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Research Article
Numerical Analysis of the Impact of Science and Technology Investment on Regional Economic Growth in the Typical Agricultural Metropolis, Bozhou City, Anhui Province, China

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Abstract
The Error Correction Model (ECM) modeling and a series of econometric tests were used to compute and estimate the impact and contribution of local science and technology investment on regional economic growth in Bozhou, China. Numerical analysis found that the correlation between regional economic growth, local science and technology investments was significant both in short-term fluctuation and long-run equilibrium in Bozhou. The overall empirical result revealed that the impact or contribution of science and technology investment on regional economic growth was positive and it proved to be true that the variable lnSTINV_BZ (Science and Technology Investment in Bozhou) did Granger caused the variable lnGDP_BZ (Gross Domestic Product in Bozhou) in the ECM modeling. It was estimated that the elasticity coefficients of the contribution of local science and technology investment on regional economic growth were -0.175065 in the long terms and 0.421282 in the short terms. Then, the Q statistic was computed as 1.069091 in Bozhou. It was inferred that the regional growth of GDP in Bozhou was promoted by local science and technology investment at the estimated rates of 0.421282 (42.1282%) in the short terms and corrected or adjusted by 0.175065 (17.5065%) in the long terms, when the science and technology investment was increased by 1% accordingly. Furthermore, it was also found the promoting efficiency of local science and technology investment on the regional GDP in Bozhou was high according to the Q statistic.

Key words: Impact, science and technology investment, economic growth, error correction model, gross domestic product

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Recent years see the rapid economic growth of different districts or regions in China (Xu, 2010; Tan, 2010; Fu and Gong, 2011; Fu *et al*., 2011; Aixiang, 2011; Hu *et al*., 2014; Yu and Ju, 2011; Zhong *et al*., 2011; Yu, 2012; Qiao and Zhu, 2012; Mao *et al*., 2013; Li and Wang, 2013; Chen *et al*., 2013; Yuan, 2013; Liu *et al*., 2014). However, the whole country of China is generally economically undeveloped, especially cities and counties in the midland districts with overall less developed industries and large agricultural populations, such as Fuyang, Bozhou and Suzhou in the Northern region of Anhui. These are typical agricultural districts of undeveloped and developing provinces in Central China. In particular, a series of supportive documents with 10 preferential policies in the governmental files had been issued by the provincial government to promote the economic development of three particular cities (i.e., Fuyang, Bozhou and Suzhou) and seven specific counties in Northern Anhui (i.e., Fengyang, Shouxian, Huoqiu, Huaiyuan, Wuhe, Guzhen and Suixi) and other counties during 2008-2014 (PGAP., 2008, 2010, 2014). Therefore, the local science and technology investment and its impact on the economic development of regional society and community are hot topics concerned by the people and the government and the utmost targeted achievements of the provincial government are to obtain the rapid development, expansion and leapfrog of the economic status and the transformation of science and technology in the Northern districts of Anhui among those special documents and policies (PGAP., 2008, 2010, 2014).

It is well known that science and technology is one of the most important influential factors and crucial linkers in the social production chain. It is agreed that the advanced science and technology will bring positive economic growth and the development of science and technology requires investment in science and technology. On the other hand, Anhui is one of the typical central agricultural districts in China and its regional investment of science and technology is a representative of Chinese agricultural areas. Therefore, research on this topic is particularly important for the government and its sectors to develop and make relevant regulatory policies and economic rules and regulations and/or in Central China. In general, investment, consumption and trade export are often referred as the three essential factors to drive economic developments in the high-speed development of modern economy. It is widely recognized that the differences in regional productivity are mainly accelerated or driven by the scientific and technological changes. Therefore, science and technology innovation is a crucial essential element of industrialization and informatization in China and other developing countries (Fan *et al*., 2004; Zhu, 2004; Meng *et al*., 2004; Su *et al*., 2006; Fu and Yang, 2009; Fortune-Devlaminckx and Haunschmied, 2010; Fu and Gong, 2011; Fu *et al*., 2011; Zhang, 2013; Liu *et al*., 2014). At present, although there was a substantial concern on the impact of Chinese domestic investment on the developments of local regions and/or firms, most of the articles focused on Foreign Direct Investment (FDI) and there is only a few reports exploring the impact and/or policy development of science and technology investment in the undeveloped countries or areas (Liu and Buck, 2007; Li, 2009; Yang *et al*., 2009; Xu, 2010; Tan, 2010; Fu and Gong, 2011; Fu *et al*., 2011; Aixiang, 2011; Hu *et al*., 2014; Yu and Ju, 2011; Zhong *et al*., 2011; Yu, 2012; Mao *et al*., 2013; Li and Wang, 2013; Zhang, 2013; Yuan, 2013; Liu *et al*., 2014). Co (2000) reviewed the activities and conditions R and D, foreign direct investment and technology sourcing in USA during the 1980s. Tse (2001) analyzed the distribution of demand, market structure and investment of technology in theory. Tassey (2004) studied the policy issues for R and D investment in the knowledge-based economy of USA. Ane *et al*. (2007) analyzed the impact of technology assimilation on investment policy of R and D. Liu and Buck (2007) empirically investigated the impact of different channels for international technology spillover of Chinese high-tech industries using panel data. Ko and Osei-Bryson (2008) reexamined the impact of information technology investment on hospital productivity by regression equations. Hritonenko (2008) reported the results of modeling the optimal investment in science and technology with nonlinear methods. Ratchford and Blanpied (2008) compared and analyzed different paths to the future for science and technology in China, India and USA. Olsen *et al*. (2008) analyzed the policies, paradigms and practices shaping US research and development and their evolution tracks. Li (2009) empirically analyzed China's regional innovation capacity in transition. Yang *et al*. (2009) compared the R and D productivity of technology-based firms (NTBFs) located within and outside of science parks by measuring the elasticity of Taiwan R and D. Fu and Yang (2009) explored the cross-country differences in patenting with a panel data of 21 OECD countries over the period of 1990-2002. Xu (2010) reported the regional differences of science and technology investment ability of large and medium industrial enterprises in China. Tan (2010) established an innovation model and empirically analyzed the clean technology R and D and innovation in China too. Fu and Gong (2011) and Fu *et al*. (2011) analyzed the roles of foreign technology and indigenous technical innovation in the emerging economies and/or developing countries like China. Motoyama *et al*. (2011) reported the national nanotechnology initiative of USA. Aixiang (2011) studied the relationship among energy consumption quality, education and R and D funds (science and technology) based on the grey relation theory of Jiangsu, China. Hu *et al*. (2014) compared the R and D efficiency and the national innovation system across 24 nations from 1998-2005. Gibson and Naquin (2011) explored the efficiency of investment in innovation and the global competitiveness of Portugal. Yu and Ju (2011) investigated the configuration status of science and technology resource in the coal industry of Heilongjiang, China. Zhong *et al*. (2011) evaluated the performance of regional R and D investments in China with DEA models. Yu (2012) analyzed the interaction of the local economic growth and the investment of science and technology in Fujian province based on the vector error correction model. Li and Wang (2013) explored the correlation between the local economic growth and the investment of science and technology in Shanxi, China. Arguedas (2013) examined whether it was socially desirable that fines for exceeding pollution standards in the polluting firms. Mao *et al*. (2013) studied the science and technology investment of Chinese agricultural research institutions in national agricultural research. Chen *et al*. (2013) investigated the effects of science, technology resources investment on the differentiated regional economic growths in China. Yuan (2013) reported the nonlinear relation between the government science, technology investment and economic growth in China. Zhang (2013) reviewed the function and role of the science and technology investment system from the practices of South Korea and Taiwan. Liu *et al*. (2014) checked the industrial characteristics affecting industry innovation activities in Chinese high-technology industries from 1998-2008. Shah *et al*. (2014) analyzed the impact of deploying suitable preservation technology for an inventory system. In fact, the global GDP shares accounted for R and D in industrialized countries have been growing steadily over the past two decades.

According to the national policy for the development of science and technology of China (2006-2020), it was proposed that the overall goal was designed as the following specific objectives by the year 2020: The R and D expenditure of the whole society will hit the amount of more than 2.5% of GDP and the contribution of science and technology to China's economy will account for more than 60% and the dependence on foreign science and technology will reduce to 30% or less. However, the shortage of R and D funds is common in the underdeveloped regions of China. Thus, it is worthy of studying concerning how much will the limited R and D funds contribute to the regional economic development.

In the present study, we explored the impact of the science and technology investment on local economic productivity using econometric tests and annual datasets collected in Bozhou, China. The study was designed to determine whether there was a strong correlation between lnSTINV_BZ and lnGDP_BZ. It was also targeted to analyze and estimate the positive impact or contribution of local science and technology investment on regional economic growth in Bozhou, China. The overall findings suggested that there was a statistically positive correlation between the amount of local science and technology investment and regional GDP in Bozhou and analysis of the related variables found the potential promoting efficiency of local science and technology investment on the regional GDP was very significant in Bozhou. The present study provided new insights into the impact of local science and technology investment on regional economic growth in Chinese rural areas.

MATERIALS AND METHODS

Data acquisition and pre-processing: The time series data of science and technology investment and regional Gross Domestic Product (GDP) were all collected annually with references to "Anhui Province Statistical Yearbook" and "Bozhou City Statistical Yearbook" during the years 1997-2012 in the study (Table 1). According to the national economic expenditure accounting approach, the annual data of science and technology investment was transformed from the annual data of science and technology expenditure since these two types of data were expected to be equal in theory. Furthermore, the logarithms of the variables of annual data were analyzed in this study. After the acquisition of original data, we processed and transformed these annual data with Consumer Price Index (CPI) based on the basic price of 1990 in order to eliminate the possible hetero-scedasticity from the annual data of the regional GDP and the science and technology investment. It should be noted that other impacting factors involved were regarded as minor factors and ignored in the subsequent regression modeling and correlation analyses. Therefore, there might be autocorrelations of variables in the modeling and correlation analyses of the regional GDP and the science and technology investment. The transformed logarithmetic data of Bozhou and the corresponding correlogram analyses were showed in Fig. 1 and 2 referred to as the abbreviation of BZ.

Econometric theory and model tests: The present study carried out unit root tests, co-integration tests and the Error Correction Model (ECM) to make a systematic computing and

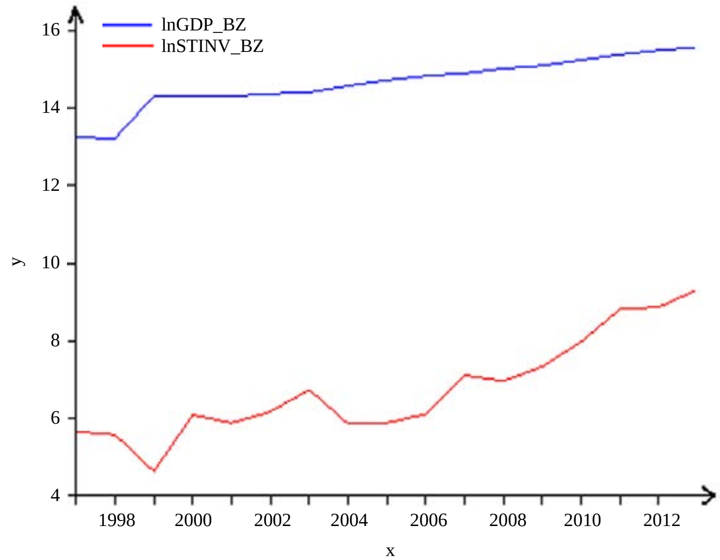

Fig. 1: Logarithmetic data of the regional GDP (lnGDP_BZ) and the science and technology investment (lnSTINV_BZ) during 1997-2012 in Bozhou

Table 1: Annual data of the regional GDP, science and technology (S and T) investment and CPIs collected in Bozhou city during 1997-2012

Year	Regional GDP	Local S and T investments	CPI in Anhui (1990 = 100)
1997	564172	285	213.6
1998	559516	262	213.6
1999	1624879	100	208.9
2000	1601006	432	210.4
2001	1640174	353	211.5
2002	1724566	467	209.4
2003	1832512	839	213.0
2004	2246429	362	222.6
2005	2650000	378	225.7
2006	2987300	480	228.4
2007	3355660	1375	240.5
2008	4042200	1261	255.4
2009	4319284	1813	253.1
2010	5127800	3553	260.9
2011	6266500	8664	275.5
2012	7156500	9383	281.8

S and T: Science and technology, GDP: Groos domestic product, CPI: Consumer price index, Unit: Ten thousand yaun

modeling of the correlations between local science and technology investments and regional economic growth magnitudes in the northern seven cities of Anhui, China (Gao, 2006).

Actually, the short-term fluctuation and long-run equilibrium correlation between the economic growth and the science and technology investment would be revealed by ECM modeling. But before executing the econometric computing of ECM equation, the variables should be tested with unit root tests of Augmented Dickey Fuller (ADF) and co-integration tests whether they were suitable to be applied in the modeling. The subsequent steps were carried out using the following unit root tests and co-integration tests and theoretical modeling with some brief descriptions here.

Unit root tests of ADF: The data of stationary sequences appears in fluctuations around a mean value and its tendency is clear to a mean value and easy to be tested. If a variable is stated in the stationary sequence, it can be represented as I (0). Meanwhile, it can be denoted as I (1), if its first-order differential variable is stated in stationary sequence. Similarly, it can be denoted as I (2), if its second-order differential variable is stated in stationary sequence. In the unit root tests of ADF, the null hypothesis is that a unit root exists and the sequenced variable or time series data is non-stationary. Therefore, these types of tests are all called unit root tests.

In the study, for any sequenced variable, the general formula of ADF unit root test is defined as Eq. 1:

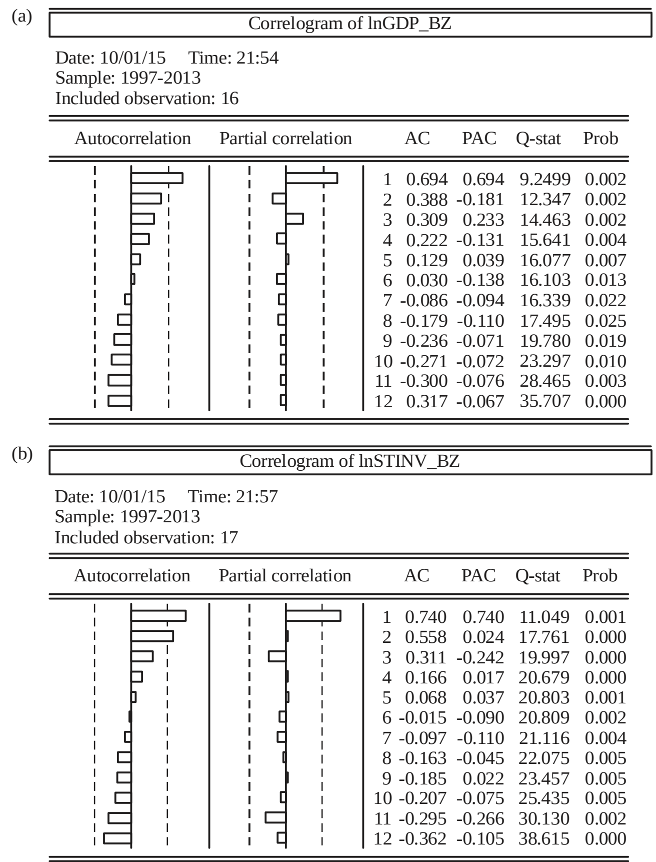

Fig. 2(a-b): The correlogram analyses of the variables, (a) lnGDP_BZ and (b) lnSTINV_BZ

$$\Delta x_t = a + bt + rx_{t-1} + \sum_{i=1}^{p} r_i \Delta x_{t-i} + \varepsilon_t \qquad (1)$$

where, the letter "a" is a constant, "t" is a variable of time trend and "p" means the number of lags. The null hypothesis (H_0) of the test is that r = 0, while the alternative hypothesis (H_1) is that $r \neq 0$. If the null hypothesis is accepted, then there exists a unit root within the variable to be tested, i.e., it is in non-stationary series. Otherwise, the alternative hypothesis should be accepted and there is no unit root within the variable tested, i.e., it is stationary.

Co-integra tion tests: The co-integration test was first proposed by the economists Engle and Granger to test the hypothesis whether, there was the co-integration relationship between two sequenced variables. Therefore, the main idea of Engle and Granger can be expressed as the following. If two or more variables are in linear combination of stability, there should be a long-term stable relationship and/or correlation between these variables, i.e., co-integration, even though the variables are in non-stationary series (i.e., each variable has a unit root). The commonly method of the co-integration test are the EG two-step method and the Johansen method. In the present study, the EG two-step method of the co-integration test were used to test the long-term stable relationship (or correlation) between GDPs and the science and technology investments in the seven northern cities of Anhui, China.

The first step of the EG two-step method is to establish the ordinary least squares regression equation using the target variables. The next step is to test if the sequenced residual of the regression model established above is stationary with the unit root tests. After these tests, if the sequenced residual data is stationary and smooth, there is to be a co-integration relationship between these variables in the initial unit root tests. Thus, we can analyze the long-term stable relationship and/or correlation between these variables and the subsequent issues with the ordinary least squares regression equation established.

Error correction modeling: If the first-order or second-order differential variables for both the endogenous and exogenous variables are stated in the stationary sequences and co-integrations, Eq. 2 can be deduced to estimate the long-run equilibrium or relationship between the variables:

$$y_t = \beta_1 x_{1t}+\beta_2 x_{2t}+\cdots+\beta_n x_{nt}+\varepsilon_t, \varepsilon_t \sim I\ (0) \quad (2)$$

The corresponding ECM modeling equation can be expressed as Eq. 3:

$$\Delta y_t = c + \sum_{i=1}^{m} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{n}\sum_{j=0}^{m} \beta_{ij} \Delta x_{i,t-j} + \delta ecm_{t-1} + e_t \quad (3)$$

where, the mark "Δ" stands for the first difference variable and the symbol "ecm" is the long-term regression equation residual.

Estimation of the contributing efficiency of local science and technology investment on regional economic growth: In order to exactly estimate the contributions and statistics of local science and technology investments on regional economic growths in the seven Northern cities of Anhui, a novel variable is introduced and defined as the promoting or contributing efficiency, which means how much does the science and technology investment contribute to the increased shares of the regional economic gain (GDP). This assumptive variable can denoted as a statistic Q:

$$Q = \frac{\sum_{i=1}^{n} S_i}{n \times \beta}$$

where, n is the reported years (n = 1997-2012), variable S_i is the annual share of the contribution of local science and technology investment in the enlargement of regional economic growth (i.e., the annual share of lnSTINV expressed in lnGDP), while the variable β is the regression coefficient in the corresponding ECM regression model. Actually, the variable β is redefined here as the elastic coefficient of the contribution of science and technology investment (lnSTINV) on regional economic growth (lnGDP). If $Q<1$, it represents the contribution or impact of the variable (lnSTINV) is negative and at a low efficiency, i.e., the increased share of GDP accounts for less than the amount of the variable itself. If $Q>1$, it indicates the contribution or impact of the variable (lnSTINV) is positive.

RESULTS AND DISCUSSION

Unit root tests of ADF: In this study, all the data (1997-2012) was dealt with the econometric software package Eviews 6.0 (Quantitative Micro Software Inc., USA). As it could be seen from the unit root test results (Table 2), the ADF test statistics showed that both the variables of the regional GDP and the science and technology investment (such as ΔlnGDP, ΔΔlnGDP, ΔlnSTINV and ΔΔlnSTINV) were analyzed and revealed in stationary sequences at the levels of the first-order or second-order differences, i.e., I (1) and I (2). Although, it was indicated that the variables themselves were non-stationary, their first-order and second-order differences were stationary and the subsequent model tests and analyses were suitable and applicable.

Co-integration tests: From the stationary analyses of the variables (Table 2) computed for Bozhou, it was obvious that the variables of the regional GDP and local science and technology investment were stationary with no unit roots at both the levels of the first-order and second-order differences, respectively.

Actually, unit root tests (Table 2) and co-integration tests (Table 3) on the regression residual variables and the subject variables (i.e., lnGDP and lnSTINV) should be made before executing the ECM modeling and other econometric tests. Then, it was found out exactly the long-run equilibrium relationship between these two types of variables by the co-integration tests on the regression residual variable in the following least squares regression Eq. 4 in the EG two-step analysis:

$$lnGDP\_BZ = 0.421282\ lnSTINV\_BZ+11.81885 \quad (4)$$

Table 2: Stationary tests of the regional GDP and the science and technology investment during 1997-2012 in Bozhou

			T-statistics for thresholds (%)				
Variables	Probability (p)	T-statistic	1	5	10	Durbin-watson statistic	Stationary
lnGDP_BZ	0.3838	-1.760316	-3.959148	-3.081002	-2.681330	2.582650	I (0), No
lnSTINV_BZ	0.9404	-0.044417	-3.920350	-3.065585	-2.673459	2.613568	I' (0), No
ΔlnGDP_BZ	0.0035**	-4.910374	-4.200056	-3.175352	-2.728985	2.642323	I (1), Yes
ΔlnSTINV_BZ	0.0012**	-5.101884	-3.959148	-3.081002	-2.681330	1.934686	I' (1), Yes
ΔΔlnGDP_BZ	0.0402*	-3.358855	-4.297073	-3.212696	-2.747676	3.006601	I (2), Yes
ΔΔlnSTINV_BZ	0.0000**	-7.701137	-4.004425	-3.098896	-2.690439	1.887189	I' (2), Yes

Variables containing lnGDP and lnSTINV showed the relevant estimates for the regional GDPs and the science and technology investment in Bozhou, China. *, **Significant values at the levels of 5 and 1% estimated by EViews 6.0, respectively. The lag order p was determined in accordance with the AIC rules

Table 3: Stationary test of the estimated regression residual variables

Variables	Probability	T-statistic	T-statistics for thresholds (%)			Durbin-watson statistic	Stationary
			1	5	10		
ϵ(BZ)	0.0239*	-3.489864	-3.959148	-3.081002	-2.681330	2.445878	I (0), Yes
Δϵ(BZ)	0.0017**	-5.013766	-4.004425	-3.098896	-2.690439	1.316406	I (1), Yes
ΔΔϵ(BZ)	0.0000**	-9.563610	-4.057910	-3.119910	-2.701103	1.333734	I (2), Yes

Variable containing ϵ showed the estimation of residual variable in Bozhou (abbreviated as BZ). *, **Significant values at the levels of 5 and 1% estimated by EViews 6.0, respectively

where, the t-statistics for the variable (lnSTINV_BZ) and the constant (C) were 4.326859 (very significant; probability = 0.0007) and 18.11976 (very significant; probability = 0), respectively. In addition, the regression coefficient for lnSTINV_BZ was revealed as 0.421282. Furthermore, the statistics R^2, $\overline{R^2}$ (i.e., adjusted R^2), DW (i.e., Durbin-Watson) statistic and F were estimated as 0.572149, 0.541589, 1.146637 and 18.72171 (probability of F-statistic = 0.000696, very significant), respectively. It was suggested that there appeared little autocorrelation in the variables according to the DW statistic (DW = 1.146637) and the stationary test of all the estimated regression residual variables analyzed in Bozhou (Table 3).

In addition, the pre-phase analysis suggested the hypothesis that science and technology investment positively promotes and contributes regional economic growth in Bozhou, Anhui, which agreed with those reported cases of other undeveloped provinces or districts in China (Su *et al*., 2006; Xu, 2010; Yu, 2012; Yuan, 2013). Therefore, ECM modeling was implemented in the subsequent parts.

ECM modeling: The results of the ECM modeling and other econometric tests for the selected four cities were showed and developed in detail in the following parts.

The ECM modeling of the contribution of local science and technology investment on regional economic growth in Bozhou was carried out with the previously established least squares regression equation as Eq. 5:

$$\text{lnGDP\_BZ} = 0.421282\ \text{lnSTINV\_BZ}+11.811885 \quad (5)$$

where, the t-statistics for the variable (lnSTINV_BZ) and the constant (C) were 4.326859 (very significant; probability = 0.0007) and 18.11976 (very significant; probability = 0) and the regression coefficient for lnSTINV_BZ was 0.421282. Moreover, the two variables, i.e., the regional GDP and the Science and Technology Investment (STI) should be regarded as co-integrated only if the variable ϵ_t of the regression equation was found to be stationary in the unit root tests. The error term ϵ_t could be expressed as Eq. 6:

$$\epsilon t = \text{lnGDP\_BZ}-0.421282\ \text{lnSTINV\_BZ}-11.81185 \quad (6)$$

It was found that there was a co-integration between the variables lnGDP_BZ and lnSTINV_BZ through the unit root tests of the error term ϵ_t. Subsequently, the ECM modeling equation was established according to the theorem of Engle and Granger with the variables in co-integration analyzed above. It should be noted that the variable ecm was computed according to the equation for the error term ϵ_t. As it was found that the residual variable had a strong trend of correlation in the first-order difference, the appropriate lagging items were added into the established ECM equation. Therefore, the final corrected ECM regression equation was expressed as Eq. 7:

$$\Delta \text{lnGDP\_BZ}_t = 0.181771-0.141327\ \Delta \text{lnSTINV\_BZ}_t-0.175065\ \text{ecm}_{t-1} \quad (7)$$

where, the t-statistics for the variable (lnSTINV_BZ) and the constant (C) were -0.141327 and 0.181771, while the regression coefficient and t-statistics for the residual variable ecm were revealed as -0.175065 and -0.911671, respectively. Moreover, the statistics R2, $\overline{R^2}$, DW and F were were estimated as 0.345239, 0.236113, 2.271106 and 3.163653 (probability of F-statistic = 0.078794, significant), respectively. The DW statistics was 2.266063, which suggested that there was no autocorrelation. Then it could be concluded that the equation was acceptable and there was no autocorrelations for the variables due to shorter sample interval and smaller values of DW tests in the ECM equation.

Estimated contributing elasticity and the related coefficients of local science and technology investment on regional economic growth in Bozhou: In the regression equation of ECM modeling, the differential coefficient could be regarded as the elasticity of the contribution of local science and technology investment on regional economic growth in Bozhou, Anhui, China. This coefficient was considered as the short-run elasticity coefficient. In the ECM regression equation, the differential coefficient of the variable of lnSTINV was at the relatively low level (i.e., 0.421282) in

Bozhou. Furthermore, in the corrected ECM regression equation, the coefficient of the variable ecm was regarded as the long-run elasticity coefficient. That ecm coefficient was computed as -0.175065 in Bozhou. Thus, it was showed that the elasticity of the contribution of science and technology investment on regional economic growth was -0.175065 in the long terms and 0.421282 in the short terms in Bozhou, Anhui, China. These elasticity coefficients of the variable ecm revealed the significant capacity of long-term equilibrium error controlling and driving the growth of GDP. Whenever, the science and technology investment was increased by 1%, the regional growth of GDP would be elevated by 0.421282 (42.1282%) in the short terms and corrected or adjusted by 0.175065 (17.5065%) in the long terms accordingly with the elasticity coefficients estimated in Bozhou. Actually, there were many researchers reported similar efficient effect or impact of science and technology investment and technical innovation (Liu and Buck, 2007; Li, 2009; Xu, 2010; Fu and Gong, 2011; Fu *et al*., 2011; Yu, 2012; Li and Wang, 2013; Mao *et al*., 2013; Liu *et al*., 2014). Liu and Buck (2007) empirically investigated the impact of different channels for international technology spillover on the innovation performance of Chinese high-tech industries and found that learning by exporting and importing effectively promoted innovation in Chinese indigenous firms. Li (2009) made an empirical study of China's regional innovation capacity in technical transition using a stochastic frontier model to estimate and explain the increasing disparity in innovation performance between Chinese regions. Their estimated results show that government support, the constitution of the R and D performers and the regional industry-specific innovation environment are significant determinants of innovation efficiency due to the large difference in the firm's innovation performance across the regions. Xu (2010) analyzed the regional differences of science and technology investment ability of large and medium industrial enterprises in China and found the regional capacities of science and technology investments were positively correlated with the economic growths and development potentials of different provinces. Fu and Gong (2011) and Fu *et al*. (2011) reported that the role of foreign technology and indigenous innovation was crucial in the emerging economies and/or developing countries like China. Yu (2012) and Li and Wang (2013) analyzed the positive correlations of the local economic growths and the investments of science and technology in Fujian and Shanxi, China, respectively. Their analyses found that the financial investments and expenditures of science and technology could promote the provincial economic growths both in the short and in the long terms to some extent, but the effects of short term financial investments and expenditures of science and technology on the economic growths were relatively less than that of the long term. Specifically, among all the input elements, the investment of science and technology was the most significant impacting influential factor of economic growth and the personnel of science and technology was regarded as the second key influencer. Mao *et al*. (2013) studied the science and technology investment of Chinese agricultural research institutions and found there were serious shortages of financial investment in the national agricultural science and technology. However, Zhong *et al*. (2011) evaluated the performance of regional R and D investments in China and found the increasing returns to scale had not yet occurred in any provinces, while the constant returns to scale had prevailed in most provinces in the Western region, while decreasing returns to scale had prevailed in most provinces in the Eastern and central regions.

Chen *et al*. (2013) reported that there were differentiated regional economic growths due to the different effects of science and technology resources investments. They found that the science and technology resources were coming into differentiation. There were different contributions of science and technology resources investments to the regional economic growths of different districts at the provincial level, while the decreased social technological progress and variations in science and technology resources investments were the main reasons for the declined efficiency of economic growths in some of the provincial districts. Mao *et al*. (2013) checked the commercialization of Chinese nanotechnology from the intertwined perspectives of academia-industry relations, government support and policy, role of venture capital and international connections. Their analysis showed that China's effort to commercialize nanotechnology has been much slower than the anticipated by the decreases of investments in science and technology resources, despite the tangible success in publishing, patenting and the creation of dedicated nanotechnology parks. Liu *et al*. (2014) explored how the characteristics of industry affect industry innovation activities in Chinese high-technology industries considering the impact of foreign competition on innovation activities at industry level in a large emerging economy. They found that the competition intensity of foreign invested enterprises and domestic skill intensity affected the industry buy and make activities and foreign competition was positively associated with the intensity of buy activity (of science and technology resources), but negatively affected the intensity of make activity (of technical innovations). Further, it was showed that domestic skill intensity weakened the impact of foreign competitive pressure on technical innovation activities.

Table 4: Estimated statistics of contributing efficiency of science and technology investment on economic growth in Bozhou

City	Initial year	End year	Coefficient β	Statistic Q
Bozhou	1997	2012	0.421282	1.069091

Estimated statistic of the contributing efficiency of local science and technology investment on regional economic growth in Bozhou: In order to estimate the exact role and contribution of science and technology investment on economic growth, a novel variable was introduced and defined as the statistic Q, which meant how much does local science and technology investment contribute to the increased shares of the regional economic gain (GDP). In the provided case of Bozhou, the statistic Q was computed as 1.069091. It is indicated the contribution of the variable (lnSTINV) was positive and the increased share of GDP accounted for more than the amount of the variable (lnSTINV) in Bozhou. The statistic Q revealed that the promoting or contributing efficiency of local science and technology investment on regional GDP in Bozhou was relatively high due to its advanced agricultural science and technology (Table 4). This result also agreed with those reported cases of other undeveloped provinces or districts in China (Su *et al*., 2006; Liu and Buck, 2007; Li, 2009; Xu, 2010; Fu and Gong, 2011; Fu *et al*., 2011; Yu, 2012; Yuan, 2013; Li and Wang, 2013; Liu *et al*., 2014).

CONCLUSION

In the present study, the ECM modeling and other econometric tests were established and used to analyze and estimate the correlation and impact or contribution of local science and technology investment on regional economic growth in Bozhou, China. Numerical analysis found that the correlation between regional economic growth and local science and technology investments was significant both in short-term fluctuation and long-run equilibrium in Bozhou from the point of view of econometric tests. The empirical result revealed that the impact or contribution of science and technology investment on regional economic growth was positive and it proved to be true that the variable lnSTINV_BZ did Granger caused the variable lnGDP_BZ in ECM modeling. Next, it was estimated that the elasticity coefficients of the contribution of local science and technology investment on regional economic growth were -0.175065 in the long terms and 0.421282 in the short terms. Moreover, the Q statistic was computed as 1.069091 in Bozhou. It was inferred that the regional growth of GDP in Bozhou was promoted by local science and technology investment at the estimated rates of 0.421282 (42.1282%) in the short terms and corrected or adjusted by 0.175065 (17.5065%) in the long terms, when the science and technology investment was increased by 1% accordingly. Furthermore, it was also found the promoting efficiency of local science and technology investment on the regional GDP in Bozhou was high according to the Q statistic. The present empirical study indicated that both the current and potential impact and contribution of local science and technology investment on regional economic growth was revealed as very significant in Bozhou.

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