$D4$ (BRA)	γ_4 (BRA)	-0.037202	0.022065	-1.686025	0.0919
c_0 (CHL)	c_0 (CHL)	-0.162213	0.048846	-3.320936	0.0009
$D1$ (CHL)	$\gamma_1(CHL)$	0.073379	0.062016	1.183234	0.2368
$D2$ (CHL)	γ_2 (CHL)	0.083731	0.051404	1.628893	0.1034
$D3$ $(CHL$	γ_3 (CHL)	0.153424	0.049847	3.077896	0.0021
$D4$ (CHL)	γ_4 (CHL)	0.135175	0.049588	2.725958	0.0064
c_0 (CHN)	c_0 (CHN)	-0.697024	0.149808	-4.652786	0.0000
$D1$ (CHN)	γ_1 (CHN)	0.384597	0.174260	2.207027	0.0274
$D2$ (CHN)	γ_2 (CHN)	0.280888	0.179918	1.561202	0.1185
$D3$ (CHN)	γ_3 (CHN)	0.615278	0.158224	4.141462	0.0000
$D4$ (CHN)	γ_4 (CHN)	0.569051	0.152974	3.719926	0.0002
c_0 (COL)	c_0 (COL)	-0.195279	0.042420	-4.603519	0.0000
$D1$ (COL)	γ_1 (COL)	0.075209	0.051715	1.454290	0.1459
$D2$ (COL)	γ_2 (COL)	-0.000552	0.056224	-0.009819	0.9922
$D3$ (COL)	γ_3 (COL)	0.135804	0.051305	2.647017	0.0081
$D4$ (COL)	γ_4 (COL)	0.059077	0.048139	1.227224	0.2198
c_0 (MEX)	c_0 (MEX)	-0.066991	0.018095	-3.702220	0.0002

contd. table 1

Variable	*Coefficient*	*Estimates*	*Std. Error*	*t-statistic*	*p value*
*D*1 (*MEX*)	γ_1 (*MEX*)	0.015281	0.026732	0.571645	0.5676
*D*2 (*MEX*)	γ_2 (*MEX*)	-0.019011	0.028938	-0.656946	0.5112
*D*3 (*MEX*)	γ_3 (*MEX*)	0.019305	0.021720	0.888796	0.3742
*D*4 (*MEX*)	γ_4 (*MEX*)	-0.025885	0.024297	-1.065379	0.2868
c_0 (*USA*)	c_0 (*USA*)	0.205620	0.042799	4.804257	0.0000
*D*1 (*USA*)	γ_1 (*USA*)	-0.072161	0.055917	-1.290510	0.1969
*D*2 (*USA*)	γ_2 (*USA*)	0.008211	0.064678	0.126957	0.8990
*D*3 (*USA*)	γ_3 (*USA*)	-0.139439	0.051264	-2.720042	0.0066
*D*4 (*USA*)	γ_4 (*USA*)	-0.033115	0.050967	-0.649740	0.5159

R-squared: 0.343562

In Table 1, the p value of the t-statistic for the estimate of β_0 shows H_0: $\beta_0 = 0$ is rejected at the 1% significance level, and the estimate of β_0 shows β_0 is positive. In *Appendix C*, p values of t-statistics for most estimates of $c_{i,0}$ show H_0: $c_{i,0} = 0$ is rejected at the 1% significance level. The regression results of β_0 and $c_{i,0}$ show the hypothesis of conditional convergence is not rejected in the 1970-1979 sub-sample.

The regression results from estimating equation (5) do not provide directly the information about β_1, $c_{i,1}$, β_2, $c_{i,2}$, β_3, $c_{i,3}$, β_4 and $c_{i,4}$, but Wald tests can be made to get the concerned information about them. Table 2 contains the main results of all Wald tests made in this paper, the original details are shown in *Appendix D.*

In Table 2, the results of the Wald test of H_0: $\beta_1 = 0$ show the p value for the Chi-square is 0.0001, thus H_0: $\beta_1 = 0$ is rejected at the 1% significance level. The estimate of β_1 ($\hat{\beta}_1 = \hat{\beta}_0 - \hat{\lambda}_1 = 0.119674$) which is implied in Table 1 shows β_1 is positive. Although the Wald test of H_0: $c_{i,1} = 0$ can be made on the country by country basis, such a job is not done in this paper because of too many countries (112 countries) in the test sample. Since most estimates of $c_{i,0}$ are significant while most estimates of $\gamma_{i,1}$ are not significant according to their p values of t-statistics shown in *Appendix C*, one can infer that most estimates of $c_{i,1} (= c_{i,0} + \gamma_{i,1})$ are significant, i.e., the results of the Wald test of H_0: $c_{i,1} = 0$ should show that H_0:

$c_{i,1} = 0$ is rejected at the 5% or 10% significance level. Thus the information obtained about β_1 and $c_{i,1}$ show that the hypothesis of conditional convergence is not rejected in the 1980-1989 sub-sample.

Table 2: The results of all Wald tests done in this paper

1.	Null Hypothesis: $\beta_1 = 0$			
	Chi-square	15.37879	p value	0.0001
2.	Null Hypothesis: $\beta_2 = 0$			
	Chi-square	20.09702	p value	0.0000
3.	Null Hypothesis: $\beta_3 = 0$			
	Chi-square	6.619603	p value	0.0101
4.	Null Hypothesis: $\beta_4 = 0$			
	Chi-square	38.14290	p value	0.0000
5.	Null Hypothesis: $y_1^*(BRA) - y_0^*(BRA) = 0$			
	Chi-square	2.100459	p value	0.1473
6.	Null Hypothesis: $y_2^*(BRA) - y_1^*(BRA) = 0$			
	Chi-square	1.329566	p value	0.2489
7.	Null Hypothesis: $y_3^*(BRA) - y_2^*(BRA) = 0$			
	Chi-square	0.653989	p value	0.4187
8.	Null Hypothesis: $y_4^*(BRA) - y_3^*(BRA) = 0$			
	Chi-square	0.454298	p value	0.5003
9.	Null Hypothesis: $y_0^*(BRA) = 0$			
	Chi-square	81.99364	p value	0.0000
10.	Null Hypothesis: $y_1^*(BRA) = 0$			
	Chi-square	12.22189	p value	0.0005
11.	Null Hypothesis: $y_2^*(BRA) = 0$			
	Chi-square	84.07182	p value	0.0000
12.	Null Hypothesis: $y_3^*(BRA) = 0$			
	Chi-square	11.48890	p value	0.0007
13.	Null Hypothesis: $y_4^*(BRA) = 0$			
	Chi-square	46.53907	p value	0.0000

14. Null Hypothesis: $y_0^*(CHN) - y_0^*(BRA) = 0$			
Chi-square	1470.358	p value	0.0000
15. Null Hypothesis: $y_1^*(CHN) - y_1^*(BRA) = 0$			
Chi-square	229.5283	p value	0.0000
16. Null Hypothesis: $y_2^*(CHN) - y_2^*(BRA) = 0$			
Chi-square	257.7875	p value	0.0000
17. Null Hypothesis: $y_3^*(CHN) - y_3^*(BRA) = 0$			
Chi-square	126.0829	p value	0.0000
18. Null Hypothesis: $y_4^*(CHN) - y_4^*(BRA) = 0$			
Chi-square	8.147911	p value	0.0043

Similarly, using the above analyzing and inferring method, one can know that β_2, β_3 and β_4 are all positive; H_0: $c_{i,2} = 0$, H_0: $c_{i,3} = 0$ and H_0: $c_{i,4} = 0$ are all rejected at the 5% or 10% significance level. So the information obtained about β_2, $c_{i,2}$, β_3, $c_{i,3}$, β_4 and $c_{i,4}$ suggest the hypothesis of conditional convergence is not rejected , respectively, in the 1990-1999 sub-sample, the 2000-2009 sub-sample and the 2010-2019 sub-sample.

As shown in Section 4, $y_i^* = \log(Y_i^* / \bar{Y}^*)$ denotes the relative steady state of per-capita output (log version) of country *i* for all *i*. Let $y_{i,0}^*$, $y_{i,1}^*$, $y_{i,2}^*$, $y_{i,3}^*$ and $y_{i,4}^*$ denote, respectively, the relative steady state of per-capita output of country *i* for all *i* in 1970s, 1980s, 1990s, 2000s and 2010s. As shown in Section 5.2, $c_i = \beta y_i^*$ holds for country *i* for all *i*, the estimates of y_i^* can be computed using the estimates of c_i and β in each sub-period. Take Brazil's relative steady state of per-capita output $y^*(BRA)$ as an example, the details of the computation are shown as follows.

$$\hat{y}_0^*(BRA) = \hat{c}_0(BRA) / \hat{\beta}_0 = -0.041925/0.199982 = -0.2096$$

$$\hat{y}_1^*(BRA) = \hat{c}_1(BRA) / \hat{\beta}_1 = [\hat{c}_0(BRA) + \hat{\gamma}_1(BRA)]/(\hat{\beta}_0 - \hat{\lambda}_1)$$
$$= (-0.041925 - 0.001682) / (0.199982 - 0.080308) / = -0.3645$$

$$\hat{y}^*_2(BRA) = \hat{c}_2(BRA)/\hat{\beta}_2 = [\hat{c}_0(BRA) + \hat{\gamma}_2(BRA)]/(\hat{\beta}_0 - \hat{\lambda}_2)$$
$$=(-0.041925 -0.054640) / (0.199982 - 0.006861)= -0.4997$$

$$\hat{y}^*_3(BRA) = \hat{c}_3(BRA)/\hat{\beta}_3 = [\hat{c}_0(BRA) + \hat{\gamma}_3(BRA)]/(\hat{\beta}_0 - \hat{\lambda}_3)$$
$$= (0.041925 + 0.016393) / (0.199982 -0.135475) = -0.3953$$

$$\hat{y}^*_4(BRA) = \hat{c}_4(BRA)/\hat{\beta}_4 = [\hat{c}_0(BRA) + \hat{\gamma}_4(BRA)]/(\hat{\beta}_0 - \hat{\lambda}_4)$$
$$= (-0.041925 -0.037202) / (0.199982 -0.037872) = -0.4879$$

Let $y^*(ARG)$, $y^*(CHL)$, $y^*(COL)$, $y^*(MEX)$, $y^*(CHN)$ and $y^*(USA)$ denote, respectively, relative steady states of per-capita output of Argentina, Chile, Colombia, Mexico, China and United States, and one can compute the estimates of them by using the above method. All estimates of the seven countries are shown in Table 3.

Table 3. Estimates of relative steady states of per-capita output of the seven countries

Names of countries	*Estimates in 1970s*	*Estimates in 1980s*	*Estimates in 1990s*	*Estimates in 2000s*	*Estimates in 2010s*
Argentina	-0.2633	-0.6577	-0.4814	-0.6422	-0.5669
Brazil	-0.2096	-0.3645	-0.4997	-0.3953	-0.4879
Chile	-0.8111	-0.7425	-0.4064	-0.1364	-0.1668
Colombia	-0.9764	-1.0041	-1.0139	-0.9225	-0.8402
Mexico	-0.3350	-0.4323	-0.4454	-0.7395	-0.5729
China	-3.4851	-2.6120	-2.1548	-1.2666	-0.7896
United States	1.0282	1.1162	1.1072	1.0264	1.0642

In Table 3, the estimates of United States are all positive. For a developed country like United States, its steady state of per-capita output $Y^*(USA)$ is much higher than the average $\bar{Y}^*$ of all countries in the test sample, so its relative steady state of per-capita output $y^*(USA)$ is significantly positive, actually around 1. The estimates of Argentina, Brazil, Chile, Colombia, Mexico and China are significantly negative or near to zero as shown in Table 3 because they are less developed countries.

How to assess whether a country's relative steady state of per-capita output changes with time? Take $y^*(BRA)$ as example and make the four null hypotheses:

$H_0: y_1^*(BRA) - y_0^*(BRA) = 0$, $H_0: y_2^*(BRA) - y_1^*(BRA) = 0$, $H_0: y_3^*(BRA) - y_2^*(BRA) = 0$, $H_0: y_4^*(BRA) - y_3^*(BRA) = 0$. In Table 2, the results of the Wald test of $H_0: y_1^*(BRA) - y_0^*(BRA) = 0$ show that the p value for the Chi-square is above 10%, which means $H_0: y_1^*(BRA) - y_0^*(BRA) = 0$ is not rejected, i.e., the gap between $y^*(BRA)$ in 1970s and 1980s is possibly not significant. So Brazil's relative steady state of per-capita output in 1980s is possibly not significantly different from its in 1970s.

Similarly, the results of the Wald tests of $H_0: y_2^*(BRA) - y_1^*(BRA) = 0$, $H_0: y_3^*(BRA) - y_2^*(BRA) = 0$ and $H_0: y_4^*(BRA) - y_3^*(BRA) = 0$ show that all of the three null hypotheses are not rejected because their p values for the Chi-square are all above 10% as shown in Table 2, i.e., as for Brazil, its relative steady state of per-capita output in 1990s is possibly not significantly different from its in 1980s, its relative steady state of per-capita output in 2000s possibly does not differ significantly from its in 1990s, and its relative steady state of per-capita output in 2010s is possibly not significantly different from its in 2000s.

The formula $y_i^* = \log(Y_i^* / \bar{Y}^*)$ shows that 0 is the average of relative steady states of per-capita output of all countries in the test sample. Now make the five null hypotheses: $H_0: y_0^*(BRA) = 0$, $H_0: y_1^*(BRA) = 0$, $H_0: y_2^*(BRA) = 0$, $H_0: y_3^*(BRA) = 0$, $H_0: y_4^*(BRA) = 0$. In Table 2, the results of the Wald tests show all above five null hypotheses are rejected at the 1% significance level because their p values for the Chi-square are all below 1%. The five estimates of $y^*(BRA)$ shown in Table 3 are all negative, showing Brazil's relative steady state of per-capita output is significantly below the average of all countries in the test sample in each of the five sub-periods.

How to assess whether a country's relative steady state of per-capita output differs from another's in the same period? Take $y^*(CHN)$ and $y^*(BRA)$ as example and make five null hypotheses: $H_0: y_0^*(CHN) - y_0^*(BRA) = 0$, $H_0: y_1^*(CHN) - y_1^*(BRA) = 0$, $H_0: y_2^*(CHN) - y_2^*(BRA) = 0$, $H_0: y_3^*(CHN) - y_3^*(BRA) = 0$ and $H_0: y_4^*(CHN) - y_4^*(BRA) = 0$. In Table 2, the results of Wald tests show all above null hypothesis are rejected at the 1% significance level because their p values for the Chi-square are all below 1%. According to the estimates of $y^*(BRA)$ and $y^*(CHN)$ shown in Table 3, $y_0^*(CHN)$ lower than $y_0^*(BRA)$; $y_1^*(CHN)$ lower than $y_1^*(BRA)$; $y_2^*(CHN)$ lower than $y_2^*(BRA)$; $y_3^*(CHN)$ lower than $y_3^*(BRA)$; $y_4^*(CHN)$ lower than $y_4^*(BRA)$. So China's relative steady state of per-capita output is lower than Brazil's in each sub-period.

6. The Paths of Relative Steady States of Per-capita Output of the Seven Countries

The path of a country's relative steady state of per-capita output shows how the country's steady state of per-capita output changes relatively in a test sample over time, i.e., in terms of steady state of per-capita output, the path shows how a country's relative position changes in a test sample over time. The path is obtained by using the estimates of a country's relative steady state of per-capita output in the successive sub-periods. The paths of Argentina, Brazil, Chile, Colombia, Mexico, China and United States are drawn by using their estimates in Table 3 and shown in Figure 2.

As shown earlier, $y_i^* = \log(Y_i^* / \bar{Y}^*)$ denotes the relative steady state of per-capita output (log version) of country *i* for all *i*. In Figure 2, the horizontal axis is for such a hypothetical country: its relative steady state of per-capita output always equals 0 or its steady state of per-capita output always equals the average level of all countries in a test sample. The path of US is obviously above the horizontal axis, so it is a typical path of a developed country. It is reasonable to believe US's steady state of per-capita output kept growing from 1970s to 2010s, but the path of US shows US's relative steady state of per-capita output did not change significantly from 1970s to 2010s, i.e., in terms of steady state of per-capita output, US's relative position did not change significantly in the test sample from 1970s to 2010s.

The paths of Argentina, Brazil, Chile, Colombia and Mexico are all below the horizontal axis, but not far away. The five paths show that the relative steady states of per-capita output of the five Latin American countries fluctuated slightly from 1970s to 2010s., i.e., in terms of steady state of per-capita output, each country's relative position did not change obviously as a whole in a test sample from 1970s to 2010s. The above situations indicate that even in terms of steady state of per-capita output, the five Latin American countries were not only developing countries but also typical "middle income trap" countries during the 1970-2019 period.

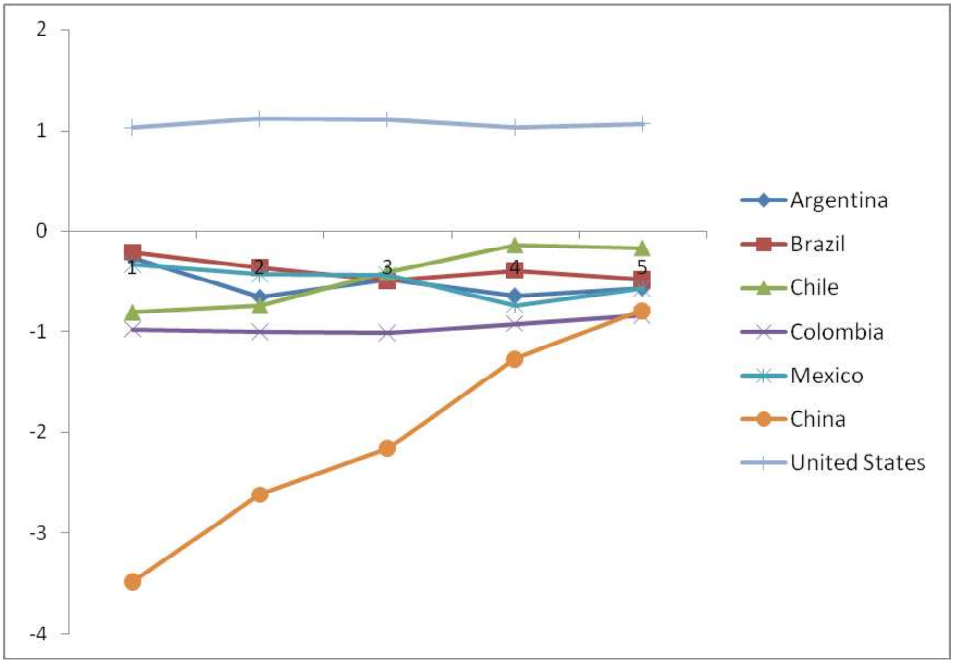

Figure 2: The paths of relative steady states of per-capita output of the five Latin American countries, China and United States (1970-2019)

Note: 1. The numbers 1, 2, 3, 4 and 5 below the horizontal axis denote 1970s, 1980s, 1990s, 2000s and 2010s, respectively. 2. The numbers at the left side of the vertical axis denote the measures of relative steady state of per-capita output.

The path of China is generally much below the horizontal axis. The path shows China's relative steady state of per-capita output was extremely low in 1970s, then kept improving dramatically, until 2010s almost caught up with the overall level of the five Latin American countries, i.e., in terms of steady state of per-capita output, China's relative position kept increasing significantly in a test sample, and in 2010s almost reached the overall level of the five Latin American countries. The path of China suggests, in terms of steady state of per-capita output, China was a developing country but not a "middle income trap" country during the 1970-2019 period, China started to face the "middle income trap" in 2010s.

7. An Analysis of the Reasons for the Relative Changes in Steady States of Per-capita Output of the Five Latin American Countries and China

Section 3 indicates social infrastructure determines the steady state of per-capita output through influencing the economic parameters and the effectiveness of labor.

By looking up historical data of the five Latin American countries, this paper reveals how their social infrastructures determined their steady states of per-capita output ($A\ f(k^*)$) through influencing their saving rates (s), population growth rates (n) and labor efficiencies (A) during the 1970-2019 period. In addition, in view of the needs of the research in this paper, the data of China and United States are also looked up.

First, look at the saving rate. The data on annual saving rate of the five Latin American countries, China and United States can be downloaded from the World Bank database, and the average annual saving rate of each country is calculated, respectively, in the 1970s, 1980s, 1990s, 2000s and 2010s, and listed in Table 4. The data in Table 4 provide the seven paths shown in Figure 3, which reflects roughly the changes in the saving rates of the seven countries during the 1970-2019 period.

Table 4: Estimates of the saving rates of the seven countries (%)

Names of countries	*Estimates in 1970s*	*Estimates in 1980s*	*Estimates in 1990s*	*Estimates in 2000s*	*Estimates in 2010s*
Argentina	30.49	17.62	15.52	18.22	13.99
Brazil	19.61	19.86	15.87	16.94	16.17
Chile	11.41	12.27	22.53	22.67	19.40
Colombia	18.11	18.27	17.35	16.24	17.50
Mexico	21.82	24.61	20.93	21.69	22.58
China	—-	35.47	39.27	44.93	48.20
United States	22.32	20.84	19.17	17.86	18.54

Note: The average annual saving rates are calculated based on data on annual saving rate in each sub-period.2. The World Bank database lacks data on China's annual saving rate in the 1970s, so China's average annual saving rate in the 1970s is blank in Table 4.

Table 4 and Figure 3 clearly show that during the period 1970-2019, the saving rates of the five Latin American countries did not change obviously on a whole (only Argentina's saving rate fell significantly in the 1980s and Chile's saving rate rose significantly in the 1990s). There are two main reasons for this situation: First, Latin American culture makes the local people get a habit of valuing consumption and neglecting saving; Second, the governments did not issue policies to encourage their nationals to increase saving. Both make contributions to their saving rates remaining at a relatively low level. The convergence theory shows, other factors remain unchanged, a higher saving rate leads to a higher level of k^* and $f(k^*)$, and the converse is also true. From 1970s to 2010s, the saving rates of the five Latin American countries

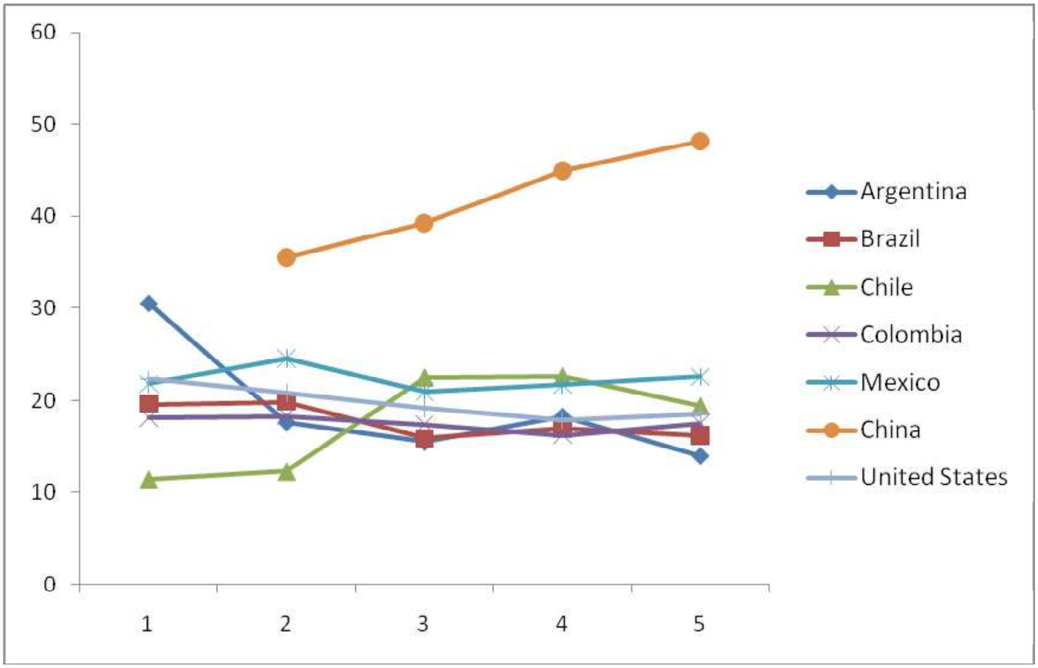

Figure 3: The paths of the saving rates of the five Latin American countries, China and United States (1970-2019)

Note: 1. The numbers 1, 2, 3, 4 and 5 below the horizontal axis denote 1970s, 1980s, 1990s, 2000s and 2010s, respectively. 2. The numbers at the left side of the vertical axis denote the measures (%) of saving rate. 3. The World Bank database lacks data on China's annual saving rate in the 1970s, so there is one corresponding blank for China's path in Figure 3.

stayed at a relatively low level (around 20%), a little lower than the world average level (around 24%), this is a reason why in terms of the steady state of per-capita output, the relative positions of the five Latin American countries remained below but not far away the average level of the test sample.

Second, look at the population growth rate. The data on annual population growth rate of the above mentioned seven countries are downloaded from the World Bank database, and the average annual population growth rate of each country is calculated, respectively, in the 1970s, 1980s, 1990s, 2000s and 2010s, and listed in Table 5. The data in Table 5 give the seven paths in Figure 4, which reflects basically the changes in the population growth rates of the seven countries during the 1970-2019 period.

Table 5: Estimates of the population growth rates of the seven countries (%)

Names of countries	*Estimates in 1970s*	*Estimates in 1980s*	*Estimates in 1990s*	*Estimates in 2000s*	*Estimates in 2010s*
Argentina	1.55	1.57	1.26	1.04	1.05
Brazil	2.40	2.16	1.63	1.18	0.86
Chile	1.56	1.49	1.48	1.08	1.15
Colombia	2.28	2.1	1.84	1.37	1.15
Mexico	2.81	2.19	1.68	1.43	1.3
China	1.97	1.43	1.13	0.61	0.50
United States	1.05	0.92	1.23	0.95	0.72

Note: The average annual population growth rates are calculated based on the data on annual population growth rates in each sub-period.

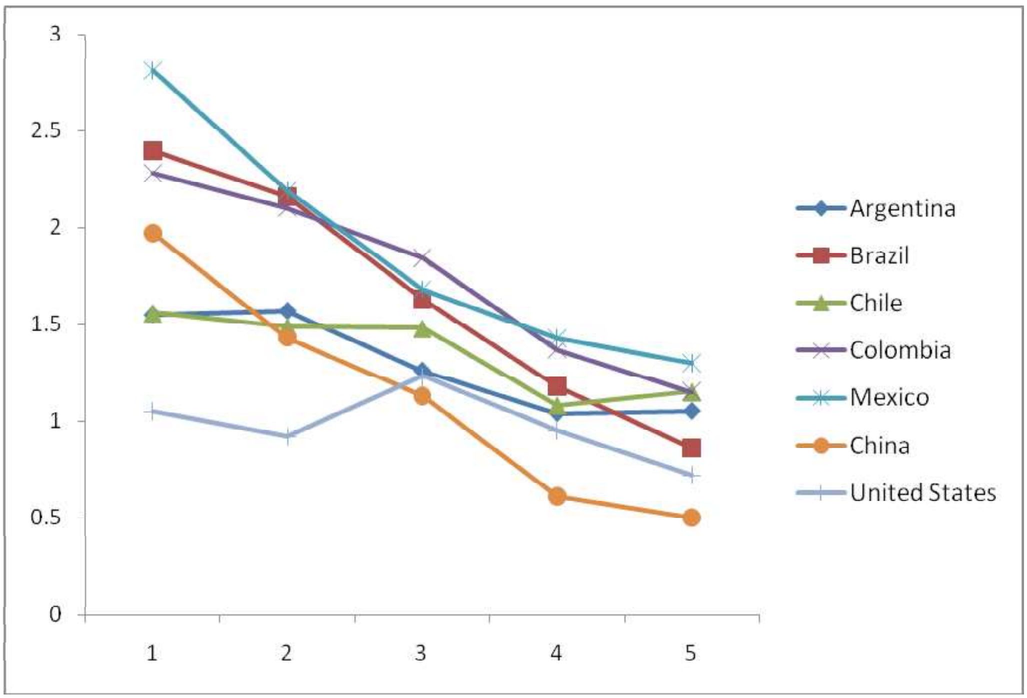

Figure 4: The paths of the population growth rates of the five Latin American countries, China and United States (1970-2019)

Note: 1. The numbers 1, 2, 3, 4 and 5 below the horizontal axis denote 1970s, 1980s, 1990s, 2000s and 2010s, respectively. 2. The numbers at the left side of the vertical axis denote the measures (%) of population growth rate.

Table 5 and Figure 4 clearly show that during the 1970-2019 period, like China's population growth rate, the population growth rates of the five Latin American countries maintained a marked downward trend on a whole, even the rate of the United States enjoyed a slightly declined trend. According to the convergence theory, when other factors remain unchanged, a lower population growth rate leads to a higher level of k^* and $f(k^*)$, and the converse is also true. During the period 1970-2019, a marked downward trend in population growth rates of the five Latin American countries could be helpful to improve their $f(k^*)$. But perhaps most countries in the test sample experienced a similar downward trend in their population growth rates during the 1970-2019 period, so the population growth rates of the five Latin American countries might not decline relatively in the test sample, making no significant contribution to the relative improvement in their $f(k^*)$ in the test sample.

Finally, look at the labor efficiency (i.e., the effectiveness of labor mentioned in Section 3). Labor efficiency (A) undoubtedly makes a huge effect on the steady-state of per-capita output $Af(k^*)$. Since human capital is the source of technological progress and innovation, one can think of human capital as the most important indicator to measure labor efficiency. Unfortunately, just in 2018 the World Bank database began to provide the data on the human capital index of countries in the world, so this paper finally chooses the tertiary school enrollment rate in the World Bank database to roughly reflect the human capital level of each country. After the

Table 6: Estimates of the tertiary school enrollment rates of the seven countries (%)

Names of countries	*Estimates in 1970s*	*Estimates in 1980s*	*Estimates in 1990s*	*Estimates in 2000s*	*Estimates in 2010s*
Argentina	20.81	29.39	42.27	63.94	81.19
Brazil	—-	—-	16.08	26.99	47.78
Chile	12.35	15.66	28.48	47.83	82.69
Colombia	6.50	11.13	17.44	29.24	50.91
Mexico	8.57	14.98	14.84	22.67	30.94
China	0.51	2.44	4.28	16.61	38.57
United States	50.87	59.32	75.90	79.52	90.37

Note: 1. The average annual tertiary school enrollment rates are calculated based on data on annual tertiary school enrollment rates in each sub-period. 2. The World Bank database lacks the data on Brazil in 1970s and 1980s, so there are two corresponding blanks for Brazil in Table 6.

data on annual tertiary school enrollment rates of the above mentioned seven countries are downloaded, the average annual tertiary school enrollment rate of each country is computed, respectively, in the 1970s, 1980s, 1990s, 2000s and 2010s, and listed in Table 6. According to the data in Table 6, the seven paths are drawn and shown in Figure 5. The seven paths show approximately the changes in the tertiary school enrollment rates of the seven countries during the 1970-2019 period, and also roughly reflect the changes in the human capital and labor efficiency of the seven countries during this period.

Table 6 and Figure 5 show that during the 1970-2019 period, all the seven countries attached importance to the cultivation of human capital because all their tertiary school enrolment rates generally maintained a marked upward trend, but

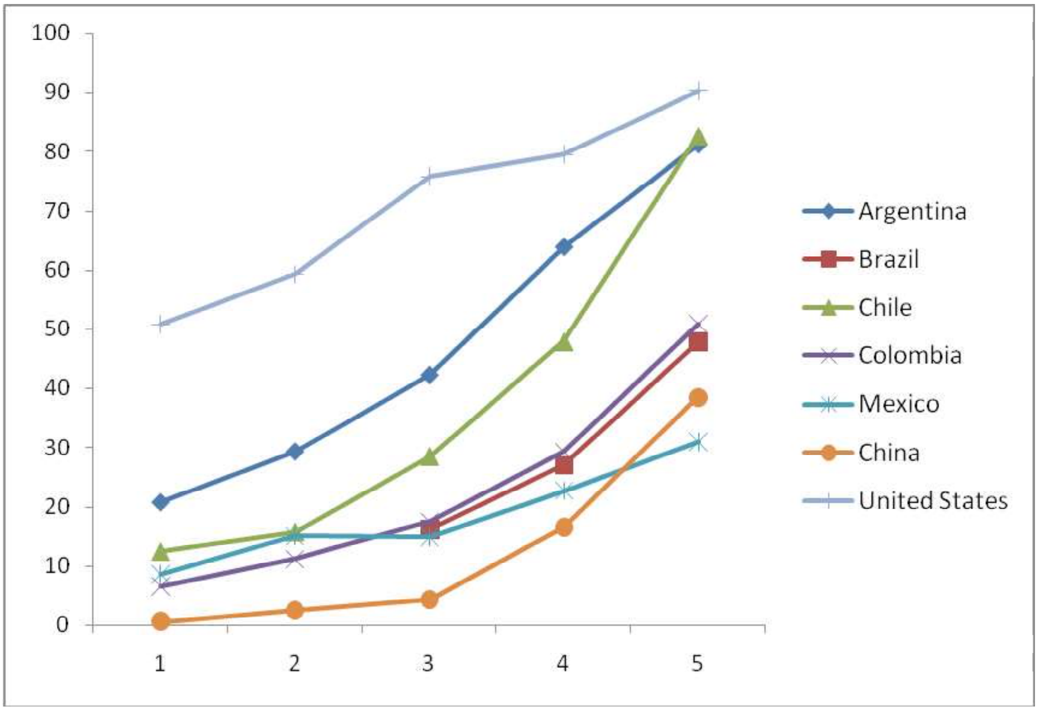

Figure 5: The paths of the tertiary school enrollment rates of the five Latin American countries, China and United States (1970-2019)

Note: 1. The numbers 1, 2, 3, 4 and 5 below the horizontal axis denote 1970s, 1980s, 1990s, 2000s and 2010s, respectively. 2. The numbers at the left side of the vertical axis denote the measures (%) of tertiary school enrollment rate. 3. The World Bank database lacks the data on Brazil in 1970s and 1980s, so there are two corresponding blanks for Brazil's path in Figure 5.

the growth rate was different across the seven countries. For example, China's tertiary school enrollment rate was extremely low (0.51%) in 1970s, but it grew much faster than others; US's rate was the highest in each sub-period, but it grew relatively slow; the other four Latin American countries' grew faster than US's except Mexico's. During the 1970-2019 period, the governments of the five Latin American countries advocated and encouraged higher education on their nationals through their human resources policies, which led to the continuous growth in human capital of the five countries. Such a change in human capital could be helpful to improve labor efficiency (A) of the five countries. But probably the tertiary school enrollment rates of most countries in the test sample experienced a similar upward trend during this period, thus the human capital of the five Latin American countries might not grow relatively in the test sample, resulting in no relative improvement in their labor efficiency (A) in the test sample, which made no significant effect on improving relatively their steady states of per-capita output $A\,f(k^*)$ in the test sample.

As for the dramatically relative improvement in China's steady state of per-capita output in the test sample, the reasons are opposite. During the 1970-2019 period, except in 1970s (the data on China's saving rate in 1970s is not available), China's saving rate kept rising and was much higher than the overall level of the five Latin American countries as shown in Table 4 and Figure 3, and should be also higher than the average level of all countries in the test sample except in 1970s; China's population growth rate experienced a similar downward trend like the five Latin American countries', but was lower than the overall level of the five Latin American countries except in 1970s as shown in Table 5 and Figure 4, and should be also lower than the average level of all countries in the test sample except in 1970s; China's tertiary school enrollment rate was obviously lower than the overall level of the five Latin American countries, but grew much faster than the five Latin American countries', even exceeded Mexico's in 2010s as shown in Table 6 and Figure 5, and undoubtedly also grew much faster than the most countries' in the test sample, implying so did China's human capital and labor efficiency. The above three reasons can explain why China's steady state of per-capita output kept rising rapidly and relatively in the test sample during the 1970-2019 period, and almost caught up with the overall level of the five Latin American countries in 2010s.

8. Conclusions

This paper makes a study on the reasons why some Latin American countries fell into and have been staying in the "middle-income trap" from the perspective of steady state of per-capita output. In this paper, the econometric method is used to illustrate the followings: (1) In terms of steady state of per-capita output, the relative positions of five Latin American countries (Argentina, Brazil, Chile, Colombia and Mexico), China and United States are revealed in a test sample, respectively, in the 1970s, 1980s, 1990s, 2000s and 2010s. (2) The relative positions of the five Latin American countries remained below but not far away the average level of all countries in the test sample during the 1970-2019 period, i.e., in terms of steady state of per-capita output, the five countries were still typical "middle income trap" countries during this period. (3) China's relative position was far below the overall level of the five Latin American countries in 1970s, but kept rising rapidly and almost reached the overall level of the five countries in 2010s, so in terms of steady state of per-capita output, China was not a "middle income trap" country during the 1970-2019 period, but China started to face the problem of how to cross the "middle income trap" in 2010s.

This paper also provides an analysis of the reasons for such a situation in the steady states of per-capita output of the five Latin American countries. In general, the social infrastructures of the five Latin American countries did not change significantly during the 1970-2019 period, resulting in the following conditions: during this period, their saving rates were no more than the average level of all countries in the test sample; their population growth rates generally experienced a similar declined trend like the most countries' in the test sample; their human capital did not improved faster than the most countries' in the test sample, implying nor did their labor efficiency. From the perspective of steady state of per-capita output, this paper finds the above three reasons why the five Latin American countries fell into and stayed in the rank of "middle income trap" countries during the 1970-2019 period.

As for the dramatic improvement in China's relative position in the test sample in terms of steady state of per-capita output, the reasons are opposite. China's social infrastructure did improve significantly during the 1970-2019 period due to its many correct policies executed from the late 1970s, resulting in the following conditions: during this period, China's saving rate remained at a high level and kept rising except in 1970s, actually much higher than the average level of all countries in the test sample except in 1970s; China's population growth rate declined fast and should be lower than the average level of all countries in the test sample except in 1970s; China's tertiary school enrollment rate was extremely low in 1970s, but it grew much faster than most countries' in the test sample, implying so did China's human capital and labor efficiency. The above three reasons can explain why China's steady state of per-capita output kept increasing quickly and relatively in the test sample during the 1970-2019 period. But it is necessary to point out, China's saving rate has been very high (48.2% in 2010s) and much difficult to increase further, its population growth rate has been very low (0.5% in 2010s) and leaves little room to decrease further, while China's tertiary school enrollment rate is relatively low (38.57% in 2010s) in comparison with others (especially with developed countries), so the future growth of China's human capital and labor efficiency will, to large extent, determine the future growth of China's steady state of per-capita output, which will decide whether China can cross the "middle income trap" in the future and finally become a developed country.

Notes

1. For the details of the Solow model, see Romer (2001, Chapter 1).
2. See Romer (2001, p.21)
3. See Romer (2001, p.143)
4. See Romer (2001, p.24)
5. Barro and Sala-I-Martin (2004. p.466), the equation on the page 466 shows the time interval (T) of observations is from year 0 to year T.
6. World Bank provides data on GDP per-capita of countries in the world, but data in 1960s are not available for too many countries, even data in 1970s are not available for a lot of countries, this paper requires a data time span from 1970 to 2019 and can only choose the 112 countries to form a test sample.
7. The natural number $e \approx 2.718$, the time interval $T \geq 1$, and β is no more than 30% (= 0.3).

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