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Research Article

Empirical Analysis of the Regional Development Levels of Contemporary Agricultural Science and Technology in Fuyang City, China

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Abstract: Contemporary agricultural science and technology is under great scrutiny. Understanding the past and current trends of Agricultural science and technology is crucial. Fuyang city is one of the Chinese traditional big agricultural cities and the largest city in terms of population in Anhui province, China. In the study, an index system for the development and innovation levels of agricultural science and technology was established and the regional innovation of current agricultural science and technology in Fuyang city was empirically evaluated and analyzed by using the index system based on the existing annual data available. The purpose of this study was to make an objective analysis and evaluation of the sub-area innovation levels among urban districts and counties in Fuyang city. All the data was processed and transformed simultaneously based on the same scales of social-economic index and next analyzed based on the methods of factor analysis in view of dimension reduction. Finally, the comprehensive evaluation was carried out and the scores was ranked as followed by Linquan county, Yingshang county, Funan county, Taihe county, Jieshou county, Yingzhou district, Yingquan district and Yingdong district. It is concluded that the innovation level of Fuyang city is unbalanced with two main features. Firstly, on the whole, the city's innovation is rather active with supports from subordinate districts and counties, but the innovation levels of subordinate counties are better than those of urban districts in view of the quantities and activities of agricultural science and technology innovation. Higher levels of agricultural science and technology innovation are seen in the natural growing zones. Secondly, in consideration of agricultural science and technology innovation, the different indicators of counties and districts in Fuyang city have shown their own advantages and disadvantages, especially on specific negative principal component score which shows that the corresponding defects on specific principal components. That is, the district or county are relatively backward in corresponding index of agricultural science and technology innovation and even some of the principal component factor have become the bottleneck of these districts or counties for innovation and sustainable development.

Keywords: Agricultural science and technology, empirical analysis, evaluation, Fuyang city

INTRODUCTION

Science and technology are at the core of agricultural change. Fundamental and applied research in biology, chemistry and genetics has resulted in a constant flow of innovations and technical changes that have greatly influenced agricultural systems (Biggs, 1990; Feder and Umali, 1993). Presently, the direction of agricultural science and technology is now under great scrutiny (Feder and Umali, 1993; Vanloqueren and Baret, 2009). Understanding the past and current trends of Agricultural science and technology is crucial if more holistic approaches has been backed and implemented by a global international assessment of Agricultural science and technology for development.

Fuyang city is located in the northwest of Anhui province, China, with a land area of 1012276.81 ha (i.e., 10122.7681 km^2) and the cultivated land area of 633043.20 ha (i.e., 6330.4320 km^2). The figure of current population in Fuyang city is more than 10 million, among which about 8.5 million people are from the agricultural population. Therefore, Fuyang city is regarded as the largest city in terms of population in Anhui province, China. Fuyang city is also one of the Chinese traditional big agricultural cities. On one hand, there are rich Chinese herbal medicine resources in Fuyang city. In recent years, the overall biological medicine industry of Fuyang city has been improved significantly and it has been one of the six pillar industries in the city. Furthermore, the climate in Fuyang city belongs to the type of warm temperate zone and semi-humid region in the climate boundary of Chinese north and south plains and mountains, in which the climate is rather well and suitable for the planting of herbal medicine and crops with flat land, fertile soil, clear seasons, adequate rainfall and sufficient sunlight.

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It is suitable for cultivation and planting of radix *Paeoniae alba* (i.e., "bai shao"), *Liquorice* (i.e., "gan cao"), bitter *Chrysanthemum* (i.e., "ku ju"), *Mugwort* (i.e., "ai gao"), *Platycodon grandiflorum* (i.e., "jie geng"). On the other hand, agricultural income becomes the main source of farmers' incomes and farming is the key source of the agricultural production in Fuyang city. Recently, the agricultural structure in Fuyang city has had a good start in adjustment and development through the practice exploration in many years. Actually, there have been some great changes in agriculture, such as the high quality of special agricultural products, the efficient economic crops, animal husbandry and aquatic products have got fast development and become the main economic growth points in Fuyang city. For instance, the main production is just beginning to concentrate in the planting to increase and widen farmers' income channels. It should be noted that the planting in Fuyang city has been designed and pushed forward in priority to food production (mainly wheat, corn, soybeans, red taro and rice crops) and economic crops as supplement (mainly vegetables, cotton, oil-bearing crops, fruit and other featured plants), with production continuing to grow in recent years. Meanwhile, animal husbandry has become a dominant industry of the rural economy in Fuyang city too with an output amounted to about 36% of the whole city's agricultural value yield. The agriculture industrialization promotion action has been launched by the city's agriculture department from 2008 to current, the city is accelerating and striving to cultivate the leading agricultural enterprises in the products processing by strong innovation in agricultural science and technology and the construction of agricultural industrialization management, in order to improve the comprehensive benefit and the market competitiveness of agricultural products. By 2012, the agriculture industrialization promotion action leaded to the city's agricultural product processing and a total agricultural industry output of 18 billion Yuan in Fuyang city. The main processing of agricultural products has been raised from 30 to >50%, while the main agricultural products deep processing ratio has been raised from 18 to 35% or above. Moreover, ten leading enterprises have been established as the core of the agricultural industry clusters Fuyang city. In recent years, in view of the development of ecological animal husbandry, the city mainly focuses on the plant-eating or pasturing animals, such as cattle and goats to seek breakthrough in animal husbandry and the further processing industry. For example, there were currently 1.7 million cattle bred in Fuyang city, which accounted for 30% of this in Anhui province and 1.2% of that in China, while there were 4.8 million goats bred, which accounted for 23% of this in Anhui province and 1.3% of that in China reported in 2012.

At present, China's agriculture is experiencing the crucial period of developmental transformation and change from traditional agriculture to modern agriculture, while various regional agricultural demands for science and technology are more and more intense, especially the requirement of agricultural science and technology achievements and their urgent transformations (Renzhou, 2008; Li and Qiang, 2009; Enping, 2010; Jun *et al*., 2012; Jinghua and Jingdun, 2012). The economy development in agricultural areas of China, such as the northern of Anhui province, needs an urgent lead and support of science and technology to improve the agricultural productivity and promote agricultural high and stable yields and the transformation of agricultural scientific and technological achievements in rural areas (Jinghua and Jingdun, 2012). However, there are relative lacks in funding and manpower resources in the agricultural science and technology of Anhui province for a long time. Furthermore, there are also lack relevant supporting policies for agricultural science and technology achievements and their transformations. Due to the influence of Chinese traditional economic structures and historical cultures, agriculture has always been the economic pillar industry in the northern of Anhui province (Jun *et al*., 2012; Jinghua and Jingdun, 2012). How to make an objective and scientific evaluation of the agriculture development and agricultural science and technology innovation levels in such a typical agricultural area is critical and vital important task and work for the scientific orientations of region agricultural development goals and corresponding correct strategy-making and measures-taking. Due to the constraints in agricultural science and technology and its resources, the agricultural modernization levels of Fuyang city and the surrounding areas fell behind and are still not prosperous and flourishing. For example, as for the productivity of agricultural labor and other essential productive factors, there are still gas between Fuyang city and some advanced domestic cities and areas.

In the study, Fuyang city is taken as an example to explore the development and innovation levels of agricultural science and technology in the traditional agriculture area of Anhui province, China. The primary analysis and evaluation of the development and innovation levels of agricultural science and technology in the counties and districts of Fuyang city are made here in order to explore their relative differences and comparative advantage for further objective and systematic analysis and evaluation of the whole development and innovation levels of agricultural science and technology in the northern of Anhui province.

MATERIALS AND METHODS

The establishing of evaluation index system for the development and innovation levels of agricultural science and technology: In the present study, all the

Table 1: The evaluation index system established for the regional development and innovation levels of agricultural science and technology

The index code	The adopted evaluation index
T1	The increased production value of agricultural industry (10,000 Yuan)
T2	The agricultural industry population (10,000)
T3	The farmers' per capita net income (Yuan)
T4	The farmers' per capita living consumption expenditure (Yuan)
T5	The total output production value of planting, forestry, animal husbandry and fishery (10,000 Yuan)
T6	The increased ecological-economic production value of planting, forestry, animal husbandry and fishery (10,000 Yuan)
T7	Number of provincial agricultural science and technology integrated unit
T8	Number of public patents applied
T9	Number of municipal science and technology achievement award item
T10	Rural social retail sales of consumer goods (10,000 Yuan)
T11	Agricultural mechanization (tractors, harvesters and threshing and tools such as pump) of the total power (kw)
T12	Large and medium-sized agricultural tractor power (kw)
T13	Agricultural small tractor power (kw)
T14	Combine-harvester tractor power (kw)
T15	Farm transporter power (kw)
T16	The commonly used arable farmland at the end of year (ha)
T17	Agricultural fertilizer usage (ton)
T18	Pesticides (ton)
T19	Agricultural diesel usage (ton)
T20	Number of science and technology stations in township
T21	Number of science and technology culture practitioners

annual data are abstracted from Fuyang "City Statistical Yearbook (2011)" and "Anhui Province Statistical Yearbook (2011)" and the original annual data was processed and transformed into logarithms based on the same scales of Chinese social and economic indexes (e.g., consumer price index and other index to eliminate the possible hetero-scedasticity), among which the R and D funds and cost data of regional agricultural science and technology were unavailable and replaced by using R and D funds and spending and their related indicator elements in all the counties and districts of Fuyang city. In consideration of the availability of regional annual data, a total of 21 indicators for corresponding indexed are included in the established evaluation index system in the study (Table 1).

To explore and compare the regional development and innovation levels of agricultural science and technology in an area, one must build a set of scientific and objective evaluation index system for the development and innovation of agricultural science and technology (Renzhou, 2008; Li and Qiang, 2009; Enping, 2010; Jun, 2012; Jinghua and Jingdun, 2012). The evaluation index for the development and innovation levels of science and technology is usually referred as some quantity and quality indicators and factors or elements adopted relevant to the input and output of enterprises or sectors or departments, mainly in including R and D (Research and Development) funds, fixed assets human capital investment and commodity output and/or the number of public service, etc., in order to monitor and analyze the progress of science and technology development and innovation, achievements and their corresponding market competition. The establishment of evaluation index system for the development and innovation levels of agricultural science and technology should follow the systematic, objectivity, timeliness and feasible principles to ensure the trustworthiness and reliability, effectiveness and easy access and operability of index elements and datasets. Due to the development and innovation of science and technology is a process of high investment and high uncertainty of activity, with the pursuit of unified processes and results, the evaluation index system for the development and innovation of agricultural science and technology must reflect the quantity and quality of input and output, resources and their indicators for the regional agricultural science and technology.

The model of factor analysis: In fact, a comprehensive analysis of 21 indicators is difficult in view of the high dimension. Since there are certain correlations between the indexes, factor analysis can be used to conduct a comprehensive analysis and reduce the high dimension and convert these 21 indicators into several index based on the method of multiple regression analysis, on the premise of lost a little information. Thus, we could only consider a few principal component elements of the evaluation index system by using the standardized processing and KMO statistical tests (Kaiser-Meyer-Olkin) in the statistical software SPSS Version 18.0. Furthermore, it is easier to seize the key influence factors of the development and innovation levels of agricultural science and technology to improve the efficiency of the analysis. Factor analysis is an objective method of weighting its original indicators with different dimensions in order to eliminate their potential influence on the evaluation results. The principal component factor score matrix can be obtained through computing the data of various counties and districts in the following principal component factor score calculation formula:

$$S = \frac{\sum_{i=1}^{4} M_i V_i}{\sum_{i=1}^{4} V_i} \quad (1)$$

In the principal component factor score calculation formula (1), the comprehensive scores for various counties and districts are recorded as S, while specific factor scores are to be remembered as Mi (marker "i" is the number of final principal component factors, herein, it is referred as from 1 to 4). Furthermore, the contribution variance of the i^{th} factor is to be labeled as Vi.

RESULTS AND DISCUSSION

The annual data are dealt with the statistical software SPSS Version 18.0 passing through the KMO (Kaiser-Meyer-Olkin) statistical tests. These variables are suitable for further factor analysis and the principal component factors and extracted information are shown in Table 2. It can be seen from Table 2 and 3 that there are four main ingredients or principal component factors of the cumulative variance contribution rate more than 90%. Moreover, these four main ingredients or principal component factors are closely related to 18 variables among the original 21 variables and the common joint degrees with those 18 variables are more than 0.90. Therefore, we can deduce that these four principal component factors generally represent the main information of the original 21 variables. However, the values of these four principal component factors and each index of the original variables are not obviously marked; the method of maximum variance rotating of principal component load matrix is further carried out to obtain a principal component rotation matrix (Table 4).

It could be inferred from Table 4 the following points of view: the first principal component factor reflects the main indexes of agricultural acquirements in the following aspects for these counties and districts in Fuyang city: the number of provincial agricultural science and technology integrated unit and relevant agricultural science and technology innovation activities (T7), the fixed asset investment (including the total power of agricultural mechanization T11, agricultural large and medium-sized tractor power T12, agricultural small tractor power T13 and farm transporter power T15), the commonly used arable farmland at the end of year (T16), agricultural intermediate consumption (including agricultural fertilizer consumption T17, pesticide consumption T18 and agricultural diesel oil consumption T19, etc.) and the investment of human capital or human resources in township agricultural science and technology culture (T20, T21) and the rural social retail sales of consumer goods (T10).

Table 2: The rotation characteristics and variance contributions of principal component factors

Principal component	Extraction S.S. loadings			Rotation S.S. loadings		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	14.703	70.014	70.014	10.574	50.351	50.351
2	1.954	9.303	79.318	3.919	18.661	69.013
3	1.636	7.789	87.106	3.088	14.706	83.719
4	1.072	5.106	92.212	1.784	8.493	92.212

S.S.: Sum of square

Table 3: Principal component factors and their joint degrees extracted from original variable

The evaluation index	The index code	Initial	Extract
The adopted evaluation index	T1	1.000	0.985
The increased production value of agricultural industry (10,000 Yuan)	T2	1.000	0.983
The agricultural industry population (10,000)	T3	1.000	0.941
The farmers' per capita net income (Yuan)	T4	1.000	0.958
The farmers' per capita living consumption expenditure (Yuan)	T5	1.000	0.985
The total output production value of planting, forestry, animal husbandry and fishery (10,000 Yuan)	T6	1.000	0.985
The increased ecological-economic production value of planting, forestry, animal husbandry and fishery (10,000 Yuan)	T7	1.000	0.869
Number of provincial agricultural science and technology integrated unit	T8	1.000	0.981
Number of public patents applied	T9	1.000	0.923
Number of municipal science and technology achievement award item	T10	1.000	0.866
Rural social retail sales of consumer goods (10,000 Yuan)	T11	1.000	0.977
Agricultural mechanization (tractors, harvesters and threshing and tools such as pump) of the total power (kw)	T12	1.000	0.762
Large and medium-sized agricultural tractor power (kw)	T13	1.000	0.948
Agricultural small tractor power (kw)	T14	1.000	0.988
Combine-harvester tractor power (kw)	T15	1.000	0.796
Farm transporter power (kw)	T16	1.000	0.989
The commonly used arable farmland at the end of year (ha)	T17	1.000	0.865
Agricultural fertilizer usage (ton)	T18	1.000	0.748
Pesticides (ton)	T19	1.000	0.978
Agricultural diesel usage (ton)	T20	1.000	0.939
Number of science and technology stations in township	T21	1.000	0.901

Table 4: The rotated principal component factor matrix

The evaluation index	The principal component			
	1	2	3	4
T1	0.850	0.376	0.345	0.028
T2	0.820	0.472	0.297	0.016
T3	-0.317	0.007	-0.913	0.087
T4	-0.312	-0.256	-0.862	0.227
T5	0.843	0.385	0.355	0.019
T6	0.850	0.376	0.345	0.028
T7	0.807	0.018	0.380	0.268
T8	0.050	0.093	-0.126	0.977
T9	0.093	0.901	-0.101	0.303
T10	0.598	0.605	0.326	-0.193
T11	0.802	0.514	0.224	-0.139
T12	0.668	0.175	0.252	-0.470
T13	0.807	0.474	0.151	-0.220
T14	0.361	0.734	0.424	-0.373
T15	0.573	0.663	0.166	-0.021
T16	0.830	0.416	0.297	-0.197
T17	0.807	0.460	-0.043	-0.008
T18	0.824	0.035	0.259	-0.020
T19	0.832	0.031	0.474	0.244
T20	0.882	0.325	0.183	-0.149
T21	0.916	0.145	0.152	-0.135

Table 5: The principal component factor score matrix

The evaluation index	The principal component factor			
	M1	M2	M3	M4
T1	0.072	0.006	0.030	0.062
T2	0.052	0.062	0.006	0.052
T3	0.136	0.060	-0.523	-0.077
T4	0.185	-0.075	-0.475	0.008
T5	0.065	0.012	0.037	0.058
T6	0.072	0.006	0.030	0.062
T7	0.131	-0.166	0.092	0.204
T8	0.000	0.069	0.053	0.587
T9	-0.171	0.467	-0.024	0.201
T10	-0.048	0.180	0.053	-0.063
T11	0.059	0.082	-0.062	-0.054
T12	0.102	-0.078	-0.067	-0.263
T13	0.091	0.054	-0.126	-0.116
T14	-0.170	0.302	0.156	-0.149
T15	-0.032	0.219	-0.021	0.022
T16	0.074	0.023	-0.030	-0.082
T17	0.139	0.050	-0.225	-0.015
T18	0.169	-0.174	-0.038	0.008
T19	0.111	-0.163	0.146	0.203
T20	0.139	-0.040	-0.116	-0.074
T21	0.200	-0.144	-0.148	-0.078

In addition, some information of the increased production value and workers of agricultural industry (T1, T2), the total output production and increased values of planting, forestry, animal husbandry and fishery (T5, T6) and other agricultural output aspects are abstracted and computed too. The second principal component factors mainly reveals the number of municipal science and technology achievement award item (T9), rural social retail sales of consumer goods (T10), agricultural fertilizer usage in the production (T17), the total power of agricultural mechanization including tractors, harvesters and threshing machine and other tools like pump (T11), especially the agricultural small tractor power (T13), combine-harvester tractor power (T14) and farm transporter power (T15). The third principal component factor indicates the levels of farmers' per capita net incomes (T3) and per capita living consumption expenditures or costs (T4), etc. The fourth principal component factors merely show the agricultural number of public patents applied (T8) in Fuyang city. These principal component factors are the basically indicators of the evaluation index for the development and innovation levels of agricultural science and technology.

In order to better measure the significance and relative weigh of each variable loaded on the principal component factor score matrix, one can take advantage of the statistical analysis, the principal component factor score matrix (Table 5) and the coefficients and scores of the ranked principal component factors computed and deduced according to principal component factor score coefficient values and their standardization (positive correlation or negative correlation, (Table 6). Herein, the composite scores of the ranked principal component factors are calculated by formula 1.

Among the counties and districts in Fuyang city, Linquan county gets the highest scores (Table 6), especially in the fourth and first principal component factors with high scores with description of its superiority in public patent application, fixed asset investment, quantity of public intermediate consumption, agricultural human capital investment, cultivated farmland, the number of provincial agricultural science and technology integrated unit, the number of municipal science and technology achievement award item, rural social retail sales of consumer goods and a number of other indicators in agriculture industry, such as the increased production value and workers of agricultural industry (T1, T2) and the total output production and increased values of planting, forestry, animal husbandry and fishery (T5, T6). The second ranked is the Yingshang county with its highest score on the first principal component factor, as one can see it also beat high in the fixed assets investment, the middle of agricultural consumption, human capital investment, the cultivated farmland at the end of year and the number of provincial agricultural science and technology integrated unit.

However, Yingshang county has got negative scores in the second and fourth principal component factors, which indicates Yingshang county is relatively backward in some agricultural science and technology innovation activities, such as patent application quantities, the number of municipal science and technology achievement award item, rural social retail sales of consumer goods and the farm transporter power and the total power of agricultural mechanization (i.e., Jieshou county and other counties have similar problems in the second and fourth principal component factors). In other words, these counties attached great importance to the input of agricultural science and technology, but neglected the transformation, application and patent applying of agricultural science and technology achievements and other protection issues of intellectual property rights, which is of importance to the northern of Anhui province and surrounding regions. It is also currently one of the main

Table 6: The regional development and innovation level scores of agricultural science and technology of subordinate counties and districts

The counties and districts	The principal component M1	M2	M3	M4	Composite score	Comprehensive ranking
Linquan county	0.991	0.781	0.753	1.128	0.882742	1
Yingshang county	1.233	-1.093	0.379	-0.322	0.774670	2
Funan county	0.575	-0.476	0.974	-0.491	0.409093	3
Taihe county	0.499	1.780	-1.024	-1.207	0.373574	4
Jieshou county	-0.461	0.260	-0.663	1.711	-0.262850	5
Yingzhou district	-0.244	-1.222	-1.426	-0.520	-0.422140	6
Yingquan district	-0.919	-0.361	-0.305	0.434	-0.678610	7
Yingdong district	-1.674	0.330	1.313	-0.732	-1.076440	8

problems of Anhui province and other neighboring provinces.

From an overall perspective, all the counties are generally better and more active than the subordinate districts in the development and innovation of agricultural science and technology, which is in accord with the actual situation in Fuyang city. Because there are less arable land or farmland in these districts than those counties in Fuyang city, agricultural science and technology cannot be commonly used in urban areas, plus the labor input in the subordinate districts and the urbanization levels of district residents are higher than those of subordinate counties, therefore, a comprehensive ranking results in first of the four counties (Linquan county, Yingshang county, Funan county, Taihe county and Jieshou county) and then the three districts (Yingzhou district, Yingquan district and Yingdong district).

CONCLUSION

In the present study, it is shown that the development and innovation levels of agricultural science and technology of subordinate counties and districts in Fuyang city are ranked as followed by Linquan county, Yingshang county, Funan county, Taihe county, Jieshou county, Yingzhou district, Yingquan district and Yingdong district, Among which Linquan county beats the highest scores and Yingdong district gets the lowest scores.

Obviously, the various ranking scores of counties and districts for the development and innovation levels of agricultural science and technology reveals there is a great imbalance in the subordinate regions of Fuyang city, which is highly related to its geographical position and the abundance of natural resources. However, various counties and districts have their own advantages and disadvantages, especially on some positive and negative principal component scores. The evaluation index system and method used in the study can also be used to comprehensive analyze the development and innovation levels of agricultural science and technology in other similar areas or agricultural districts or subordinate parts of a city.

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