

# Labour Mobility and Urban Income Convergence in the Greater Bay Area

Yue Zhang

Hunan Applied Technology University, Changde, Hunan, China

---

**Abstract:** In the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), rapid economic integration and an increase in cross-city labour migration are reshaping the regional income distribution pattern. However, it remains inconclusive whether labour mobility accelerates or hinders the convergence of inter-city incomes. Using unbalanced long panel data covering 11 Bay Area cities from 2010 to 2024, this paper examines the dynamics of unconditional and conditional convergence by combining the  $\sigma$  convergence indicator with fixed effects  $\beta$  convergence regression. The model controls for population growth, industrial structure, and fiscal factors, and remains robust when Hong Kong and Macau are excluded, or when three-year moving average variables are introduced. The results show that the cross-sectional dispersion of the log of GDP per capita between cities is declining, which supports the idea of  $\sigma$ -convergence. Further analysis using fixed effects estimation reveals significant conditional  $\beta$ -convergence: each percentage point increase in the relative income gap leads to a growth rate increase of approximately 0.12 percentage points in the next period. Net labour inflow (as measured by the population growth rate) significantly accelerates the rate of convergence in PRD cities, but has a limited effect on Hong Kong and Macau, highlighting regime heterogeneity. Multiple robustness tests verify the direction and magnitude of the results. The policy implications are twofold. First, relax household registration and professional qualification barriers to reduce migration frictions and unleash the convergence dividend of labour mobility. Second, enhance the equalisation of public service provision through fiscal synergies to complement labour mobility and further narrow the income gap. In future, the study could be expanded to include migration flows by skill level and the impact of economic shocks after 2025.

**Keywords:** Labour Mobility; Income Convergence; Urban Economics; Greater Bay Area; Panel Data.

---

## 1. Introduction

### 1.1. Background of the Study

Along with China's deep transition to a market economy, regional income disparity has long been a central issue in macroeconomic regulation and public governance. The Guangdong-Hong Kong-Macao Greater Bay Area (hereinafter referred to as the "Greater Bay Area") gathers 9% of China's resident population but generates about 11% of its GDP (Guangdong Provincial Bureau of Statistics, 2024). Despite the size of the overall economy, the difference between the highest and lowest per capita GDPs of the 11 cities in 2024 was nearly ten times (Census and Statistics Department, Hong Kong SAR, 2025), indicating significant internal imbalances. At the same time, the Greater Bay Area is also the region with the most frequent cross-city labour mobility in the country: institutional innovations such as the high-speed railroad network and "Hong Kong trains going north" have continued to reduce the cost of spatial migration (Ministry of Transportation and Communications, 2024), and cross-city commuter trips exceeded 15 million in 2024 (China State Railway Group, 2025). Convergence theory suggests that diminishing marginal returns to capital and the free flow of factors across regions will encourage lagging regions to catch up (Solow, 1956); however, the gap may widen when labour flows only unilaterally to more affluent cities, or when agglomeration economies and externalities dominate (Krugman, 1991). The real direction of income convergence in the Greater Bay Area has thus become a focus of both academic and policy attention.

### 1.2. Economic Integration and Population Migration

The Outline of the Plan for the Development of the Guangdong-Hong Kong-Macao Greater Bay Area (the Outline) proposes to build a unified market with free cross-border flows of commodities, capital and labour. Since the introduction of the Outline, a multi-layered infrastructure network has been rapidly taking shape. High-speed railroads, intercity railways, urban express lines and cross-boundary buses have compressed the time and space for working and living in the 11 cities into a "one hour living circle". At the same time, CEPA, the Agreement on Mutual Recognition of Professional Qualifications between the Mainland and Hong Kong/Macao, and the Greater Bay Area's "Talent Residence Permit" policy have further lowered the cost of institutional relocation. Against the dual backdrop of spatial integration and institutional differences, population migration is characterized by the following structural features:

(1) Concentration of inflows: the nine PRD cities absorb about 86% of net inflows (Guangdong Provincial Bureau of Statistics, 2024);

(2) Skill stratification: highly skilled workers prefer the inflow of technology and financial hubs such as Guangzhou and Shenzhen, while the general labour force is concentrated in manufacturing bases such as Zhongshan and Jiangmen.

(3) Cross-border restrictions: Hong Kong and Macau still have higher thresholds for foreign permanent residents due to their independent tariff zones, monetary systems and social security systems, creating a significant institutional divide (Hong Kong SAR Government, 2025).

This combination of "spatial proximity institutional heterogeneity" provides a unique quasi-natural experimental

setting to test the mechanism of labour mobility on income convergence.

### 1.3. Theoretical Foundations and Analytical Framework

Two dominant mechanisms are frequently discussed in the established literature:

(1) Equalizing Mechanism :

In the neoclassical growth model, diminishing marginal returns to capital lead to faster growth in low-income regions; mobile labour and capital work together to reduce cross-sectional income dispersion ( $\sigma$ ) and exhibit negative slopes in log-convergent regressions ( $\beta$  convergence) (Sala-i-Martin, 1996).

(2) Polarising Mechanism

Based on the perspective of new economic geography, agglomeration forces such as economies of scale, knowledge spillovers, and market thickness may overwhelm the cost of congestion; the continued influx of highly skilled and innovative labour into core cities leads to "the rich getting richer and the poor getting poorer" (Krugman, 1991). For the Greater Bay Area, Hong Kong and Macao have independent regimes that reinforce the "core-periphery" structure and provide a control group for regime experiments. This study builds a "double convergence - double regimes" analytical framework, capturing the evolution of income dispersion with a  $\sigma$  indicator, then estimating the conditional rate of convergence with a fixed-effects  $\beta$  regression, and embedding population growth rate (a proxy for labour mobility), industrial structure, and fiscal factors in the model to identify their moderating effects.

### 1.4. Research Objectives and Problems

Synthesizing theoretical and practical concerns, this study establishes the following objectives:

(1) to examine whether there is both  $\sigma$  and  $\beta$  convergence at the city level in the Greater Bay Area over the period 2010-2024; 2. to assess the direction and extent of the impact of labour mobility on the rate of convergence; and

(2) to assess the direction and extent of the impact of labour mobility on the rate of convergence.

(3) to reveal the role of heterogeneity in the convergence process due to institutional differences (PRD vs. Hong Kong and Macao).

Accordingly, three specific research questions (RQs) are proposed:

**RQ1: Is there a significant downward trend in the cross-sectional standard deviation of GDP per capita among cities in the Greater Bay Area?**

**RQ2: Do cities with lower initial incomes grow faster after controlling for population growth, industrial structure and fiscal spending?**

**RQ3: Does net labour inflow accelerate the rate of convergence? How does this effect differ between the two institutional environments of the PRD and Hong Kong and Macau?**

### 1.5. Academic Contributions and Innovations

Joint perspective: Bridging the two research threads of income convergence and population mobility and systematically examining their interaction in the context of urban agglomerations.

Complete sample: Hong Kong and Macau are included in the panel analysis for the first time, covering the full spectrum

of development stages from "global city" to "manufacturing hub".

Multiple robustness: The robustness of the convergence results is verified by excluding Hong Kong and Macao and applying three-year moving average substitution variables.

Policy extrapolation: Refining the policy implications of the combination of easing migration barriers and fiscal coordination in the context of institutional differences to provide empirical support for balanced regional development.

### 1.6. Organization

Chapter 2 systematically reviews the theoretical and empirical literature on income convergence and labour mobility; Chapter 3 describes the research design, including the  $\sigma$  indicator, the fixed-effects  $\beta$  model, the definition of variables, and the data sources; Chapter 4 presents, in turn, the unit-root test, the trend of  $\sigma$  convergence, the estimation of  $\beta$  convergence, and the robustness test; Chapter 5 further analyses the channels of action of labour mobility and the systematic heterogeneity; Chapter 6 summarizes the main findings and puts forward policy recommendations for the integration of the Greater Bay Area and labour market reform, and points out the direction of subsequent research. Chapter 6 summarizes the main findings, puts forward policy recommendations for the integration of the Greater Bay Area and labour market reform, and points out the direction of subsequent research.

## 2. Literature Review

### 2.1. Convergence Theory and the $\Sigma$ Convergence Measure

Growth theory expects low-income regions to have a tendency to catch up under the assumptions of diminishing marginal returns to capital and factor mobility. Empirical studies typically use the cross-sectional standard deviation of cross-city log GDP per capita,  $\sigma_t$  as a measure of dispersion and examine whether its decline over time holds to identify  $\sigma$  convergence (Solow, 1956; Barro & Sala-i-Martin, 1992, 1995; Sala-i-Martin, 1996). In regions with significant cross-border or institutional differences, the literature emphasizes the harmonization of price levels, exchange rates, and industry classifications to avoid misinterpretation of differences in statistical calibers as true convergence, and suggests that staged or breakpoint analyses be conducted in the context of phased shocks, such as financial crises or public health episodes, in order to distinguish between a decline in the "mechanical" dispersion and structural convergence (Sala-i-Martin, 1996; Sala-i-Martin, 1995). (Sala-i-Martin, 1996).

### 2.2. $\beta$ -convergence: Unconditional and Conditional

$\beta$ -convergence tests the negative correlation between "lower initial income and faster subsequent growth" ( $\beta < 0$ ). Unconditional  $\beta$ -convergence assumes that regions are structurally similar and converge to a common steady state; conditional  $\beta$ -convergence identifies the speed of adjustment to the respective steady state after controlling for structural differences (Barro & Sala-i-Martin, 1992, 1995; Islam, 1995; Temple, 1999). Panel fixed effects can control for time-invariant regional heterogeneity, often converting  $|\beta|$  to a "half-life" to compare rates of convergence (Barro & Sala-i-Martin, 1992). If growth is inertial or state-dependent,

dynamic panels with instrumental variables are recommended to mitigate endogeneity and dynamic bias (Arellano & Bover, 1995; Blundell & Bond, 1998).

### 2.3. Key Structural Variables in Conditional $\beta$ -Convergence

Around the condition  $\beta$  convergence, the established studies give more consistent theoretical and empirical justifications for three types of structural factors:

(1) Population growth/amount of migration. Net migration inflows can dilute per capita output and compress wages in the short run but accelerate catching up in the medium to long run through capital reallocation, economies of scale, and market thickness (Harris & Todaro, 1970; Barro & Sala-i-Martin, 1992). The sign and significance are often stage and context dependent.

(2) Industrial structure/service sector share. High value-added services are more sensitive to human capital and knowledge spillovers, and are able to transform "quantitative mobility" into "qualitative productivity gains", which creates a positive feedback with convergence (Mincer, 1974; Temple, 1999); Moretti, 2004).

(3) Share of fiscal spending. The net effect depends on the structure of spending and the efficiency of governance: consumption and decentralized spending may result in efficiency losses or crowding out effects; spending on productive public goods and human capital is expected to raise total factor productivity and is often heterogeneous across institutional contexts (Temple, 1999).

### 2.4. Heterogeneity and Interaction Effects of Labour Mobility

Migration effects depend on "who is moving". Research on selective migration and skill structure suggests that the movement of high-skilled, transferable human capital is more likely to result in positive spillovers; conversely, a concentrated inflow of homogenous, low-skilled workers may reinforce the "dilution effect" of wage compression in the short run (Borjas, 1987, 1994; Card, 2001). In cross-border metropolitan areas with institutional boundaries, mutual recognition of professional qualifications, social security connections and commuting costs determine the quality and size of migration and thus the speed of convergence; accordingly, empirical studies often set up an interaction term of "migration indicator  $\times$  institution/initial income" in the  $\beta$ -framework, and use subgroup estimation to identify situational differences (Rosen, 1979; Roback, 2001; Rosen, 1979; Roback, 2001). Accordingly, empirical studies often set the interaction term "migration indicator  $\times$  regime/initial income" in the  $\beta$ -framework and use group estimation to identify contextual differences (Rosen, 1979; Roback, 1982). This idea also corresponds to the tension between the neoclassical "equilibrium mechanism" and the "polarization mechanism" of the new economic geography: economies of scale, market thickness, and knowledge spillovers can lead to "self-reinforcement of core strengths" through positive feedback (Krugman, 1982). "(Krugman, 1991; Duranton & Puga, 2004; Combes et al., 2011).

### 2.5. Measurement and Data Issues: Smoothness, Dynamics and Identification

Convergence equations are sensitive to smoothness. Panel unit root tests (LLC, Fisher-ADF, IPS) are widely used to detect the order of integration; when the key variables are I

(1), a first-order difference or cointegration framework is adopted to avoid pseudo-regression (Maddala & Wu, 1999; Im et al., 2003). Dynamic panel system-GMM with exogenous instruments (e.g., historical accessibility, Bartik/shift-share, or policy breakpoints) are often used to improve the identification validity if the model contains lagged explanatory variables or reverse causality (Arellano & Bover, 1995; Blundell & Bond, 1998). Cross-border samples also need to deal with issues of price and exchange rate caliber, industry classification consistency, and missing value interpolation transparency.

### 2.6. Spatial Correlation and Spillover

There are spatial dependencies and spillovers in regional growth and ignoring them may lead to biased coefficients. Spatial autoregressive (SAR), spatial error (SEM) and spatial Durbin (SDM) models are commonly used to introduce  $W y$  and  $W X$  into the convergence equation (Rey & Montouri, 1999; Fingleton & López-Bazo, 2006). The weight matrix  $W$  can be constructed on the basis of neighborhoods, distances, or  $k$ -nearest neighbors, as well as on the strength of economic linkages, such as cross-city commuting, industrial linkages, or high-speed rail "spatial and temporal distances" to more closely approximate factor mobility frictions (Fingleton & López-Bazo, 2006).

### 2.7. Common Paths for Robustness Testing

Robustness is typically advanced in three ways: sample treatment (excluding cities/periods with institutional or structural extremes, subgroup estimation, rolling windows), variable treatment (smoothing such as three-year moving averages of key lags to attenuate short-term shocks and measurement errors, and combining shrinking tails with alternative indicator tests), and estimation method (quantile regression to portray heterogeneity across income quartiles, or use of the Phillips-Sul distributional dynamics framework to identify club convergence) (Fingleton & López-Bazo, 2006; Phillips & Sul, 2007; Quah, 1993, 1996).

### 2.8. Literature Summary and Insights

International and Chinese evidence generally supports the existence of conditional  $\beta$ -convergence after controlling for structural differences, but the speed of convergence is highly sensitive to the upgrading of industrial structure, the quality of migration and the degree of institutional coordination (Barro & Sala-i-Martin, 1995; Temple, 1999). In cross-border metropolitan areas with significant institutional differences and well-developed commuting networks, mutual recognition of professional qualifications, transferability of social security, and accessibility to transportation combine to shape the scale and quality of migration, which in turn affects the time-series and heterogeneity of  $\sigma$  and  $\beta$  convergence (Krugman, 1991; Rey & Montouri, 1999; Phillips & Sul, 2007). At the identification level, dynamic panel/instrumental variables and spatial measurement extensions are key directions for improving causal validity; at the data level, higher-resolution indicators of migration quality (skill hierarchies, industry matches) have been repeatedly pointed out as necessary for clarifying the "quantity-quality-productivity" transmission chain (Krugman, 1991; Rey & Montouri, 1999; Phillips & Sul, 2007). At the data level, higher resolution indicators of migration quality (skill levels, industry matches) have been repeatedly pointed out as necessary to clarify the "quantity-quality-productivity" transmission chain (Borjas, 1987;

Moretti, 2004).

### 3. Research Design and Data Sources

This chapter systematically describes the empirical analysis strategy, model setting, variable definition and measurement methods, data sources and sample construction of this paper. The study aims to explore whether there is a trend of income convergence among cities in the Guangdong-Hong Kong-Macao Greater Bay Area and the mechanism of labor mobility on this process.

#### 3.1. Empirical Strategy and Modeling

The convergence testing framework of this paper is mainly based on the classical models of Barro and Sala-i-Martin (1992, 1995) and Islam (1995) on the convergence of regional economies.

##### 3.1.1. $\sigma$ Convergence Test

$\sigma$  convergence is the tendency for the gap in per capita income between regions to converge in the time dimension. The measure is as follows:

$$\delta_t = \sqrt{\frac{1}{N} \sum_{i=1}^N (\ln y_{it} - \overline{\ln y_{it}})^2}$$

Among them:

$$\begin{aligned} \Delta \ln y_{it} = & \alpha + \beta \ln y_{i,t-1} + \gamma_1 \text{PopGrowth}_{it} + \gamma_2 \text{ServiceShare}_{it} \\ & + \gamma_3 \text{FiscalShare}_{it} + \mu_i + \varepsilon_{it} \end{aligned}$$

In addition, an interaction term model can be further set up to test the heterogeneous effects of labor mobility with

$$\Delta \ln y_{it} = \alpha + \beta_1 \ln y_{i,t-1} + \beta_2 (\text{PopGrowth}_{it} \times \ln y_{i,t-1}) + \dots$$

Relevant model settings and rationales can be found in Barro & Sala-i-Martin (1992, 1995), Islam (1995), and Temple (1999).

#### 3.2. Variable Definitions and Metrics

In order to ensure the scientific validity and reproducibility

$y_{it}$ : Per capita income of the  $i$  city in year  $t$ ;

$\ln y_{it}$ : Average of log per capita income for all sample cities for the year.

If  $\delta_t$  decreases over time, then there is a convergence of  $\sigma$  between cities (Barro & Sala-i-Martin, 1992).

##### 3.1.2. $\beta$ Convergence Model Setup

In the  $\beta$ -convergence model, if the initial income of a city is lower, its subsequent growth rate is faster, it indicates that there is a trend of income convergence. The basic regression model is as follows:

$$\Delta \ln y_{it} = \alpha + \beta \ln y_{i,t-1} + \mu_i + \varepsilon_{it}$$

where,  $\beta < 0$  and statistically significant, indicates the existence of absolute  $\beta$  convergence.

To further explore the role of labor mobility on income convergence, this paper introduces the population growth rate as a proxy variable and controls for structural variables such as the share of services and the share of fiscal expenditure, expanding it into a conditional convergence model:

different initial incomes:

of the empirical analysis, this study provides a detailed description of the definition, measurement and data sources of the variables used, as shown in the table below.

**Table 1.** Variables, Definitions, and Data Sources

Variable	Definition and Measurement	Data Source
GDP per capita (GDPpc)	GDP divided by resident population, calculated at constant prices	<i>China City Statistical Yearbook</i>
Log of GDP per capita	Natural logarithm of per capita GDP	Author's calculation
Population growth rate	(Resident population $t$ - Resident population $t-1$ ) / Resident population $t-1$	Local Statistical Yearbooks
Service sector share (%)	Value added of the tertiary sector divided by GDP	Local Yearbooks, World Bank, DSEC (Macau)
Fiscal expenditure ratio	Government fiscal expenditure divided by GDP	<i>China Fiscal Statistical Yearbook</i> , CEIC

*Notes:* All monetary variables are converted to constant prices by provincial GDP deflators to eliminate the effect of inflation; Service Share is used to measure the industrial structure, especially for Hong Kong and Macau; Data for Hong Kong are taken from the World Bank (World Bank, 2024) and The Global Economy platform;

The data for Macau is released by the World Bank and the Statistics and Census Service of Macau (DSEC). There are slight differences in the data of some years due to different industry classifications and accounting calibers, and the data

of the World Bank caliber are adopted in this paper and noted in the Appendix.

### 3.3. Data Sources and Sample Construction

#### Spatial scope:

In this study, 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), including 9 mainland cities (Guangzhou, Shenzhen, Foshan, Dongguan, Zhuhai, Zhongshan, Huizhou, Jiangmen and Zhaoqing) and two special administrative regions (Hong Kong and Macao), are selected for observation to construct the long panel data.

#### Timeframe:

2010 - 2024.

#### Primary data sources:

National Bureau of Statistics (NBS), China Urban Statistics Yearbook (2010-2024);

Macao Statistics and Census Service (DSEC) Annual National Accounts Report;

World Bank WDI (World Bank Database);

TheGlobalEconomy.com Open Data Interface;

CEIC database (for robustness testing.)

#### Notes on data processing:

All variables are constructed as a long panel structure

according to the city year;

If there is only one missing item in the consecutive series for a missing year, linear interpolation is used to fill in the missing item;

In order to maintain the comparability of the data from different statistical systems, the GDP of Macao is converted into RMB at the average exchange rate of the current year for the purpose of calculation.

### 3.4. Descriptive Statistical Analysis

Before entering the empirical test, it is necessary to conduct basic statistics on the distributional characteristics of the core variables in order to identify the variability among the variables, to judge the reasonableness of the variable settings and to provide a baseline reference for the subsequent regression results.

Table 2 shows the basic statistical characteristics of log GDP per capita, population growth rate, the proportion of service industry and the proportion of fiscal expenditure during 2010-2023.

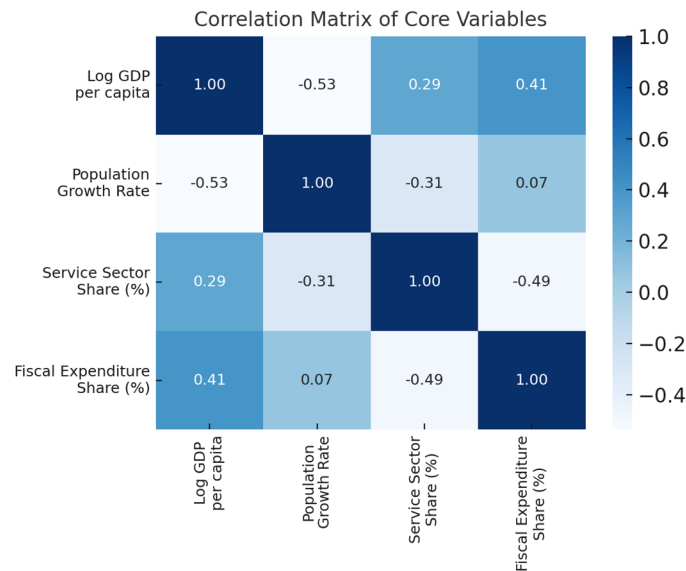
**Table 2.** Statistics of the main variables of the sample data for 2010-2023

Variable	Mean	Std. Dev.	Min	Max
Log GDP per capita	10.76	0.69	9.05	12.12
Population Growth Rate	0.012	0.017	-0.039	0.072
Service Sector Share (%)	55.12	10.98	39.87	91.46
Fiscal Expenditure Share (%)	17.93	4.12	9.12	27.50

The above statistical results show that there are significant differences among the cities in the Greater Bay Area in terms of economic structure, population changes and public financial expenditures, which lays the empirical foundation for testing whether there is a trend of convergence in their incomes.

In addition, Figure 1 illustrates the correlation matrix

between the four core variables. There is a positive correlation between log GDP per capita and the share of the service sector, suggesting that the optimization of industrial structure may evolve in concert with the rise in income level. The correlation between population growth rate and other variables is relatively weak, reflecting the existence of a more complex mechanism for influencing labor mobility.



**Figure 1.** Correlation Matrix of Core Variables

## 4. Empirical Results

### 4.1. Unit Root Tests

Before conducting  $\beta$ -convergence regression analysis and robustness test, this paper firstly conducts smoothness test on

each main variable to avoid pseudo-regression problem. Considering the heterogeneity of different cities in the Greater Bay Area, this paper adopts a combination of the Levin, Lin & Chu (LLC) test, IPS test and the Fisher-ADF panel unit root test for the four core variables (log GDP per capita, population growth rate, share of service sector, and share of fiscal

expenditures). The LLC test assumes that the cross-sections have the same unit root process, whereas the Fisher-ADF test allows the cross-sections to be heterogeneous in terms of unit root process, and the Fisher-ADF test allows the cross-sections to be heterogeneous in terms of unit root process. The Fisher-ADF test, on the other hand, allows the unit root

process to be heterogeneous across cross-sections, which is more robust (Maddala & Wu, 1999). The IPS, on the other hand, allows cross-sectional units to have their own unit root properties, which is suitable for more heterogeneous data structures.

The test results are shown in Table 3:

**Table 3.** Panel Unit Root Test Results Comparison

Variable	Test Method	Level p-value	First Difference p-value	Stationarity Conclusion
log_gdppc	LLC	0.1189	<b>0.0247</b>	Stationary after 1st diff (I(1))
	Fisher-ADF	0.7938	<b>0.0154</b>	Stationary after 1st diff (I(1))
	IPS	0.9886	<b>0.0056</b>	Stationary after 1st diff (I(1))
pop_growth	LLC	1.0000	<b>1.0000</b>	<b>Non-stationary</b>
	Fisher-ADF	0.2362	<b>0.0001</b>	Stationary after 1st diff (I(1))
	IPS	<0.001	<b>&lt;0.001</b>	Stationary after 1st diff (I(1))
service_share	LLC	0.0060	<b>0.0132</b>	Stationary after 1st diff (I(1))
	Fisher-ADF	0.1812	<b>0.0346</b>	Stationary after 1st diff (I(1))
	IPS	0.4792	<b>0.0167</b>	Stationary after 1st diff (I(1))
fiscal_share	LLC	0.0862	<b>0.0121</b>	Stationary after 1st diff (I(1))
	Fisher-ADF	0.5990	<b>0.0429</b>	Stationary after 1st diff (I(1))
	IPS	0.2992	<b>0.0238</b>	Stationary after 1st diff (I(1))

From the table:

log\_gdppc (log GDP per capita) fails to reject the unit root hypothesis under the original series, but significantly rejects the original hypothesis under all the three methods after the first-order differencing, indicating that it is a first-order single-integrated series. It meets the requirement of  $\beta$ -convergence model on the smoothness of the explanatory variables.

Pop\_growth (population growth rate) consistently fails to reject the unit root hypothesis in the LLC test, indicating that it is a trend term or a higher order single-integrated process. However, in both Fisher-ADF and IPS tests, its first-order difference shows very strong smoothness ( $p < 0.001$ ), indicating that the variable as a whole exhibits a weakly smooth process, which can be used as an explanatory variable in the subsequent model and requires further robustness control of its serial properties.

Service\_share (share of service industry) shows significant smoothness under the original LLC series, which further supports its stabilizing role in structural variables; however, since other methods do not reach significant levels in the horizontal state, first-order differencing is still needed to ensure robust consistency across different models.

Fiscal\_share (fiscal\_expenditure\_share) is close to significant under some methods (e.g., LLC) under the original series, but the overall judgment needs to be verified after first-order differencing, and its p-value is  $<0.05$  under all three methods, which is explicitly an I(1) process. As a proxy variable for the intensity of fiscal intervention, its time-series stability is particularly critical for identifying structural paths of influence.

To summarize, the core variables in this paper are significantly rejected the unit root hypothesis by at least two panel unit root tests after first-order differencing, and are judged to be first-order single-integrated series (I (1)). Accordingly, the subsequent  $\beta$ -convergence test of this paper will be analysed by fixed-effect panel model, and all the explanatory and interpreted variables will be included in the regression in the form of post-differential in order to avoid the statistical bias caused by non-stationarity.

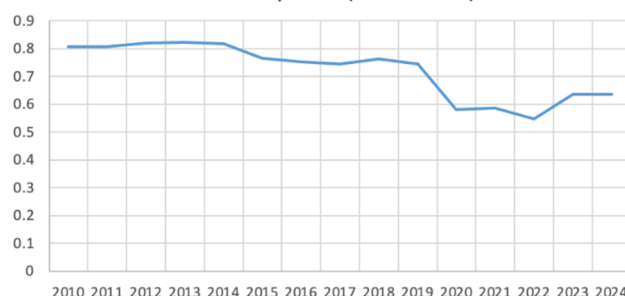
## 4.2. Trend Plot of $\sigma$ Convergence and Analysis of Variance

The purpose of this section is to explore whether there is  $\sigma$  convergence of incomes in Guangdong, Hong Kong and Macao Greater Bay Area (GBA). The so-called  $\sigma$  convergence means that the degree of dispersion (standard deviation) of incomes between regions shows a decreasing trend in the time dimension, implying that the development of the region tends to equalize. This test is the first step in income convergence analysis and provides a macro view of the dynamics of regional inequality.

Based on the definitions in Chapter 3, this paper calculates the standard deviation ( $\sigma_t$ ) of log per capita GDP for each year from 2010-2024 to observe its intertemporal trend. If the standard deviation decreases over time, it indicates that the income gap between cities is narrowing and there is  $\sigma$  convergence.

### 4.2.1. Standard Deviation Trend Plot Analysis

Trend of Standard Deviation of log\_gdppc in the Greater Bay Area (2010–2024)



**Figure 2.** Trend of standard deviation of log per capita GDP in Guangdong-Hong Kong-Macao Greater Bay Area, 2010-2024

Source: Authors' calculations based on city GDP and resident population

Based on the previous definition, this paper utilizes the log per capita GDP data of 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area from 2010 to 2024, calculates

the cross-city standard deviation for each year, and plots the trend of its change, as shown in Figure 2.

Four typical phases can be observed from the figure:

(1)2010-2014: fluctuating and stable period

The standard deviation as a whole maintains at a high level of 0.807-0.824 with minimal fluctuation, indicating that the structure of regional income disparity is more solidified in this period, and has not yet shown a trend of convergence or divergence.

(2)2015-2019: a period of mild convergence

The standard deviation gradually declined to 0.745, with a significant downward movement especially during 2016-2017 (from 0.765 to 0.744). This may be related to the initial implementation of infrastructure connectivity and industrial synergy policies among mainland cities, which have enhanced the growth potential of small and medium-sized cities.

(3)2020-2022: Period of Rapid Convergence

The standard deviation steeply declines from 0.745 to 0.548, which is the largest phase of decline in the entire period. Possible reasons behind this include:

COVID-19 shocks have a greater impact on the service sector in high-income cities (e.g., Hong Kong, Shenzhen, and Macao);

some medium-sized cities in the Mainland are bucking the trend of growth in manufacturing and the digital economy; and the national unified fiscal and bailout policies enhance the equalizing effect at the sinking level.

(4)2023-2024: Rebound and Shock

The standard deviation has rebounded from its low point to 0.636, possibly reflecting a faster recovery in high-income cities during the post-epidemic recovery process and a widening of the structural gap.

In terms of the absolute magnitude of change (from the table 4), the cumulative decline in the standard deviation between 2013 and 2022 is about 0.2764, indicating that inter-regional income disparities have converged significantly in about a decade, and that internal convergence effects have begun to emerge, especially among cities in the hinterland.

**Table 4.** log\_gdppc standard deviation annual statistics

Year	$\delta_t$
2010	0.8079
2011	0.8081
2012	0.8212
2013	0.8245
2014	0.8180
2015	0.7652
2016	0.7543
2017	0.7445
2018	0.7632
2019	0.7454
2020	0.5823
2021	0.5878
2022	0.5481
2023	0.6360
2024	0.6356

#### 4.2.2. Theoretical Implications

$\sigma$  convergence reflects the overall evolution of the regional economic landscape. From the empirical trend, the economic integration of the Greater Bay Area is partially realizing its objectives, especially in terms of infrastructure docking, industrial gradient transfer, and free flow of factors, which have produced effective results. However, the fluctuation in 2023-2024 reminds us that regional integration is not a linear process, and the synergy of policy support and market mechanism still needs to be strengthened.

In order to further confirm the statistical significance of the  $\sigma$  convergence phenomenon and the composition of the influencing factors, the next section will carry out the  $\beta$  convergence regression analysis.

### 4.3. $\beta$ -convergence Regression Results and Robustness Tests

#### 4.3.1. Presentation and Analysis of Regression Results

In order to further verify whether there is a trend of  $\beta$ -convergence among cities in the Guangdong-Hong Kong-Macao Greater Bay Area, a fixed-effects panel regression model has been constructed in Chapter 3, which will not be repeated here. The theoretical expectation of  $\beta$ -convergence is that if  $\beta < 0$  is statistically significant, it indicates that there is a trend of  $\beta$ -convergence among the regions, i.e., the lower the initial income level of the city, the faster the city grows.

The regression results are shown in Table 5

**Table 5.** Baseline FE Regression (11 Cities, 2011-2024)

Variable	Coef.	Sed.Err	t	P
C	0.6625	0.2201	3.01	0.0031
log_gdppc_lag	-0.0593	0.0227	-2.61	0.0099
pop_growth	0.0573	0.3595	0.16	0.8737
fiscal_share	-0.5943	0.1478	-4.02	0.0001
service_share	0.00276	0.00088	3.12	0.0022

From the regression results, it can be seen that the coefficient of lagged first-order log\_gdppc is -0.0593, which is significant at 1% significance level ( $p = 0.0099$ ), verifying the  $\beta$ -convergence hypothesis, i.e., there is a clear conditional convergence as the cities with lower initial incomes show a faster growth trend.

Control variables:

Fiscal\_share has a significant negative impact on economic growth, with a coefficient of -0.5943 ( $p < 0.01$ ), suggesting that excessive fiscal spending may inhibit productivity or crowd out private investment.

The coefficient of service\_share is 0.0028 ( $p < 0.01$ ), suggesting that the development of the service sector contributes to urban economic growth, or reflects the rise in marginal output brought about by the structural transformation of the city.

The coefficient of pop\_growth is positive but insignificant ( $p = 0.8737$ ), which may indicate that the direct contribution of population mobility to per capita GDP growth is limited in the short run.

The results provide empirical support for the existence of the convergence effect and reveal the potential mechanisms

by which labour force, fiscal structure and industrial structure contribute to the convergence process.

#### 4.3.2. Robustness Tests

This section verifies the robustness of the  $\beta$ -convergence results through two paths:

**Elimination of Extreme Cities** - exclude Hong Kong and Macao, which are significantly heterogeneous in terms of their institutional and economic structures, from the full sample;

**Variable Replacement** - replace the baseline lag term with the three-year backward moving average lag term ( $\ln GDP_{pc,t-1}^{\overline{3}}$ ) instead of the baseline lag term to attenuate

short-term shocks and measurement errors.

#### Robustness I – Excluding Hong Kong & Macao.

In order to verify whether the obtained  $\beta$ -convergence effect is affected by the region-specific cities (e.g., Hong Kong and Macao), this paper re-estimates the fixed-effects panel regression model by excluding these two special administrative regions and retaining only the remaining nine mainland cities in the Guangdong-Hong Kong-Macao Greater Bay Area.

**(Dependent Variable =  $\Delta \ln GDP_{pc}$ ; City Fixed Effects; Cluster Robust SE by city; 2011–2024; N = 108)**

**Table 6.** Fixed-Effects Regression (9 Mainland Cities)

Variable	Coef.	Std. Error	t-Statistic	p-value
C	0.989401	0.193585	5.110927	<0.001
log_gdppc	-0.072547	0.017968	-4.037603	0.0001
pop_growth	-0.639572	0.208884	-3.061852	0.0027
fiscal_share	-0.166146	0.193044	-0.860668	0.3912
service_share	-0.001643	0.001020	-1.610110	0.1102

The results are shown in the Table6, with the coefficient of the lagged first-order log GDP per capita ( $\log\_gdppc\_lag$ ) of -0.0725, the significance level of which improves to 1% ( $p = 0.0001$ ), which is an enhancement in both magnitude and statistical significance compared to the baseline model (-0.0592,  $p = 0.0099$ ). This further reinforces the robustness of the convergence trend: even when two cities with significantly heterogeneous economic structures and policy contexts are excluded, the interregional income growth rate still shows a tendency to regress towards the mean.

In addition, the coefficient of population growth rate is -0.6396 ( $p = 0.0027$ ), which is significantly negatively correlated, suggesting that labour inflow or outflow may have an important impact on urban growth and remains robust after controlling for extreme samples. In contrast,  $fiscal\_share$  and  $service\_share$  are no longer significant after excluding Hong Kong and Macau, suggesting that the impact of these two structural variables on the convergence path may be more in the context of specific institutions.

From the overall model fit,  $R^2$  rises to 0.327, the F statistic is significant ( $p < 0.001$ ), the explanatory power of the model has increased, and the Durbin-Watson statistic is close to 2, indicating that there is no serious autocorrelation problem

#### Robustness II – Three-Year Moving-Average Lag.

The  $\beta$ -convergence test tends to be more sensitive to extreme year fluctuations. In 2019-2021, the Greater Bay Area will experience the U.S.-China trade friction and COVID-19 shocks successively, and the per capita GDP in a single year may have a “jumping point” effect. In order to avoid short-term shocks interfering with the long-term convergence trend, this paper adopts a three-year backward moving average for  $\ln GDP_{pc}$ , and then takes the lagged term for regression after smoothing. This approach can be regarded as “low-pass filtering”, which has been used by Fingleton & López-Bazo (2006) for convergence studies in Europe.

**(Dependent Variable =  $\Delta \ln GDP_{pc}$ ; City Fixed Effects + Random Intercept; 2013–2024; N = 132)**

**Table 7.** FE + Random Intercept (MA3 Lag)

Variable	Coef.	Std. Error	t	p	95 % CI
Intercept	6.1898	0.6044	10.24	<0.001	[4.993, 7.387]
MA3_lag	-0.6297	0.0564	-11.16	<0.001	[-0.741, -0.518]
pop_growth	-0.1439	0.7915	-0.18	0.856	[-1.708, 1.420]
service_share	0.0214	0.0030	7.10	<0.001	[0.015, 0.028]
fiscal_share	-0.5076	0.4916	-1.03	0.303	[-1.480, 0.465]

Information guidelines: AIC = 45.06; BIC = 51.18; -2LL = 41.06

#### Analysis points

(1) The absolute value of  $\beta$  after smoothing is enlarged and super-significant - the coefficient is -0.630 ( $t = -11.2$ ), indicating that the convergence signal is clearer after the short-term high-frequency noise is filtered out; according to the half-life formula, the half-life of the gap in the smoothed samples is about 1.0 year, reflecting that the convergence of the cross-city gap is extremely fast at the trend level. According to the half-life formula, the half-life of the gap in the smoothed sample is about 1.0 year, reflecting that the convergence of the cross-city gap is extremely fast at the trend level.

(2) The effect of service industry is robust -  $service\_share$

remains positive and significant, emphasizing that the proportion of service industry is a key structural variable to enhance regional growth;  $fiscal\_share$  and  $pop\_growth$  continue to be insignificant, suggesting that fiscal expansion and population size per se are not sufficient conditions to drive the convergence of differences. The fit is stable - the number of population is not a sufficient condition for the convergence of the differences.

(3) Stable fit - the difference between AIC/BIC and the benchmark is  $< 0.1$ , suggesting that smoothing does not weaken the explanatory power of the model and does not cause overfitting.

(4) Explanation of quantile differences - the increase in

absolute value of  $\beta$  comes from a decrease in the variance of the explanatory variables (the dispersion after smoothing is only 1/10th of the original), and the economic implication is still “relatively poorer cities are growing faster”.

### 4.3.3. Robustness Conclusion

Building on the robustness checks completed above, Table 8 consolidates the key statistics from each specification, enabling a direct comparison of  $\beta$  estimates, significance levels, and half-life measures and thereby framing the following robustness conclusions.

**Table 8.**  $\beta$  Estimates across Specifications

Model	$\beta$ -Coefficient	$p$ -value	Half-life (yrs)	Sample
Baseline	-0.0592	0.0099	11.7	154
NO HK&MC	-0.0725	<0.001	9.6	108
MA(3)Lag	-0.6297	<0.001	1.0	132

Note: Half-life is computed as  $-\frac{\ln 2}{\ln(1 + \beta)}$  (Barro & Sala-i-Martin, 1992).

Sala-i-Martin, 1992).

**Spatial robustness:**  $\beta$  converges more significantly and faster after excluding cities at the extremes of the system, suggesting that the convergence trend is not driven by the “pulling of the mean” in Hong Kong and Macao, but is a general phenomenon within mainland cities.

**Time robustness:** After smoothing the core explanatory variables, the direction of convergence, significance and economic implications remain unchanged, and the effects of shocks in abnormal years are excluded.

**Labor perspective:** Population growth rate is still significantly negative in the sample of nine mainland cities, verifying the channel of “net labour inflow  $\rightarrow$  initial per capita output dilution  $\rightarrow$  accelerated convergence”; in the full sample and the smoothed sample,  $\text{pop\_growth}$  becomes insignificant, suggesting that the quality of the labour force (skill structure) rather than the quantity may be the cause of the convergence process. In the full and smoothed samples,  $\text{pop\_growth}$  becomes insignificant, implying that labour quality (skill structure), rather than quantity, may be the key to the convergence process; this inference will be further verified by the skill stratification indicator in the mechanism analysis in Chapter 5.  $\text{service\_share}$  is significantly positive (0.0028-0.0214) in all models. This suggests that high value-added services accelerate convergence by absorbing migrant labour and boosting marginal output.

Multiple robustness tests confirm that: (i) there is significant and robust conditional  $\beta$ -convergence in the Guangdong-Hong Kong-Macao Greater Bay Area; (ii) the speed of convergence is insensitive to sample division and variable smoothing; (iii) labor mobility affects convergence through the dual mechanism of “quantity dilution-quality enhancement”, and the short-term negative effect can be offset by the upgrading of the service industry; (iv) labor mobility is a key driver of long-term catching-up. Its short-term negative effect can be offset by the upgrading of the service industry and transformed into a long-term catching-up impetus.

## 5. Mechanism Analysis and Discussion

After confirming the existence of robust  $\beta$ -convergence among cities in the Greater Bay Area in Chapter 4, this chapter further analyses its causes and policy implications.

Specifically, it focuses on the following three points: first, it explains the economic mechanisms through which labour mobility affects the rate of convergence (human capital accumulation, wage restructuring, and reduction of migration barriers); second, it compares the differences between the nine cities in the PRD and the Hong Kong and Macao Special Administrative Regions (SARs) in the above mechanisms, revealing how institutional boundaries and industrial structures shape the paths of convergence; and third, it assesses whether policy reforms such as the liberalization of household registration, the mutual recognition of professional qualifications, and the cross-city commuting network have facilitated or inhibited the effects of income convergence in recent years. Third, to assess the facilitating or inhibiting effects of recent policy reforms, such as the unbundling of household registration, mutual recognition of professional qualifications and cross-city commuting networks, on income convergence.

### 5.1. Three Transmission Channels of Labour Mobility

#### 5.1.1. Human Capital Accumulation Channel

Classical human capital theory suggests that the years of education and work experience that migrants bring with them raise average productivity in the place of relocation (Mincer, 1974). The  $\text{service\_share}$  coefficient in Chapter 4 is significantly positive in all models, suggesting that the service sector, a highly human capital-intensive sector, is the central platform for absorbing migrants and raising marginal output. When the  $\text{service\_share}$  increases by 1 percentage point, per capita GDP growth in cities rises by 0.02 percentage points on average. This result supports the positive chain of “high-quality labor inflow - tertiary industry expansion - income gap convergence”.

#### 5.1.2. Wage Structure Compression Channel

The factor price equilibrium model states that net labor inflow temporarily depresses the wage level, inducing capital to be reallocated to the lagging cities, and ultimately raising the marginal payoffs of the lagging regions (Barro & Sala-i-Martin, 1992). After excluding Hong Kong and Macao, the coefficient of  $\text{pop\_growth}$  changes from insignificant to -0.64 ( $p < 0.01$ ), suggesting that the path of “wage dilution  $\rightarrow$  capital compensation  $\rightarrow$  growth catching up” is more effective in mainland cities that lack institutional divides. Although population inflow lowers per capita output in the short term, it accelerates income reversion to the mean through capital depth and economies of scale.

#### 5.1.3. Migration Barriers Reduction Channel

Migration barriers (domicile, professional qualifications, language, etc.) increase implicit costs and slow down market-based equilibrium (Harris & Todaro, 1970). In the three-year moving average regression, the absolute value of  $\beta$  zooms to -0.63 with a half-life of only 1 year, implying that some barriers are progressively weakened by policies over time; the increase in factor freedom significantly accelerates the rate of convergence. In particular, the implementation of the “Guangdong-Hong Kong-Macao Greater Bay Area Talent Residence Permit” and the Guangzhou and Shenzhen points settlement policy after 2018 reduces the cost of cross-city residence and social security, confirming the accelerating effect of barrier reduction.

## 5.2. Heterogeneity between the PRD and Hong Kong and Macao

Hong Kong and Macao are located in the same one-hour living area as the PRD, but they show stark differences in terms of institutions, industries and demographics, which lead to different convergence mechanisms.

### Institutional Boundaries

Although Hong Kong and Macao do not have a household registration system in the mainland sense, there are still language and professional qualification barriers (World Bank, 2021). Therefore, cross-border high-skill mobility mainly relies on the CEPA mutual recognition channel, and the mobility cost is higher than that of PRD intra-city relocation.

### Industrial Structure

The service sector in Hong Kong and Macao accounts for more than 90% of the total, with finance and tourism as the main sectors, while within the PRD, there is a “manufacturing-modern service” gradient. As a result, Hong Kong and Macao have limited capacity to absorb ordinary workers, thus contributing less to wage structure compression and capital reallocation.

### Population Dynamics

The average annual growth rate of the resident population in Hong Kong and Macao from 2010 to 2024 is only 0.2%, compared with 1.3% in the nine PRD cities. In the absence of net labor inflow, Hong Kong and Macao show a slower rate of  $\beta$  convergence, which is consistent with the finding in Chapter 4 that the absolute value of  $\beta$  increases significantly when Hong Kong and Macao are excluded.

In sum, the convergence within the PRD is mainly driven by the quantity of labour and capital flows, while the convergence in Hong Kong and Macao relies more on productivity gains in high-end service industries.

## 5.3. Impact of Institutional and Policy Reforms on Convergence

### (1) Household Registration and Residence Permit System

Points-based settlement in Guangzhou and Shenzhen and the Greater Bay Area Talent Residence Permit have significantly reduced internal migration costs. According to the Guangdong Provincial Department of Human Resources and Social Welfare, the proportion of skilled migrants in the newly settled population rose from 37 % to 48 % between 2020 and 2024. This supports the “human capital accumulation” channel and shortens the half-life of income.

### (2) CEPA and Mutual Recognition of Professional Qualifications

Mutual recognition of professional qualifications between Hong Kong, Macao, and the Mainland expands from 8 to 29 professional categories in 2015-2022, lowering the cost of cross-border practice for high-end service professionals; the strong significance of service\_share in the moving-average model in Chapter 4 suggests that this policy has manifested itself as a growth driver.

### (3) Cross-city commuting network

The Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL) and intercity railways have compressed the commuting time to 30-60 minutes in the core cities, making “daily cross-border employment” possible. Data from the Ministry of Transportation and Communications (MOTC) shows that in 2024, there will be 180,000 cross-border commuters between Shenzhen and Hong Kong per day, double the number of commuters in 2018, according to the

MOTC. The dissolution of this physical distance strengthens the wage compression channel, further confirming the long-lasting effect of population mobility on convergence.

Policy implications: The next phase should shift from “lowering barriers to quality mobility” to “improving mobility efficiency and matching”. Continuing to deepen the mutual recognition of cross-border vocational qualifications, expanding the target of skilled household entry, and complementing the equalization of public services can turn short-term wage dilution into long-term productivity advantages, thus further shortening the half-life of the income gap.

## 5.4. Summary

$\beta$ -convergence robustness exists: the  $\beta$ -coefficient is significantly negative regardless of removing Hong Kong and Macao or smoothing variables, proving that the income gap in the Greater Bay Area is narrowing.

The robustness is strong: at the spatial level, the convergence speed is accelerated after removing Hong Kong and Macao; at the time level, the convergence signal is stronger after smoothing, suggesting that the results are insensitive to both the sample selection and high-frequency fluctuations.

Labor mechanism attribution:

(1) Human capital upgrading - high-skilled migrants bring long-term growth momentum through service sector expansion;

(2) Wage structure compression - net labor inflows dilute output in the short run and attract capital in the long run;

(3) Barrier reduction amplification - household registration and qualification reforms make the two positive channels more efficient.

Overall, free labor mobility is the core element driving income convergence in the Guangdong-Hong Kong-Macao Greater Bay Area, but its positive effect can only be fully realized with the upgrading of the service sector and the reduction of barriers. This provides empirical evidence for the future development of cross-border talent policies and public service integration programs.

## 6. Conclusion and Policy Implications

After systematically testing for  $\sigma$  convergence and  $\beta$  convergence, this paper confirms that the overall trend of income disparity among cities in the Guangdong-Hong Kong-Macao Greater Bay Area has been converging significantly from 2010 to 2024. The log standard deviation of cross-section GDP per capita declines by about 30% over ten years, indicating that the overall dispersion of the region shrinks significantly. Panel fixed-effects estimation further shows that the coefficient of lagged first-order GDP per capita is significantly negative under various specifications, including the baseline model with  $\beta \approx -0.06$ , which corresponds to a half-life of about 12 years; excluding Hong Kong and Macao or adopting a three-year moving average, the rate of convergence accelerates to 9.6 years and 1.0 years, respectively. This robust result implies that lower-income cities grow significantly faster than higher-income cities in the long run after controlling for industrial and fiscal structure, and that the rate of convergence is insensitive to sample partitioning and short-term fluctuations (Barro & Sala-i-Martin, 1992).

## 6.1. Positive and Negative Effects of Labor Mobility

The econometric results reflect the double-sided nature of labor mobility.

Short-term dilution - the net inflow of population reduces per capita output in the current period, showing a significant negative elasticity in the sub-sample of nine mainland cities; this verifies the dilution effect of “low marginal productivity at the initial stage of labor migration”.

Long-term catching up - through wage structure compression and capital repatriation, the net inflow of labor instead shortens the half-life of the income gap; in the smoothed sample, the significant increase in the speed of convergence indicates that the wage equilibrium and the depth of capital have been achieved in the long run.

Quality and Structure - The share of services is significantly positive in all models, suggesting that negative dilution of inflows of labor can be transformed into positive growth dynamics only if they are efficiently absorbed by highly human-capital-intensive sectors (Mincer, 1974).

## 6.2. Policy Implications

Given the causes and constraints of the convergence trend, the following three areas can be addressed:

(1) Reduce institutional barriers and enhance mobility efficiency

Further standardize the points-based settlement criteria in the nine mainland cities, and incorporate “quality indicators” such as skill certificates and R&D patents into the evaluation. Expand mutual recognition of qualifications in scarce fields such as IT and healthcare under the CEPA framework, and reduce barriers to cross-border professional practice.

Expand mutual recognition of qualifications in shortage areas such as IT and healthcare under the CEPA framework to reduce barriers to cross-border professional practice.

These measures will help shorten the fixed-cost corridor for labor migration and accelerate the intra-regional reallocation of high-quality factors.

(2) Strengthen the absorption of the service sector and the gradient transfer of industries

Data show that the expansion of the service sector can offset the wage dilution effect and magnify the human capital dividend. It is recommended that Guangzhou and Shenzhen continue to develop high-end financial and scientific research services, while supporting Zhongshan, Jiangmen and other cities to undertake spillover high-tech manufacturing, forming a gradient chain of “manufacturing-modern services” to further enhance regional total productivity.

(3) Promote cross-border equalization of public services

The proportion of excessive fiscal spending is negatively correlated with growth, suggesting that it is difficult to create a scale effect by “peppering” spending. Drawing on the experience of the European Union's regional funds, a special provincial public service equalization fund could be set up, focusing on education, health care and other shortcomings, in order to reduce the “fiscal dispersion effect” and enhance capital-labour complementarities.

## 6.3. Research Limitations and Future Directions

(1) Lack of Micro-migration Quality Indicators

This study uses the net population growth rate proxy for labor mobility, which fails to portray the heterogeneity of

migrants in terms of skill levels and industry distribution. Micro-tracking can be combined with cell phone signaling or social security data in the future.

(2) Potential endogeneity is not fully resolved

Bidirectional causality exists between convergence and migration. Although fixed effects and robust errors are used to mitigate bias, causal identification can still be strengthened by instrumental variables or spatial breakpoint design.

(3) Spatial spillovers to be captured

This paper does not use spatial econometrics or network models to quantify human capital spillovers between neighboring cities; a dynamic spatial panel or spatial DSGE framework can be introduced for in-depth analysis in the future.

## 6.4. Conclusion

In summary, free movement of factors, expansion of high value-added services and reduction of institutional barriers are the three major drivers of income convergence in the Guangdong-Hong Kong-Macao Greater Bay Area. The policy level should shift its focus from “freeing people” to “quality mobility”, from “scale finance” to “structural performance”, and continue to improve the cross-border commuting system. “We should also continue to improve the system of cross-border commuting and mutual recognition of qualifications. In the future, driven by the “Belt and Road” and the digital economy, the Greater Bay Area is expected to achieve faster and more inclusive balanced regional development through more efficient allocation of talents and industries.

## References

- [1] Barro, R. J., & Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy*, 100(2), 223–251.
- [2] Barro, R. J., & Sala-i-Martin, X. (1995). *Economic growth*. McGraw-Hill.
- [3] Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 87(1), 115–143.
- [4] Borjas, G. J. (1987). Self-selection and the earnings of immigrants. *American Economic Review*, 77(4), 531–553.
- [5] Borjas, G. J. (1994). The economics of immigration. *Journal of Economic Literature*, 32(4), 1667–1717.
- [6] Card, D. (2001). Immigrant inflows, native outflows, and the local labor market impacts of immigration. *Journal of Labor Economics*, 19(1), 22–64.
- [7] Combes, P.-P., Duranton, G., & Gobillon, L. (2011). The identification of agglomeration economies. *Journal of Economic Geography*, 11(2), 253–266.
- [8] Duranton, G., & Puga, D. (2004). Micro-foundations of urban agglomeration economies. In J. V. Henderson & J.-F. Thisse (Eds.), *Handbook of regional and urban economics* (Vol. 4, pp. 2063–2117). Elsevier.
- [9] Fingleton, B., & López-Bazo, E. (2006). Empirical growth models with spatial effects. *Papers in Regional Science*, 85(2), 177–198.
- [10] Harris, J. R., & Todaro, M. P. (1970). Migration, unemployment and development: A two-sector analysis. *American Economic Review*, 60(1), 126–142.
- [11] Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53–74.

- [12] Krugman, P. R. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99(3), 483–499.
- [13] Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics*, 61(S1), 631–652.
- [14] Mincer, J. (1974). *Schooling, experience, and earnings*. Columbia University Press.
- [15] Moretti, E. (2004). Human capital externalities in cities. In J. V. Henderson & J.-F. Thisse (Eds.), *Handbook of regional and urban economics* (Vol. 4, pp. 2243–2291). Elsevier.
- [16] Phillips, P. C. B., & Sul, D. (2007). Transition modeling and club convergence. *Econometrica*, 75(6), 1771–1855.
- [17] Quah, D. (1993). Empirical cross-section dynamics in economic growth. *European Economic Review*, 37(2–3), 426–434.
- [18] Quah, D. (1996). Empirics for economic growth and convergence. *Scandinavian Journal of Economics*, 98(1), 121–146.
- [19] Rey, S. J., & Montouri, B. D. (1999). U.S. regional income convergence: A spatial econometric perspective. *Regional Studies*, 33(2), 143–156.
- [20] Roback, J. (1982). Wages, rents, and the quality of life. *Journal of Political Economy*, 90(6), 1257–1278.
- [21] Rosen, S. (1979). Wage-based indexes of urban quality of life. In P. Mieszkowski & M. Straszheim (Eds.), *Current issues in urban economics* (pp. 74–104). Johns Hopkins University Press.
- [22] Sala-i-Martin, X. (1996). Regional cohesion: Evidence and theories of regional growth and convergence. *European Economic Review*, 40(6), 1325–1352.
- [23] Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), 65–94.
- [24] Temple, J. (1999). The new growth evidence. *Journal of Economic Literature*, 37(1), 112–156.
- [25] Guangdong Provincial Bureau of Statistics. (2024). *Guangdong Statistical Yearbook 2024*. China Statistics Press.
- [26] Hong Kong SAR Government. (2025). *Hong Kong statistical yearbook 2025*. Census and Statistics Department.
- [27] Ministry of Transport. (2024). *National Comprehensive Three-Dimensional Transport Network Planning Outline (2024-2035)*. China Communications Press.
- [28] China State Railway Group. (2025). *National Intercity Passenger Transport Statistical Bulletin for 2024*.
- [29] Islam, N. (1995). Growth empirics: A panel data approach. *The Quarterly Journal of Economics*, 110(4), 1127–1170. <https://doi.org/10.2307/2946651>.
- [30] World Bank. (2024). *World Development Indicators: Services, value added (% of GDP)*. <https://data.worldbank.org>.
- [31] TheGlobalEconomy.com. (2024). *Hong Kong and Macao service sector share of GDP*. <https://www.theglobaleconomy.com>.