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Research on the Integration and Development of Technology Innovation, Cultural Creativity and Manufacturing Industry

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ABSTRACT: *This paper constructs the vector autoregressive (VAR) model by quantitative analysis method and studies interactive integration of technology innovation, culture creativity and manufacturing industry. The results show that: There is a two-way influence relationship between technology innovation, culture creativity and manufacturing industry transformation and upgrading. The integration between culture innovation and manufacturing industry is more frequent, while the integration between technology innovation and manufacturing industry is still to be developed. Technology innovation and cultural creativity promote each other, the interaction of which can promote the transformation and upgrading of the manufacturing industry. Finally, the policy suggestions are put forward.*

KEY WORD: *Technology Innovation; Culture Creativity; Advanced Manufacturing; Transformation and Upgrading; Data Analysis*

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I. INTRODUCTION

At present, the trend of global economic integration is obvious. And the development of science and technology is growing rapidly. On the one hand, with the improvement of quality of people's life and the education, products with scientific and cultural connotations and new lifestyles are becoming more and more popular. And the spiritual need of consumers is increasing. The role of the manufacturing industry as a support for technological innovation and the development of the cultural industry is constantly emerging. And it is facing the challenge of transformation and upgrading [1]. On the other hand, the transformation of China's economic development model impels manufacturing industry to introduce new manufacturing technologies, reduce resource consumption, and shift to low-carbon manufacturing [2]. The integration of technology innovation and manufacturing industry produce internal upgrading effects for enterprises to promote the diversified development of manufacturing industry [3]. The development of science and technology has a restrictive effect on the demand structure. Major breakthroughs in technology will stimulate the demand of consumers, change the structure of demand, and promote the transformation of manufacturing industry. At the same time, technology innovation has a significant impact on the innovation capability of the manufacturing process. It optimizes the work process, improve the technical level of manufacturing equipment, shorten the production cycle [4], increase the productivity of manufacturing industry [5], and promote the transformation of manufacturing industry to produce products with high technology and added value [6-7]. Besides, the integration of cultural creativity and manufacturing industry can reduce energy consumption and pollution, which not only meets the development concept of low-carbon manufacturing industry, but also meets the high-level spiritual needs of consumers [8]. The integration and penetration of cultural creativity elements and manufacturing industry can promote manufacturing industry to update equipment, optimize manufacturing process, enhance the cultural value and connotation of products, promote product innovation, and enhance brand awareness, thus leading the transformation and upgrading of manufacturing industry [9].In addition, cultural creativity can promote scientific and technological progress through knowledge innovation, thus promoting industrial transformation [10]. Interactive integration of cultural creativity with science and technology will not only promote technology innovation, but also change the structure of consumer demand, affect the product life cycle, and improve the economic efficiency of the manufacturing industry. Therefore, the integrated development of technology innovation, cultural creativity and manufacturing industry is crucial to the transformation and upgrading of manufacturing industry. As a global science and technology innovation center, Shanghai has the foundation for developing high-end manufacturing and high-tech manufacturing. And under the trend of integration of informatization and industrialization in China, the development of Shanghai's manufacturing industry is facing technological changes and industrial transformation. Therefore, this paper studies the interaction and fusion of technology innovation, cultural creativity and manufacturing industry thoroughly by the VAR model taking Shanghai manufacturing industry as a research sample, and then puts forward specific suggestions.

II. STUDY DESIGN

2.1 Model Design

This paper selects the vector autoregressive model and the corresponding index variables to investigate the interaction between technology innovation, cultural creativity and manufacturing transformation and upgrading so as to infer the integration of technology innovation, cultural creativity and manufacturing industry, and identify the core direction of the integration of technology innovation. cultural creativity and manufacturing industry.

Interaction test model： This paper constructs vector autoregressive model (VAR model) and impulse response model, observes the current and future trends of other variables after applying a shock through a certain variable, this paper, and studies the dynamic connection between technology innovation, cultural creativity and manufacturing transformation and upgrading. Its expression is as follows:

$$\mathrm{Y}_t = A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + \varepsilon_t \qquad t = 1, 2, \cdots, T$$

$$Y_t = \left(I - A_1 L - \cdots - A_p L^p \right)^{-1} \varepsilon_t \qquad t = 1, 2, \cdots, \mathrm{T}$$

Where, Y_t is the vector of variables. p is the lag order. T is the sample size. $A_1, \cdots, A_p$ is the coefficient matrix. ε_t is the perturbation vector. L is the lag operator.

Impact test model： This paper constructs a variance decomposition model to explore the degree of interaction between technology innovation, cultural creativity and manufacturing transformation and upgrading. The expression is as follows:

The prediction error of the previous s period is:

$$C_0\varepsilon_1 + C_1\varepsilon_{\mathrm{t}-1} + C_2\varepsilon_{\mathrm{t}-2} + \cdots + C_{\mathrm{s}-1}\varepsilon_{\mathrm{t}-s+1}$$

The relative variance contribution rate (RVC) is：

$$RVC_{j \to i}(s) = \frac{\sum_{q=0}^{s-1} (c_{ij}^{(q)})^2 \sigma_{ij}}{\sum_{j=1}^{k} \left\{ \sum_{q=0}^{s-1} (c_{ij}^{(q)})^2 \sigma_{ij} \right\}}, \quad i, j = 1, 2, \cdots, k$$

According to the formula , we can get relative contribution of the variance of the j-th variable to the variance of Y_i based on shock, thus studying the influence degree of the j-th variable to the i-th variable.

2.2 Construction of Index System

2.2.1 Construction of the evaluation index system for technology innovation

This paper synthesizes the research of several scholars [11-15], and selects five indicators such as the internal expenditure of R&D funds, the full-time equivalent of R&D personnel, the ratio of R&D expenditure to GDP, the number of patent applications, and the number of patent grants.

2.2.2 Construction of the evaluation index system for cultural creative

Cultural creativity highlights the creative elements of cultural products. And the embedding of creative elements in traditional culture has a positive impact on the sustainable development and innovation of culture. The cultural creativity industry, as an industry with cultural creativity as its main production factor, will improve labor productivity through its integration with manufacturing industry, thus promoting the transformation and upgrading of manufacturing industry. Therefore, this paper constructs an evaluation index system that includes the number of Internet users, Internet penetration rate, total telecommunications business, per capita disposable income, and total output value of cultural and creative industry. Among them, the cultural creativity industry draws on the statistical caliber proposed by Cao Yuxia and GengHaoyi (2017 [16]).

2.2.3 Construction of the evaluation index system for transformation and upgrade of manufacturing industry

This paper synthesizes the research of many scholars [16-20], and innovatively incorporates cultural manufacturing industry into the index system, and builds an index system from two aspects of transformation and upgrading. The transformation includes two dimensions of structural optimization and green development. The upgrading includes quality and efficiency dimensions. Based on the three dimensions of structural optimization, quality and efficiency, and green development, an evaluation system for manufacturing industry

transformation and upgrading is established. The definition of the cultural manufacturing industry draws on the research results of Cao Yuxia and GengHaoyi (2017). The specific variables and index are selected in Table 1.

Table 1 the selection of variables and indicators

Variables	Index	Index description	Index direction
Technology Innovation（TEC）	The internal expenditure of R&D funds	Internal expenditure of R&D funds / main business income	Forward
	The ratio of R&D expenditure	Proportion of R & D expenditure to GDP	Forward
	the full-time equivalent of R&D personnel	Sum up after conversion of full-time and part-time R & D personnel	Forward
	Number of patent applications	Number of annual patent applications in the region	Forward
	Number of patent grants	Number of annual patent authorizations in the region	Forward
Cultural Creative（CUL）	Number of Internet users		Forward
	Internet penetration rate		Forward
	Total telecommunications business		Forward
	Per capita disposable income		Forward
	The total output value of cultural and creative industry		Forward
manufacturing transformation and upgrade（TRA）	Proportion of capital-intensive industries	Total output value of capital intensive industry / total output	Forward
	Proportion of technology-intensive industries	Total output value of technology intensive industry / total output	Forward
	Proportion of cultural manufacturing industry	Total output value of cultural manufacturing industry / total	Forward
	Quality competitiveness index	Reflect the level and status of quality competitiveness	Forward
	Total labor productivity	Total output value of manufacturing industry / number of manufacturing	Forward
	Energy consumption per unit output value	Total industrial energy consumption / total industrial output value	Reverse
	Power consumption per unit output value	Total industrial power consumption / total industrial output value	Reverse
	Exhaust emission per unit output value	Total industrial waste gas emission / total industrial output value	Reverse
	Wastewater discharge per unit output value	Total industrial wastewater discharge / total industrial output	Reverse

III. EMPIRICAL RESEARCH

3.1 Data Sources

All data in this paper come from China Statistical Yearbook, China Energy Statistical Yearbook, China Environmental Statistical Yearbook, China Internet Development Statistical Bulletin, China Manufacturing Industry Quality Competitiveness Index Bulletin, Shanghai Statistical Yearbook. In this paper, the entropy weight method is used to process the initial data, transforming multiple indicators into a representative comprehensive indicator, and the processed data is shown in Table 2.

Table 2Index data of TEC, CUL, and TRA

Year	TEC	CUL	TRA
2003	7978	3625	86
2004	6342	4090	97
2005	9209	4607	105
2006	10714	5212	120
2007	14599	5973	134
2008	15729	6749	144
2009	19805	7232	141
2010	24388	7987	173

2011	26157	9015	205
2012	27410	9945	201
2013	27590	10445	214
2014	27035	11368	227
2015	32827	12079	233
2016	37577	12935	244
2017	41760	14587	278

3.2 Empirical Analysis

3.2.1 Variable correlation analysis

This paper analyzes the Pearson correlation coefficient of the main indicators by SPSS 19.0, and initially explores the relationship between technology innovation, cultural creativity and transformation and upgrading of manufacturing industry. The data shows that there is a high positive correlation among the three, the correlation coefficients of which are all above 0.95.

Table 3 The correlation coefficients of TEC, CUL, and TRA

		TEC	CUL	TRA
TEC	Pearson Correlation	1	.985**	.980**
	Significance (bilateral)		.000	.000
	N	15	15	15
CUL	Pearson Correlation	.985**	1	.992**
	Significance (bilateral)	.000		.000
	N	15	15	15
TRA	Pearson Correlation	.980**	.992**	1
	Significance (bilateral)	.000	.000	
	N	15	15	15

**. indicates significant correlation at. 01 level (bilateral)。

3.2.2 Model validity test

VAR model requires that the time series must be stable. So it is necessary to test the stability of the series before VAR Modeling. Otherwise it may lead to the problem of "pseudo regression". This paper judges the stability of each time series using the ADF (augmented Dickey fuller test) unit root test method, and the results are shown in Table 4.In order to eliminate the possible Heteroscedasticity in the original data, the natural logarithm is taken for the three groups of data: TEC, CUL and TRA. It is recorded as LNTEC, LNCUL and LNTRA respectively, and the unit root test results are shown in Table 4. The first-order difference sequence of variables is stationary. Therefore, follow-up analysis and inspection are carried out.

Table 4Test results of variable stationarity

Variable	Test Type（C,T,L）	ADF	Critical Value（5%）	Result
DLNTEC	(c,0,0)	-5.697388	-3.119910	Stable
DLNCUL	(c,t,4)	-4.560678	-4.107833	Stable
DLNTRA	(c,t,1)	-4.317619	-3.875302	Stable

This VAR model has three variables and the lag order is one, so there will be three characteristic roots (Table 5). Moreover, the reciprocal modulus of all feature roots is less than one (Table 6).So that the VAR model constructed in this paper is stable and can be analyzed later.

Table 5 Determination of the best lag order of VAR model

Lag Order	AIC Value	SC Value	HQ Value
0	-8.631580	-8.510353	-8.676462
1	-9.102046*	-8.617139*	-9.281575*
2	-8.276247	-7.427660	-8.590424

Table 6AR characteristic root of VAR model

Root	Modulus
-0.185536 - 0.386528i	0.428751
-0.185536 + 0.386528i	0.428751
0.264687	0.264687

This paper tests the cointegration relationship between variables using E-G two-step method (Table 7). The original hypothesis is rejected, and the residual is a stable sequence. So that there is a cointegration relationship between variables. That is, there is a long-term equilibrium relationship between variables.

Table 7Test results of stationarity of residual sequence

t Value	1% Critical Value	5% Critical Value	10% Critical Value	P Value
-4.630562	-4.582648	-3.320969	-2.801384	0.0095

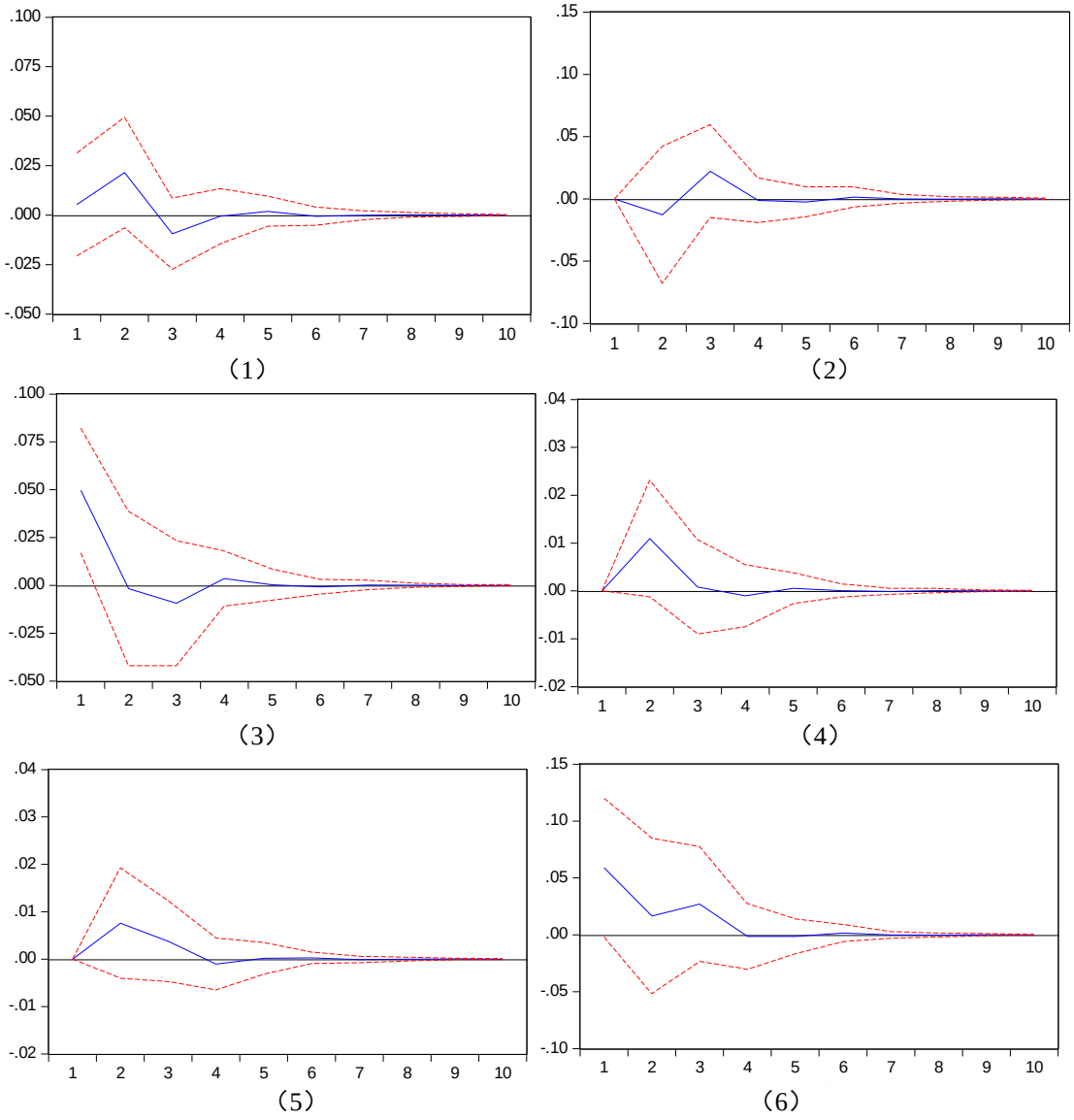
3.2.3 Test on the interaction between technology innovation, cultural creativity and transformation and upgrading of manufacturing industry

One of the important applications of vector autoregressive model is impulse response function analysis. This paper analyzes the influence on other variables when one variable in the model changes using the impulse response function method. When one variable in the model is impacted, the change of the other variables will reflect the affected path of each variable comprehensively. The results are shown in Table 8 and figure 1.

Table 8Impulse response function value

	Response of DLNCUL		Response of DLNTEC:		Response of DLNTRA:	
Period	DLNTEC	DLNTRA	DLNCUL	DLNTRA	DLNCUL	DLNTEC
1	0.000000	0.000000	0.059058	0.000000	0.049677	0.005376
	(0.00000)	(0.00000)	(0.03045)	(0.00000)	(0.01630)	(0.01302)
2	0.007593	0.010939	0.016597	-0.012762	-0.001680	0.021556
	(0.00585)	(0.00609)	(0.03418)	(0.02752)	(0.02017)	(0.01407)
3	0.003764	0.000831	0.027019	0.022252	-0.009360	-0.009404
	(0.00428)	(0.00493)	(0.02523)	(0.01866)	(0.01632)	(0.00903)
4	-0.001049	-0.001030	-0.001397	-0.001234	0.003539	-0.000610
	(0.00274)	(0.00323)	(0.01448)	(0.00899)	(0.00720)	(0.00700)
5	0.000154	0.000568	-0.001376	-0.002408	0.000354	0.001921
	(0.00167)	(0.00161)	(0.00763)	(0.00605)	(0.00406)	(0.00381)
6	0.000257	6.96E-05	0.001577	0.001440	-0.000797	-0.000606
	(0.00061)	(0.00069)	(0.00379)	(0.00401)	(0.00194)	(0.00230)
7	-9.12E-05	-0.000106	-0.000115	-3.43E-06	0.000225	-0.000132
	(0.00034)	(0.00033)	(0.00147)	(0.00172)	(0.00125)	(0.00111)
8	-5.08E-06	3.27E-05	-0.000191	-0.000241	6.23E-05	0.000159
	(0.00019)	(0.00022)	(0.00084)	(0.00089)	(0.00054)	(0.00058)
9	2.09E-05	9.10E-06	0.000106	9.55E-05	-6.46E-05	-3.48E-05
	(8.3E-05)	(8.6E-05)	(0.00049)	(0.00054)	(0.00027)	(0.00032)
10	-6.18E-06	-8.94E-06	-3.01E-07	1.06E-05	1.23E-05	-1.65E-05
	(4.6E-05)	(4.2E-05)	(0.00020)	(0.00022)	(0.00015)	(0.00013)

Figure 1 Interactive impulse response function curve



Among them, the horizontal axis represents the number of lag periods of the impact; the vertical axis represents the change of the variable growth rate; the solid line represents the impulse response function; the dashed line represents the deviation band of plus or minus two standard deviations.

Figure 1-(1) shows the impact of technology innovation on the transformation and upgrading of the manufacturing industry. Giving a percentage point to technology innovation will have a positive impact on the transformation and upgrading of the manufacturing industry. The degree of influence reaches the maximum in the second period, then there is a negative fluctuation, and finally tends to be stable. Figure 1-(2) shows the impact of transformation and upgrading of manufacturing industry on technology innovation. Giving a percentage point to transformation and upgrading of the manufacturing industry will have a positive impact on technology innovation, followed by positive and negative fluctuations, with complex and uncertain response.

Figure 1-(3) shows the impact of cultural creativity on the transformation and upgrading of the manufacturing industry. Giving a percentage point to cultural creativity will have a positive impact on transformation and upgrading of the manufacturing industry. In the first period, it increased to 0.0496, and then the growth rate decreased. It fluctuated in the negative direction and started to stabilize after the fifth period. Figure 1-(4) shows the impact of transformation and upgrading of manufacturing industry on cultural creativity. Giving a percentage point to transformation and upgrading of the manufacturing industry will have a positive impact on cultural creativity. The value of the first period is zero and the second period reaches a maximum of 0.01. Since then, it has continued to decline to zero, and has been showing a positive response.

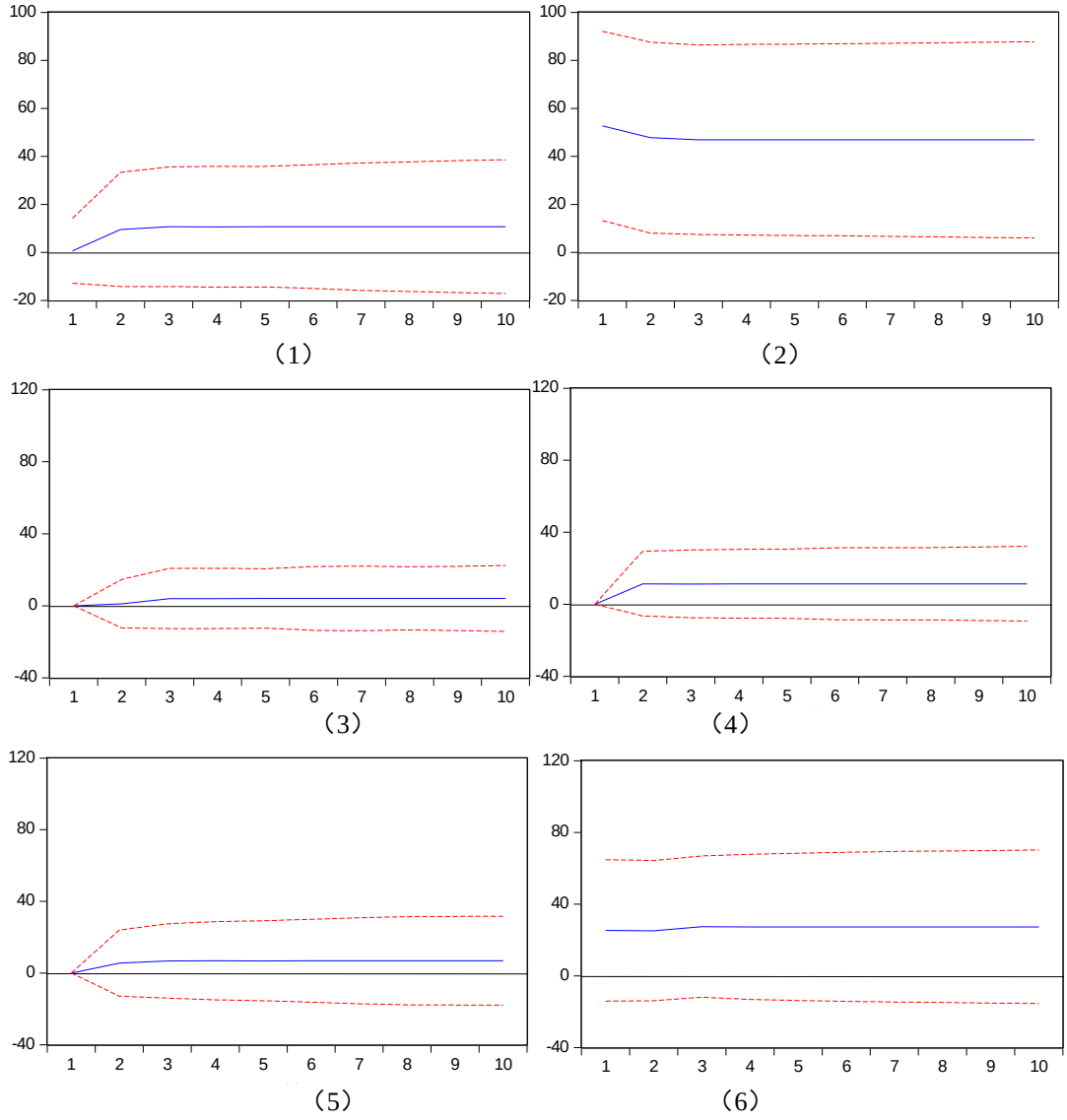
Figure 1-(5) shows the impact of technology innovation on cultural creativity. Giving a percentage point to technology innovation will have a positive impact on cultural creativity. The value of the first period is zero,

then it increases. It reaches the maximum in the second period, then decrease continually, and started to reach zero in the fourth period. Figure 1-(6) shows the impact of cultural creativity on technology innovation. Giving a percentage point to cultural creativity will have a positive impact on technology innovation. There is the largest impact during the first period, and then it continues to decline, and reaches zero in the fifth period.

3.2.4 Examination of the impact of technology innovation, cultural creativity and transformation and upgrading of manufacturing industry

The previous test shows that the VAR model is stable and suitable for variance decomposition. Therefore, this paper uses Eviews 8.0 software to perform 10-stage variance decomposition on a VAR model containing three variables: DLNCUL, DLNTEC, and DLNTRA. The results are shown in Figure 2.

Figure 2Variance decomposition curve of interactive influence of TEC, CUL, TRA



Where, the horizontal axis represents the number of lag periods, and the vertical axis represents the contribution rate of the variable to the target variable.

Figure 2-(1) shows the variance contribution rate of technology innovation to the transformation and upgrading of manufacturing industry, which roses from 0.08% in the initial period to 8.74% in the third period, and then remains at about 8.7%. Figure 2-(2) shows the variance contribution rate of cultural creativity to the transformation and upgrading of manufacturing industry, which drop from 54.74% in the initial period to 50.39% in the second period, and basically stabilizes at about 50% after the third period.

Figure 2-(3) shows the variance contribution rate of transformation and upgrading of manufacturing industry to technology innovation, which roses from a value of 0 in the initial period to 4.13% in the third period,

and then remains basically at 4.13%. Figure 2-(4) shows the variance contribution rate of transformation and upgrading of manufacturing industry to cultural creativity, which roses from a value of 0 in the initial period to 10.65% in the second period, and then basically fluctuates around 10.6%.

Figure 2-(5) shows the variance contribution rate of technology innovation to cultural creativity, which roses from a value of 0 in the initial period to 5.28% in the third period, and then basically stabilizes at 5.28%. Figure 2-(6) shows the variance contribution rate of cultural creativity to technology innovation, which increases from 31.62% in the initial period to 38.06% in the third period, and then remains basically around 38.03%.

3.3 Results Analysis

As shown in Figure 1-(1) and Figure 1-(3), technology innovation and cultural creativity have a significant role in promoting the transformation and upgrading of the manufacturing industry. Among them, cultural creativity will have a positive impact in the current period, and technology innovation will have the greatest promotion effect in the second period. This may because the transformation of technology innovation results takes time, so there is a lag in promoting the transformation and upgrading of manufacturing industry. And as shown in Figures 2-(1) and (2), cultural creativity has a greater impact on the transformation and upgrading of manufacturing industry, while technology innovation has a relatively small impact on the transformation and upgrading of manufacturing industry. This shows that the current degree of integration of cultural creativity and manufacturing industry is relatively high, and the integration of technology innovation needs to be further developed.

As shown in Figure 1-(2) and Figure 1-(4), the transformation and upgrading of the manufacturing industry also has a significant role in promoting technology innovation and cultural creativity. Among them, the transformation and upgrading of the manufacturing industry has a direct and effective role in promoting the innovation and development of culture. This may be due to the diversified forms of manufacturing industry and cultural creativity, which are directly effective and have a significant impact on the results. The impact of the transformation and upgrading of the manufacturing industry on technology innovation is uncertain. And as shown in Figures 2-(3) and (4), the transformation and upgrading of the manufacturing industry has a relatively large impact on cultural creativity and a relatively small impact on technology innovation. This shows that compared with technology innovation, the degree of integration of manufacturing industry and cultural creativity is higher.

As shown in Figures 1-(5) and (6), technology innovation and cultural creativity interact and promote each other. The synergy and fusion of technology innovation and cultural creativity not only enhances the experience of cultural products, promotes the spread of culture, but also provides a physical basis for the widespread application of technology innovation. Cultural creativity cultivates a creative cultural ecology for technology innovation, and stimulates the vitality and thinking of people. In addition, as shown in Figures 2-(5) and (6), cultural creativity has a greater impact on technology innovation, while technology innovation has a smaller impact on cultural creativity. It shows that at present, technology innovation and cultural creativity have not reached the level of coordinated development, and the degree of integration needs to be further improved.

IV. CONCLUSIONS AND RECOMMENDATIONS

This paper uses Shanghai's data as a sample to study the two-way interaction between technology innovation, cultural creativity and the transformation and upgrading of manufacturing industry. The results show that: there is a significant two-way influence relationship between technology innovation, cultural creativity and the transformation and upgrading of manufacturing industry. The degree of integration of cultural creativity and the manufacturing industry is good. The degree of interaction between technology innovation, cultural creativity and the transformation and upgrading of the manufacturing industry is different, indicating that there are still some restrictions or problems in the process of interactive integration, and the integration of technology innovation and manufacturing industry needs to be carried out optimized for more reasonable and coordinated development. In addition, there is a significant mutual promotion between cultural creativity and technology innovation. The coordinated development of the two will promote its interaction with the manufacturing industry and promote the transformation and upgrading of the manufacturing industry.

According to the results of the above analysis, in order to promote the rapid transformation and upgrading of China's manufacturing industry, this article proposes the following suggestions. While carrying out technology innovation, enrich the channels for the transformation of scientific and technological achievements, optimize the institutional environment for the transformation of scientific and technological achievements, improve the ability to transform achievements, and accelerate the transformation of scientific and technological achievements, lift the restrictions and problems in the integration process, and promote the interactive integration of technology innovation and manufacturing industry. At the same time, based on the actual situation, the integration of technology innovation and manufacturing industry needs to be optimized to promote the integration of the two entire industrial chains, including the consumer, production, and supply sides, thus

improving the efficiency of various production links in the manufacturing industry. In addition, pay attention to the coordinated development of cultural creativity and technology innovation, promote the integration of technology, cultural creativity and manufacturing industry, and promote the transformation and upgrading of manufacturing industry. The innovation and synergy of culture and technology and its integration and development with manufacturing industry, not only enrich the cultural value and connotation of the product, but also increase the consumer's product experience, which can better extend the product life cycle, thus promoting economic growth in the manufacturing industry and internal cultural prosperity, and promoting the transformation of manufacturing industry to high-tech cultural manufacturing industry with personalized manufacturing models and flexible production processes.

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