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Assessment of coordinated development of digital technology and cultural industries in sustainable environment: evidence from provincial level data in mainland China

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ABSTRACT

This article proposes an analytical framework for evaluating digital technology and cultural industries in a sustainable environment, employing the entropy weight method and the coordinated development model to measure the level of coordinated development of digital technology and cultural industries in each province in the Chinese mainland. The results show that most provinces in mainland China are in the early stage of coordinated development, but some problems have occurred. First, there is still a big gap between the technological innovation of digital technology and the value creation of cultural industries in each province. Second, although most provinces can adopt effective coordinated development plans based on their conditions, certain provinces are still constrained by economic considerations and are in an uncoordinated development stage. Future research will be optimised and improved by concentrating on summarising a more accurate analytical framework and analysis model or locating more pertinent data resources to define and represent each indicator.

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1. Introduction

In the 'Report of the World Commission on Environment and Development', sustainable development was regarded as 'Humanity can make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.' Currently, sustainable development has become a 'golden concept' widely employed in ecological and economic domains such as environmental protection, industrial development, and technological innovation. Some economic scientists claim that when engaged in economic activities, we

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must make responsible use of our finite resources and develop global economic connections to ensure that future economic growth is environmentally sustainable (Andrijasevic et al., 2021; Barbier, 2007; Brad et al., 2016; Harrington et al., 2004).

In China, combining digital technology and cultural industries has become a strategy to create a sustainable environment. In November 2020, the Ministry of Culture and Tourism of the People's Republic of China issued the 'Opinions on Promoting the High-quality Development of the Digital Cultural Industry'. This proposes accelerating the digitisation of the cultural industry by employing digital technology to enrich the product content and input parts of the cultural industry, or by extending the cultural industry supply chain to encourage innovative applications of digital technologies. The advancement of these opinions has accelerated the coordinated development of digital technology and cultural industries in sustainable development. In order to evaluate the coordinated development of digital technology and cultural industries and find some general problems, we selected provincial data in mainland China for calculation.

This study aims to establish a framework for evaluating digital technology and cultural industries in a sustainable environment. On the other hand, to introduce the entropy weight method and the coordinated development model to measure the coordinated development of digital technology and cultural industries using provincial data from mainland China. This article is divided into five sections: the introduction presents the current research status and research planning; the second section is a literature review; the third section is the construction of the evaluation framework, which primarily describes the composition of evaluation indicators of digital technology and cultural industries; the fourth section is the selection of models, data sources, and quantitative tools to conduct empirical research; the fifth section discusses the findings, and the final section concludes.

2. Literature review

Currently, digital technologies in a sustainable environment are discussed primarily in terms of individual and collective innovation capabilities. As digital technology becomes an important tool in daily life, it promotes personal creativity, critical thinking, and the ability to form a more productive and continuous interaction with our world (Bach et al., 2013; Sen, 1997). Moreover, digital technology significantly impacts innovation, possibly motivating enterprise technology upgrading (Monaghan et al., 2020). By enhancing the supply of enterprise technology products and industrial collaboration, digital technology actively responds to consumer demands, improves traditional technical issues, and supports sustainable production momentum and innovation cycles (Parker et al., 2016; Yoo et al., 2012). On this basis, digital technologies take technical characteristics and potential as inputs and convert them into sustainable economic outputs through customers and marketplaces (Chesbrough & Rosenbloom, 2002). Cultural industries also play an essential role in shaping a sustainable environment. First, the cultural industry connects traditional knowledge with customers through cultural industry clusters, cultural groups, and other models to fulfil cultural and commercial aims by increasing the traditional cultural connotation

of cultural products (Fan & Xue, 2018; Yang & Černevičiūtė, 2017). Secondly, from the perspective of industrial cooperation, some researchers have found that the cultural industry can improve industrial competitiveness through industrial cooperation, especially the integration with agriculture and tourism has become the major policy and industry planning of some countries (Navabakhsh & Tamiz, 2013; Su et al., 2019). The researchers conclude by discussing cultural industry policies in a sustainable environment, such as how to protect and maintain the operation and influence of green cultural organisations and industries (Duxbury et al., 2017), realise the protection of cultural landscape or heritage (Jelinčić, 2021), and promote the trade in cultural products. (Szolnoki et al., 2022). Therefore, a sustainable environment necessitates the coordinated development of digital technology and cultural industries in depth, which is crucial for advancing the digital economy and cultural industries.

Several studies have recently examined the connection between cultural industries and digital technologies. Digital technology has changed the symbols, carriers, and presentation techniques used in the cultural sector. Frontier technologies such as virtual reality (VR) and artificial intelligence (AI) have opened the door to the virtual world of the cultural industry. Cultural symbols have also changed from specific cultural objects to abstract data (Bruni, 2015; Kim et al., 2019). Digital technology has broadened the communication channels and production techniques available to the artistic sector. Some cultural items can only be produced using digital technology, freeing them from the constraints of human labour and allowing them to share cultural information with customers through digital platforms (McGinnis et al., 2020; Zhang et al., 2022).

Besides, many researchers focus on the coordinated development of digital technology and cultural industry research on the 'digital cultural industry'. Firstly, throughout the pandemic period, an abundance of study on the content of digital culture industries has arisen. For instance, the game industry, which is part of the digital culture business, has developed due to recurrent home quarantine rules that have restricted the movement of individuals across space (López-Cabarcos et al., 2020). At the same time, it also directly promotes the e-sports industry's growth, a new category of digital cultural industries (Kim et al., 2020). However, further research showed that the impact of video game consumers' positive emotions on psychological well-being would be weaker with a high level of perception of the severity of COVID-19 (Kim, 2021). The digital media industry is also integral to the digital cultural industry. Scholars believe that improving the digital media industry during the epidemic will help to enable concert halls, museums, and other landscapes to provide digital cultural services remotely (Meng et al., 2022; Vincent, 2022). Second, research has begun concentrating on developing individual digital literacy within the digital cultural industry. With the growth of the digital cultural industry, individuals have access to a greater variety of cultural reception channels, fostering the development of necessary digital cultural innovation and digital cultural analytical skills. These skills serve as digital literacy for all individuals, enabling them to interact critically and creatively in digital media and society, thereby expressing their 'artistic' voice in the digital realm (Parry et al., 2020). However, with disinformation and algorithmic culture penetration, people's digital literacy is facing a crisis of insufficient creativity

(Dezuanni, 2021). Third, the digital cultural and creative industry has become a research hotspot in the field of digital cultural industry. Its emphasis on 'creativity' is the source of industrial wealth (Snowball et al., 2021). Unlike digital cultural literacy, which focuses on individual innovation, the cultural and creative sector emphasises the issues posed by the widespread adoption of digital technology for cultural institutions (Lazzeretti et al., 2022). Nowadays, corporate managers, policymakers, and practitioners in the digital cultural and creative sectors conflict with generating and promoting creator-owned material while also testing the limits of protectionism (Yecies et al., 2020).

The current research highlights two issues. Initially, most studies introduced how digital technology and cultural industry coordinated and integrated, proposed the integration path and industrial structure, but did not systematically analyse the coordinated development of digital technology and cultural industry. Second, despite the fact that some studies have investigated and summarised the degree of digitalisation of a particular type of cultural business, the study objects are too limited for us to assess the extent of coordinated development between digital technology and the cultural industry as a whole. Thirdly, empirical research focuses on the large majority of developed nations, while the coordinated development of digital technology and cultural sectors in developing nations and their issues are frequently disregarded.

In general, we are committed to addressing the three issues above by using a developing nation as a context, utilising more macroscopic and accessible data, analysing the coordinated development of digital technology and cultural industry, and assessing the level of coordinated development of digital technology and cultural industry in this nation. The study's significance is mainly in two factors: first, the necessity for digital technology in both developing and developed nations to enhance and optimise the traditional cultural industries constrained by regional space to achieve the coordinated development of the two in the face of the epidemic. On the other hand, we strive to provide a means of measuring the degree of coordination between the growth of digital technology and the cultural sector, making it simple for path researchers to explain and validate using measurement methods.

3. Analytical framework and evaluation metrics

3.1. How to measure digital technology and cultural industries: an analytical framework

Continuing the common view of 'sustainability,' we regard 'sustainability' as a 'process that can be maintained for a long time through self-circulation'. According to this definition, we tentatively propose a 'sustainability' for digital technology and cultural industries' 'sustainable' analytical framework in Figure 1.

In economics, 'investment-production-trade-feedback' is an important process of creating value through self-circulation. Investment is used to acquire and assemble raw materials and resources. Materials and resource quality will greatly affect production efficiency and economic growth. For example, the investment in contemporary innovative technology resources will greatly promote the improvement of production efficiency and enable economic development (Vogel, 2015). The market will also

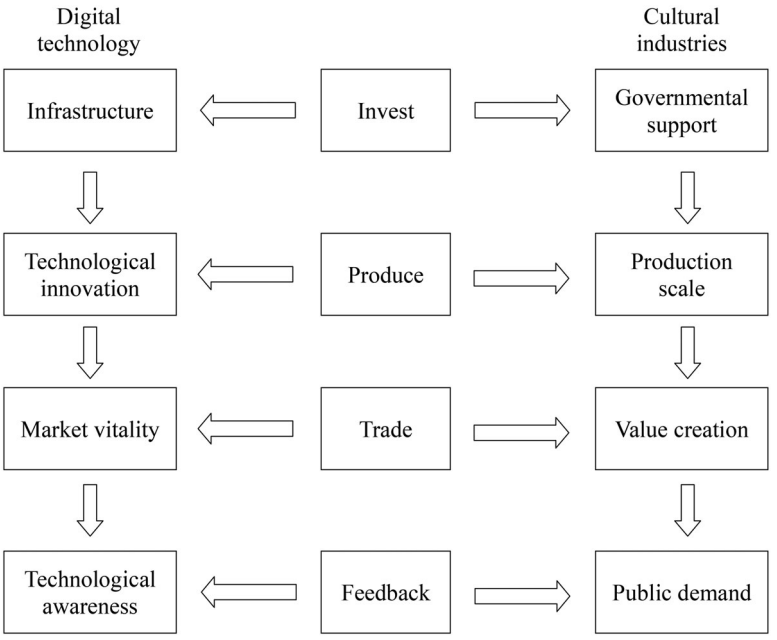

Figure 1. Framework and indicators.
Source: Authors'own make.

verify the results of production. Generally speaking, high-quality, creative and intellectual production will become widely acclaimed commodities in the market. So they will be purchased by many consumers and form a trade relationship (Ginesti et al., 2018). The majority of the results of such trade will be returned to producers, who will change input links based on market reactions, trade conditions, and client desire (Cao et al., 2012), to ensure production activities' operation and the completion of transaction behaviours. Therefore, it can be said that 'investment-production-trade-feedback' is a sustainable analytical framework in economics. Whether digital technology or cultural industry, most create value along this line and seek self-iterative upgrading.

3.2. Indicators for assessing digital technology and cultural industries

The analysis framework proposes four major digital technology evaluation indicators: infrastructure, technological innovation, market vitality, and technological awareness. First, the ability to organise and control infrastructure is a hallmark factor for measuring investment in digital technology because the connection and combination of digital technologies often require building these infrastructures (Ratner & Plotnikof, 2022). More investment is made in digital technology as infrastructure is developed and used more widely. Second, the mainstay of the development of digital technology is technological innovation. Market-based digital transformation driven by tech-forward businesses can alleviate funding restrictions and attract government subsidies (Xue et al., 2022), thereby expanding digital technology products' scale and improving production

efficiency. Third, market vitality represents the reputation that digital technology products and services gain in trade activities. Higher trade volume and frequency indicate that digital technology has attracted sufficient market audiences and a higher reputation, making the market for digital technology more dynamic by default. Third, feedback on digital technology is measured by public 'technological awareness'. The result of digital technology is the transformation of personal rationality and thinking processing ability (Gangadean, 2010). When individuals appreciate the convenience of digital technology, they are also willing to embrace the alteration of personal consciousness and capacity brought about by digital technology; consequently, the public's scientific and technological awareness grows. The public's reliance and confidence in digital technology can be reflected by the improvement of technological awareness, which serves as crucial feedback and a foundation for future digital technology growth.

According to the analysis framework, four major cultural industry evaluation indicators are proposed: government support, production scale, value creation, and public demand. Firstly, government support is the main driving force for the cultural industry in the invention process because culture has strong guidance and diversity. When the market is filled with too many cultural elements, it is difficult to have a culture that can form a pillar industry. So some government-supported projects, such as financial investment, play a role as a 'wind vane' (Kwon & Kim, 2014). Secondly, the production scale measures the production of the cultural industry. When more workers and businesses participate in the production and operation of the cultural industry, the production scale tends to increase, and the cultural industry becomes more prosperous. Thirdly, the value creation of the cultural industry can represent the trade frequency and trade volume of the cultural industry market since only those cultural industries with competitiveness, attractiveness and originality can be traded and paid for by the market (Chou et al., 2022). Fourth, the public demand of the cultural industry is a kind of feedback to the producers (Al Halbusi et al., 2020). Public demand can adjust the producers' resource input and business behaviour by reflecting the public's preference for cultural industry content such as cultural scenes and products.

In order to quantify the evaluation indicators more clearly and precisely, we have established a specific evaluation system, as shown in Table 1. In order to describe infrastructure, technological innovation, market vitality, and technological awareness with regard to digital technology, we have chosen the number of Internet access ports in each province, the number of businesses engaged in innovation cooperation in each province, the number of technology contracts (including inflows and outflows) in each province's technology market, and the number of visitors to each province's science and technology museums. In contrast, for the cultural industry, we selected the provincial general public budget culture, tourism, sports and media expenditures, the number of cultural and related industry enterprises in each province, the enterprise operating income of cultural and related industries in each province, and the number of participants in cultural and artistic activities, exhibitions, and training courses in each province to describe the government support, production scale, value creation, and public demand.

Table 1. Descriptive statistics of variables.

	Variable	Definition	Data Sources
Digital Technology	Infrastructure	the number of Internet access ports in each province	China Statistical Yearbook (2021)
	Technological innovation	the number of enterprises that have carried out innovation cooperation in each province	China Statistical Yearbook on Science and Technology (2021)
	Market vitality	the number of technology contracts (including inflows and outflows) in each province's technology market	China Statistical Yearbook on Science and Technology (2021)
	Technological awareness	the number of visitors to science and technology museums in each province	China Statistical Yearbook on Science and Technology (2021)
Cultural Industries	Governmental support	the provincial general public budget culture, tourism, sports and media expenditure	China Statistical Yearbook on Culture and Related Industries (2021)
	Production scale	the number of cultural and related industry enterprises in each province	China Statistical Yearbook on Culture and Related Industries (2021)
	Value creation	the enterprise operating income of cultural and related industries in each province	China Statistical Yearbook on Culture and Related Industries (2021)
	Public demand	the number of participants in cultural and artistic activities, exhibitions, and training courses in each province	China Statistical Yearbook on Culture and Related Industries (2021)

Source: Authors'own make.

4. Selection principles and operational process of evaluation methods

4.1. Selection principles of entropy weight method and coordinated development model

First, the objectivity of mathematical operations is one of the important reasons why the humanities and social sciences are increasingly advocating quantitative research. This scientific tradition of breaking through the appearance of things, finding their quantitative stipulations, and then seeking precision and longing for axioms is also an important scientific heritage of ancient Greece. Secondly, the entropy weight method and the coordinated development model are more inclusive. On the one hand, the entropy weight method mainly assigns weights according to the discrete degree of a data series. Therefore, as long as the data has differences in the data matrix, the entropy value calculation can be performed. On the other hand, the coordinated development model mainly emphasises the coordination and development between two related themes. Coordinated development analysis can be carried out as long as the two themes are related and have the same dimensions.

4.2. The operation process of the entropy weight method and the coordinated development model

4.2.1. Standardisation of data

Commonly used data standardisation methods include range transformation, linear scale transformation, vector normalisation, and standard sample transformation. In this article, the maximum value is mainly used for standardisation.

$$r_{ij} = b_{ij}/b_{\max} \tag{1}$$

In formula (1), r_{ij}, b_{ij}, and b_{max} represent the standard, sample, and maximum values under the j indicator.

4.2.2. The operation process of the entropy weight method

The basic principle of the entropy weight method is as such: in the index data matrix $X = \{x_{ij}\}_{n\times m}$ composed of n indicators to be evaluated and m evaluation schemes. The dispersion of the data is positively related to the amount of information provided by the data and the weight of the data.

The first step is to calculate the information entropy value of the indicator, based on the formula:

$$e_j = -K\sum_{i=1}^{m} y_{ij}\ln y_{ij} \tag{2}$$

In formula (2), e_j is the entropy value of the j-th index; K is a constant, $K > 0$;$y_{ij}$is the proportion of the standard value of the i-th evaluation object index under the j-th evaluation index (r_{ij} in formula (1)) to the sum of the evaluation object standard values of the evaluation index, based on the formula:

$$y_{ij} = r_{ij}/\sum_{i=1}^{m} r_{ij} \tag{3}$$

The second step is to calculate the weight of the indicator, based on the formula:

$$w_j = \frac{1-e_j}{n-\sum_{j=1}^{n} e_j} \tag{4}$$

And to satisfy condition 1: $0 \le w_j \le 1$ and condition 2:

$$\sum_{j=1}^{n} w_j = 1 \tag{5}$$

e_j is the entropy value of the j-th index, and w_j is the entropy weight of the j-th index.

4.2.3. The operation process of the coordinated development model

Based on the research about the coordination degree model proposed by scholar Yang, this article constructed a related model for evaluating the coordination degree of digital technology and cultural industries (Yang, 1994). Among them, x_i ($i = 1,2 \ldots 4$) is the standard value of the relevant indicators of digital technology; y_j ($j = 1,2 \ldots 4$) is the standard value of the relevant indicators of the cultural industry.Then the sum of these two levels can be expressed by the following formula:

$$g_{(x)} = \sum_{i=1}^{4} a_i x_i; g_{(y)} = \sum_{j=1}^{4} b_j y_j \tag{6}$$

In formula (6), a_i and b_j represent the weights of the selected indicators in the evaluation. a_i refers to the weight of each index in the digital technology function, and b_j refers to the weight of each index in the cultural industries function.

According to the understanding of the concept of coordination, we hope that the dispersion of g(x) and g(y) is as small as possible. Based on the formula:

$$C = \left| \frac{g_{(x)} \times g_{(y)}}{\left[(g_{(x)} + g_{(y)})/2 \right]^2} \right|^k \tag{7}$$

In formula (7), C is the coordination degree (coordination coefficient), and k is the adjustment coefficient. Based on experts' opinions, this article determines the adjustment coefficient K as 2.

In order to take into account the comprehensive level composed of digital technology and cultural industries, this article introduces a coordinated development model based on the coordination degree model:

$$D = \sqrt{C \times T} \tag{8}$$

$$T = \alpha \times g_{(x)} + \beta \times g_{(y)} \tag{9}$$

In formula (8), D represents the degree of coordinated development, and C represents the degree of coordination; in formula (9), T represents the comprehensive level index composed of digital technology and cultural industries. Substituting formula (6), formula (7) and formula (9) into formula (8), the calculation formula of the degree of coordinated development can be obtained as:

$$D = \left(\alpha \sum_{i=1}^{4} a_i x_i + \beta \sum_{j=1}^{4} b_j y_j \right)^{1/2} \times \left| \frac{\sum_{i=1}^{4} a_i x_i \times \sum_{j=1}^{4} b_j y_j}{\left[\left(\sum_{i=1}^{4} a_i x_i + \sum_{j=1}^{4} b_j y_j \right)/2 \right]^2} \right|^{k/2} \tag{10}$$

In formula (10), α and β are undetermined weights. This article assumes that digital technology and cultural industries are equally important, so take $\alpha = \beta = 0.5$.

Table 2. The result of entropy weight method.

The entropy weight of digital technology	Infrastructure	Technological innovation	Market vitality	Technological awareness
	0.14	0.37	0.34	0.15
The entropy weight of cultural industries	Governmental support	Production scale	Value creation	Public demand
	0.1	0.31	0.42	0.17

Source: Authors'own calculations.

5. Empirical results

5.1. Analysis results based on entropy weight method

5.1.1. The difference inentropy weight of each index is relatively small

The entropy weight results can reflect each province's dispersion degree under each indicator (Table 2). In general, the entropy weights of all indicators have small differences, indicating that each indicator has a relatively balanced explanatory power. Among them, the technological innovation and market vitality index of digital technology, the production scale and the value creation index of cultural industries have relatively strong discreteness. However, the highest value is not higher than 0.45, and most other indicators have entropy weights between $0.1 \sim 0.3$. Therefore, the dispersion of the indicators is the average.

5.1.2. The index of technological innovation and value creation has the strongest dispersion

The indicators of technological innovation (0.37) and value creation (0.42) have the highest weight in the digital technology and cultural industries indicator systems, respectively. This indicates that the technological innovation capabilities of various provinces in the production and application of digital technology vary significantly. In the cultural industries, the value creation of different provinces is also relatively different, which means that the explanatory power of these indicators is stronger than others.

5.1.3. Infrastructure indicators and government support indicators have the weakest dispersion

The indicators of infrastructure (0.14) and government support (0.1) have the lowest weights in the indicator system. Therefore, there are no significant differences between provinces in terms of infrastructure for digital technology and government support for cultural industries. However, the indicator of infrastructure and government support reached above 0.1, which means that these two indicators still have little explanatory power.

5.2. Analysis results based on the coordinated development model

According to the score of the coordinated development of each province, and with the help of the optimised classification method, we divided the coordinated development degree of digital technology and cultural industries in each province into the following echelons (Table 3). Overall, all provinces' coordinated development level of digital technology and cultural industries is high. Among them, the highest province

Table 3. The result of coordinated development of each province.

Degree	Score	Type	Province
Balance	∈ (0.900-1.000)	High coordinated development	
	∈ (0.800-0.899)	Well coordinated development	
	∈ (0.700-0.799)	Intermediate coordinated development	Henan, Guangxi, Qinghai, Jiangsu, Guizhou, Yunnan, Shanxi, Hainan, Chongqing, Tianjin
Transition	∈ (0.600-0.699)	Primary coordinated development	Sichuan, Fujian, Zhejiang, Xinjiang, Hebei, Hubei, Hunan, Guangdong, Anhui, Jiangxi, Shanghai, Beijing, Shandong, Inner Mongolia
	∈ (0.500-0.599)	Barely coordinated development	Ningxia, Shaanxi, Gansu, Jilin, Liaoning
	∈ (0.400-0.499)	Barely imbalance recession	Heilongjiang
	∈ (0.300-0.399)	Primary imbalance recession	Tibet
Imbalance	∈ (0.200-0.299)	Intermediate imbalance recession	
	∈ (0.200-0.199)	Severe imbalance recession	
	∈ (0.000-0.099)	High imbalance recession	

Source: Authors'own calculations.

reached 0.706 (Jiangsu, Henan, Guangxi, Qinghai), and all provinces are also in the 'transition' type, which means these provinces have the potential to enter the stage of coordinated development. The average score of the coordinated development degree of digital technology and cultural industries in each province reached 0.649, the primary coordinated development in general.

The provinces' coordinated development level is very concentrated. Many provinces belong to the intermediate and primary coordinated development (24 in total). This means there are still some problems in the coordinated development of digital technology and cultural industries in mainland China, and there is room for improvement.

Provinces with a coordinated development degree of more than 0.6 are distributed in mainland China's eastern, central and western regions. Among them, all the eastern coastal provinces have entered the stage of coordinated development. At the same time, Beijing, Shanghai, Tianjin and other municipalities have maintained the coordinated development of digital technology and cultural industries. And some inland provinces, such as Qinghai and Xinjiang, also have coordinated development. This shows that most provinces in mainland China have found suitable solutions for digital technology and cultural industries.

The non-coordinated provinces in mainland China have also entered into transition. They are located in the northeastern and western regions of mainland China. Although most of these non-coordinated provinces have also entered the stage of barely coordinated development, a small number of provinces are in the bare imbalance recession or even primary imbalance recession.

6. Discussion and conclusion

Mainland China's digital technology and cultural industries generally maintain a coordinated development trend in a sustainable environment. However, from this research findings, there are still some problems to be solved.

6.1. Discussion

6.1.1. The technological innovation of digital technology in different provinces varies greatly

Technological innovation has given birth to the prosperity of digital technology. Once the potential to develop is lost, digital technology will no longer be able to address the needs of people to enhance living conditions and work productivity. And, other people who do not know digital technology expertise would naturally dispute the usefulness and significance of digital technology and even consider that digital technology is just an idealistic mirage. Currently, the technological innovation in various provinces is quite different, which can easily lead to the emergence of the 'technology trust crisis phenomenon'.

Provinces with weak technological innovation capabilities generally have common points. First, the economic level of these provinces is in the middle and lower reaches of mainland China. Second, these provinces have long regarded the primary or secondary industry as a pillar industry and do not have sufficient experience in digital technology research and development. In addition, most provinces rely on importing mature digital technology products for industrial purposes. Third, most of the technological innovation enterprises in these provinces are not as large as others. They lack leading companies like Alibaba and Tencent, resulting in a lack of funding, willingness, and planning for innovation cooperation among these businesses.

6.1.2. The value creation of cultural industries in different provinces varies greatly

Compared with other industries, there is a wonderful relationship between the input and output involved in the cultural industry. If the rich cultural elements of the input cannot be fully processed and beautified, achieving the desired output will not be easy. The large difference in the value creation of cultural industries in mainland China is that even if some provinces have sufficient cultural resources, they cannot properly utilise and plan to increase the added value of related cultural industries. On the one hand, the production scale of cultural industries in these provinces is relatively small, and it is difficult to form a systematic cultural industry chain. These provinces still regard traditional industries such as tourism and catering as the core of the cultural industry. However, in the context of the epidemic, traditional industries in these cultural industries have been hit hard, compressing the profit space of local cultural industries.

6.1.3. The coordinated development strategies of the provinces have significant regional differences

The degree of coordinated development among provinces does not indicate that provinces with greater economic levels are better equipped to maintain coordinated

development of digital technology and cultural industries. Among the 'intermediate coordinated development' provinces with high scores, there are relatively developed provinces such as Jiangsu, Chongqing, Tianjin, and Henan, as well as relatively developing provinces such as Guangxi, Qinghai, and Yunnan. At the same time, it is not that provinces with stronger digital technologies or more developed cultural industries can ensure the coordinated development of digital technologies and cultural industries. Provinces such as Qinghai, Yunnan, Shanxi, and other provinces are inferior in digital technology capabilities to Shanghai, Zhejiang, Guangdong, and other major digital provinces. This situation shows that different provinces have planned with significant regional characteristics when planning strategies for the coordinated development of digital technology and cultural industries. For example, strong digital technology has become its core competitiveness in Jiangsu.

For this reason, digital cultural tourism has become the main development direction of its future cultural industry. In Yunnan, the multi-ethnic culture is a characteristic that distinguishes it from other provinces. Therefore, combining ethnic cultural industry and digital media is the main way Yunnan can achieve the coordinated development of digital technology and cultural industries.

6.1.4. Provinces with uncoordinated development are mostly constrained by their economic

Coordinated development provinces include economically developed provinces, as well as a large number of economically developing provinces. However, the majority of provinces with uncoordinated development are economically undeveloped, indicating that economic strength limits the coordinated expansion of digital technology and cultural industries in these regions. Returning to the original data, provinces with uncoordinated development fall significantly behind other provinces in terms of infrastructure, market vitality of digital technology, government support, and production scale of cultural industries. These have led to the inability to coordinate the development of digital technology and the cultural industries, reflecting the pessimism of local economic conditions and production levels.

6.2. Conclusion and future recommendations

This study examined the coordinated growth of digital technology and cultural business in a sustainable setting. In this investigation, we identified the following problems that need to be resolved in the future study. This article first assesses digital technology and cultural sectors independently and then measures their amount of synchronised development. It is necessary to establish comprehensive indicators and models for unified evaluation in the future. Moreover, researchers can attempt to develop and employ more mature and high-quality econometric analysis models and visualisation techniques to more precisely characterise the degree of coordinated development of digital technology and cultural sectors in different spots (Fernandez-Lores et al., 2022). Furthermore, future research will identify more suitable data resources for describing and reflecting each indication.

Disclosure statement

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References

Al Halbusi, H., Jimenez Estevez, P., Eleen, T., Ramayah, T., & Hossain Uzir, M. U. (2020). The roles of the physical environment, social servicescape, co-created value, and customer satisfaction in determining tourists'citizenship behavior: Malaysian cultural and creative industries. *Sustainability*, *12*(8), 3229. https://doi.org/10.3390/su12083229

Andrijasevic, M., Pasic Tomic, V., & Jovanovic, V. (2021). Post-COVID sustainable economic development. *ProblemyEkorozwoju*, *16*(2), 58–65. https://doi.org/10.35784/pe.2021.2.07

Bach, A., Shaffer, G., & Wolfson, T. (2013). Digital human capital: Developing a framework for understanding the economic impact of digital exclusion in low-income communities. *Journal of Information Policy*, *3*(1), 247–266. https://doi.org/10.5325/jinfopoli.3.2013.0247

Barbier, E. B. (2007). Frontiers and sustainable economic development. *Environmental and Resource Economics*, *37*(1), 271–295. https://doi.org/10.1007/s10640-007-9120-9

Brad, S., Mocan, B., Brad, E., & Fulea, M. (2016). Environmentally sustainable economic growth. *Amfiteatru Economic Journal*, *18*(42), 446–460. http://hdl.handle.net/10419/169012

Bruni, L. E. (2015). Sustainability, cognitive technologies and the digital semiosphere. *International Journal of Cultural Studies*, *18*(1), 103–117. https://doi.org/10.1177/1367877914528121

Cao, Y., Myers, L. A., & Omer, T. C. (2012). Does company reputation matter for financial reporting quality? Evidence from restatements. *Contemporary Accounting Research*, *29*(3), 956–990. https://doi.org/10.1111/j.1911-3846.2011.01137.x

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: Evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change*, *11*(3), 529–555. https://doi.org/10.1093/icc/11.3.529

Chou, S. C., Cheng, Y. H., & Martia, D. Y. (2022). Fundraising policies in cultural and creative industries: Public stock market and crowdfunding channels. *International Journal of Cultural Policy*, *28*(6), 730–754. https://doi.org/10.1080/10286632.2021.2011253

Dezuanni, M. (2021). Re-visiting the Australian Media Arts curriculum for digital media literacy education. *The Australian Educational Researcher*, *48*(5), 873–887. https://doi.org/10.1007/s13384-021-00472-6

Duxbury, N., Kangas, A., & De Beukelaer, C. (2017). Cultural policies for sustainable development: Four strategic paths. *International Journal of Cultural Policy*, *23*(2), 214–230. https://doi.org/10.1080/10286632.2017.1280789

Fan, T., & Xue, D. Q. (2018). Sustainable development of cultural industry in Shaanxi province of Northwest China: A SWOT and AHP analysis. *Sustainability*, *10*(8), 2830. https://doi.org/10.3390/su10082830

Fernandez-Lores, S., Crespo-Tejero, N., & Fernández-Hernández, R. (2022). Driving traffic to the museum: The role of the digital communication tools. *Technological Forecasting and Social Change*, *174*, 121273. https://doi.org/10.1016/j.techfore.2021.121273

Gangadean, A. (2010). Integral consciousness through the global lens: The great shift in the presiding technology of consciousness. *Futures*, *42*(10), 1049–1055. https://doi.org/10.1016/j.futures.2010.08.003

Ginesti, G., Caldarelli, A., & Zampella, A. (2018). Exploring the impact of intellectual capital on company reputation and performance. *Journal of Intellectual Capital*, *19*(5), 915–934. https://doi.org/10.1108/JIC-01-2018-0012

Harrington, D. R., Khanna, M., & Zilberman, D. (2004). Conservation capital and sustainable economic growth. *Oxford Economic Papers*, *57*(2), 336–359. https://doi.org/10.1093/oep/gpi010

Jelinčić, D. A. (2021). Indicators for cultural and creative industries'impact assessment on cultural heritage and tourism. *Sustainability*, *13*(14), 7732. https://doi.org/10.3390/su13147732

Kim, M. (2021). Does playing a video game really result in improvements in psychological well-being in the era of COVID-19? *Journal of Retailing and Consumer Services*, *61*, 102577. https://doi.org/10.1016/j.jretconser.2021.102577

Kim, S., Im, D. U., Lee, J., & Choi, H. (2019). Utility of digital technologies for the sustainability of intangible cultural heritage (ICH) in Korea. *Sustainability*, *11*(21), 6117. https://doi.org/10.3390/su11216117

Kim, Y. H., Nauright, J., & Suveatwatanakul, C. (2020). The rise of e-sports and potential for post-COVID continued growth. *Sport in Society*, *23*(11), 1861–1871. https://doi.org/10.1080/17430437.2020.1819695

Kwon, S. H., & Kim, J. (2014). The cultural industry policies of the Korean government and the Korean Wave. *International Journal of Cultural Policy*, *20*(4), 422–439. https://doi.org/10.1080/10286632.2013.829052

Lazzeretti, L., Oliva, S., Innocenti, N., & Capone, F. (2022). Rethinking culture and creativity in the digital transformation. *European Planning Studies*, 1–9. https://doi.org/10.1080/09654313.2022.2052018

López-Cabarcos, M. Á., Ribeiro-Soriano, D., & Piñeiro-Chousa, J. (2020). All that glitters is not gold. The rise of gaming in the COVID-19 pandemic. *Journal of Innovation & Knowledge*, *5*(4), 289–296. https://doi.org/10.1016/j.jik.2020.10.004

McGinnis, G., Harvey, M., & Young, T. (2020). Indigenous knowledge sharing in Northern Australia: Engaging digital technology for cultural interpretation. *Tourism Planning & Development*, *17*(1), 96–125. https://doi.org/10.1080/21568316.2019.1704855

Meng, Y., Chu, M. Y., & Chiu, D. K. (2022). The impact of COVID-19 on museums in the digital era: Practices and challenges in Hong Kong. *Library Hi Tech*. https://doi.org/10.1108/LHT-05-2022-0273

Monaghan, S., Tippmann, E., & Coviello, N. (2020). Born digitals: Thoughts on their internationalization and a research agenda. *Journal of International Business Studies*, *51*(1), 11–22. https://doi.org/10.1057/s41267-019-00290-0

Navabakhsh, M., & Tamiz, R. (2013). Influences of rural industries on sustainable social and environmental developments. *International Journal of Environmental Science and Technology*, *10*(1), 191–198. https://doi.org/10.1007/s13762-012-0109-8

Parker, G., Van Alstyne, M. W., & Jiang, X. (2016). *Platform ecosystems: How developers invert the firm*. Boston University Questrom School of Business Research Paper No. 2861574. http://dx.doi.org/10.2139/ssrn.2861574

Parry, R., Howard, F., & Penfold, L. (2020). Negotiated, contested and political: The disruptive Third Spaces of youth media production. *Learning, Media and Technology*, *45*(4), 409–421. https://doi.org/10.1080/17439884.2020.1754238

Ratner, H., & Plotnikof, M. (2022). Technology and dis/organization: Digital data infrastructures as partial connections. *Organization Studies*, *43*(7), 1049–1067. https://doi.org/10.1177/01708406211053200

Sen, A. K. (1997). Human capital and human capability. *World Development*, *25*(12), 1959–1961. https://doi.org/10.1016/S0305-750X(97)10014-6

Snowball, J., Tarentaal, D., & Sapsed, J. (2021). Innovation and diversity in the digital cultural and creative industries. *Journal of Cultural Economics*, *45*(4), 705–733. https://doi.org/10.1007/s10824-021-09420-9

Su, Z., Aaron, J. R., McDowell, W. C., & Lu, D. D. (2019). Sustainable synergies between the cultural and tourism industries: An efficiency evaluation perspective. *Sustainability*, *11*(23), 6607. https://doi.org/10.3390/su11236607

Szolnoki, G., Bail, S., Tafel, M., Feher, A., & Veith, C. (2022). A cross-cultural comparison of new implemented sustainable wine tourism strategies during the COVID-19 crisis. *Sustainability*, *14*(8), 4688. https://doi.org/10.3390/su14084688

Vincent, C. (2022). The impacts of digital initiatives on musicians during COVID-19: Examining the Melbourne Digital Concert Hall. *Cultural Trends*, 1–17. https://doi.org/10.1080/09548963.2022.2081488

Vogel, J. (2015). The two faces of R & D and human capital: Evidence from Western European regions. *Papers in Regional Science*, *94*(3), 525–551. https://doi.org/10.1111/pirs.12084

Xue, L., Zhang, Q., Zhang, X., & Li, C. (2022). Can digital transformation promote green technology innovation? *Sustainability*, *14*(12), 7497. https://doi.org/10.3390/su14127497

Yang, S. (1994). Research on the forecast and control of the coordinated development of Guangzhou's urban environment and economy. *ScientiaGeographicaSinica*, *1994*(2), 136–143 + 199. (in Chinese)

Yang, J., & Černevičiūtė, J. (2017). Cultural and Creative Industries (CCI) and sustainable development: China's cultural industries clusters. *Entrepreneurship and Sustainability Issues*, *5*(2), 231–242. https://doi.org/10.9770/jesi.2017.5.2(6)

Yecies, B., Yang, J. J., & Lu, Y. (2020). Korean webtoons and collective innovation: Expanding Europe's creative industries through competitive localization. *Innovation: The European Journal of Social Science Research*, *33*(4), 459–473. https://doi.org/10.1080/13511610.2020.1828839

Yoo, Y., Boland, R. J., Jr., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, *23*(5), 1398–1408. https://doi.org/10.1287/orsc.1120.0771

Zhang, L., Li, M., Zhang, L., Liu, X., Tang, Z., & Wang, Y. (2022). MasterSu: The sustainable development of Su embroidery based on digital technology. *Sustainability*, *14*(12), 7094. https://doi.org/10.3390/su14127094