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Coupling and Coordination Analysis of Film and Television Art Media Culture Development and Digital Cultivation of Media Talents Based on Fuzzy Comprehensive Judgment Model

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Abstract In this paper, the entropy weight method and fuzzy comprehensive judgment model are combined with the evaluation index system of cultural development of film and media and digital cultivation of talents to realize the measurement of the level of cultural development of film and media and digital cultivation of talents. The coupling coordination degree model is used to calculate the coupling coordination degree between cultural development and digital cultivation of talents, and Dagum Gini coefficient, kernel density estimation and convergence test are used to explore the reasons for the differences in the coupling coordination degree between cultural development and digital cultivation of talents, the distribution characteristics, and the convergence. The results of the study show that the mean value of the coupling coordination degree between cultural development and digital cultivation of talents in Guangdong, Hong Kong and Macao Greater Bay Area ranges from 0.466 to 0.501 from 2013 to 2023, and shows a fluctuating and slowly increasing trend. The average contribution of intra-group gap, inter-group gap and hypervariable density in the three metropolitan areas of Guangzhou-Foshan-Zhaoxing, Shenzhen-Dongguan-Huizhou and Zhuhai-Zhongjiang are 28.676%, 40.102% and 31.221%, respectively, and the inter-group gap is the main factor contributing to the difference in the coupling coordination degree of the three metropolitan areas. Meanwhile, the convergence of the coupling coordination degree of the Pearl River Delta and the three metropolitan areas is good, and improving the coordination between cultural development and digital cultivation of talents in cities with low levels of coupling coordination degree can effectively narrow the gap between them and cities with high levels of coupling coordination degree.

Index Terms entropy weight method, fuzzy comprehensive judgment, coupling coordination model, Dagum Gini coefficient, cultural development

I. Introduction

With the increasing popularization of the Internet and the wide application of mobile devices, people's access to information and entertainment has changed dramatically. This also means that the influence, communication effect, and media structure of traditional film and art media will be greatly impacted [1], [2]. Nowadays, short video users as high as 1.04 billion, the daily output of short video can reach 150 million, the content generated by users using the platform or other software accounted for 70%, the video interactive effect is amazing, with fragmented content to attract different users to continue to use, so that the development of film and television art media culture presents a new form [3], [4]. The main manifestations are that mobile media allows users to watch rich movie and television content anytime and anywhere, streaming media platforms provide massive on-demand and live services, immersive content applications such as VR/AR bring users an unprecedented experience, and the use of ultra-high-definition technology in film and television images to upgrade the clarity of the screen, making the effect of film and television art media improved [5]-[8]. In order to adapt to the new market environment, the film and television art media industry change, transformation and upgrading is imminent, centered on the benefits, committed to digital technology-driven transformation, but need to actively deal with the film and television art media in the generation of content in the individuality of the demand for innovation and the generation of the contradiction between the standards [9]-[11]. At the same time, the changes in the film and television art media industry, but also promote the transformation of talent demand. The adaptability of traditional media talents is declining, and the contradiction between the update of digital technology and the training of media talents is prominent [12]. In the past media talent training, the relevant institutions follow the old teaching materials and methods, did not update the knowledge system and teaching forms, in the development of industry-teaching integration of talent training, the actual

participation in the enterprise project of the training of the form of few, resulting in the students in the beginning of the employment of the need for 3-12 months of adaptation period [13], [14]. Media talent training programs in institutions need to be based on the needs of today's media development, and the implementation of educational concepts to update and emphasize students' thinking ability and comprehensive application ability. Therefore, in the transformation of the development of film and television arts and media culture, it is also necessary to pay attention to the needs of media talent training, and it is of practical significance to study the coordination mechanism and benefits of the two.

The coupling coordination degree model serves as a precise assessment of the degree of interaction and coordination between multiple systems, or elements. It skillfully combines the coupling degree model and the coordination index model, and through a series of quantitative means, it provides insight into the subtle connections and dynamic changes between systems, and is widely used in the study of synergy in the fields of ecology-life, industry-school-institute, economy-ecological environment, and science and technology-industry, etc. [15]-[18]. But the coupled coordination degree model is a new research in the field of film and media culture development. Fuzzy comprehensive judgment is a systematic analysis method using fuzzy mathematical principles to analyze and evaluate things with “fuzziness”. It is a fuzzy reasoning-based analysis and evaluation method that combines qualitative and quantitative methods, and unifies the precise and imprecise, which provides a new form of coupled coordination mechanism and benefit evaluation for media culture development and talent training due to the unique superiority of this method in dealing with a variety of complex systemic problems that are difficult to be described by precise mathematical methods [19].

Based on the fuzzy comprehensive judgment model, this paper studies the coupling and coordination relationship between the development of film and television media culture and the digitalization of talents. Collecting theories related to the development of film, television and art media culture and the digital cultivation of media talents, the evaluation sub-systems of digital cultivation of media talents and the development of film, television and art media culture are constructed respectively from the dimensions of quantity, structure, quality as well as economic benefits and social benefits. The entropy weight method and fuzzy comprehensive evaluation model are used to quantitatively measure the level of the subsystems, and the coupling coordination degree model is used to calculate the coupling coordination level between the cultural development of film and art media and the digital cultivation of talents. In order to further explore the differences and sources of the coupling coordination level between cultural development and digital cultivation of talents, this paper adopts the Dagum Gini coefficient method to calculate the degree of difference in the coupling coordination level of different regions, and explores the main factors that cause the differences through the contribution rate of intra-group differences, inter-group differences and hypervariable density. Kernel density estimation method is used to characterize the distribution of the coupling degree of coordination between cultural development and digital cultivation of talents in different regions, and the convergence of the coupling degree of coordination in different regions is examined by using the σ convergence and β convergence models, which provide reference for further improving the coupling degree of coordination between cultural development of film and art media and digital cultivation of talents, and narrowing the gap of coupling degree of coordination between different regions.

II. Study design

II. A. Indicator system and data sources

II. A. 1) Construction of the indicator system

Following the principles of scientificity, systematization and representativeness, taking into account factors such as data availability, combined with the relevant theories of film and television art media culture development and talent training, 17 indicators were selected to construct a comprehensive evaluation index system for the development of film and television art media culture and the digital training of media talents, and the results are shown in Table 1, and all indicators are positive indicators. Seven indicators were selected from three aspects: quantity, structure and quality. It should be noted that due to the impact of the decline in the overall number of digital training of talents in China's media industry in 2019~2022, there are certain limitations in reflecting the scale of digital training of media talents only by quantitative indicators such as "the number of film and television media graduates", so structural indicators such as "the proportion of film and television media graduates to the total number of graduates" are also needed in the selection of indicators. The media and cultural development subsystem selects 10 indicators from the economic and social benefits of the cultural industry. Among them, in the economic benefits, "input-output rate = operating income of cultural industry enterprises / local general public budget expenditure on culture, sports and media", "capital profit and tax rate = total profit and tax of cultural industry enterprises / total assets", "labor productivity = operating income of cultural industry enterprises / employees", "operating profit rate = profit rate of cultural industry enterprises / operating income". In the social benefits, the "number of publications per capita" and

"library circulation rate" are respectively "the number of publications" and "the total number of library circulation" and other quantitative indicators divided by the "total population at the end of the year".

Table 1: Index system and weight

System		Index	Weighting
Digital talent cultivation	Quantity	Number of graduates of film and television media	0.006
		Number of students of film and television media	0.293
		The number of students enrolled in film and television media	0.179
	Structure	Number of graduates of film and television media/total graduates	0.286
		Number of admissions for film and television media/total number of admissions	0.120
		Number of students enrolled in film and television media programs/total number of students enrolled	0.064
	Quality	The proportion of film and television media graduates obtained professional certification books	0.052
Development of media and cultural industry	Economic benefit	Ratio of input and output	0.053
		Ratio of profits and taxes on funds	0.052
		Labor productivity	0.152
		Operating margin	0.063
	Social benefit	Per capita number of publications	0.076
		Library circulation rate	0.097
		Museum visit rate	0.159
		Media activity viewing rate	0.122
		Training rate of training course	0.139
		Exhibition attendance rate	0.087

II. A. 2) Data sources

The study area of this paper, the Guangdong-Hong Kong-Macao Greater Bay Area, selected nine prefecture-level cities in the Pearl River Delta (Hong Kong and Macao were not taken into consideration due to the high number of missing values in the data of Hong Kong and Macao). The main data were obtained from the Education Statistics 2013-2023 published by the Department of Development Planning of the Ministry of Education, as well as the China Statistical Yearbook, China Labor Statistical Yearbook, Guangdong Statistical Yearbook, Guangdong Education Statistical Yearbook, and China Statistical Yearbook of Cultural and Related Industries for 2014-2024. For individual indicator data that cannot be directly accessed, missing values are assigned by calculating the proportion structure of neighboring years.

II. B.Research methodology

II. B. 1) Entropy weight method

Entropy weight method is an objective method of assigning weights [20]. Specifically, the entropy weight method is to use the information entropy to calculate the entropy weight of each indicator according to the degree of change of each indicator, and then use the entropy weight to correct the weight of each indicator, so as to obtain a more objective weight, the specific steps are as follows:

The standardized processing of the evaluation index data of the level of cultural development of film and media and digital cultivation of talents is expressed by formula (1):

$$Y_{iji}=\begin{cases}\dfrac{x_{iji}-\min(x_j)}{\max(x_j)-\min(x_j)}+L & \text{Forward indicator}\\ \dfrac{\max(x_j)x_{iji}}{\max(x_j)\min(x_j)}+L & \text{Negative indicator}\end{cases} \tag{1}$$

where Y_{ijt} is x_{ijt} standardized indicator data. x_{ijt} refers to the raw data of the j indicator of the i city in the t year. $\max(x_j)$ and $\min(x_j)$ refer to the maximum and minimum values of the raw data of the j th indicator in the Guangdong-Hong Kong-Macao Greater Bay Area, respectively. $i=1,2,...,n$ (n represents the 9 cities in the Guangdong-Hong Kong-Macao Greater Bay Area). $j=1,2,\ldots,m$ (m represents the evaluation indicators).

$t=1,2,\ldots,r$ (r represents the 11 years from 2013 to 2023). L is the panning amplitude, which indicates the reduction of the effect of panning on the data, L is taken as 10^{-5}.

The information entropy e_j is calculated utilizing equation (2):

$$e_j = k \times \sum_{t=1}^{'} \sum_{i=1}^{n} P_{ijt} \times \ln P_{ijt} \tag{2}$$

where $k = 1/\ln(r \times n)$; $p_{ijt} = \dfrac{Y_{ijt}}{\sum_{i=1}^{r}\sum_{i=1}^{n} Y_{ijt}}$.

The coefficient of variability of the indicator g_j is calculated using equation (3):

$$g_j = 1 - e_j \tag{3}$$

The indicator weights w_j are calculated using equation (4):

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j} \tag{4}$$

In this paper, the results of the weight calculation of the index system of cultural development and digital cultivation of talents in film, television and art media by using the entropy weight method are shown in Table 1.

II. B. 2) Fuzzy synthesized assessment methods

The fuzzy comprehensive judgment method was used to calculate the index of the level of cultural development and digital cultivation of talents, as in equation (5):

$$u = Y * w \tag{5}$$

Where u is the index of the level of cultural development and digital cultivation of talents, Y is the standardized value of evaluation indexes, and w is the weight of indexes.

II. B. 3) Coupling harmonization model

Coupling degree refers to the interaction between two or more systems, which can measure the correlation between two or more systems and reflect the degree of mutual constraints and interdependence between the systems. By constructing the coupling degree model of the development of film and media culture and the digital cultivation of talents, the degree of correlation between the two can be measured. The coupling degree C is calculated as formula (6):

$$C = 2 \times \frac{\sqrt{u_1 \times u_2}}{u_1 + u_2} \tag{6}$$

In the formula, the value of coupling degree C is in the range of (0~1], the larger the value indicates that the degree of mutual influence between the development of film and media culture and the digital cultivation system of talents is more significant. u_1 represents the level of film and television media culture development. u_2 represents the level of talent digital cultivation.

The coupling degree can reflect the degree of mutual influence between the development of film and media culture and the digital cultivation of talents, but it can't reflect its overall coordination in the analysis of its spatio-temporal evolution law, therefore, the coupling coordination degree [21] is chosen to measure the coordination relationship between the development of film and media culture and the digital cultivation of talents. Analyzing the coupling coordination degree score can better understand the degree of coordination between these two systems, and the coupling coordination degree can provide a more comprehensive and accurate assessment of the relationship between the development of film and media culture and the digital cultivation of talents, which is calculated as formula (7):

$$D = \sqrt{C \times (\alpha u_1 + \beta u_2)} \tag{7}$$

In the formula, the value range of coupling coordination degree D is (0~-1]. α,β represent the coefficients to be determined for the development of film and media culture and the digital cultivation of talents respectively. In the current development situation, it can be seen that the development of film and media culture and the digital cultivation of talents are in the same important position, i.e. $\alpha=\beta=0.5$. The numerical size of the coupling coordination degree indicates the level of overall coordination, the larger the value represents the higher level of overall coordination, and vice versa, the lower the level.

Based on the relevant research results of various countries, combined with the reality of the development of film and television media cultural industry and the digital cultivation of talents in the Guangdong-Hong Kong-Macao Greater Bay Area, the coupling coordination degree types of film and television media cultural development and digital training of media talents are divided, and the results are shown in Table 2, in which T1-T9 represent 9 coupling coordination degree types, namely severe disorder, severe disorder, mild disorder, near disorder, reluctant coordination, primary coordination, intermediate coordination, good coordination, and high-quality coordination. Depending on the type of coupling coordination, the interrelationship between the two systems can be better understood.

Table 2: The coupling coordination degree and interval division

Coupling coordination	Type	Interval
(0.0,0.2]	T1	Unacceptable interval
(0.2,0.3]	T2	Unacceptable interval
(0.3,0.4]	T3	Unacceptable interval
(0.4,0.5]	T4	Transition interval
(0.5,0.6]	T5	Transition interval
(0.6,0.7]	T6	Acceptable interval
(0.7,0.8]	T7	Acceptable interval
(0.8,0.9]	T8	Acceptable interval
(0.9,1.0]	T9	Acceptable interval

II. B. 4) Dagum's Gini coefficient and its decomposition

The Gini coefficient is commonly used to measure the disparity in income distribution among residents, which is decomposed into the within-group coefficient G_w, between-group coefficient G_b and hypervariable density coefficient G_t on the basis of the Gini coefficient. This study will use Dagum's Gini coefficient and its decomposition in order to further analyze the differences in the degree of coordination of the coupling of cultural development of film and media and digital cultivation of talents and its sources. The formula for the overall Gini coefficient G is as follows:

$$G=\frac{\sum_{j=1}^{k}\sum_{k=1}^{k}\sum_{i=1}^{n_j}\sum_{r=1}^{n_k}|y_{ji}-y_{hr}|}{2n^2\overline{y}} \tag{8}$$

where k is the total number of regions divided into the Guangdong-Hong Kong-Macao Greater Bay Area, n is the number of all regions, j and h represent the regions divided, i and r represent each region, n_j represents the number of regions within j of the divided region, n_h represents the number of regions within h of the divided region, y_j represents the coupling coordination degree of the cities i in the divided j region, and similarly, y_{hr} It represents the coupling coordination degree of the cities r in the divided h region, and y is the average coupling coordination degree of the Guangdong-Hong Kong-Macao Greater Bay Area during the sample period. The within-group Gini coefficients G_{jj} and between-group Gini coefficients G_{jk} are calculated as follows:

$$G_{jj}=\frac{\frac{1}{2\overline{y}_j}\sum_{i=1}^{n_j}\sum_{r=1}^{n_j}|y_{ji}-y_{jr}|}{n_j^2} \tag{9}$$

$$G_{jh}=\frac{\sum_{i=1}^{n_j}\sum_{r=1}^{n_h}|y_{ji}-y_{kr}|}{n_j n_k(\overline{y}_j+\overline{y}_k)} \tag{10}$$

where $\overline{y}_j$ denotes the mean value of the coupling coordination degree in j region, and $\overline{y}_h$ denotes the mean value of the coupling coordination degree in h region. y_i, y_j denote the coupling coordination degree of municipalities i,r in the partitioned j-region, and y_{hr} denotes the coupling coordination degree of municipalities r in the partitioned h-region, respectively. n_j denotes the number of municipalities in the divided region j, and n_k denotes the number of municipalities in the divided region k.

Setting the contribution of intra-region variation G_w, the net contribution of inter-region variation G_{nb}, and the density of inter-region hypervariation G_t, there are:

$$\begin{aligned} G=&\sum_{j=1}^{k}G_{jj}p_j s_j \\ &+\sum_{j=2}^{k}\sum_{k=1}^{j-1}G_{jk}(p_j s_k+p_k s_j)D_{jk} \\ &+\sum_{j=2}^{k}\sum_{k=1}^{j-1}G_{jk}(p_j s_k+p_k s_j)(1-D_{jk}) \end{aligned} \tag{11}$$

$$G=G_{\infty}+G_{nb}+G_t \tag{12}$$

where p_j denotes the proportion of region j containing municipalities in the full sample, s_j denotes the proportion of the coupling coordination of region j divided into the full sample, s_h denotes the proportion of the coupling coordination of region h divided into the full sample, and p_h denotes the proportion of region h contains the proportion of municipalities in the full sample, and with $\sum p_i=\sum s_j=\sum_{j=1}^{k}\sum_{i=1}^{k}p_i s_k=1$, D_{jh} denotes the relative influence of the coupling coordination between regions j and h, calculated as follows:

$$D_{jk}=\frac{d_{jk}-p_{jk}}{d_{jk}+p_{jk}} \tag{13}$$

$$d_{jk}=\int_0^{\infty}dF_j(y)\int_0^{y}(y-x)dF_h(x) \tag{14}$$

$$p_{jh}=\int_0^{\infty}dF_h(y)\int_0^{y}(y-x)dF_j(x) \tag{15}$$

where d_{jh} denotes the difference in coupling coordination between regions j and h, p_{jh} denotes the hypervariable first-order moments between regions j and h, and F_j and F_h denote the cumulative density distribution function of the coupling coordination between regions j and h, respectively.

II. B. 5) Kernel density estimation

Kernel density estimation can be based on the data, using the kernel function to construct a kernel density function, and calculating the kernel density function values for each data point, and performing a weighted average of these function values to obtain an overall kernel density function estimate [22]. The kernel density estimation can be used to infer the distributional characteristics of the coupled coordination degree, given the density function $f(y)$, there are:

$$f(y)=\frac{1}{nh}\sum_{i=1}^{n}K\left(\frac{y_i-\overline{y}}{h}\right) \tag{16}$$

where n is the number of sample data, y_i denotes the number of observations in the sample, y denotes the mean of the observations, $K(\cdot)$ denotes the kernel density function, which measures the weight given to the

observations in which the coupling coordination develops, and h denotes the smoothing bandwidth of the kernel density estimate.

II. B. 6) Convergence test

The main types of convergence models are σ convergence and β convergence. σ convergence refers to the tendency of the divergence of variables between regions to decrease over time. β convergence indicates that over time, regions with lower levels of coupling coordination degree grow faster and can gradually narrow the gap with regions with higher levels of coupling coordination degree development, thus showing β convergence, β convergence can be categorized into absolute β convergence and conditional β convergence, absolute β convergence refers to the convergence of the coupling coordination degree in the absence of the consideration of the Other factors affecting the development of coupling coordination degree, the coupling coordination degree development will all converge to the same steady state. Conditional β convergence means that when considering various factors that may have an influence on the coupling coordination degree, after a long period of time, there is a convergence phenomenon in the regions with similar structure.

In this paper, we use the coefficient of variation measure σ convergence, which is calculated as follows:

$$\sigma = \frac{\sqrt{\sum_{i=1}^{n}(NPF_{ij} - \overline{NPF}_{ij})^2 / n_j}}{NPF_{ij}} \tag{17}$$

where NPF_{ij} denotes the coupling coordination of region i in region j, $\overline{NPF}_{ij}$ denotes the mean value of coupling coordination in region j, and n_j denotes the number of regions in region j.

The general panel model with absolute β convergence is set up as follows:

$$\ln(\frac{NPF_{i.t+1}}{NPF_{it}}) = \alpha + \beta \ln(NPF_{it}) + \gamma_i + \gamma_i + \varepsilon_{it} \tag{18}$$

where $NPF_{i,t+1}$ denotes the coupled coordination degree of region i in period $t+1$, NPF_i denotes the coupled coordination degree of region i in period t x, $\ln(\frac{NPF_{i,t+1}}{NPF_{it}})$ denotes the region i growth rate of coupled coordination in period $t+1$, β is the convergence coefficient, γ_i is the area fixed effect, γ_i is the time fixed effect, and ε_i is the random error term.

Spatial panel models are introduced in absolute β convergence and conditional β convergence. Spatial econometric models are generally categorized into spatial error models (SEM), spatial lag models (SAR) and spatial Durbin models (SDM). Assuming that there are n regions and the distance between i places and j places is w_i, a spatial weight matrix W is constructed:

$$W = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{n1} & w_{n2} & \cdots & w_m \end{bmatrix} \tag{19}$$

where the main diagonal elements indicate the distance to the same place, so all are 0. In this study, the economic distance matrix ω_i is chosen to take the inverse of the difference between the average annual GDP of each city from 2013-2023 to measure the economic distance relationship between the two regions. Then there are:

$$SEM: \ln(\frac{NPF_{i,t+1}}{NPF_{i,t}}) = \alpha + \beta \ln(NPF_{i,t}) + \gamma_i + \gamma_i + \mu_{i,t}, \mu_{i,t} = \lambda \sum_{j=1}^{n} \omega_k \mu_{i,t} + \delta_{i,t} \tag{20}$$

$$SAR: \ln(\frac{NPF_{i,t+1}}{NPF_{i,t}}) = \alpha + \beta \ln(NPF_{i,t}) + \rho \sum_{j=1}^{n} \omega_{i,t} \ln(\frac{NPF_{i,t+1}}{NPF_{i,t}}) + \gamma_{i,t} + \gamma_{i,t} + \varepsilon_{i,t} \tag{21}$$

$$SDM:\ln(\frac{NPF_{i,t+1}}{NPF_{i,t}})=\alpha+\beta\ln(NPF_{i,t})+\rho\sum_{j=1}^{n}\omega_{i,t}\ln(\frac{NPF_{i,t+1}}{NPF_{i,t}})$$
$$+\theta\sum_{j=1}^{n}\omega_{ij}\ln(NPF_{i,t})+\gamma_i+\gamma_i+\varepsilon_{i,t} \tag{22}$$

where ρ is the spatial autocorrelation coefficient, μ_α is the spatial autocorrelation error term, δ_α is the error term, λ is the coefficient of the spatial autocorrelation error term, ε_α is the stochastic error term, and θ is the spatial lag variable coefficient.

Conditional β convergence model is based on the absolute β convergence to add variables that may affect the degree of coupling coordination, then the conditional β convergence model specific formula is as follows:

$$\ln(\frac{NPF_{i\cdot t+1}}{NPF_{it}})=\alpha+\beta\ln(NPF_{it})+\eta X_{i\cdot t+1}+\gamma_i+\gamma_i+\varepsilon_{it} \tag{23}$$

$$SAR:\ln(\frac{NPF_{i,t+1}}{NPF_{it}})=\alpha+\beta\ln(NPF_it)$$
$$+\rho\sum_{j=1}^{n}\omega_{ij}\ln(\frac{NPF_{i,t+1}}{NPF_{it}})+\eta X_{i,t+1}+\gamma_i+\gamma_i+\varepsilon_{it} \tag{24}$$

$$SEM:\ln(\frac{NPF_{i,t+1}}{NPF_{i,t}})=\alpha+\beta\ln(NPF_{i,t})$$
$$+\eta X_{i,t+1}+\gamma_i+\gamma_i+\mu_{i,t},\mu_{i,t}=\lambda\sum_{j=1}^{n}\omega_i\mu_{i,t}\delta_{i,t} \tag{25}$$

$$SDM:\ln(\frac{NPF_{i,t+1}}{NPF_{i,t}})=\alpha+\beta\ln(NPF_{i,t})+\rho\sum_{j=1}^{n}\omega_{i,t}\ln(\frac{NPF_{i,t+1}}{NPF_{i,t}})$$
$$+\theta\sum_{j=1}^{n}\omega_{ij}\ln(NPF_{it})+\eta X_{i,t+1}+\gamma_i+\gamma_i+\varepsilon_{it} \tag{26}$$

where $X_{i.t+1}$ denotes a set of control variables that have an impact on the coupling coordination degree, and η is the parameter vector.

III. Analysis of results

III. A. Measurement of the level of coupling coordination

On the basis of using the fuzzy comprehensive judgment model to measure the level of development of film and media culture and the level of digital cultivation of media talents, this paper further adopts the coupling coordination degree model to calculate the coupling coordination degree of the two, and analyzes the trend of time series evolution during the observation period, and the results are shown in Figure 1. From the figure, it can be found that there is a certain degree of variability in the trend change of the development level of film and media culture, the level of digital cultivation of media talents and the level of coupling coordination between the two.

From the perspective of the development of film and television media culture, the level of media culture development during the observation period has shown a steady upward trend, with the average value rising from 0.108 in 2013 to 0.306 in 2023, with an average annual increase of 11%, which indicates that new film and television production and dissemination methods are gradually playing a greater role in promoting the overall level of development of film and television media culture to a new level. From the perspective of digital training of media talents, the level of digital training of film and television media talents in the study area has shown a fluctuating upward trend during the same period. Combined with the policy documents released in the relevant years, it can be seen that the digital cultivation of media talents in the Guangdong, Hong Kong and Macao Greater Bay Area can be roughly divided into four stages, namely, the initial stage of policy-driven development, the exploration stage of connotative construction, the stage of strengthening reform and system improvement, and the stage of rapid development and quality enhancement. From the perspective of the coupling coordination degree, the mean value of the development of film and media culture and the digital cultivation of talents in Guangdong, Hong Kong and Macao Greater Bay Area ranges from 0.466 to 0.501, which is on the verge of being out of order, indicating that the level of the coupling coordination degree of the two is on the low side as a whole. In terms of trend, the coupling

coordination degree shows more repetitive in the process of slowly rising, indicating that the establishment of the coupling coordination relationship between the two during the observation period is not stable and there is more uncertainty. In particular, the coupling coordination degree during 2020-2022 showed a clear downward trend, with a large fluctuation, which is likely to be caused by the impact of the epidemic, but fortunately, the coupling coordination degree was corrected in 2022-2023, and returned to the slowly rising development track. It can be seen that the foundation of the coupling and coordination relationship between the development of film and media culture and the digital cultivation of talents is still fragile and susceptible to the interference of external factors, which requires the government and relevant departments to strengthen the guidance and support, and to establish a more elastic and adaptive development mechanism, so as to better promote the in-depth integration and development of the two.

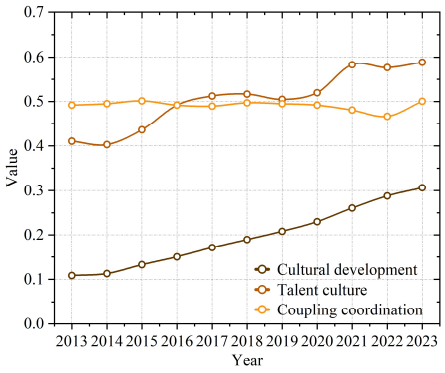

Figure 1: The sequence of succession of the system

From the regional level, the coupling coordination degree of the development of film and media culture and the digital cultivation of talents in different regions has a great deal of variability, as shown in Figure 2, in which the numbers in the outer circle denote the year, and the nine cities of Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing are denoted by GZ, SZ, ZH, FS, HZ, DG, ZS, JM, and ZQ, respectively, the same as below. According to the measurement results, the coupling harmonization degree of each place in the Guangdong-Hong Kong-Macao Greater Bay Area ranges from 0.35 to 0.70. In terms of the spatial distribution pattern, except for Shenzhen and Guangzhou, the coupling coordination degree of the remaining cities is mostly in the stages of mild dislocation and barely dislocation, generally showing the pattern of “East (Shenzhen, Huizhou, Dongguan) > Central (Guangzhou, Foshan) > West (Zhuhai, Zhongshan, Jiangmen) > Northeast (Zhaoqing)”. The average value of coupling coordination water in the eastern region in each year is generally between 0.540 and 0.616, although always ahead of other regions, when the overall has not been significantly improved. Among them, Shenzhen's coupling coordination level ranked higher, indicating that the interaction and integration between the development of film and media culture and the digital cultivation of talents in the region is relatively close, and the synergistic development trend is good. The average value of the coupling coordination degree in the central region is between 0.422 and 0.564, and the difference in the coupling coordination degree level is not big, and the overall situation is relatively balanced. Among them, the coupling coordination level of Guangzhou is relatively high, indicating that the place actively responds to the national policy, increases the investment in the development of film, media and culture, and also pays attention to the docking of professional settings and industrial demand, and promotes the benign interaction between the digital cultivation of talents and the development of film, media and culture through the strengthening of the cooperation between industry, academia and research. In addition, due to the limitations of geographic environment and industrial foundation, as well as the relative disadvantages in the concentration of resources such as capital, talents and technology, the level of coupling coordination between the western and northeastern regions is on the low side as a whole.

III. B. Regional Gaps in PRD Coupling Harmonization and Their Decomposition

In order to further explore the regional differences in the development of film, media and culture and the digital cultivation of talents in the Guangdong-Hong Kong-Macao Greater Bay Area, the overall Gini coefficient for the coupling and coordination of the development of film, media and culture and the digital cultivation of talents in the PRD in the period of 2013-2023 has been computed by applying the Dagum's Gini coefficient and its decomposition method.) (hereinafter referred to as the “Outline of the Plan”), the three major metropolitan areas of Guangzhou, Foshan and Zhaoqing (G1), Shenzhen, Dongguan and Huizhou (G2) and Zhuzhongjiang (G3) were decomposed,

and the disparity in the degree of coupled coordination of the development of film, media and culture and the digital cultivation of talents between the regions was measured.

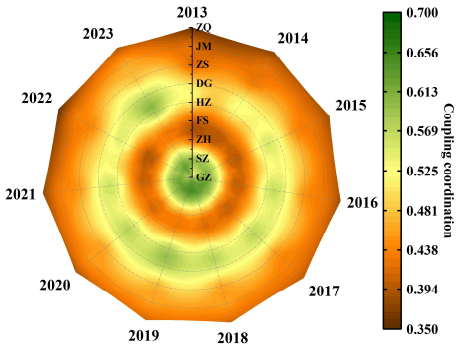

Figure 2: Trend of coupling coordination level of each region

III. B. 1) Overall differences in the degree of coordination of PRD coupling

Table 3 shows the regional gap in the coupled coordination degree of the development of film and media culture and the digital cultivation of talents in the Pearl River Delta (PRD) and its decomposition results from 2013-2023. From the overall Gini coefficient of the Pearl River Delta presented in the table, from 2013 to 2023, the overall gap in the coupling coordination degree of the development of film and media culture and the digital cultivation of talents showed a trend of gradual expansion, and the overall Gini coefficient increased from 0.251 to 0.275 during the 11-year period, with an overall growth rate of 9.56%.The change in the coupling coordination degree from 2013 to 2017 was small, and the coupling coordination degree gap gradually widened after 2018, and the year-on-year growth rate accelerated in 2021 and 2021. After 2018, the coupling coordination gap gradually widens, and the overall Gini coefficient accelerates year-on-year growth, and realizes the highest growth rate of 8.43% in 2021-2022.

Table 3: The regional gap between coupling coordination and its decomposition

Year	Total Gini	Intragroup difference			Intergroup difference		
		G1	G2	G3	G1-G2	G1-G3	G2-G3
2013	0.251	0.238	0.217	0.153	0.251	0.252	0.272
2014	0.242	0.235	0.218	0.169	0.251	0.257	0.272
2015	0.252	0.224	0.217	0.163	0.249	0.264	0.287
2016	0.255	0.201	0.219	0.141	0.239	0.255	0.294
2017	0.244	0.203	0.206	0.172	0.243	0.248	0.307
2018	0.251	0.207	0.212	0.165	0.251	0.236	0.318
2019	0.263	0.244	0.235	0.178	0.281	0.255	0.296
2020	0.271	0.245	0.233	0.184	0.276	0.258	0.292
2021	0.261	0.237	0.261	0.188	0.291	0.248	0.298
2022	0.283	0.252	0.269	0.172	0.296	0.265	0.293
2023	0.275	0.245	0.279	0.156	0.287	0.273	0.298

III. B. 2) Within-group differences in coupling harmonization among the three metropolitan areas

Combined with the data in Table 3, we visualize the changes in the intra-group differences among the three metropolitan areas from 2013 to 2023, and the specific results are shown in Figure 3.

In the Guangzhou-Foshan-Zhaoxing metropolitan area, the intra-group coupling coordination gap between the development of film, media and culture and the digital cultivation of talents fluctuates relatively little, with an overall fluctuation of no more than 0.055. During the period of examination, the intra-group gap goes through four major phases of “narrowing-stabilizing-expanding-stabilizing”. In the Shenzhen-Dongguan-Huizhou Metropolitan Area, the intra-group coupling coordination gap fluctuates the most, reaching 0.073. From the development trend, the gap in the degree of coordination of intra-group coupling generally shows a trend of narrowing and then widening, and the corresponding Gini coefficient also shows a “U”-shaped trend of change. The Zhuzhongjiang Metropolitan Area has the smallest intra-group coupling coordination gap, with an overall fluctuation of 0.047. During the period under examination, the gap in intra-group coupling and coordination has gone through four major phases of “expanding - narrowing - expanding - narrowing”.

In a horizontal comparison, the imbalance in the level of intra-group coupling harmonization in the Zhuhai-China-Jiangsu metropolitan area is much lower than that in the other two metropolitan areas, and its intra-group Gini coefficient is much lower than that of the other two groups in all years. In addition, the results of comparing the values of the beginning and the end years of the study period show that the gap between the intra-group coupling and coordination levels of the three major metropolitan areas is showing a tendency to widen, especially the inequality in the intra-group coupling and coordination levels of the Shenzhen, Dongguan and Huizhou Metropolitan Area is getting worse and worse. Therefore, in the process of building the film and media culture industry in the Guangdong, Hong Kong and Macao Greater Bay Area, it is necessary to take into account the coordinated development of film and media culture development and the digital cultivation of talents within the region.

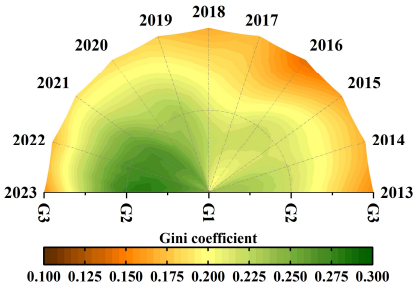

Figure 3: Differences in Gini coefficient within the three major metropolitan areas

III. B. 3) Between-group differences in coupling coordination among the three metropolitan areas

Combined with the data in Table 3, the three metropolitan areas constitute three pairs of intergroup differences in two pairs, and this paper plots the evolutionary trend of intergroup differences among the three metropolitan areas from 2013 to 2023, as shown in Figure 4.

The Guangzhou-Foshan-Zhaoxing-Shenzhen-Dongguan-Huizhou metropolitan area has the smallest intergroup difference in coupling coordination degree in the starting year, and the corresponding intergroup Gini coefficient is 0.251. From the trend of change in the 11-year period, the intergroup difference in coupling coordination degree narrows and then expands. The Guangzhou-Foshan-Zhuhai-Zhongjiang Metropolitan Area has the smallest intergroup coupling coordination gap, and the largest intergroup gap occurs in 2023, with a corresponding value of 0.273. In terms of the development trend, the intergroup coupling coordination gap shrinks and then oscillates and expands in the period from 2013 to 2023. Different from the other two pairs of metropolitan areas, the inter-group gap in the coupling coordination degree of the Shenzhen-Dongguan-Huizhou-Zhuhai-Zhongjiang metropolitan area goes through three major phases of “expanding-shrinking-stabilizing”.

In a horizontal comparison, among the three pairs of inter-group disparities, the inter-group coupling and coordination of the SZGW-Zhuhai-Zhongjiang Metropolitan Area is significantly more unbalanced than that of the other two pairs of metropolitan areas, and its inter-group Gini coefficient is higher than that of the other two pairs in all years except 2022. In addition, the inter-group coupling and coordination gap among the three major PRD metropolitan areas shows an increasing trend, especially the inequality in inter-group coupling and coordination among the Guangzhou-Foshan-Zhaoxing-Shenzhen-Dongguan-Huizhou metropolitan areas, which has increased over time. This indicates that there are still obvious interregional differences in the coupling and coordination of the development of film and media culture and the digital cultivation of talents in each metropolitan area, and that this gap has not been equalized with economic and social development.

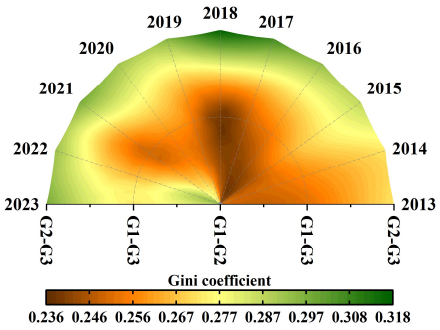

Figure 4: Differences in Gini coefficient among three major metropolitan areas

III. B. 4) Contribution of differences in coupling coordination among the three metropolitan areas

In order to further explain the reasons for the coupled coordination gap between the development of film, media and culture and the digital cultivation of talents in Guangdong, Hong Kong and Macao Greater Bay Area, this paper measures the contribution value of the intra-group gap G_w, the inter-group gap G_{nb} and the hyper-variable density G_t in the three major metropolitan areas as well as their contribution rates, and the results are shown in Table 4. The average contribution rates of the three during the examination period are 28.676%, 40.102%, and 31.221%, so the influencing factors that cause the coupling coordination gap of the three major metropolitan areas are, in order, inter-group gap, hypervariable density and intra-group gap, and inter-group inequality is the most important factor that causes the difference in the degree of coupling coordination.

Table 4: The coupling coordination area gap source decomposition

Year	Contribution value			Contribution rate/%		
	G_w	G_{nb}	G_t	G_w	G_{nb}	G_t
2013	0.073	0.096	0.081	29.200	38.400	32.400
2014	0.077	0.099	0.085	29.502	37.931	32.567
2015	0.074	0.109	0.077	28.462	41.923	29.615
2016	0.071	0.119	0.066	27.734	46.484	25.781
2017	0.073	0.131	0.059	27.757	49.810	22.433
2018	0.067	0.126	0.060	26.482	49.802	23.715
2019	0.076	0.113	0.074	28.897	42.966	28.137
2020	0.081	0.099	0.092	29.779	36.397	33.824
2021	0.079	0.094	0.105	28.417	33.813	37.770
2022	0.080	0.088	0.108	28.986	31.884	39.130
2023	0.081	0.085	0.102	30.224	31.716	38.060
Mean	0.076	0.105	0.083	28.676	40.102	31.221
Increase	0.008	-0.011	0.002	1.024	-6.684	5.660

In terms of the contribution rate of each indicator, the overall change of the contribution rate of the disparity within the three metropolitan area groups is relatively smooth, remaining at the level of 28.676% and fluctuating around the level of the contribution rate. The contribution rate of the gap between the three metropolitan area groups, on the other hand, shows an inverted U-shaped trend of rising and then falling, and remains the most important factor in the differences in the degree of coordination of the coupling of the development of film, media and culture and the digital cultivation of talents in the Pearl River Delta in this period.

III. C. Time-dynamic evolution of coupled coordination degree in the PRD

The relative intra-group differences, relative inter-group differences and source contributions of the coupled coordination degree of film, media and cultural development and digital cultivation of talents in the three major metropolitan areas of the PRD are portrayed above, while the distribution dynamics of the absolute differences in the coupled coordination degree and the evolutionary laws of ductility and polarization can be depicted with the help of the Kernel density estimation method. Similarly, in addition to depicting the PRD as a whole, this section also depicts the kernel density distribution of the coupling coordination degree by the three major metropolitan areas.

III. C. 1) Time-dynamic evolution of PRD coupling coordination degree

The kernel density distribution of the coupling coordination degree of the development of film and media culture and digital cultivation of talents in PRD cities is shown in Figure 5. From the shape of the distribution curve, the coupling coordination degree of the PRD has increased, and the absolute difference in coupling coordination degree between cities has narrowed. From the viewpoint of distribution curve extensibility, there is a gradual increase in the number of cities with high coupling coordination degree and a gradual decrease in the number of cities with low coupling coordination level within the PRD. In terms of distribution curve polarization, there is an initial polarization of coupling coordination in the PRD.

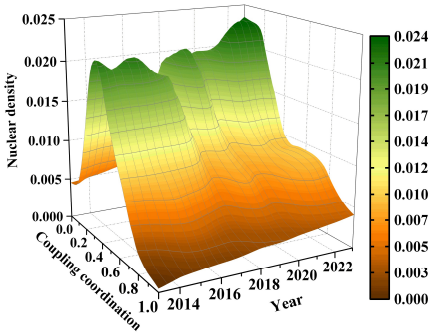

Figure 5: Kernel density distribution of coupling coordination in the Pearl River Delta

III. C. 2) Dynamic evolution of Guangzhou-Foshan-Zhaoxing coupling coordination time

The kernel density distribution curve of the coupling coordination degree of film, media and culture development and digital cultivation of talents in Guangzhou-Foshan-Zhaoxing metropolitan area is shown in Figure 6. From the distribution curve, the coupling coordination degree of the metropolitan area has slightly decreased, but the decrease is not large, and the coupling coordination degree level gap between cities has been decreasing. From the viewpoint of distribution curve extensibility, the ratio of cities with high level of coupling coordination to those with low level of coupling coordination within the circle remains unchanged in general. In terms of the polarization of the distribution curve, the phenomenon of unipolarization persists.

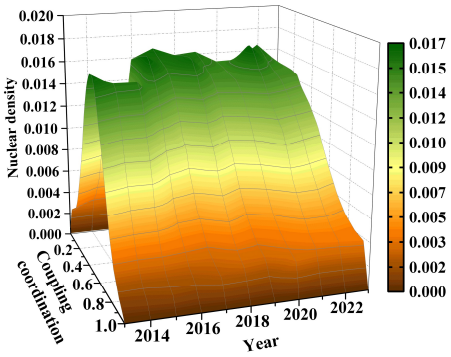

Figure 6: Kernel density distribution of coupling coordination in the G1

III. C. 3) Time-dynamic evolution of the coupling coordination degree in Shenzhen, Dongguan and Huizhou

The kernel density distribution of the coupling coordination degree of film, media and culture development and digital cultivation of talents in Shenzhen-Dongguan-Huizhou metropolitan area is shown in Figure 7. From the distribution curve, the coupling coordination degree of the metropolitan area shows a small increase, and the absolute gap of the coupling coordination degree between cities still maintains a widening trend. From the viewpoint of distribution curve extensibility, the ratio of high-level and low-level cities in the circle remains unchanged. From the polarization of the distribution curve, the coupling coordination degree of Shenzhen, Dongguan and Huizhou metropolitan area has a gradient effect, showing a polarization trend.

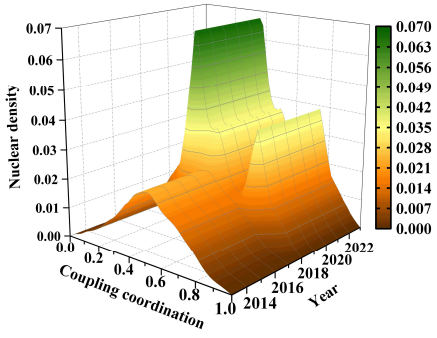

Figure 7: Kernel density distribution of coupling coordination in the G2

III. C. 4) Evolution of coupled coordination time dynamics in the Zhuhai-Zhongjiang metropolitan area

The distribution of kernel density map of coupling coordination degree of film and media culture development and digital cultivation of talents in Zhuzhongjiang metropolitan circle is shown in Figure 8. From the distribution curve shape, the metropolitan area coupling coordination degree shows a decreasing trend, expanding trend for the absolute difference in the coupling coordination degree within the circle of the change trend. From the viewpoint of distribution curve extensibility, the ratio of high level and low level cities of coupling coordination degree within the circle remains unchanged in general. From the polarization of the distribution curve, the change of the coupling coordination degree of the metropolitan area is consistent with that of the Shenzhen-Dongguan-Huizhou metropolitan area.

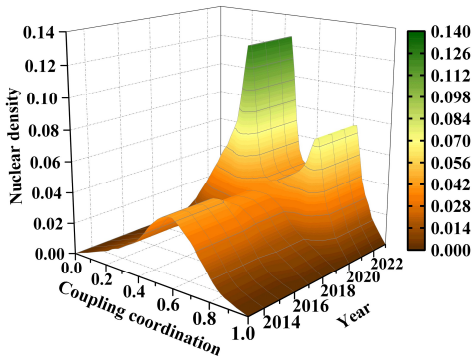

Figure 8: Kernel density distribution of coupling coordination in the G3

III. D. Convergence analysis of coupling coordination degree

III. D. 1) σ convergence

The σ convergence results are shown in Figure 9. Overall, the coefficient of variation (σ value) of the coupling coordination degree of the development of film and media culture and digital cultivation of talents in the Pearl River Delta and the three major metropolitan areas all show a fluctuating downward trend, and the σ convergence feature is obvious, indicating that the coupling coordination degree of the Pearl River Delta and the three major metropolitan areas shows a fluctuating convergence trend, and that the gap in the coupling coordination degree of the development of film and media culture and the digital cultivation of talents is narrowing. In terms of sub-regions, the order of the decrease of the coefficient of variation from the largest to the smallest is as follows: Shenzhen, Dongguan and Huizhou Metropolitan Area > Guangzhou, Foshan and Zhaozhao Metropolitan Area > Zhuhai-China-Jiangsu Metropolitan Area, which is basically the same as the intra-regional variation results derived from Dagum's Gini coefficient.

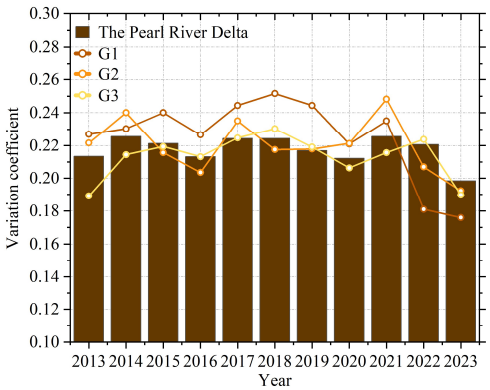

Figure 9: Coupling coordination degree σ convergence

III. D. 2) β convergence

Table 5 shows the results and speed of convergence of the coupling coordination degree β of the development of film and media culture and the digital cultivation of talents in the Pearl River Delta and the three major metropolitan areas, with ***, ** and * in the table indicating that they are significant at the 1%, 5% and 10% levels, respectively. Firstly, LM is utilized to test whether there is a spatial effect in β convergence. Second, the LR test and Wald test

are utilized to determine which spatial model to use. Again, the Hausman test was used to select either a random effects model or a fixed effects model. Finally, to determine whether to use time fixed effects, spatial fixed effects or double fixed effects (the relevant test coefficients have been omitted for lack of space).

Without considering the role of control variables, first, the convergence coefficients of the PRD and Zhuhai-China-Jiangsu metropolitan areas are negative at the 1% significance level, with coefficients of -0.583 and -0.587, respectively, indicating that there is a β convergence in the degree of coupled coordination of the PRD and Zhuhai-China-Jiangsu metropolitan areas, which is in line with the results of convergence. The coefficients of divergence of Shenzhen-Dongguan-Huizhou metropolitan area and Guangzhou-Foshan-Zhaoqing metropolitan area are 0.661 and 0.596 respectively, which are significant at 1% level, indicating that there is a tendency of divergence in the degree of coupled coordination of the two metropolitan areas. Secondly, the convergence speeds (v) of the coupling coordination degrees of the PRD and different metropolitan areas show differences, with the average convergence speeds of the PRD and the Zhuhai-China-Jiangsu metropolitan area close to each other, at 6.872% and 6.868% respectively. In terms of dispersion speed, the dispersion speed of Shenzhen-Dongguan-Huizhou Metropolitan Area is higher than that of Guangzhou-Foshan-Zhaoxing Metropolitan Area, with the dispersion speeds of the two metropolitan areas being 8.396% and 6.914%, respectively. Third, in terms of the spatial effects of coupling coordination, the PRD, Guangzhou-Foshan-Zhaoxing Metropolitan Area and Shenzhen-Dongguan-Huizhou Metropolitan Area all have different levels of spatial spillover effects, while the Zhuzhongjiang Metropolitan Area does not have any spatial spillover effects. The ρ/λ coefficients of the coupling coordination of the PRD, Guangzhou-Foshan-Zhaoxing Metropolitan Area and Shenzhen-Dongguan-Huizhou Metropolitan Area are significantly positive at the 1% level, indicating that an increase in the degree of coupling coordination in the PRD will accelerate the speed of convergence and reduce the overall differences. The improvement of the coupling coordination of Guangzhou-Foshan-Zhaoxing and Shenzhen-Dongguan-Huizhou metropolitan areas will accelerate the speed of divergence, thus expanding the difference in the coupling coordination of the development of urban film, television and media culture and the digital cultivation of talents.

Table 5: β convergence results

Region	PRD	G1	G2	G3
Model type	Double fixation SDM	Double fixation SEM	Double fixation SDM	Double fixation SDM
β	-0.583***	0.596***	0.661***	-0.587***
θ	0.108***	-0.182***	-0.138***	
ρ/λ	0.073***	0.132***	0.067***	0.031
v	6.872%	6.914%	8.396%	6.868%
Obs	9	3	3	3

IV. Conclusion

This paper focuses on the exploration of the coupling and coordination relationship between the cultural development of film and television art media and the digital cultivation of media talents. The quantitative measurement of the coupling coordination degree between cultural development and digital cultivation of talents is realized through the models of fuzzy comprehensive evaluation and coupling coordination degree, and Dagum Gini coefficient and other methods are used to explore the gap and sources of coupling coordination degree in different regions.

The results show that the coupling coordination degree between cultural development and digital cultivation of talents in the Guangdong, Hong Kong and Macao Greater Bay Area selected in this paper will increase by about 7.51% from 2013 to 2023, which is still at a low level in general. Moreover, the coupling coordination degree fluctuates significantly during the 11-year period and is susceptible to interference by external factors. In addition, the overall Gini coefficient of the Pearl River Delta (PRD) has increased by 9.56% during the 11-year period, and the intra-group gaps in the coupling degree of the three major metropolitan areas in descending order are as follows: Shenzhen, Dongguan and Huizhou Metropolitan Area > Guangzhou, Foshan and Zhaozhao Metropolitan Area > Zhuhai-China-Jiangsu Metropolitan Area, and the inter-group gaps also indicate that there are regional imbalances in the coupling degree of coordination of cultural development and the digitalization of human resources.

Through further exploration, it is found that the average contribution rates of intra-group gap, component gap and hypervariable density in the three metropolitan areas are 28.676%, 40.102% and 31.221% respectively, and that the inter-group gap is the main factor contributing to the existence of significant regional differences in the degree of coordination of the coupling of cultural development and digital cultivation of talents. From the results of

convergence analysis, the σ convergence characteristics of the Pearl River Delta (PRD) and the three major metropolitan areas are obvious, but only the overall PRD and the Pearl River Delta (PRD) and the Pearl River Delta (PRDJ) metropolitan areas have β convergence characteristics, with the convergence coefficients of -0.583 and -0.587, respectively, while there is a tendency of dispersion of the degree of coordination of coupling between the Shenzhen-Dongguan-Huizhou and the Guangzhou-Foshan-Zhaoqing metropolitan areas. Therefore, it is necessary to reduce the gap between the coupling coordination degree of the development of film and media culture and the digital cultivation of talents among the regions in parallel.

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