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Computing and Analysis of the Impact and Contribution of Science and Technology Investment on Regional Economic Growth: An Empirical Study Based on Annual Data in Fuyang City During 1997-2012

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ABSTRACT

The econometric error correction model was used to study the impact and contribution of the science and technology investment on local economic growth in Fuyang city in the northern of Anhui province, China. Analysis of the short-term fluctuations and long-run equilibrium correlation between the economic growth and the science and technology investment was done too in Fuyang city. It was found that there was a statistically significant correlation between the amount of the science and technology investment and the local economic growth from the point of view of the contribution and promoting elasticity coefficients, i.e., 0.171785 in the long term and 0.340016 in the short term. It was estimated that the regional growth of GDP in Fuyang city would be driven by 0.171785 in the long term and 0.340016 in the short term when the science and technology investment was increased by 1% according to the elasticity coefficients. Moreover, the index of potential promoting efficiency of the science and technology investment on the regional GDP was very remarkable with the Q statistic of 9.497250794. The present study indicated that the potential effect and contribution of promotion of the science and technology investment on local economic growth in Fuyang city was very huge.

Key words: Science and technology investment, economic growth, R&D, GDP, Fuyang city

INTRODUCTION

Since the economic reform of 1978, China has experienced vigorous development in the areas of science and technology and these achievements have provided strong support for sustainable economic growth and social development. However, many of the cities and counties in China are economically undeveloped, especially the three cities and seven counties in the Northern region of Anhui province (i.e., Fuyang city, Bozhou city, Suzhou city, Fengyang county, Shouxian county, Huoqiu county, Huaiyuan county, Wuhe county, Guzhen county and Suixi county) where there are less developed industries with a large agricultural proportion of population. These are the typical districts of developing provinces in central China. During 2008-2010, a series of special documents for the northern three cities and seven counties had been issued by the government of Anhui province to promote and boost the economic development of these districts. Among those special documents, 10 preferential policies were given by the provincial government to accelerate the economic development in these cities and counties, enabling the rapid economic development of Fuyang city. Therefore, the phrase "Northern of Anhui province" is referred the districts with less developed or undeveloped industrial economic development, such as these three cities and seven counties. Therefore, the northern three cities and seven counties should grasp the opportunities rapidly and enhance the competitiveness for economic development and accelerate the processes of industrialization and urbanization, with their relative superiorities brought into full play. Their utmost and final objectives are to achieve leapfrog developments in the transformation and upgrading of economics in the northern areas of Anhui province. Hence, the science and technology investment and its impact on economic and social promotion are one of the most important aspects required and frequently considered by the government departments and/or sectors used to make policies.

Generally, 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. In other words, the continued growth of the national or regional economy needs the augment of investment while the stimulation of increasing investment will accelerate the expansion of consumers' demand. It is widely recognized that differences in productivity are a major source of cross country income variations and that technological change is a driver of productivity growth. Science and technology innovation is, therefore, a key element of industrialization and catch-up in developing countries, like China. However innovation is costly, risky and path-dependent. Although, there is a substantial literature on the impact of domestic investment on local firms, most of the literature focuses on Foreign Direct Investment (FDI). Research exploring the impact of research and development investment is rare, especially in the undeveloped countries and areas. However, many scholars have been engaged in the research on the impact and policy of the science and technology investment. Co (2000) reviewed and systematically developed the activities and conditions R&D, foreign direct investment and technology sourcing in USA during the 1980s. Tse (2001) analyzed the distribution of demand, market structure and investment in technology. He thought that the prices innovators might charge for their innovations and could obtain market shares at any one time under the dispersion in the demand for quality influences in a quality-ladder growth model. Under a more dispersed distribution, the innovator might only charge a lower price to cover the entire market while the declines of payoff to innovation would cause investment to fall. Tassey (2004) studied some policy issues for R&D (i.e., Research and Development) investment in the knowledge-based economy of U.S.A and provided the conceptual framework and data as inputs available for the analysis of Federal R&D investment strategies regarding the national innovation system. Ane *et al.* (2007) analyzed the impact of technology assimilation on investment policy a dynamic model of optimization of R&D intensity. Liu and Buck (2007) empirically investigated the impact of different channels for international technology spillover on the innovation performance of Chinese high-tech industries using panel data and found that learning-by-exporting (and importing) promoted innovation in Chinese indigenous firms.

Ko and Osei-Bryson (2008) reexamined the impact of information technology investment on hospital productivity using regression tree and Multivariate Adaptive Regression Splines (MARS). 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, respectively. Li (2009) made an empirical study of China's regional innovation capacity in transition. In the study, a stochastic frontier model was estimated to explain the increasing disparity in innovation performance between Chinese regions. The estimated results show that government support, the constitution of the R&D performers and the regional industry-specific innovation environment are significant determinants of innovation efficiency due to the large difference in the firms' innovation performance across the regions. Yang *et al.* (2009) compared the R&D productivity of new technology-based firms (NTBFs) located within and outside of science parks by measuring the elasticity of R&D with respect to output using panel data from Taiwan. They found that the elasticity of R&D with respect to outputs of NTBFs located within HSIP was significantly higher than that of other firms and NTBFs located in the science park invest was more efficiently. Fortune-Devlaminckx and Haunschmied (2010) analyzed the diversity of Austrian firm's life cycle adapted from the firm's technology investment decision and discerned whether the firm's technology investment had the long-run positive effect or the short-run adverse effect on its sales volume. Tan (2010) established an innovation model and empirically studied the clean technology R&D and innovation in China. Fu and Yang (2009) explored the cross-country differences in patenting with a panel data of 21 Organization for Economic Co-operation and Development (OECD) countries over the period of 1990-2002 using a stochastic frontier approach. They sought to explain the innovation efficiency and inefficiency of these countries and found the gap between Europe and the world leaders in terms of basic patenting capacity and efficiency remained substantial with little sign of convergence over the sample period while three countries (Japan, Germany and Italy) had improved their relative positions. The institutional factors are found to be significantly associated with the patenting efficiency in terms of a national economy.

Fu and Gong (2011) and Fu *et al.* (2011) systematically analyzed the role of foreign technology and indigenous innovation in the emerging economies and/or developing countries, such as China, taking into account sectoral specificities in technical changes. Motoyama *et al.* (2011) analyzed the national nanotechnology initiative of USA. Aixiang (2011) studied the relationship between energy consumption quality and education, science and technology based on the grey relation theory of Jiangsu province, China. The study showed that the influence factors of Jiangsu energy consumption quality was mainly scientific and technological personnel, the number of college students per ten thousand and the number of R&D funds. Hu *et al.* (2014) explored and analyzed the R&D efficiency and the national innovation system using the distance function approach for Stochastic Frontier Analysis (SFA). In the present study, they compared the R&D efficiency across 24 nations, including 16 European, 4 Asian and 4 North and South American, from 1998-2005 and found the involvement of government sector in R&D activities significantly improved national R&D efficiency. Gibson and Naquin (2011) comparatively analyzed the efficiency of investment in innovation and the global competitiveness of Portugal. BaiLin and XiaoFeng (2011) made an empirical investigation on configuration status of science and technology resource in the coal industry of Heilongjiang Province, China. Zhong *et al.* (2011) evaluated the performance of regional R&D investments in China with models of Data Envelopment Analysis (DEA) based on the first official China economic census data in 2004. They found that increasing returns to scale had not yet occurred in any province. 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.

Cao *et al.* (2013) examined the commercialization of nanotechnology in China from the intertwined perspectives of academia-industry relations, government support and policy, role of venture capital and international connections. Their results showed that despite tangible success in publishing, patenting and the creation of dedicated nanotechnology science parks, China's effort to commercialize nanotechnology has been much slower than anticipated by scientists and political leadership. Arguedas (2013) explored whether it was socially desirable that fines for exceeding pollution standards depend not only on the degree of non-compliance but also on technology investment efforts by the polluting firms. Recently, Liu *et al.* (2014) examined how industry characteristics affect industry innovation activities using panel data analysis for a sample of Chinese high-technology industries from 1998-2008. Shah *et al.* (2014) analyzed the impact of deploying suitable preservation technology for an inventory system in which units are subject to constant rate of deterioration.

The global share in GDP accounted for R&D in industrialized countries has been growing steadily over the past two decades. According to the national policy for medium and long-term scientific development of China (2006-2020) made in 2006, it was proposed that the overall goal of science and technology development was designed as the following specific objectives by the year 2020: The R&D expenditure of the whole society will hit the amount of more than 2.5% of GDP (Gross Domestic Product) and there would be no shortage of R&D funds, 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, etc. However, the shortage of R&D funds is common in the underdeveloped regions of China. Thus, it would receive a great amount of attention how much will the limited R&D funds contribute to the regional economic development. In the present studt, we examine the impact of the science and technology investment on local economic productivity using time series of data of domestic science and technology investment and local GDP share in Fuyang city in the northern of Anhui province, China. This study contributes as the first empirical study investigating specifically the impact of the science and technology investment on the economic productivity in the undeveloped district. Our findings suggest that there was a statistically positive correlation between the amount of domestic science and technology investment and regional or local GDP and established a variable (Q statistic) and found the potential promoting efficiency of the science and technology investment on the regional or local GDP was very significant. First, the co-integration test was executed to analyze the degree of correlation between the science and technology investment and the local economic growth in Fuyang city. Next, the econometric Error Correction Model (ECM) was used to analyze the short-term fluctuations and long-run equilibrium correlation between the local economic growth and the science and technology investment to explore the quantitative contribution of the science and technology investment with mathematical equations in this economically undeveloped district. Finally, the promoting elasticity coefficient of the science and technology investment on the local economic growth was estimated based on annual data (1997-2012) in Fuyang city.

MATERIAL AND METHODS

Data acquisition and pre-processing: In the study, the data of the science and technology investment and regional GDP were all the time series of annual data (1997-2012) collected with the references from "Fuyang City Statistical Yearbook" and "China City Statistical Yearbook" in relevant years. It should be noted that the annual science and technology investment was transformed from the annual data of science and technology expenditure, since these two types of data are expected to be equal in theory. In addition, it proved to be difficult to obtain the complete data of the science and technology investment in practice, as the science and technology investment could not be used up every year. The logarithms of the prices were analyzed in this study. After the

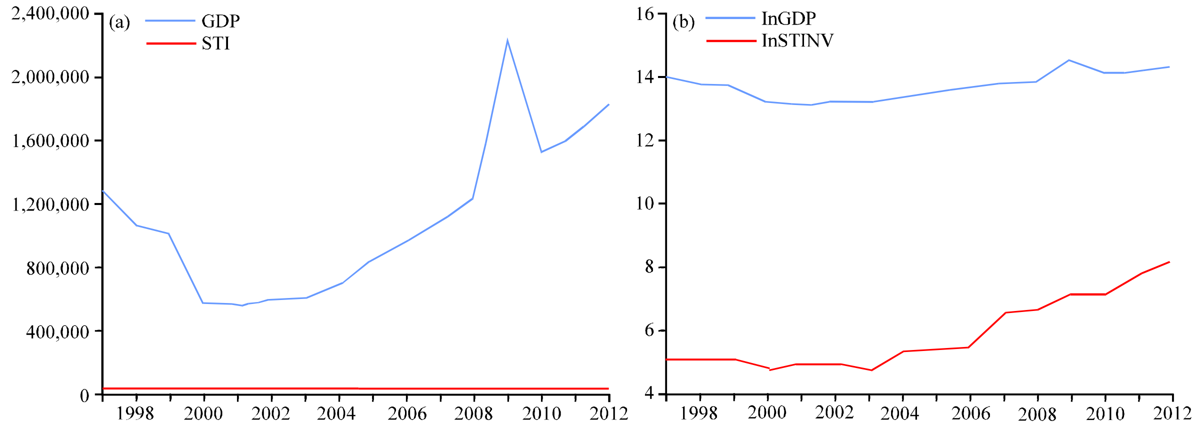

Fig. 1(a-b): Evolutionary trends of (a) Original and (b) Logarithmetic data of the regional GDP (marked as GDP and lnGDP) and the science and technology investment (marked as STI and lnSTINV) in Fuyang city during 1997-2012

acquisition of original data, we processed and transformed the data with Consumer Price Index (CPI) based on the basic price of 1992 in order to eliminate all the possible hetero-scedasticity from the annual data of the regional GDPs and the science and technology investment. The original and transformed data in logarithmetic scaling were showed in Fig. 1.

Econometric theory and model tests: The present study carried out unit root tests (Gao, 2006), co-integration tests (or Granger Causality tests) and the Error Correction Model (ECM) to make a systematic computing and modeling of the correlation between the science and technology investment and the local economic growth magnitude in Fuyang city.

The short-term fluctuations and long-run equilibrium correlation between the economic growth and the science and technology investment was revealed by the error correction model. Before executing the econometric computing of error correction model, the variables should be tested with the Augmented Dickey-Fuller (ADF) method of unit root tests and the co-integration tests (alias the Granger Causality test) whether they were suitable to be applied in the modeling. The subsequent steps were carried out using the following the unit root tests and the co-integration tests and theoretical modeling with some brief descriptions.

Unit root tests: The data of stationary sequences appears in fluctuations around a mean value and its tendency to the mean value is clear and easy to test. If a variable is stated in stationary sequence, it can be represented as I(0). If its first-order differential variable is stated in stationary sequence, it can be denoted as I(1). Similarly, if its second-order differential variable is stated in stationary sequence, it can be denoted as I(2). In the unit root tests, 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, the Augmented Dickey-Fuller (ADF) tests were used. For any sequenced variable, the general form of the ADF test is defined as:

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

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

Co-integration tests (Granger causality 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, it is also called the Granger Causality Test. The main idea of the Granger Causality Test 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 investment in Fuyang city.

The first step of the EG two-step method is to establish the ordinary least squares regression model (or equation) using the target variable. The next step is to test if the sequenced residual of the regression model established above is stationary with the unit root tests. After tests, if the sequenced residual data is stationary and smooth, there is 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 model: If the first-order or second-order differential variables for both the endogenous and exogenous variables are stated in stationary sequence and co-integration, it can deduce the following equation to estimate the long-run equilibrium or relationship between variables:

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

The corresponding Error Correction Model (ECM) equation could be expressed as the following:

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

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

RESULTS AND DISCUSSION

Unit root tests: 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 can be seen from the unit root test results (Table 1), the ADF test statistics showed that both the variables of the regional GDPs

Table 1: Stationary test results of the regional GDP and the science and technology investment in Fuyang city during 1997-2012

Variables	Inspection (C,T,P)	t statistic	t-statistics for thresholds (%) 1	5	10	Durbin-Watson statistic	Stationary?
lnGDPFY	(C,T,0)	-2.283962	-4.728363	-3.759743	-3.324976	2.426887	I (0), No
lnSTIFY	(C,T,0)	-1.420864	-4.800080	-3.791172	-3.342253	2.307989	I' (0), No
ΔlnGDPFY	(N,N,P)	-4.200073*	-4.800080	-3.791172	-3.342253	1.987040	I (1), Yes
ΔlnSTIFY	(N,N,P)	-5.776096**	-4.800080	-3.791172	-3.342253	2.199924	I' (1), Yes
Δ(2)lnGDPFY	(N,N,P)	-5.695469**	-4.992279	-3.875302	-3.388330	2.785279	I (2), Yes
Δ(2)lnSTIFY	(N,N,P)	-4.709699*	-4.992279	-3.875302	-3.388330	2.394639	I' (2), Yes

(C, T, P) indicated the presence of a constant and time trend terms while (N, N, P) represents the constant term and time trend does not exist. The variables containing GDPFY and STIFY showed the relevant estimates for the regional GDP and the science and technology investment in Fuyang city, respectively. *,**Significant at the levels of 5 and 1%, respectively. The lag order P was determined in accordance with the AIC rules

Table 2: Result of Granger causality tests (Pairwise tests)

Null hypothesis	F-statistic	Prob.	Acceptable?
I does not Granger cause G	20.6191	0.0161	Yes
G does not Granger cause I	5.02850	0.1078	Yes, with care

Sample: 1997-2012

and the science and technology investments, ΔlnGDPFY, Δ(2) lnGDPFY, ΔlnSTIFY and Δ(2) lnSTIFY, were stated 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 (granger causality tests) and the error correction model: From the analyses above, it is obvious that all the variables of the regional GDPs and the science and technology investments in Fuyang city were stationary with no unit roots at the levels of the first-order and second-order differences, respectively. The study found out exactly the long-run equilibrium relationship between these two types of variables by means of co-integration tests with the EG two-step method and the least squares regression analysis. The result of Granger Causality Tests (Pairwise Tests) was showed in Table 2 and other results are developed in detail in the subsequent parts. The error correction model of the contribution of the science and technology investment on the local economic growth Fuyang city was established as the following:

$$\ln GDPFY_t = 0.316341 \ln STIFY_t + 11.95432$$

where, the t-statistics for the variable (lnSTIFY) and the constant (C) were 5.745953 (very significant; probability = 0.0001) and 36.02454 (very significant; probability = 0) while the regression coefficient for lnSTIFY was revealed as 0.316341. Moreover, the statistics R^2, $\sqrt{R^2}$, DW (Durbin-Watson) statistic and F were estimated as 0.702229, 0.680960 and 0.832551 (significant), respectively. It was suggested that there were no autocorrelations in the variables according to the DW statistics. In addition, the two variables, i.e., the regional GDP and the science and technology

Table 3: Stationary test result of the regression residual variable estimated by the error correction model for Fuyang city

Variables	Inspection (C,T,P)	t statistic	t-statistics for thresholds (%) 1	5	10	Durbin-Watson statistic	Stationary?
ε(FY)	(C,T,0)	-2.553938	-4.728363	-3.759743	-3.324976	2.055927	I(0), No
$\Delta\varepsilon$(FY)	(C,T,0)	-3.795425*	-4.800080	-3.791172	-3.342253	2.081154	I(1), Yes
$\Delta(2)\varepsilon$(FY)	(C,T,0)	-7.314160**	-4.992279	-3.875302	-3.388330	2.762203	I(2), Yes

(C, T, P) indicated the presence of a constant and time trend terms. The variable containing ε(FY) showed the relevant estimate for the residual variable. *,**Significant at the levels of 5% and 1%, respectively. The lag order P was determined in accordance with AIC rules in EViews 6.0

investment, should be regarded as co-integrated only if the variable ε_t of the regression equation was found being stationary in the unit root tests. The error term ε_t could be expressed as follows:

$$\varepsilon_t = \ln GDPFY_t - 0.316341 \ln STIFY_t - 11.95432$$

It was found that there was a co-integration between the variables lnGDPFY and LnSTIFY through the unit root tests of the error term ε_t (Table 3). Subsequently, the error correction model was established according to the Granger Causality Theorem 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 (Table 3). 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 Error Correction model. Therefore, the final two regression equations of the error correction model were expressed as the following:

$$\ln GDPFY_t = 0.356765 \ln STIFY_t + 0.335947 \ln GDPFY_{t-1} - 0.253532 \ln STIFY_{t-1} + 11.723731088$$

where, the t-statistics for the variables (ΔlnGDPFY, lnSTIFY,ΔlnSTIFY) and the constant (C) were 6.178288, 1.299850, -1.165745 and 35.50488, respectively. In addition, the statistics $R^2, \sqrt{R^2}$, DW and F were estimated as 0.825342, 0.777708, 0.802857 and 17.32675 (significant), respectively.

$$\Delta \ln GDPFY_t = 0.340016 \Delta \ln STIFY_t - 0.548839 ecm_{t-1} - 0.041434$$

where, the t-statistics for the variable (ΔlnSTIFY) and the constant (C) were 2.365083 and 0.727506, respectively while the regression coefficient for the residual variable ecm was revealed as -2.612327. Moreover, the statistics $R^2, \sqrt{R^2}$, DW and F were estimated as 0.565020, 0.492523, 2.023314 and 7.793722 (significant), respectively. The DW statistics was 2.023314 which suggested that there was no autocorrelation. Thus, it could be concluded that the equation was acceptable and there was no autocorrelations for the variables due to the shorter sample interval and smaller values of DW tests in the error correction model.

Elasticity of the contribution of the science and technology investment on the local economic growth: In the error correction model, the differential coefficient could be regarded as the elasticity of the contribution of the science and technology investment on the local economic growth in Fuyang city. In the model, the differential coefficients of the variables of lnSTIFY were somehow at the intermediate levels, i.e., the long-run elasticity coefficient was computed as:

$$0.171785\left(\text{i.e.,}\frac{0.356765-0.253532}{1-0.335947}\right)$$

and the short-run elasticity coefficient was 0.340016. In other words, it was indicated that the elasticity of the contribution of the science and technology investment on the local economic growth was 0.171785 in the long term and 0.340016 in the short term. Whenever the science and technology investment was increased by 1%, the regional growth of GDP would be elevated by 0.171785 in the long term and 0.340016 in the short term accordingly with the elasticity coefficients estimated.

Estimate of promoting efficiency and performance evaluation of the science and technology investment on the local economic growth of fuyang city: In order to estimate the exact role and contribution of the science and technology investment on the local economic growth in Fuyang city, a novel variable was introduced and defined as the so-called "the relative driving efficiency" which meant how much does the science and technology investment contribute to the increased shares of the whole regional economic gain (GDP). This variable denoted as Q:

$$Q=\frac{\sum_{1}^{n}(SST_i/INGDP_i)}{n}$$

where, n was the reported years (n = 1996-2012) and the variable SST was the annual share of the contribution of the regional science and technology investment in the enlargement of the local economic growth (i.e., the annual increased GDP share InGDP) while the variable INGDP was defined as GDP×GDP growth rate. If Q<1, it represented the contribution or impact of the variable (lnSTIFY and ΔlnSTIFY) was negative and the increased share of GDP accounted for less than the amount of the variable itself. If Q>1, it indicated the contribution or impact of the variable (lnSTIFY and ΔlnSTIFY) was positive and the increased share of GDP accounted for more than the amount of the variable itself. In the case of Fuyang city analyzed in the present study, the Q statistic was computed as 9.497250794 which meant the promoting efficiency of the science and technology investment on the regional GDP in Fuyang city was very significant (Table 4).

Endogenous growth theory appreciates the crucial role played by science and technology in the fostering of economic growth. Many developing countries around the world are looking at investments in science and technology as a means to spur regional economic development and wealth creation while preserving national competitiveness. Nevertheless, there are huge scientific and technological gaps among developed, emerging and developing countries, between developed and undeveloped areas within a country. In fact, the performance of the science and technology investment on local economic growth (or GDP) is usually higher in emerging and developing and undeveloped countries and/or areas than that of developed countries and/or areas. As it was analyzed and indicated in Table 4, the promoting efficiency of the science and technology

Table 4: Estimate of promoting efficiency and performance evaluation of the science and technology investment on the local economic growth in Fuyang city

Initial year	End year	SST/GDP statistic	Q statistic
1997	2012	151.9560127	9.497250794

investment on the local economic growth of Fuyang city was very remarkable according to the Q statistic of 9.497250794. Many researches utilizing various methods got the similar results to that of the present study, i.e., investments in science and technology were the determinant factors and crucial means to accelerate the local economy growth. For instance, Co (2000) investigated the impact of R&D, foreign direct investment and technology sourcing on the economic growth using a panel data. They found that FDI could affect the host country's R&D activities and the increase in R&D intensity was attributed to foreign firms' R&D activities to acclimatize to the conditions of USA. Zhong *et al.* (2011) reported the performance evaluation of 30 regional R&D investments in mainland China with Data Envelopment Analysis (DEA) models and found undeveloped provinces were technical efficient and their performance of regional R&D investments needed to be improved. Particularly, constant returns to scale had prevailed in most provinces in the Western region with the highest average radial efficiency score while decreasing returns to scale had prevailed in most provinces in the Eastern and Central regions, although there were no direct relationships between global technical efficiency and the amount of R&D investment. Hu *et al.* (2014) applied the distance function approach for Stochastic Frontier Analysis (SFA) to compare the national R&D efficiency with efficiency scores across 24 nations during 1998-2005. They found that many factors, such as intellectual property rights protection, technological cooperation among business sectors, knowledge transfer between business sectors and higher education institutions, agglomeration of R&D facilities and involvement of the government sector in R&D activities, significantly improve the national R&D efficiency and economic infrastructure. Fu and Gong (2011) and Fu *et al.* (2011) explored the role of indigenous and foreign innovation efforts in technological change and technology catching-up and their interactions in the developing countries or emerging economies. They found collective indigenous R&D activities at the industry level were the major driver of technology upgrading of indigenous firms that pushed out the national and/or local economy. While foreign investment appeared to contribute to static industry capabilities, R&D activities of foreign-invested firms had exerted a significant negative effect on the technical change of local firms over the sample period in China. Other scholars concentrated on innovation or technological innovation and its performance and impact on the national and/or local R&D activities which gave us salutary examples, references and suggestions in decision-making. These are indirect or relevant evidences for the impact of the science and technology investment on the local economic growth since innovation or technological innovation could contribute more to the production efficiency and yield and competitiveness of firms or industries. Gibson and Naquin (2011) regarded innovation investment as an exact science in the study of Portugal investing in technological innovation. They discovered that in some cases, an investment in the capacity building of human networks to engage in technology transfer and commercialization related activities could act as a stronger facilitator for the transformation of economies and produce a larger return on investment in innovation for the country. They pointed out that it could be surmised that continued investing in innovation was critical to the development for Portugal, despite the economic uncertainty of the country and region financial models. Liu *et al.* (2014) examined how industry characteristics affect industry innovation activities (i.e., make and buy activities) using panel data analysis for a sample of Chinese high-technology industries from 1998-2008. They found that foreign competition and industry skill intensity and their interaction were the most impacting factors affecting the intensity of both buying and making activities that were positively associated with the degree of buy activities and the production efficiency and output of high-technology industries.

CONCLUSION

The present study established the error correction model and analyzed the correlation between the science and technology investments and the regional GDPs in Fuyang city. As can be seen from the analysis of elastic coefficients, the potential impact or contribution of the science and technology investments on the regional GDPs was significant in Fuyang city. It was found that there was a significant correlation between the local science and technology investment and the amount of regional economic growth (GDPs) from the point of view of the contribution and promoting elasticity coefficients, in which it was estimated that the regional growth of GDP in Fuyang city would be driven by 0.171785 in the long term and 0.340016 in the short term when the science and technology investment was increased by 1% according to the elasticity coefficients. Moreover, the index of potential promoting efficiency of the science and technology investment on the regional GDP was very remarkable with the Q statistic of 9.497250794. As Fuyang is a typical undeveloped city in industry, the results of the present study are suitable for understanding the phenomena of economic development and needs of increasing the R&D capital investments in undeveloped or less developed areas. That is to say, the potential impact or contribution of the science and technology investments on the local economic growth would be very huge. The local government could invest more funds, human capital and material resources in the regional scientific research and development expenditure to promote and/or accelerate the local economic growth rapidly.

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