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Can the establishment of the Guangdong-Hong Kong-Macao Greater Bay Area promote Capital Mobility and regional economic integration?

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Abstract

This paper assesses the economic integration and regional capital mobility in the Guangdong-Hong Kong-Macao Greater Bay Area (hereinafter referred to as the GBA) of China during the period from 1978-2020 by employing panel cointegration and the fully modified OLS (FMOLS) method. To consider the factors influencing the capital market environment, we extended the traditional F-H (Feldstein & Horioka) model by constructing the unconditional F-H model and the conditional F-H model. The overall capital mobility and the overall economic integration of the GBA indeed improved, with Guangdong and Macao being the regions with the greatest benefits, except for Hong Kong where capital mobility has been hampered at this stage.

JEL classification numbers: E60, E66, O10, O20.
Keywords: Regional economic integration, Capital mobility, Guangdong-Hong Kong-Macao Greater Bay Area (GBA), Feldstein–Horioka (F-H) model, Panel cointegration and panel FMOLS.

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1. Introduction

To reinvigorate economic development in megacities and to strengthen economic prosperity in the Pearl River Delta region, on October 28, 2009, the government departments of Guangdong, Hong Kong and Macao jointly issued research on the Coordinated Development Planning of the City Cluster in the Greater Pearl River Delta (hereinafter referred to as the GBA policy) in Macao; proposed building the Bay Area of the Pearl River Estuary; and promulgated the policy of cooperation among Guangdong, Hong Kong, and Macao to build a world-class city cluster. In recent years, the economic development of GBA has been characterized by rapid progress, diversification, and convergence (Dang et al., 2023). As a core area for capital accumulation, the GBA injects development capital into high return and high growth industrial projects within the region, promoting the development of emerging industries and forming a diversified economic development situation, thereby enhancing the economic resilience and ability to resist financial risks of the Greater Bay Area (Sheng et al., 2024). The GBA holds an important strategic position in China’s future economic development. Its purpose is to further strengthen the economic ties between the cities in the Pearl River Delta (Hui et al., 2020) and to facilitate cooperation among Guangdong, the Hong Kong Special Administrative Region, and the Macao Special Administrative Region. The goal is for the GBA to become a world-class bay area and a world-class city cluster with international vitality, outstanding innovation capabilities, an optimized industrial structure, and a healthy ecological environment (Lin & Li, 2020).

Economic integration is considered an important driving force for economic institutions and economic factors (Coulibaly et al., 2018; Nguyen & Su, 2021; Díaz-Dapena et al., 2019; Cheng et al., 2025; Bian et al., 2024). Economic integration reduces regional economic development disparities through cross regional resource allocation, enhances the cohesion of the economy and society within the region, and thus improves the overall competitiveness of the region (Fratesi et al., 2019). Numerous scholars have studied the impact of economic integration on China's economy, Egger and Larch (2011), Mann (2015) and Cutrini (2019) studied the impact of EU integration on economic growth. The impact of global and regional factors on stock market returns has been amplified by increased market liberalization and integration (Essayem et al., 2023). Zhang et al.(2023) and Zhao et al.(2023) examine the relationship between financial development and economic globalization using Europe and Asia as examples. Rekiso (2017) studied the relationship between industrialization and regional economic integration in Sub-Saharan Africa (SSA). Ma (2022) used the Belt and Road Initiative (B&R) to study the growth effect of the local economy based on the exogenous innovation model of regional economic integration launched by the Chinese government. Song et al. (2021) empirically tested the effect of economic integration on stock market movements between India and major Asian markets. Hashiguchi and Tanaka (2015) proposed that the agglomeration of manufacturing enterprises in the Yangtze River Delta region of China significantly improves productivity and capital investment under economic integration. However, although China has made progress in economic reform and development, the domestic capital market is not perfect, and the economic integration between regions has not reached the desired level (Boyreau-Debray & Wei, 2005; Chan et al., 2011; Yang, 2002). Younas & Chakraborty (2011) used the Feldstein-Horioka savings-investment approach and found that economic openness and financial market integration have a greater impact on developing countries. Whether the establishment of China's GBA can effectively strengthen economic cooperation among Guangdong, the Hong Kong Special Administrative Region and the Macao Special Administrative Region and promote economic integration requires further investigation.

Economic integration refers to the elimination of economic barriers within a region through the signing of cooperation agreements, enabling the free flow of capital and other factors, and achieving the optimal allocation of overall resources within the region. There are significant differences in capital mobility across different regions. Generally, regions with developed banking sectors have stronger capital mobility, while regions with weaker banking systems have lower capital mobility. Moreover, developed banking areas in neighboring regions may absorb surrounding funds, further weakening the capital mobility of adjacent regions (Coccorese et al., 2024). In a pioneering study, Feldstein and Horioka (1980) used an indirect approach to describe capital mobility. They argued that if capital could move perfectly between countries, domestic investment could be financed by savings from other countries, and domestic savings could be used for investment projects in other countries to generate higher returns. Therefore, a weak correlation between the savings rate (the ratio of savings to GDP) and the investment rate (the share of investment in GDP) is a sign of high capital mobility. However, their investigation of the relationship between domestic savings and domestic investment in 16 OECD countries from 1960 to 1974 showed a high correlation, which was inconsistent with the data. This finding revealed a paradox known as the Feldstein-Horioka (F-H) puzzle. Feldstein (1983) further analyzed the relationship between savings and capital mobility, suggesting that domestic savings are converted into domestic investment through international capital flows, with long-term savings closely correlated with investment. Subsequent research by Tesar (1991) also confirmed the main findings of Feldstein and Horioka (1983) in industrialized countries, showing a high correlation between national savings and investment rates. Similarly, Barros & Gil-Alana (2015) also found that when capital mobility restrictions were low in the Angolan economy, there was still a significant positive correlation between domestic long-term savings and investment. However, Ford & Horioka (2017) provided a new explanation for the Feldstein-Horioka puzzle, stating that the mobility of goods and services is an important barrier to international capital flows. Drakos et al. (2018) found a long-term relationship between national savings and investment in 14 EU countries, with a low magnitude of the savings retention coefficient that was statistically different from zero, providing weak evidence for the Feldstein-Horioka puzzle; most of these countries maintain long-term international solvency. Moreover, Akkoyunlu (2020) confirmed the Feldstein-

Horioka hypothesis in a closed economy.

There are two noteworthy aspects of previous research on the F-H problem. First, some scholars believe that in the case of large countries (those with larger economies) in the survey sample, a high correlation between the savings rate and the investment rate and high capital mobility can exist at the same time. David et al. (2023) suggested that domestic savings indeed lead to investment in developing economies, while in developed countries, the correlation observed in empirical results seems to be caused by endogeneity bias. This phenomenon is attributed to the large country effect (Ho & Huang, 2006; Ma & Li, 2016; David et al., 2023). Productive investment is financed by portfolio investment, so it affects the growth rate, while long-term portfolio investment is positively correlated with economic growth in developing countries, but not in developed countries (Sugozu et al., 2023). Second, some scholars believe that in the absence of measurement errors, the difference between the domestic savings rate and the investment rate reflects the current account balance. Therefore, the correlation between a higher savings rate and the investment rate may reflect the government's target for current account balances (Taylor, 2002). Similarly, Sinn (1992) believe that the high correlation between the savings rate and investment rate directly reflects a country's long-term current account solvency constraints or intertemporal budget constraints; it does not well reflect capital mobility between countries. A country's long-term solvency constraints require that the current account balance as a proportion of GDP remain stable because the accumulated balance of payments or national debt cannot increase explosively. Since the current account balance is the difference between savings and investment, the two variables are cointegrated. In addition, Gomes et al. (2008) questioned the assumption of Feldstein and Horioka (1980) in the model that the same correlation exists between countries since each country has a specific level of financial openness and capital controls. A few scholars believe that the analytical framework of Feldstein and Horioka (1980) may not provide an effective assessment of international capital mobility. However, within a country, different regions are not restricted by current account solvency constraints and can effectively avoid the effects of large powers and capital control. Several researchers have adjusted the framework of Feldstein and Horioka (1980) to study cross-regional capital mobility within a country. Sinn (1992) was the first to use the framework of Feldstein and Horioka (1980) to assess domestic capital mobility in the U.S. The F-H model is more suitable for intercountry or intraregional capital mobility tests than for cross-country capital mobility tests and is used to evaluate the degree of regional financial synergy (Boyreau-Debray & Wei, 2005). Similarly, Yamori (1995), Dekle (1996), Iwamoto and Van Wincoop (2000), and Ketenci (2015) evaluated capital mobility among regions within the United Kingdom, Japan, Canada, and Russia. Among countries such as the United States, the United Kingdom, and Japan, which have developed domestic financial markets and a high degree of economic integration, the savings rate and investment rate are relatively low. Feldstein and Horioka (1980) originally stated that capital mobility reflects the degree of economic integration. The theoretical analysis is consistent with this assertion

(Chan et al., 2011).

The emerging GBA, as a key driving force for China's future reforms (Anguelov et al., 2023), leads the core region of China's rapid economic development. Analyzing the process of economic integration in the GBA is crucial for understanding capital flows within the region and their role in promoting high-quality economic development in China. Based on existing research on regional integration and capital flows (Dong et al., 2023), and drawing on the studies of Boyreau-Debray and Wei (2005), Chan et al. (2011), and Wang (2016), which examined China's capital mobility through the correlation between savings rates and investment rates, we apply the Feldstein and Horioka (1980) framework to test whether the establishment of the GBA can promote capital flows among Guangdong Province, the Hong Kong Special Administrative Region, and the Macau Special Administrative Region, thereby enhancing economic integration among these three regions. Our research differs from previous scholars' research on capital mobility in China in four ways. First, we consider the capital mobility of the GBA after excluding the internal and external environmental factors of the capital market (government intervention and business cycle fluctuations). Second, by comparing the correlation coefficient between the savings rate and the investment rate without excluding the influence of the capital market environment, we study the influence of the capital market environment on capital mobility in the GBA at the present stage. We decompose the sample data into three parts, 1997 and 2009, as the demarcation points to test capital mobility in the region and to test whether China's GBA plan truly promoted economic integration in the GBA region.

The remainder of this paper is organized as follows: In Section 2, we present the expanded Feldstein–Horioka (F-H) model. In Section 3, we provide empirical results describing the capital mobility of the GBA as a whole and across regions within it and analyze the factors that affect these capital mobilities. Finally, Section 4 concludes the paper.

2. Methods and Data

2.1 Methods

In the nearly 40 years since Feldstein and Horioka proposed the famous F-H model in their seminal study (Feldstein & Horioka, 1980), ongoing research has continually improved the F-H model, and the model has a rich theoretical basis. The F-H model can measure capital mobility succinctly and effectively and reflects the degree of economic integration. Feldstein and Horioka estimate the following cross-sectional regression:

$$(I/Y)_i = \lambda + \beta(S/Y)_i + u_i \quad (1)$$

where I is domestic investment within one year, S is domestic savings, Y is national GDP, i=1,2,3,…16 are the 16 OECD member states, and the coefficient β is the savings retention coefficient (SRC). The SRC measures the relationship between

domestic savings and investment; thus, it reflects the degree of international capital mobility. When the world economy is poorly integrated and each country's financial markets are completely closed to each other, domestic investment must be financed by domestic savings because capital cannot be moved between countries in the form of international loans, for example. In this case, the SRC will be high and close to 1. On the other hand, when the world economy is very integrated, capital can move freely between countries, allowing it to be invested where it will produce the highest returns, and domestic investment can be easily financed by international funds rather than by domestic savings. In this case, the SRC will be low and close to 0.
The original F-H model was a cross-sectional regression model and was further expanded into a panel data model:

$$(I/Y)_{it} = \lambda + \beta(S/Y)_{it} + u_{it} \tag{2}$$

where $(I/Y)_{it}$ is the investment rate of region *i* at time *t*, $(S/Y)_{it}$ is the savings rate of region *i* at time *t*, and the meanings of the other variables are the same as those in Equation (1). The model above is also known as the "unconditional F-H model".
The investment rate and savings rate are often affected by the capital market and thus produce a certain endogeneity. We follow the research method used by Iwamoto and Van Wincoop (2000) in their study of capital mobility in Japan. These authors introduced new conditional restrictions based on the unconditional F-H model and designed an F-H model that can exclude the influence of internal and external factors in the capital market; this model is also known as the "conditional F-H model". Among these factors, local government intervention is regarded as an internal factor affecting the capital market, and business cycle fluctuations are regarded as an external factor affecting the capital market. Drawing inspiration from the research method of Iwamoto and Van Wincoop (2000), we further expand the unconditional F-H model; the factors influencing government intervention are removed, and we obtain the following:

$$S_{it} = \alpha_i + \alpha_F F_{it} + e_{it}^{S1} \tag{3}$$

$$I_{it} = \beta_i + \beta_F F_{it} + e_{it}^{I1} \tag{4}$$

where S_{it} and I_{it} represent the amount of savings and investment in area *i* in period *t*, respectively; and F_{it} is the government intervention in area *i* in period *t*, calculated by using government fiscal expenditure as a percentage of local GDP. The savings series and investment series after excluding the factors influencing the local government are represented by residual series e_{it}^{S1} and e_{it}^{I1}, respectively, generated in Equations (3) and (4), respectively, and the new savings series e_{it}^{S1} and investment series e_{it}^{I1} are used in a further regression to obtain Equation (5):

$$e_{it}^{I1} = \alpha + \beta' e_{it}^{S1} + \varepsilon_{it} \tag{5}$$

β' is the SRC that is obtained after excluding internal factors affecting the capital market, that is, the influence of government intervention. This SRC is not perfect, and we have further expanded it to eliminate external factors affecting the capital market. Drawing on the research method of Iwamoto and Van Wincoop (2000), we filter the GDP of the region. Additionally, we use the filtering method proposed by Hamilton (2018) to smooth the GDP of the region to remove the influence of business cycle fluctuations and substitute it into the expanded F-H model to obtain Equations (6) and (7):

$$S_{it} = \alpha_i + \alpha_y y_{it} + \alpha_F F_{it} + e_{it}^{S2} \tag{6}$$

$$I_{it} = \beta_i + \beta_y y_{it} + \beta_F F_{it} + e_{it}^{I2} \tag{7}$$

where y_{it} is the GDP of region *i* in period *t* obtained after using the filtering method proposed by Hamilton (2018). The meanings of the remaining variables in Equations (6) and (7) are the same as those in Equations (3) and (4). Regressing the new saving series e_{it}^{S2} and investment series e_{it}^{I2} again, we obtain Equation (8):

$$e_{it}^{I2} = \alpha + \beta'' e_{it}^{S2} + \varepsilon_{it} \tag{8}$$

Finally, we obtain the new SRC β'' after adjusting for the internal and external factors of the capital market. By comparing the new SRC β'' calculated by the conditional F-H model with the SRC β calculated by the unconditional F-H model, we obtain the capital mobility situation after excluding the internal and external environmental factors of the capital market (government intervention and business cycle fluctuations). If the SRC calculated by the conditional F-H model (after excluding the internal and external factors of the capital market) is lower than the SRC calculated by the unconditional F-H model, this indicates that the current capital market environment hinders capital mobility and that the government should improve this situation. In contrast, the current capital market environment is conducive to capital mobility, and the government should protect or strengthen this environment. Based on these parameters, we analyze whether the environmental factors of the capital market in the GBA have an impact on the economic integration of this region.

2.2 Data

We studied GBA data covering the period from 1978–2020. According to the accepted definition, the region's investment (I) is expressed as the total capital formation; the regional savings amount (S) is expressed by the difference between GDP (Y) and final consumption. To ensure the consistency of the data caliber, the GDP (Y) of a region is calculated by the expenditure method. Government intervention (F) is calculated as the proportion of government fiscal expenditure to total GDP. The data sources for our study are as follows: The Guangdong Province data are from the National Bureau of Statistics (http://www.stats.gov.cn/tjsj/) and the Guangdong Statistical Yearbook (http://stats.gd.gov.cn/gdtjnj/). The data on the Hong Kong Special Administrative Region are from the Hong Kong Information Line (https://data.gov.hk/sc/), and the data on the Macao Special Administrative Region are from the Statistics and Census Bureau of Macao (https://data.gov.hk/sc/).

3. Empirical results and analysis

3.1 Descriptive statistics

Table 1 and Figure 1 show some descriptive statistics. Table 1 clearly shows that Guangdong's investment rate is relatively high, at approximately 0.37, Hong Kong's investment rate remains at approximately 0.25, and Macao's investment rate remains at approximately 0.28. However, all three GBA regions have relatively high savings rates, with Macao even reaching approximately 2.3. Hong Kong followed closely, with an average of approximately 0.7; Guangdong had the lowest, at approximately 0.56. In terms of standard deviation, Guangdong's investment rate and savings rate are relatively stable, always remaining below 0.07, while Hong Kong and Macao are higher. We illustrate this below in conjunction with Figure 1.

Table 1: Descriptive statistics

	1978-2020							
	$(\boldsymbol{I/Y})_{\boldsymbol{it}}$				$(\boldsymbol{S/Y})_{\boldsymbol{it}}$			
	Mean	**Sd**	**Min**	**Max**	**Mean**	**Sd**	**Min**	**Max**
Hong Kong	0.248	0.040	0.170	0.333	0.697	0.697	0.044	0.620
Macao	0.283	0.157	0.092	0.690	0.787	0.590	0.260	2.308
Guangdong	0.372	0.060	0.130	0.449	0.558	0.068	0.468	0.698

Note: (1) Mean refers to the mean value, Max refers to the maximum value, Min refers to the minimum value, and Sd refers to the standard deviation. (2) $(I/Y)_{it}$ represents the investment rate (the proportion of investment in GDP), and $(S/Y)_{it}$ represents the savings rate (the proportion of savings in GDP).

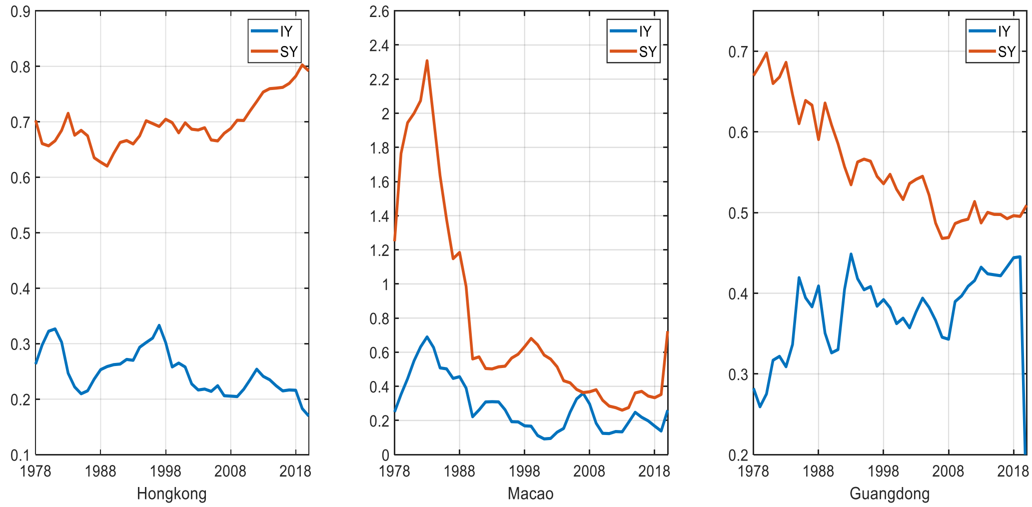

Figure 1: Line chart of the investment rate and savings rate of the GBA

As shown in Figure 1, the fluctuations in the investment rates of Guangdong, Hong Kong and Macao have been relatively smooth over time, but the fluctuations in the savings rates of Hong Kong and Macao have been relatively large. In addition, we find that before 2009, there was a significant deviation in the changes in the investment and savings rates in Hong Kong, Macao, and Guangdong. This provides a basis for us to use 2009 as the demarcation point to analyze the changes in GBA Capital Mobility in two different periods, before and after.

The SRC obtained by the F-H model is the result of the cross-sectional regression model, which focuses only on the SRC at a certain time point. However, savings and investment are correlated in the long-term (Gundlach & Sinn, 1992). Therefore, it is more appropriate to use a panel regression model to further explore whether GBA policy promotes economic integration in the GBA. We draw inspiration from Iwamoto and Van Wincoop (2000), Narayan (2005), Narayan et al. (2008), Fouquau et al. (2008), Herwartz and Xu (2010), Narayan and Narayan (2010), and Lin & Deng (2021).to conduct further analysis and verify the results of the panel regression model.

3.2 Stationarity test

To avoid the problem of "pseudoregression", it is necessary to test the smoothness of the data, and the use of different methods to test the smoothness of the data may lead to different results. Therefore, we applied a variety of panel unit root test methods, including the LLC test,[3] IPS test,[4] and Hadri-LM test.[5] The results are

[3] The LLC-T was proposed by Levin et al. (2002).

[4] The IPS-W was proposed by Im et al. (2003).

[5] Hadri (2000) extended the Kwiatkowski et al. (1992) (KPSS) test to the panel data model and proposed the Hadri-LM test of the original hypothesis that the time series of each cross-sectional unit is stationary or trend-stationary.

shown in Table 2. First, the LLC-T test shows the results of the various panel unit root tests. However, the investment rate $(I/Y)_{it}$ in the unconditional F-H model after first-order differencing shows that there is still a unit root present. Therefore, we add the IPS-W test, which has an advantage over the LLC-T test in that the test relaxes the assumption of a common unit root and allows for heterogeneity in the autoregressive coefficients. The IPS-W test shows that the presence of a unit root is rejected after the first-order difference. Combining the IPS-W test results and the LLC-T test results, we can see that when testing the level values of each variable, the null hypothesis of "presence of unit root" could not be rejected. When testing the first-order difference values of each variable, the results rejected the null hypothesis at the 1% level of significance. As a robustness test, we add the Hadri-LM test, which has the null hypothesis of no unit root and that all panel data are stationary.

These results reveal the nonstationary characteristics of the investment rate $(I/Y)_{it}$ and savings rate $(S/Y)_{it}$ in the unconditional F-H model, as well as the new savings series e_{it}^{S2} and investment series e_{it}^{I2} in the conditional F-H model, and provide the foundation for the following panel cointegration analysis. The results of Coakley et al. (2004), Kim et al. (2005), Adedeji and Thornton (2008), Chan et al. (2011), Ketenci (2015), Ma and Li (2016), and Bineau (2021) imply similar conclusions.

Table 2: Panel unit root test of the data

Model		LLC-T	IPS-W	Hadri LM		
Unconditional F-H model	$(I/Y)_{it}$	0.27	-0.220	21.82***	15.60***	11.25***
	$\triangle(I/Y)_{it}$	-1.03	-3.845***	0.36	0.20	-0.06
	$(S/Y)_{it}$	0.27	0.967	32.30***	33.57***	16.01***
	$\triangle(S/Y)_{it}$	-4.19***	-6.368***	0.77	0.45	0.15
Conditional F-H model	e^{I2}_{it}	0.06	-0.480	4.93***	2.35***	2.13**
	$\triangle e^{I2}_{it}$	-3.01***	-5.053***	-0.03	-0.01	-0.35
	e^{S2}_{it}	0.45	0.436	10.56***	7.08***	4.80***
	$\triangle e^{S2}_{it}$	-2.70***	-5.449***	0.32	0.17	0.04

Note: (1) ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively. (2) (No demean, Trend, Lags) = (0,0,0), with the elimination of common time effects, without the trend term from the estimated equation; no lag length is used for all individuals. (3) The Z(mu) statistic only includes intercepts; Homo: homoscedastic disturbances across units; Hetero: heteroskedastic disturbances across units; and Ser Dep: controlling for serial dependence in errors (lag trunc =2).

3.3 Cointegration test

When considering the nonstationary property, we need to address the issue of cointegration, which can be viewed as a statistical expression of the long-term equilibrium relationship between composite variables. Therefore, we used the Kao residual cointegration test proposed by Kao (1999) and Kao and Chiang (2001) and the cointegration test proposed by Pedroni (1999).

As shown in Tables 3 and 4, in the Kao and Chiang (2001) cointegration test, five statistics (Dickey-Fuller, Modified Dickey-Fuller, Augmented Dickey-Fuller, Unadjusted modified Dickey-Fuller, Unadjusted Dickey-Fuller) all show a cointegration relationship between the unconditional F-H model and Conditional F-H models. The results of the Pedroni (1999) cointegration test show that the Phillips–Perron statistic and the Augmented Dickey–Fuller statistic is insignificant for the unconditional F–H model. However, given the small sample size, the usual cointegration test still has low power against many alternatives. Small sample sizes, as in our case, usually make the rejection of the null of cointegration more difficult (Montiel, 1994).

Table 3: Pedroni cointegration test

Model	Statistic	T-statistic	P value
Unconditional F-H model	Phillips–Perron t	-0.86	0.20
	Augmented Dickey–Fuller t	-1.20	0.12
	Modified Phillips–Perron t	-1.66	0.05**
Conditional F-H model	Phillips–Perron t	-2.2	0.01**
	Augmented Dickey–Fuller t	-2.45	0.01***
	Modified Phillips–Perron t	-3.19	0.00***

Note: (1) ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Kao residual cointegration test

Model	Statistic	T-statistic	P value
Unconditional F-H model	Modified Dickey–Fuller t	-4.67	0.00***
	Dickey–Fuller t	-2.21	0.01**
	Augmented Dickey–Fuller t	7.98	0.00***
	Unadjusted modified Dickey–Fuller	-3.83	0.00***
	Unadjusted Dickey–Fuller t	-2.07	0.02**
Conditional F-H model	Modified Dickey–Fuller t	-7.03	0.00***
	Dickey–Fuller t	-3.05	0.00***
	Augmented Dickey–Fuller t	3.46	0.00***
	Unadjusted modified Dickey–Fuller	-5.73	0.00***
	Unadjusted Dickey–Fuller t	-2.92	0.00***

Note: (1) ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Westerlund (2005b) proposed a nonparametric test, the variance ratio test, to overcome the limitations of existing parametric and semiparametric tests (Westerlund, 2005a). The method does not require any correction for the time dependence of the data but is still able to accommodate individual-specific short-term dynamics, individual-specific intercepts and trend terms, and individual-specific slope parameters. Moreover, the test has relatively stable critical values for small samples, which makes it easy to obtain robust and reliable conclusions in practical applications; furthermore, the test is suitable for the sample study in this paper. Westerlund (2005b) proposed two new methods for panel cointegration testing based on the nonparametric unit root test in Breitung (2002): the variance ratio test (VRT) and the modified variance ratio test (MVRT). Here, we apply the variance ratio test (VRT).

The results of the Westerlund (2005b) panel cointegration test are displayed in Table 5. This implies that the variables have some fixed long-run relationships in both the conditional F-H model and the unconditional F-H model. Thus, it is intuitive to perform a cointegration regression between savings and investment rates, and panel regression will not cause spurious regression. The Kao residual cointegration test results shown in Table 3 are consistent with the test results of Kim et al. (2005), Adedeji and Thornton (2008), Chan et al. (2011), and Ketenci (2015). Additionally, the Pedroni cointegration test results shown in Table 4 are consistent with the test results of Dash (2019). The Westerlund cointegration test results shown in Table 5 are consistent with the test results of Singh (2008) and Long et al. (2023).

Table 5: Westerlund panel cointegration test

Model	Statistic	T-statistic	P value
Unconditional F-H model	Variance Ratio	-1.68	0.05**
Conditional F-H model	Variance Ratio	-1.75	0.04**

Note: (1) ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

3.4 Model regression results

At present, scholars are widely using ordinary least squares (OLS) and generalized least squares (GLS) methods to estimate model parameters. In fact, in complex real-world economic activities, it is difficult to avoid problems of endogeneity and serial correlation Ma and Li (2016). Therefore, to avoid spurious regression, we use the fully modified OLS (FMOLS) method following Phillips and Hansen (1990) to calculate the overall SRC in the GBA by using the unconditional F-H model and the conditional F-H model because FMOLS corrects for the effects of endogeneity and serial correlation and asymptotically eliminates sample bias.

During the SRC measurements, there were cases in which the SRC was greater than 1 and less than 0 (Dekle,1996; Thomas, 1993; Yamori, 1995; Kim et al., 2007; Chan et al., 2011; Holmes and Otero, 2014). For the negative SRC in the study of regional capital mobility in China, scholars such as Boyreaure-Debray and Wei (2005) believe that the negative SRC justifies the use of the F-H model to analyze capital mobility in various regions within China. In fact, the degree of savings– correlation across Chinese provinces approaches or even exceeds the degree of intercountry correlation revealed by recent findings based on nonstationary panel techniques, such as Coakley et al. (2004), Kim et al. (2005), and Chakrabarti (2006).

Table 6 reports the result of unconditional F-H model test. Taking 1997 as the cutoff point, the SRC in the Hong Kong and Guangdong regions exhibited an upward trend, rising from approximately 1.68 to approximately 2.61 and from approximately -0.73 to approximately 0.185, respectively. The SRC of the GBA as a whole also rises from approximately 0.107 to approximately 0.213. These results seem to indicate that there are barriers to capital mobility between the regions of the GBA during this period. In the period from 2010 to 2020, the SRC in the Hong Kong region decreased to approximately 0.73, that in the Guangdong province decreased to approximately -9.97, and that in the GBA showed the same trend, dropping to approximately -1.01. The SRC of the Macao region is almost flat, with a slight increase to approximately -0.423. This trend seems to indicate that interregional capital mobility in the country is strengthening. However, as Iwamoto and Van Wincoop (2000) noted in their study of F-H coefficients in the Japanese region, saving and investment are also functions related to the economic cycle and the role of government intervention; therefore, we further analyze the role of business cycle fluctuation in influencing the role of the government to study the role of the government perspective in analyzing capital mobility in the GBA as a whole and capital mobility in the internal region.

Table 6: Unconditional F-H test

	1978-2020	**1978-1997**	**1998-2009**	**2010-2020**
Hong Kong	-0.394	1.683***	2.611***	-0.730***
	(0.378)	(0.502)	(0.704)	(0.125)
Macao	0.253***	0.229***	-0.454*	-0.423***
	(0.050)	(0.034)	(0.265)	(0.075)
Guangdong	-0.206	-0.734***	0.185*	-9.974***
	(0.207)	(0.234)	(0.108)	(0.279)
GBA	-0.032	0.107**	0.213	-1.012***
	(0.925)	(2.111)	(1.116)	(-14.240)

Note: (1) ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.
(2) The p-values are in parentheses.

Table 7 reports the results of the conditional F-H model. After controlling for the effects of government intervention and business cycle fluctuation, the SRC in each region of the GBA is affected to varying degrees, but the differences in the factors responsible for these changes are more pronounced across regions. Using 1997 as the cutoff point, the SRC of the GBA as a whole, as well as that of the Macao and Guangdong regions in 1998-2009, are all greater than the results for 1978-1997. After 2009, the SRCs of the Hong Kong region, the Macao region, the Guangdong region, and the GBA as a whole for the period of 2010–2020 were all lower than those in the 1998–2009 period. Among them, the SRC of Hong Kong decreased to approximately -1.037, the SRC of Macao decreased to approximately 3.267, the SRC of the Guangdong region decreased to approximately -5.373, and the capital mobility of the GBA as a whole decreased to approximately -0.286. Except for the SRC in the unconditional F-H model of Macao, which is almost the same as that in the previous period, the SRC in the conditional F-H model and the SRC in the unconditional F-H model of the overall GBA and other regions show the same decreasing trend from 2010–2020. Next, we need to compare the two model results for an in-depth analysis.

Table 7: Conditional F-H test

	1978-2020	**1978-1997**	**1998-2009**	**2010-2020**
Hong Kong	0.129	1.095	-0.730	-1.037***
	(0.459)	(0.761)	(0.483)	(0.282)
Macao	0.241***	0.182***	31.295***	3.267***
	(0.073)	(0.060)	(3.128)	(0.461)
Guangdong	-1.132***	-1.285***	-0.174*	-5.373***
	(0.284)	(0.326)	(0.095)	(0.418)
GBA	-0.069	-0.001	2.763**	-0.286***
	(-0.117)	(0.161)	(2.009)	(-2.845)

Note: (1) ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.
(2) The p-values are in parentheses.

Table 8 briefly labels the comparative results for excluding the effect of business cycle fluctuation on the study of the role of the government perspective of the conditional and unconditional models for SRC over time. These results show that the role of government intervention in the GBA provinces and cities hindered the development of capital mobility in this region during the period 1998-2009. During the period from 1998-2009, the SRCs of the GBA as a whole and of Macao both increased and appeared to be greater than 1, which indicated the formation of a capital importation state, which was in line with the status quo of economic development at that time. In this period, the cities in the region were in a state of rapid economic development since the reform and opening up, gathering a large amount of domestic and foreign capital, which led to the construction of various enterprises and financial institutions. The impact of FDI on economic growth is much greater than that of domestic savings (Baharumshah & Thanoon, 2006). Since the liberalization of Macao's gambling rights, the gaming industry has attracted large-scale domestic and foreign capital. The rapid growth of the gaming industry has contributed to the growth of Macao's tourism industry and commerce, with many foreign banks opening branches in Macao. As a result, the SRC of the GBA is high and even appears to be greater than that of input capital 1, which also leads to the local financial capital of the GBA being used for local construction, and the capital mobility is low.

Table 8: Comparison of SRC results

Posterior vs. Prior				
	Unconditional F-H model		**Conditional F-H model**	
	Using 1997 as a cutoff point	Using 2009 as a cutoff point	Using 1997 as a cutoff point	Using 2009 as a cutoff point
Hong Kong	Increase	Decrease	Decrease	Decrease
Macao	Decrease	Increase	Increase	Decrease
Guangdong	Increase	Decrease	Increase	Decrease
GBA	Increase	Decrease	Increase	Decrease
Conditional F-H model vs. Unconditional F-H model				
	1998-2009		**2010-2020**	
Hong Kong	Lower		Lower	
Macao	Higher		Higher	
Guangdong	Lower		Higher	
GBA	Higher		Higher	

Notes: Table 8 presents a comparative analysis of Tables 6 and 7.

During the period from 2010-2020, we find that the SRC of the conditional F-H model is greater than that of the unconditional F-H model in the GBA, Macao, and Guangdong. As the financial industries of the regions in the GBA continue to develop and mature, the financial capital gathered both domestically and internationally has begun to not only limit itself to investing in the local construction of the regions but also begun to increase its outward investment to seek a higher return on investment. The rapid development and maturity of the financial industry has led to a reduction in the SRC between the GBA as a whole and the provinces and municipalities, a smooth cross-regional movement of capital and an increase in the degree of capital mobility. In this period, the financial industry in Guangdong Province developed rapidly, with Shenzhen becoming an economically active city in China based on its favorable geographical location and resource conditions and with financial institutions such as stock exchanges making foreign investments. Macao is an international free port in China with free capital mobility and does not have a foreign exchange control policy, which allows for a smooth flow of foreign exchange. Moreover, Macao's GDP experienced negative growth during this period, which can be seen as a sign of weak internal demand and a regression in the economy, leading to an increase in foreign investment. However, Hong Kong presented the opposite result. Although Hong Kong's SRC results of the conditional F-H model were lower after 2009 than in the previous year, the conditional SRC results were lower than the unconditional SRC results when government intervention was removed. This suggests that the policy at this stage is a hindrance to capital mobility in Hong Kong. At the same time, it also shows that Hong Kong already has better internal market mechanism power to promote the degree of capital mobility in this period than does relying on external forces, government intervention or opening to external forces. Hong Kong's shift from importing more overseas capital into mainland China to beginning to absorbing more of the capital to build itself under the influence of factors related to government intervention was in line with the Chinese government's policy of strengthening Hong Kong's international financial center in 2016 (Zhang and Liu 2023; Jones, 2018; Fang et al., 2023).

4. Conclusion

In this study, using the framework of Feldstein and Horioka (1980), we examined the capital mobility of China's GBA as a whole and within different regions and analyzed whether the planning policies for China's GBA promoted the intended outcomes (strengthening the economic integration between Guangdong Province, the Hong Kong Special Administrative Region and the Macao Special Administrative Region). We combined the basic analytical framework of Feldstein and Horioka (1980) with the research methods of Iwamoto and Van Wincoop (2000) to consider capital mobility in the GBA after excluding the influence of the capital market environment (including government intervention and business cycle fluctuations). By comparing the SRC with and without the impact of the internal and external factors on the capital market, we clarify the impact of the macro capital market environment on the GBA to test its effectiveness. In addition, we used the FMOLS regression model to ensure the robustness of the results.

Through the regression of the GBA as a whole, we have evidence that since the introduction of the GBA plan in 2009, regardless of whether the influence of the capital market environment was excluded, the capital mobility of the GBA indeed increased, and the degree of economic integration increased. Moreover, we found that the capital market environment created by government intervention promoted capital mobility in the GBA to a certain extent. In addition, the SRC of the GBA from 2010 to 2020 changed from a positive value (approximately 2.763) in the previous period to a negative value (approximately -0.286), which we believe is a kind of capital output and not only indicates that the capital Capital Mobility of the GBA itself is gradually increasing. This also means that the GBA can provide financial support for other regions, improve its own income, and promote the economic development of other regions. By comparing the savings retention rates after excluding the impact of the capital market environment, we find that the capital mobility of all regions in the GBA improves under the influence of the capital market environment, such as government intervention, with Macao improving significantly under the influence of the role of the government; however, Hong Kong is still a cause for concern.

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