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THE RELATIONSHIP BETWEEN KNOWLEDGE OF AGRICULTURAL ENTREPRENEURS AND AGRICULTURAL PRODUCTIVITY GROWTH IN RURAL CHINA: A QUANTILE REGRESSION APPROACH

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Abstract

Knowledge of agricultural entrepreneurs plays a vital role in promoting agricultural growth. This paper adopts cross-sectional data from 2003 to 2013 and employs quantile regression model to investigate the contribution of entrepreneurial knowledge to agricultural growth in China. The graphical results of the quantile regression reveal some discrepancies between the OLS and the quintile coefficients. The results show that patent application greatly contributes to the growth of agricultural production during the study period. The influence of patent application is higher at lower quantiles (15th, 25th, 35th ad 75thquantiles) but decreases at 90th quantile. The contribution of agricultural research shows a continuous increase at the 15th, 25th and 95thquantile with all variables being statistically significant. The effect of agricultural research and development institutions on the upper 95th quantile growth is greater than the values at the other quantiles, owing to an improved technology by the R&D institutions in China.

Keywords: Agricultural entrepreneurs; Knowledge; Agricultural growth; R&D; China

INTRODUCTION

The contribution of agricultural entrepreneurs to the growth of agricultural sector is a vital issue, which has not received the attention it deserves for some decades. According to Schumpeter (2000), entrepreneur is prime mover in the economy and his new combination leads to enterprise creation for economic growth . For the past decades, several studies have investigated into the consequences of entrepreneurs in relation to the performance of an economy. Theories in entrepreneurial development have disclosed that an increase in the aggregate economic growth in every economy is due to entrepreneurial activities (Carree & Thurik, 2003, 2010). The growth of every economy, according to economist is measured by an increase in gross domestic products, which is possible due to the activities entrepreneurs (Acs, Audretsch, & Lehmann, 2013). Numerous studies analyzing the impact of entrepreneurship on economic performance measured growth in terms of the knowledge of its entrepreneurs. According to endogenous growth theory, investment in new knowledge serves as a conduit to economic growth (Audretsch, 2007; Grullón). Empirical studies used R&D stock variable to determine the development of total factor productivity (TFP)(Ganyaupfu; Sunding & Zilberman, 2001). The major role of technological innovation to economic growth in both theoretically and empirically is deeply rooted in the economic literature, however, the contributions of entrepreneurs to the development of an economy have not been highlighted in the economic research (Mansfield, 1972; Solow, 1956; Wong, Ho, & Autio, 2005). Studies which tried to study entrepreneurial knowledge and growth concentrated on how firms can generate knowledge both intrinsically and extrinsically through investment in R&D (Griliches, 1979; Nelson, 1987; Ramani, El-Aroui, & Carrère, 2008).Theory has maintained that the competency of a firm is determined by its knowledge base, which is identified through the combination of both scientific and technological mechanisms. However, the entrepreneurial competencies and available resources should be efficiently combined to promote economic growth and development (Nesta & Saviotti, 2005; Wu & Huarng, 2015).

The rapid growth of today's economy as a result of technological changes in the areas of ICT and telecommunication revolution has compelled many countries to adopt to ever changing word by introducing knowledge –based economic activities instead of the conventional large-scale production (Audretsch, 2007; Audretsch & Thurik, 2001a). The commercialization of knowledge-based economic activities by entrepreneurs is restricted due to the asymmetric and subjective nature of knowledge (Audretsch, Keilbach, & Lehmann, 2006).

The aim of this paper is to adopt flexible statistical techniques to reconcile the relationship between knowledge and agricultural growth. Surprisingly, few studies on this topic has employed semi-parametric regression model to study the complex relationship between knowledge of agricultural entrepreneurs and growth in agricultural sector. However, we adopts quantile regression, which is the appropriate quantitative technique to measure the relationship between knowledge of agricultural entrepreneurs and agricultural productivity growth in China by using cross-sectional data from 2003 to 2013.

The rest of the paper is organized as follows. Section 2 introduces the related literature, focusing on entrepreneurial knowledge in agriculture. Section 3 talks about representation of knowledge. Section 4 describes the methodological aspect of the study, which cover data source and empirical model. Section 5 presents the empirical results and discussions of the study. Finally, section 6 of the study illustrates the conclusion.

LITERATURE REVIEW

Entrepreneurial Knowledge in Agriculture

The contributions of knowledge to the process of innovation cannot be underestimated, since the introduction of new products is the sole responsibility of knew knowledge creation. Theory supports that effective knowledge management promotes innovation performance (KIKLA; Lai, Hsu, Lin, Chen, & Lin, 2014). According to Knowledge Spillover of Entrepreneurship (KSTE), knowledge is automatically equated with economic knowledge but not the same as traditional factors of production rather it involves knowledge spilling over (Acs, Braunerhjelm, Audretsch, & Carlsson, 2009). However, Audretsch, Coad, and Segarra (2014) argue that the creation of new knowledge serves as a source of available opportunities for entrepreneurs to come out with innovative ideas which are translated into new products and services. The commercialization of new knowledge created by incumbent firms and research institutions happens to be the activities of entrepreneurs (Audretsch et al., 2014). However, the entrepreneurial activity can be shaped by the economic and the institutional factors(Simón-Moya, Revuelto-Taboada, & Guerrero, 2014). KSTE is generally concerned with the various variables such as incumbent firms and research organizations that reshape entrepreneurship through knowledge creation (Ghio, Guerini, Lehmann, & Rossi-Lamastra, 2015). The theory also believes that entrepreneurship is not concerned solely with the individual characteristics, behaviors and traits but more importantly the endogenous response to the available opportunities created by the environment in which they find themselves (Audretsch, 2007).

The major role of agricultural entrepreneurship in today's technological market is to combine both the human and physical resource to promote industrial or agricultural growth (Naudé, 2015). Agricultural innovation is a process whereby partnerships and alliances are connected with knowledge users, knowledge producers and other actors involve in making innovation possible at the market place, policy and civil society arenas. Theories have disclosed that agricultural innovation is not just about investing into new knowledge but more importantly adding socioeconomic and environmental value to new ideas (Sunding & Zilberman, 2001). According to Coad and Rao (2008), investment made into R&D by entrepreneurs and organizations is risky activity; however, firms should make it possible to combine marketing expertise and to the new knowledge created to pave way for innovative products, which translate into firm's performance. Agricultural entrepreneurship comprises of industries in agricultural sector, which deal directly and indirectly with the production of agricultural products for profit maximization.

Agricultural innovation goes beyond what happens at the farm level, but more importantly, adding value along the value chain process and including policy level in agribusiness by stakeholders. According to Zhao (2005), there is a direct relationship between entrepreneurial development, innovation and productivity growth. The most outstanding feature of entrepreneur is the ability to take risk, indulge in creative destruction and come out with innovative activities (Morris, Kuratko, & Covin, 2010). The reactions between entrepreneurship and innovation contribute to the growth and survival of industries in today's competitive marketing environment. Therefore, the culture of the organization and management style are also major factors that can reshape and develop entrepreneurial innovative behavior (Zhao, 2005). To overcome the various challenges faced by entrepreneurs, there is the need to build collaborative innovation. This is defined as the pursuit of innovations across firm boundaries through the sharing of new ideas, new knowledge, expertise and the various opportunities available (Ketchen, Ireland, & Snow, 2007). The focus of agricultural innovation is on the characteristics of farm-levels and how innovation is adopted in the agricultural sector. According to innovation system theory, donors encourage innovations platform (IPs) for development through collaborations. Effective IP approaches and detail analysis of the value chain context will contribute to the sustainability and development of entrepreneurs in small businesses (Van Paassen, Klerkx, Adu-Acheampong, Adjei-Nsiah, & Zannoue, 2014).

For the past decades, researchers have tried to find the relationship between entrepreneurial competence, competence development and entrepreneurial performance in small business. For effective identification and pursuit of entrepreneurial opportunity, there should be a relationship between entrepreneurial performance and the development of competencies in all fields (Lans, Van Galen, Verstegen, Biemans, & Mulder, 2014). Studies on entrepreneurship in agriculture have increased because aside craftsmanship and managerial functions, farmers need entrepreneurial skills and culture to survive at the marketplace. The major problem associated with agricultural entrepreneurship is how to transit from production-orientation to multifunctional farming. Furthermore, re-development of an entrepreneurial identity, crossing the boundaries of agriculture and opening up a family farm has become major concerns for farm entrepreneurs (Seuneke, Lans, & Wiskerke, 2013. Theories have reported that practitioners, researchers and other stakeholders should find inroads into championing entrepreneurship into today's agriculture because entrepreneurship in agriculture provides a useful framework, which promotes agricultural growth (Seuneke, Lans, & Wiskerke, 2013).

Entrepreneurship, value chains and market linkages are terms that are currently used when talking about agriculture and farming (Kahan, 2012). Entrepreneurialism in agriculture is now associated with the role of any other entrepreneur, which focuses on gaining profit, efficiency, specialization, expansion and optimization of management to maximize profit (Lans, Van Galen, Verstegen, Biemans, & Mulder, 2014). Entrepreneurship in agriculture is a complex phenomenon due to the productive activity that farmers have to undertake and constant development of their personalities to become highly competitive and survive in the agri-business**.**

For the survival of farming enterprises in dynamic economy, farmers have to develop entrepreneurial skills and culture and aim at earning profits by taking calculated risk in their operations. Currently, agricultural entrepreneurs are compelled to take risks because the outcome of the various choices are unknown due to limited information (Mikko Vesala, Peura, & McElwee, 2007). According to Kahan (2012), since farmer-entrepreneurs are operated in a complex and dynamic environment, they are also considered as been part of value chain process. They belong to collection of people in the value chain such as suppliers, traders, transporters, processors, and other actors in the value chain process who deal in production and supplying of goods to the final consumer. Moreover, for farmer-entrepreneur to be successful in the farm business he needs to be technically competent, innovative, avoid high risk and set goals and objectives, which are attainable.

Representation of Entrepreneurial Knowledge

A study conducted by Coad and Rao (2008) has maintained that the related activities to innovation at either at the firm's level or organizational level can consist of research and development, acquisition of machinery, external technology, industrial design and linking training and marking to technological advances. The above items mentioned in one way or the other contributes to the growth of a firm or organization. However, these extraneous activities are quantifiable, which can be used to measure growth. Though, data on knowledge or innovation is hard to find and difficult to quantified, we strongly believe that for survival of agricultural sector in China, the contribution of agricultural entrepreneurs in terms of the level of innovation and knowledge will pivotal role. For the purpose of this theoretical exposition, we will represent entrepreneurial knowledge by patent applications, research and development personnel contributions, agricultural papers published in scientific journals and research institutions in the area of agricultural production.

However, that capital investment, fertilizer application, agricultural machinery and labor inputs and other conventional inputs are not the only factors promoting agricultural growth, but entrepreneurial knowledge exhibited by entrepreneurs fosters agricultural productivity growth (Audretsch & Thurik, 2001b; Long-bao, 2005). According to Shane and Venkataraman (2000), the investments made by entrepreneurs in R&D results in production of new knowledge output in the form of patent applications, codified knowledge published books, scientific papers or in patent publications and tacit knowledge in the field of technology which serves as a source of its knowledge base (Ghio et al., 2015). The model of the knowledge production function, formalized by Griliches (1979), also assumes that firms exist exogenously and then engage in the pursuit of new economic knowledge as input into the process of generating innovative activity. According to Audretsch and Feldman (2004), intellectual property acquired by a firm or an entrepreneur can be used to measure the growth rate of the firm. Audretsch (2012), indicates that firms with higher growth rates have a high tendency of holding intellectual property and intangible access such as trademarks as compared to firms with lower growth. Romer (1986), states that growth rate of the stock of knowledge depend positively on the amount of labor devoted to R&D. Moreover, Abdih and Joutz (2005) has that permanent increase in the amount of labor devoted to R&D have a long run effect on the growth rate of a firm. Audretsch and Feldman (2004), also, models the knowledge production function from the literature on innovation and technological change as $\mathrm{I} = \alpha \mathrm{K}D^{\beta}{}_{1}\mathrm{HK}^{Y}{}_{J}\varepsilon_{i}$ where, where *I* is the degree of innovative activity, *RD* represents R&D inputs, and *HK* represents human capital inputs. The unit of observation for estimating the model of the knowledge production function, reflected by the subscript *i*, has been at the level of countries, industries and enterprises. Also, Ramani et al. (2008), report that the investment in R&D generates new knowledge which results in patent application by a firm. The study further explained that patent application is affiliated to more than one technology classes, which promotes productivity growth. In addition, Ramani et al. (2008) proposes that 'knowledge created' by firm *i* in period *t* as $\mathrm{PA}_{i,t}$' where $PA_{i,t} = \left(PA^{1}_{i,t}, PA^{2}_{i,t}, \ldots, PA^{\mathrm{M}}_{i,t}\right)$ is a vector whose components are the number of patent applications of a firm *i* in year *t* in the various technology domain. Furthermore, the study states that given the possibility of affiliation to more than one technology class, the total number of patent applications by a firm could be less than the sum of patent applications affiliated to the different technology classes.

This is presented as;

$$PA_{i,t} \leq \sum_{k} \left(PA_{i,t}^{1} + PA_{i,t}^{2} + ...PA_{i,t}^{k} + ... + PA_{i,t}^{M} \right).$$

In addition, Ramani et al. (2008) reports that when firms invest in R&D expenditure, part of the knowledge generated by such investment will be accessible without costs to other firms as an externality, which also promote entrepreneurial knowledge and growth . Moreover, Coad and Rao (2008) in their study used patent applied by a firm and amount of research undertaken to represent innovation of a firm. The study concludes that patent and research undertaken by entrepreneurs promote firm growth; however, the major limitation of the use of patent as an indicator is that not all the inventions are patented or 'patentable'.

METHODOLOGY

Data source

We use time series data over the period of 2000 to 2013 from National Bureau of Statistics of China 2014 and China Statistical yearbook, various issues, 2014.

The Gross Output Value of total agricultural production (GROWTH) refers to the total value of products of agriculture, animal husbandry and fishery. It reflects the total scale and results of agricultural production from 2003 to 2013 and it is expressed in 100 million Yuan. Patent application (PtAPP), is the invention and utility of patents accepted and granted by international classification in the area of agriculture, forestry, animal husbandry and fishery. Scientific papers publication *(SCPP)* is the scientific papers (Social Science Citation Index(SSCI), Science Citation Index (SCI) and Conference proceedings Citation Index-Science (CPCI-S) taken by major foreign in the areas of the agriculture, forestry, livestock and aquatic.

Research personnel (RDPSnl) are taken from statistics on R&D activities and patents of full-time equivalent of R&D personnel (man-year) in the manufacturing and processing of agricultural products, food, beverages, tobacco, textile, timber, wood, leather and other agricultural products used for the basic statistics. Research and Development institution (RD Institution) is the number of scientific and development institutions in the area of manufacturing and processing of agricultural products, food, beverages, tobacco, textile, timber, wood, leather and other agricultural products used for the basic statistics.

Summary descriptive statistics and correlation matrix on the variables are given in table 1 and table 2 below.

Table 1. The statistical description of all the variables

Variable	Observations	Mean	Std.Dev	Min.	Max.	Skewness	Kurtosis
Total output	11	10.92	0.39	10.298	11.48	-0.036	-1.234
Patent	11	9.45	0.75	8.48	10.74	0.599	-0.782
RD Personnel	11	11.29	0.45	10.67	12.03	0.282	-0.682
Publication	11	7.78	0.65	6.72	8.52	-0.249	-1.529
RD Institution	11	8.21	0.05	8.05	8.27	-0.2524	7.763

Data source: ("National Bureau of Statistics, China Statistical Yeabook, various issues," 2000-2014)

Table 2. Correlation Matrix of the variables

Variable	1	2	3	4	
(1) Total output	1				
(2) Patent	0.975**	1			
(3) RD Personnel	0.765**	0.831**	1		
(4) Publication	0.920**	0.878**	0.810**	1	
(5) RD Institution	0.283	0.184	-0.051	0.06	1

Data Source: ("National Bureau of Statistics, China Statistical Yeabook, various issues," 2000 to 2014)

Empirical Model

To measure the effects of patent application, R&D institution, R&D personnel and agricultural papers published on the growth of agricultural production, the study adopts quantile regression (QR) over the ordinary least square model (OLS) for the estimation. The classical quantile regression model firstly introduced by (Koenker, 2004; Koenker & Bassett Jr, 1978) is regarded as an extension of OLS regression model. Least squares regression only measures how the changes in the vectors of the covariates x affects the conditional mean function of y .Theories have reported that OLS regression may not be the appropriate tool to measure the effect of x on y when the distribution of the responses is skewed (Baum, 2013; Uematsu, Khanal, & Mishra, 2013). Moreover, OLS regression is very sensitive to outliers, which may lead to inaccurate predictions due to the presence of multicollinearity, homoskedasticity, abnormal distribution and the independent nature of the residuals (Uematsu et al., 2013). However, QR is more robust to the non-normal error term and outliers in the model and takes into consideration the major effects of the covariates on the distribution of y holistically and not only the conditional mean. In addition, QR is invariant to monotonic transformation, which is different from OLS and also gives a detailed information about the estimated variables and give estimates coefficients of various-quantiles and forecast the coefficients as well (Huarng & Yu, 2014, 2015; Koenker & Bassett Jr, 1978; Uematsu et al., 2013).

According to Baum (2013), quantile regression is an appropriate tool to model conditional quartiles of the joint distribution of x and y. The quantile regression model firstly introduced by Koenker and Bassett Jr (1978) is presented by Baum (2013) as follows;

Let $\hat{y}(x)$ be the prediction function and $\varepsilon(x) = y - \hat{y}(x)$ be the prediction error.

Therefore, $L(\varepsilon(x)) = L(y - \hat{y}(x))$, denoting the losses in the prediction error. However, if $L(\varepsilon) = \varepsilon^2$ signifies the availability of squared error loss the least square becomes the optimal predictor. Med (y/x) ad the optimal prediction changes to $\hat{\Phi}$, which causes reduction of $\Sigma_i \left|y_i - x_i \Phi\right.$. Since the squared-error and absolute –error loss function becomes asymmetric; the prediction error sign becomes irrelevant (Koenker, 2004). However, if *q* is not 0.5, it means asymmetry increased as *q* get closer to either 0 or 1.

This study adopts the specifications of the previous literature on quantile regression. The conditional quantiles function for quantile τ firstly introduced by Koenker and Bassett Jr (1978) can be written as;

$$Q(\Phi_q) = \sum_{i:y_i \geq x_i^{'}\Phi}^{P} q\left|y_i - x_i \Phi_q\right| + \Sigma \sum_{i:y_i < x_i^{'}\Phi}^{P} (1-q)\left|y_i - x_i^{'}\Phi_q\right. \tag{1}$$

Where, *q* is the chosen quantile and Φ is the vector of parameters to be estimated.

According to Uematsu et al. (2013), the asymptotic distribution of quartile regression cam be modeled as:

$$\hat{\boldsymbol{\Phi}}_q \;\square\; \boldsymbol{P}\left(\boldsymbol{\Phi}_q, \boldsymbol{M}^{-1}\boldsymbol{L}\boldsymbol{M}^{-1}\right),$$

Where,

$$M = \Sigma_i q(1-q) x_1 x_i^{'}, L = \Sigma_i f_{u_q}\left(0\left|x_i\right.\right) x_i x_i^{'} \tag{2}$$

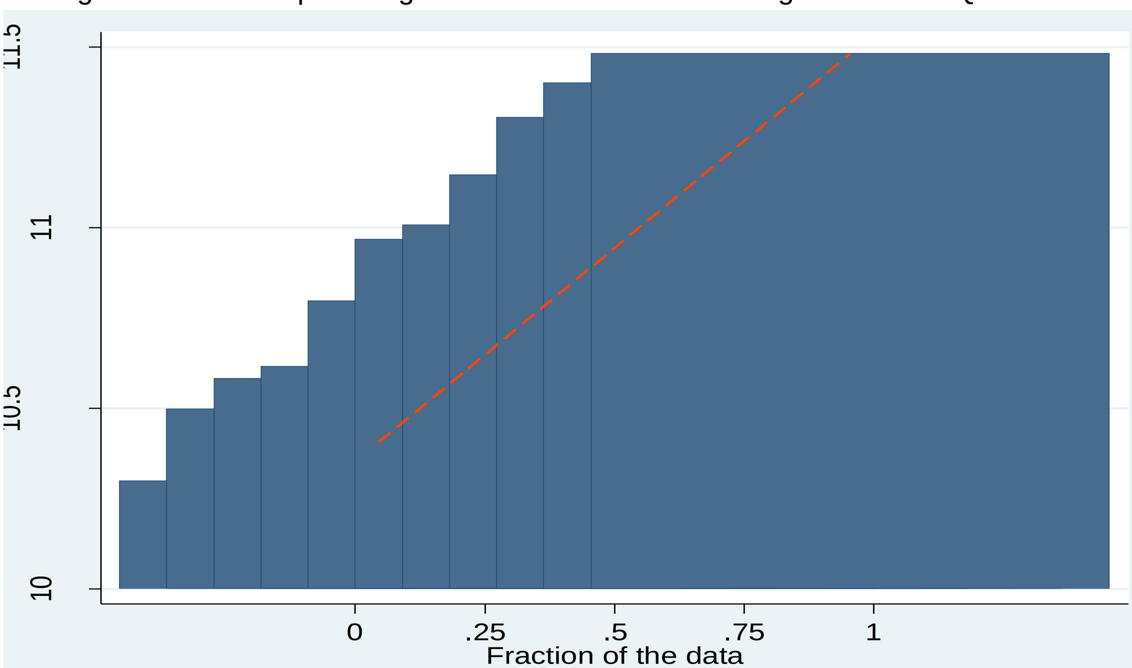
Where, $f_{u_q}\left(0\left|x_i\right.\right)$ is the conditional density function of error term for *qth* conditional quantile, $u_q = y - x^{'}\hat{\Phi}_q$ evaluated at $u_q = 0$.

We now estimate the linear regression model as below;

$$LnGROWTH_t = \alpha + \gamma_1 LnPtAPP_t + \gamma_2 LnPblc_t + \gamma_3 LnRDPsnl_t + \gamma_4 LnRDInst_t + \varepsilon_t \quad (3)$$

Where, GROWTH is estimated by the Gross Output Value of total agricultural production within a study period, (*PtAPP)* patent application in the area of agriculture, (*SCPP)* refers to scientific papers taken by major foreign in the areas of agriculture, (*RDPSnl)* is full-time R&D personnel and *RDInst* is the number of research institutions in agricultural production. γ is parameters to be estimated, ε is the error term and t is the year indices and *Ln* denotes that variables are in natural logarithm form.

Figure 1: Total Output of Agricultural Production Showing at Different Quantiles



Data Source: ("National Bureau of Statistics, China Statistical Yeabook, various issues," 2000 to 2014)

RESULTS AND DISCUSSIONS

In this section of our study, we presented the empirical results. Firstly, the scatter plots of variables of interest were conducted and the results for quantile regression are presented.

Figure 2 gives the results of scatterplots of patent, RD personnel, RD institution and publication on agricultural productivity growth. Apart from the results of RD personnel, which is different from what is expected, there is a strong correlation between the remaining variables and agricultural productivity growth. As stated by Coad and Rao (2008), though the scatterplots give us a clear picture of how the independent variables relate to dependent variables it cannot be used for any empirical conclusion since the plots do not have any control over misleading variable that may affect growth. However, quantile regression analysis was carried out to measure the actual effects.

Figure 2: Scatter plots of Publications and RD personnel on agricultural growth

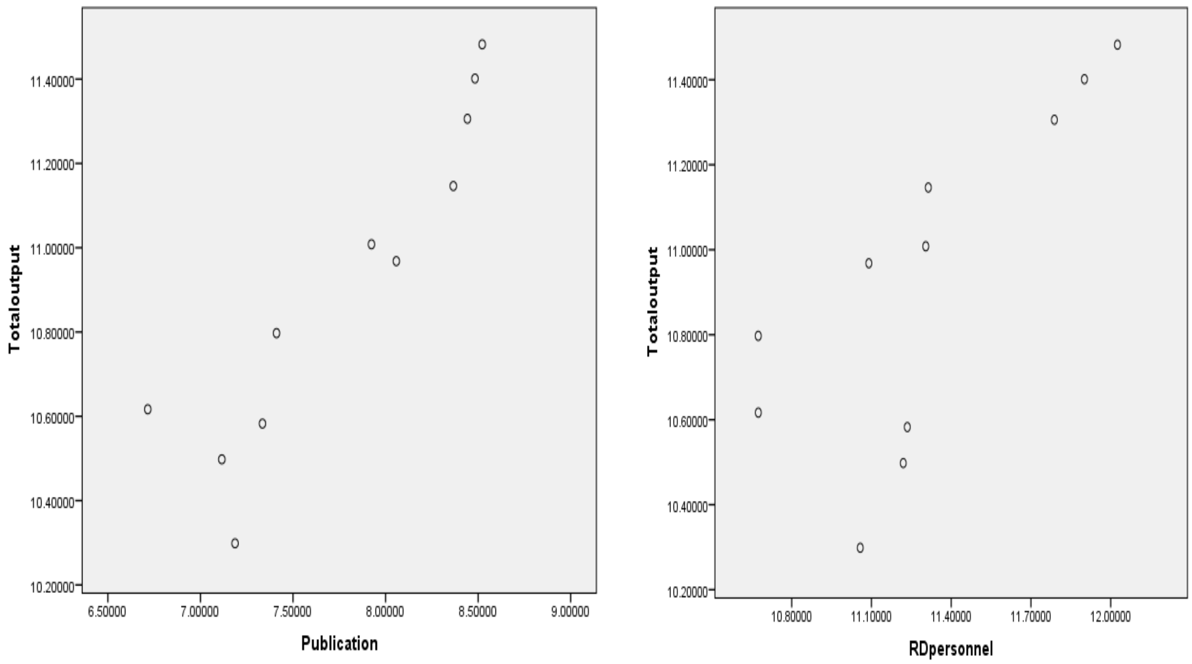
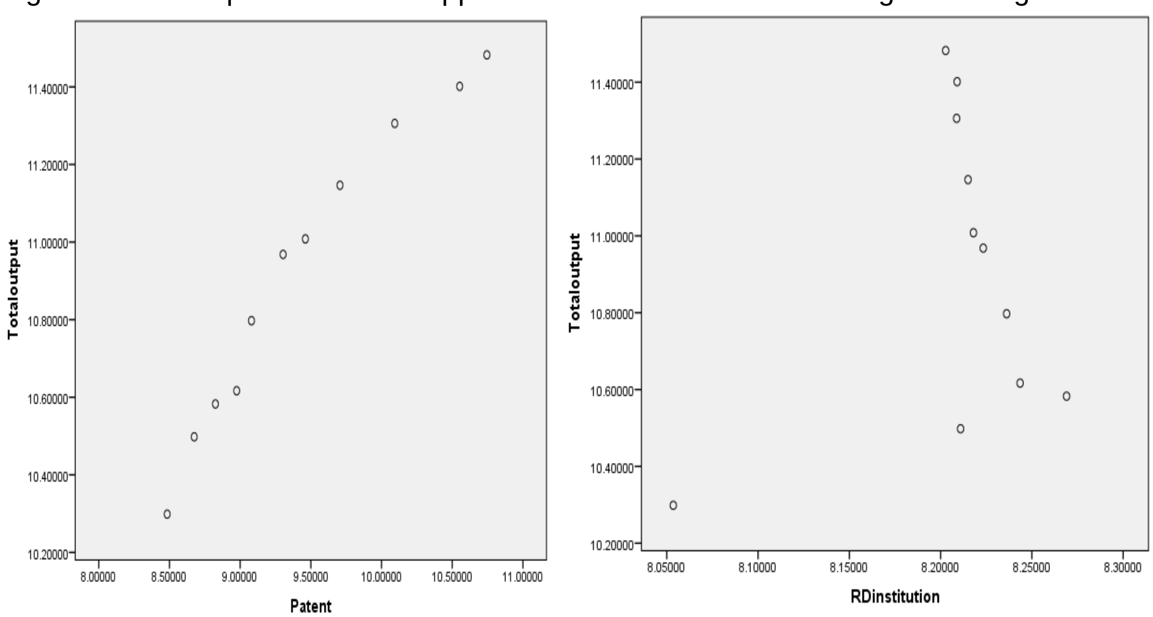


Figure 3: Scatter plots of Patent Application and RD institution on agricultural growth



Data source: ("National Bureau of Statistics, China Statistical Yeabook, various issues," 2000 to 2014)

Quantile Regression Analysis

For effective comparative analysis, we included the estimation of the model using OLS regression and the results are presented in the first column of table 3. In addition, quantile regression proposed by Koenker and Bassett Jr (1978) was adopted to control the heterogeneity of the distribution. Each selected quantile demonstrates the distribution characteristics of agricultural productivity growth and the marginal effects of growth output in agriculture is estimated by applying the quantile regression (Lv & Xu, 2016). For effective application of quantile regression to the study, the results of the quantile regression are reported for the 15th, 25th, 35th, 45th, 55th, 65th, 75th, and 95th percentiles. The estimation results of the quantiles are provided in table 1 and fig 3. Table 1 indicates that the coefficients of the various parameters used for the study change across both OLS and the selected quantiles at the magnitude and direction.

For patent, the results indicate that the impact of patent application on agricultural productivity growth changes monotonically across the quantiles. However, the effect of patent application differs slightly, despite its strong effect on agricultural productivity growth at all the selected quantiles. For example, the coefficient of patent application in the 75th quantile is almost the same as compare to the coefficient in OLS regression. According to OLS results, a unit increase in patent application increase agricultural output by 0.39 percent. Moreover, the parameter estimate of the OLS regression is quite lower than the estimate in the 75th quantile but higher than the values in the 45th, 55th, 75th and 95th quantiles. However, at all the quantiles the coefficients of patent are positive and statistically significant at the 1% level. This is consistent with the argument that investment in new knowledge promotes growth (Audretsch et al., 2014). However, patent application has significant effect in the 45th, 55th, 65th and 95th quantile, implying that investment in new knowledge paves way for innovative ideas, which is considered as basic instrument for the survival of entrepreneurs(Soriano & Huarng, 2013). For innovative customer solutions by farm entrepreneurs in the farming business, there is the need to shift from conventional farming practices to more innovative-oriented strategies to be highly competitive in the current technological market (Pantano, Priporas, Sorace, & Iazzolino, 2017). Moreover, investment in both patent and R&D by agricultural entrepreneurs and other stakeholders in agricultural sector may not guarantee an increased in output growth in the 95th qauntile.

Current theories of knowledge spill over Audretsch and Lehmann (2006), reports that the problem of absorptive capacity prevents firms and entrepreneurs to commercialize the new knowledge, which leads to knowledge spillover for others to benefit, hence, the decline in output at the mid-quantiles. According to Coad and Rao (2008), since investing in R&D is risky activity, agricultural entrepreneurs and other corporate bodies should link the invention with manufacturing and marketing know-how, which will transform the basic idea into a successful end product for innovation to promote agricultural growth. This study is consistent with the work of Liu, Cao, and Song (2014) who maintain that China's innovation policy in global patenting activities in agriculture serves as a conduit in promoting agricultural growth**.**

Again, for R&D personnel, the OLS and QR regression result indicate a weak relationship between personnel in agricultural R&D centers and agricultural growth in mainland China. Regarding R&D personnel in agricultural sector, we can observe that from OLS estimates and results across selected quantiles record negative relationship between personnel in research institutions and agricultural growth. However, the coefficients of OLS and 15^{th}, 25^{th}, 35^{th} quantiles are significant at 5% and 10% level. According to OLS results, a unit increase in R&D personnel contributes to a decline in agricultural production by 0.15 percent, though statistically significant at 5% level.

The differences across the selected quantiles in the conditional distribution of R&D personnel show a monotonic contribution of labor in research institutions to agricultural productivity growth. The contribution of R&D personnel in the various research institutions to agricultural growth according to the results of this study is abysmal and unexpected. The coefficient of R&D personnel is significant in the 15th, 25^{th}, 35^{th} quantiles only at 5% and 10% level (Table 3), however, the magnitude of the coefficients decrease monotonically. The results indicate that in the 15^{th} quantile a unit (1%) increase in research personnel decreases agricultural productivity growth by 0.2 percent, 0.13 percent and 0.15 percent at 55^{th} and 95^{th} quantiles respectively (table 1).

At the higher end of the distribution, above 35^{th} quantile the magnitude of the research personnel coefficient is relatively higher as compare to the lower levels in table 3. The evidence here suggests that an increase in the number of personnel in agricultural research institutions make no significant contribution to the agricultural productivity growth in China within the study period.

Table 3. OLS and quantile regression estimates of factors affecting agricultural productivity growth

Coefficients	OLS	Selected quantile							
		Q(0.15)	Q(0.25)	Q(0.35)	Q(0.45)	Q(0.55)	Q(0.65)	Q(0.75)	Q(0.95)
Constant	0.501	1.922	1.922	1.995	-1.421	-1.483	-1.483	-1.363	-1.942
	(0.24)	(0.11)	0.11	0.12	-0.08	-0.08	-0.061	-0.005	-0.06
Patent	0.394***	0.414***	0.412***	0.429***	0.376***	0.374***	0.374***	0.412***	0.378***
	(10.02)	(6.78)	6.78	7.08	6.02	5.15	4.3	4.42	4.12
RD Personnel	-0.151**	-0.201*	-0.201*	-0.194**	-0.07	-0.133	-0.113	-0.087	-0.146
	(2.86)	(-2.86)	-2.26	-2.45	-1.35	-0.89	-0.77	-0.64	-0.9
Publication	0.235	0.245***	0.245***	0.228***	0.214***	0.221***	0.221***	0.208***	0.272
	(5.82)	(6.92)	7.03	4.84	4.59	4.27	4.01	4.13	3.50***
RD Institution	0.799	0.664	0.663	0.641	1.027	1.027	1.027	0.948	1.082
	(3.35)	(0.31)	0.31	0.32	0.34	0.34	0.33	0.28	0.3
R2	0.9945								
Pseudo R2		0.9596	0.9467	0.9429	0.9445	0.943	0.9405	0.935	0.9394
Observation	11	11	11	11	11	11	11	11	11

t statistics are in parentheses; **P*< 0.05, ***P*< 0.0, **P*< 0.001

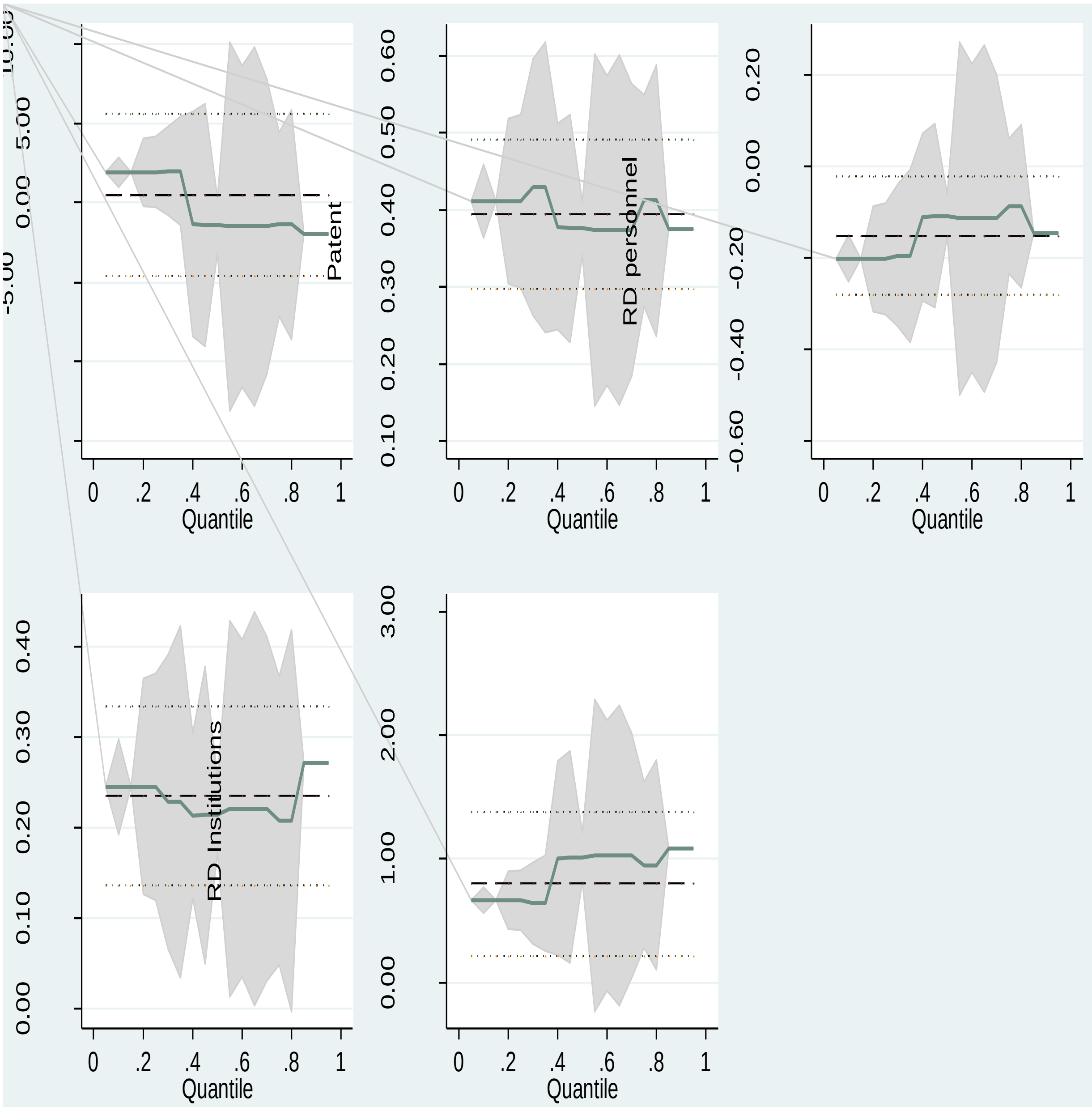
However, agricultural research institutions should equip their personnel the requisite resources and support to improve upon their knowledge know-how and know- what, because effective use of knowledge intensive business services (KIBS) fosters innovative ideas, which increase production (Mas-Tur & Soriano, 2014).

Furthermore, the coefficients of publication are highly significant and positive at the various selected quantiles (the 15th, 25th, 35th, 45th, 55th, 65th, and 75th quantiles) except for 95th quantile and OLS estimate result. According to OLS results, a percentage increase in agricultural research leads to 0.235 percent increase in agricultural production. In addition, in the 95th quantile the coefficient for publication becomes insignificant but increases its value from 0.208 percent at 75th quantile to 0.272%. The quadratic term of publication reveals that there is a monotonic relationship between agricultural research and agricultural productivity growth. This implies that the higher the number of agricultural research conducted and published, the higher the agricultural productivity growth since publications in scientific journals increases entrepreneurial knowledge. According to theories of innovation, agricultural research provides coherent and effective information to agricultural entrepreneurs, which is translated into innovation to promote growth in the sector (Anandajayasekeram, Puskur, & Zerfu, 2009). The results from table 3 indicate that one percent increases in scientific publication increase agricultural productivity growth by 0.245% (15th quantile) to as high as 0.272% (95th quantile).

Regarding R&D institutions, we can observe that the coefficient of agricultural research and development institution is positive but insignificant at all levels (table 3). The results for OLS regression indicate that a unit increase in agricultural research and development institutions contribute significantly to the output growth of agriculture at 0.799 percent over the study period. Moreover, across the selected quantiles, the influence of agricultural research and development institution on agricultural production increases from the lower quantile to highest quantile. That is the coefficients decrease at the 15th quantile to 35th quantile and increases from 45th quantile to 65th quantile, and decreases again at 75th quantile. The coefficient finally increases at the 95th quantile, which is the highest level. From table 3, it is vividly clear that the values of R&D institution across quantiles differ considerably and have a significant impact on agricultural growth at all levels. This demonstrates a strong relationship between R&D institutions and agricultural productivity growth. According to the study conducted by (Álvarez, Bilancini, D'Alessandro, and Porcile (2011)), agricultural institutions serve as the means by which new knowledge is spill over for entrepreneurs to benefit and convert it into innovative products by commercializing it.

QUANTREG procedure was adopted for plotting quantile graphs to demonstrate the visual effects of patent, RD personnel, RD institution and publication on agricultural productivity growth and the variations over the quantiles. In addition, we also use the graphs to illustrate how the impact of the various quantiles differs as compare to OLS coefficient and the confidence intervals around each coefficient. The OLS and quantile regression curves are presented in figure 3, whereby, OLS estimates are in horizontal lines with confident intervals. The shaded portion in figure 3 above shows confidence intervals across different quantiles. According to the quantile regression, curves plotted the value of estimated coefficients of patent, RD personnel; RD institution and publication slightly vary over the distribution of conditional growth rate. However, the influence of patent to output growth is positive in both 0.05th and 0.95th quantiles and declines at above 0.95th quantile. This implies that the output growth of agricultural production responds to patent application in the opposite direction at 0.015th and 0.95th quantiles in figure 3. Again, in figure 3, the influence of R&D personnel on agricultural growth according the curve is high at 0.05th quantile but declines again at above 0.95th quantile. In addition, the influence of RD institution to the productivity growth of agricultural production is positive across different quantiles and its influence above 0.95th quantile is stronger than that under 0.05th quantile. Furthermore, the influence of publication to output growth of agriculture, according to figure 3 decreases under 0.05th quantile but rises sharply above 0.95th quantile.

Figure 2: The effects of Patent application, Publication, RD personnel, RD institution on agricultural growth: OLS versus quantile regression



Notes: The dashed lines represent OLS parameter estimate, and the dark shaded areas are 95% confidence intervals for the estimation of quantile regression parameters.

Data Source: ("National Bureau of Statistics, China Statistical Yeabook, various issues," 2000 to 2014)

CONCLUSION

For the past decades, factors contributing to the growth of agricultural production in China have aroused the interest of many scholars interested in food production, but most of these studies used OLS regression for the estimate. In contrast to the existing studies, this study employs quantile regression to investigate the relationship between agricultural productivity growth and entrepreneurial knowledge by using cross-sectional data in China during 2003-2013. The use of quantile regression goes beyond the traditional OLS estimates to measure the functions of different quantiles. Estimates from this study indicate that the impact of patent application on agricultural productivity growth is positive and significant across the all quantiles. The parameter estimate of the OLS regression is higher than the values for 45^{th}, 55^{th}, 75^{th} and 95^{th} quantiles. The results show that the coefficients of publication are highly significant and positive at the various selected quantiles (the 15^{th}, 25^{th}, 35^{th}, 45^{th}, 55^{th}, 65^{th}, and 75^{th} quantiles), with the exception of 95^{th} quantile and OLS mean regression estimate. According to OLS results, a percentage increase in agricultural research leads to 0.235 percent increase in agricultural production. In addition, at the 95^{th} quantile the coefficient for publication becomes insignificant but increases its value from 0.208 percent at 75^{th} quantile to 0.272 percent. Moreover, the findings for OLS regression results indicate that a unit increase in agricultural research institutions increases output growth of agriculture by 0.799 percent.

Furthermore, across the selected quantiles, the effect of agricultural research and development institution on agricultural production decrease from the 15^{th}, 35^{th} and 7^{th} quantiles but increases at 45th quantile and 65th quantile. Finally, the contribution of R&D personnel in the various research institutions to agricultural growth is statistically significant from 15^{th} to 35^{th} quantile but recorded negative effect on agricultural growth across the selected quantiles and OLS estimate.

Despite the contributions of this paper, research gaps still exist in the area of the causal effect of agricultural growth and entrepreneurial knowledge. Therefore, it is suggested that future research should highlight this issue in measuring the cause-effect of entrepreneurial knowledge and agricultural productivity growth in rural China.

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