Empirical Analysis on Factors Influencing Distribution of Vegetal Production

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Abstract Since the reform and opening-up, there has been a great change in spatial pattern of China's vegetable production. This paper studied vegetable production in provinces of China in 1978 -2013. From the sequential characteristics, China's vegetable production area is constantly growing and takes on stage characteristic. From the spatial distribution, China's vegetable production takes on the trend of "going down the south" and "marching the west". In order to grasp rules of changes of vegetable production and the influence factors, this paper made theoretical and empirical analysis on factors possibly influencing distribution of vegetable production. Results show that major factors influencing distribution of China's vegetable production include irrigation condition, non-agricultural employment, market demand, knowledge spillover, comparative effectiveness, rural road and government policies.

Key words Vegetable, Production distribution, Influence factors

1 Introduction

Vegetable is essential agricultural product for national life. Ensuring stable vegetable production concerns the national economy and the people's livelihood. However, due to restriction of resource environment, little land, small scale, insufficient funds, extensive production, rising cost, varied quality, low production benefit, and weak competitiveness, transforming vegetable production mode has becoming a top propriety of vegetable industry development[1]. At present, researches of agricultural location distribution focus on major type of planting industry and grain crops, and mainly touch on current situations, time-space distribution characteristics and change trend of industrial distribution[2-9]. Most existing researches take grain crops as objects, while few make quantitative analysis on distribution of agricultural production, and less on vegetable varieties. Vegetable is a traditional sector in agriculture, and its planting characteristic leads to great difference in production distribution from other crops. Studying distribution characteristics of vegetable production and finding out reasons of changes are of great significance for optimizing distribution of vegetable production, bringing into play comparative advantage of vegetable production, lifting integrated production capacity, ensuring local vegetable supply, and promoting reasonable and healthy development of vegetable industry. Optimizing distribution of vegetable production is favorable for bringing into play comparative advantages of local areas, reducing production and sales costs, promoting brand building and characteristic production of vegetable, improving vegetable quality, stimulating development of related industries, upgrading local agricultural industry structure, and raising competitiveness of agricultural products. Thus, it is an ideal path for realizing modernization of vegetable production. Study on change in distribution of vegetable production is of great significance for adjusting agricultural industry structure, optimizing distribution of vegetable production, local agricultural industry policies and agricultural economic development.

2 Analysis on distribution characteristics of China's vegetable production

2.1 Distribution and change characteristics of vegetable production

2.1.1 Development stages of vegetable production. Fig. 1 indicates that vegetable production experienced four stages in 1978 - 2013. The first stage is slow growth stage (1978 - 1992), with vegetable production area increasing from 3.331 million ha to 7.031 million ha, annual growth up to 0.264 million ha. The second stage is rapid growth stage (1992 - 2003), with vegetable production area increasing from 7.031 million ha to 17.352 million ha, annual growth up to 0.992 million ha. The third stage is fluctuating decline stage (2003 - 2006), with vegetable production area falling from 17.953 million ha to 16.639 million ha, annual growth up to 0.438 million ha. The fourth stage is steady rising stage (2006 - 2013), with vegetable production area increasing from 16.639 million ha to 20.899 million ha, annual growth up to 0.609 million ha. In general, vegetable production area has been increasing since the reform and opening up, increasing from 3.331 million ha in 1978 to 20.899 million ha in 2013, annual growth of 0.517 million ha.

2.1.2 Vegetable production takes on the trend of "going down the south" and "marching the west". Fig. 2 and Fig. 3 reflect changes in the proportion of vegetable production area of provinces to total vegetable production area in 1978 - 2013.

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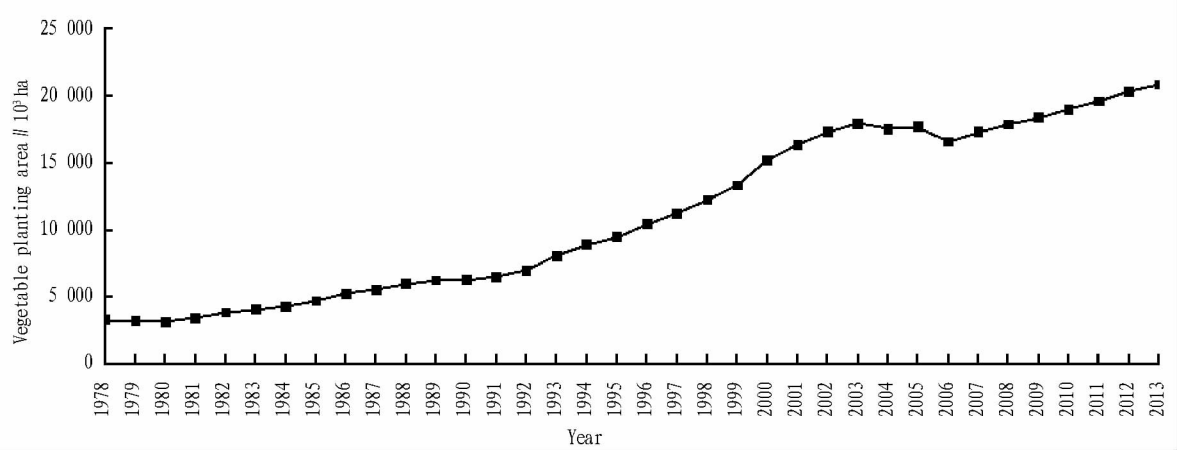


Data source: *China Statistical Yearbook* (1978 – 2013).

Fig. 1 Changes in vegetable production area in 1978 – 2013

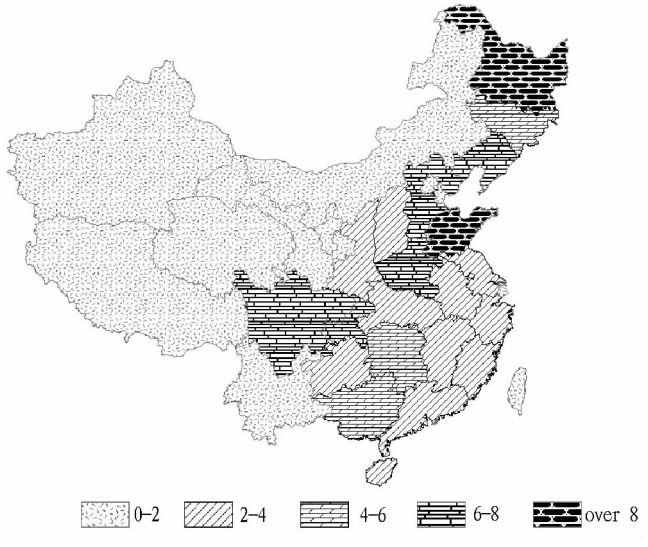
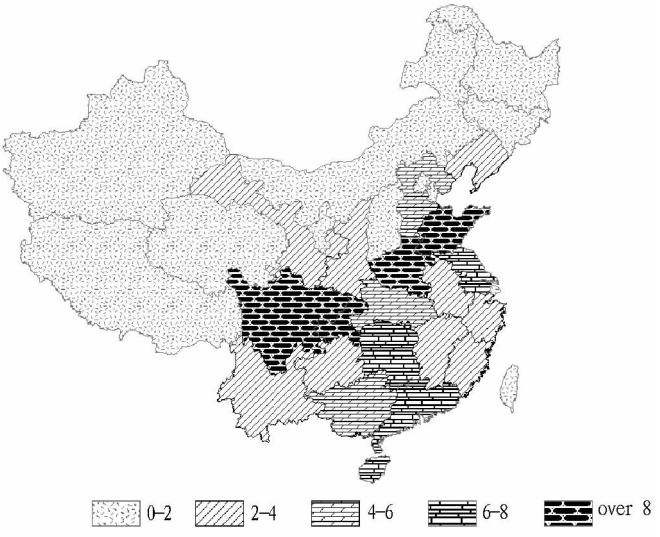


Fig. 2 Vegetable production area of provinces in 1978



Data source: *China Statistical Yearbook* (1978 – 2013).

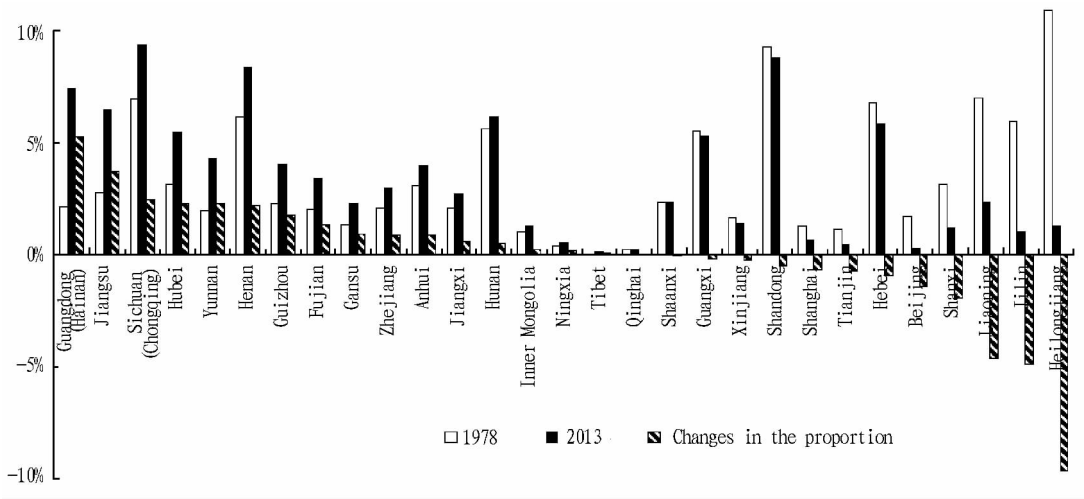
Fig. 3 Vegetable production area of provinces in 2013

From the comparison, we can see obvious changes of vegetable production: in 1978 – 2013, vegetable production area of Heilongjiang, Jilin, Liaoning, Shanxi and Hebei gradually shrinks, while the vegetable production area of Guangdong (Hainan), Jiangsu, Hubei, Fujian, Zhejiang and Anhui, Sichuan (Chongqing), Yunnan, Guizhou, and Gansu gradually expands. In sum, vegetable production takes on the trend of "going down the south" and "marching the west".

3 Empirical analysis on factors influencing distribution of vegetal production

3.1 Theoretical framework With constant promotion of vegetable commercialization, regional, large-scale and specialized development of vegetable production is constantly deepening and factors influencing distribution of vegetable production is increasingly diverse. As for time-space characteristics of vegetable production distribution, there are geographical and economic geographical factors.

3.1.1 Geographical factor is initial condition of vegetable production distribution. Vegetable production is subject to surrounding natural environment, especially temperature, sunlight, irrigation, and soil. Therefore, vegetable production must conform to ecological suitability of natural resources. Initial distribution of vegetable production is subject to natural conditions. Taking Guangxi as an example, temperate climate, sufficient sunshine, and plentiful rainfall promote rapid development of vegetable production. Low costs will bring high yield and quality, accordingly lift competitiveness of vegetable production. In the past researches, Shi Peijun *et al.* (1997) studied the relationship between climate changes, natural disasters and grain production, and held that the 17.6% and 8.1% of area affected by disasters to planting area are resulted from bloods and droughts[10]. Lu Wencong *et al.* (2007) made empirical analysis on factors influencing changes in distribution of grain production using grain yield data of provinces in 1978 – 2005, discussed influence of natural factors, and concluded that natural condition exerts a great influence on agricultur-



Data source: China Statistical Yearbook (1978 – 2013).

Fig. 4 Changes in the proportion of vegetable production area of provinces to total vegetable production area in 1978 – 2013

al industry distribution[11].

3.1.2 Economic geographical factor can lead to changes in distribution of vegetable production. If appearance of a certain industry in a region can not be explained by endowment of natural resources, the appearance of this industry is benefited from spatial externality. As to spatial externality, even there is similar natural condition in surrounding areas, cost reduction and income increase resulted from scale effect and externality can segment market and accordingly lead to distribution of the industry in this area[12]. The process of vegetable production marching from self-sufficiency to commoditization just follows achievements of this mechanism. Economic geographical factors for appearance and formation of vegetable production including following aspects:

(i) Market demand is primary force for vegetable production. On the one hand, with constantly accelerating urbanization process, both commodity rate of vegetable and rural per capita land area are increasing, and rural planting industry structure and regional industry structure are constantly optimizing. With growth of urban population and rise of urbanization, it opens broad market for vegetable. Besides, international trade promotes increasingly growth of vegetable export.

(ii) Development of science and technology supports development of vegetable production. Scientific and technological progress is manifested in production technology, storage and transportation, processing, and sales. Development of breeding technology improves ecological suitability of seed; extension of greenhouse planting technology improves production condition of vegetable in northern areas; development of storage technology improves location condition of vegetable production; development of processing and sales technology increases added value of vegetable, reduces sales cost, and affects structure and scale of vegetable products.

(iii) Policy and system are catalytic factors of vegetable production. In the distribution of vegetable production, through government policy and system arrangement, it is expected to provide guidance and support for vegetable production in local areas, establish a new industrial growth pole, guide distribution of production factors, cultivate market, extend technologies, and so as to promote comparative advantage of local vegetable production to become competitive edge of vegetable production.

(iv) Non-agricultural employment increases opportunity costs for engaging in vegetable production. In China, agricultural production is subject to non-agricultural employment, so vegetable production is no exception. Like Beijing and Tianjin, farmers have many opportunities of non-agricultural employment, so their non-agricultural income takes up a larger portion, which will influence their action of engaging in agricultural production. In comparison, there are less non-agricultural employment opportunities in agricultural provinces, planting is still their major income source. In general, areas with higher proportion of non-agricultural employment will have less distribution of vegetable production.

(v) Infrastructure provides favorable condition for development of vegetable production. Infrastructure of vegetable production area such as irrigation and traffic plays a great role in development of vegetable production and transportation. For example, improvement of traffic condition expands market of vegetable sales from depth and scope, saves transportation expenses, and shortens economic distance of vegetable production. Infrastructure is an essential influence factor of distribution of vegetable production, especially traffic and water conservancy in rural areas, promotes vegetable production and transportation, and is favorable for expansion of vegetable production.

(vi) Planting level has experience and knowledge spillover effect on development of vegetable production. At present, vegetable production is mainly distributed in suburbs and agricultural provinces. In agricultural areas, it is mainly planting, especially in areas with higher planting efficiency, there are more farmers grasping planting skills and experience, long time of knowledge experience promotes generation of higher knowledge spillover. In-

dustrial development type and planting development level may exert greater knowledge spillover effect on vegetable production.

(vii) Comparative benefit directly promotes vegetable production. Per capita vegetable output reflects the vegetable production efficiency of a region. It is the result of many factors. Areas with higher vegetable production efficiency will have more income from vegetable production than those with lower efficiency, and will receive higher comparative benefits from planting vegetable. Farmers are rational men and have higher economic motive tendency to expand vegetable production.

3.2 Empirical analysis

3.2.1 Proposition of hypothesis models. Summarizing the above theoretical analysis, we proposed following hypothesis models:

H_1: positive correlation between natural conditions and distribution of vegetable production;

H_2: positive correlation between market demand and distribution of vegetable production;

H_3: positive correlation between sci-tech development and distribution of vegetable production;

H_4: positive correlation between government policies and distribution of vegetable production;

H_5: positive correlation between non-agricultural employment and distribution of vegetable production;

H_6: positive correlation between water conservancy projects and distribution of vegetable production;

H_7: positive correlation between knowledge spillover and distribution of vegetable production;

H_8: positive correlation between comparative benefits and distribution of vegetable production;

H_9: positive correlation between substandard road and distribution of vegetable production.

3.2.2 Data source and explanation. In this study, we adopted panel data consisted of time series and cross-section data of provinces in 1994 – 2013. Relevant data were selected from *China Statistical Yearbook of Agriculture in* 1949 – 2008, *China Rural Statistical Yearbook*, and *China Statistical Yearbook*. Provinces are mainland provinces and municipality directly under the central government (not including Hong Kong, Macao, and Taiwan). To ensure consistency of data, Hainan was consolidated into Guangdong and Chongqing was integrated into Sichuan. The calculation method is as follows: area of affected vegetable = area of affected crops × (vegetable sown area ÷ crop sown area); effective irrigation area of vegetable = irrigation area of crops × (vegetable sown area ÷ crop sown area); per capita grain yield of provinces = total grain yield ÷ rural labor; non-agricultural employment level of provinces = (total rural labor – agricultural labor) ÷ total rural labor; vegetable price level of provinces is the fresh vegetable consumer price index issued by statistical bureau; X_7 refers to dummy variable of priority distribution planning policy for national agricultural products, taking the year 2003 as the line, before 2003, it is 0, and after 2003, it is 1.

3.2.3 Model building and variable explanation. According to the above hypotheses, combining actual situations of vegetable production, we built following model for influence factors of distribution of vegetable production:

$$Y_i = \alpha + \beta LnX_{1i(t-1)} + \beta_2 LnX_{2i(t-1)} + \beta_3 LnX_{3i(t-1)} + \beta_4 LnX_{4it} + \beta_5 LnX_{5i(t-1)} + \beta_6 LnX_{6it} + \beta_7 LnX_{7it} + \beta_8 X_8 + \beta_8 X_9 + \mu_i$$

where Y_i denotes the proportion of vegetable production area to national production area in current year and is used as an indicator for measuring vegetable production scale; $X_{1i(t-1)}$ is the affected area of vegetable for the province i in the t-1 year, reflecting the circumstance of vegetable production influenced by natural environment; $X_{2i(t-1)}$ signifies the effective irrigation area of vegetable for the province i in the t-1 year, reflecting infrastructure situation of vegetable production; $X_{3i(t-1)}$ refers to per capita grain yield for the province i in the t-1 year, reflecting knowledge spillover of planting industry in province i; X_{4it} is the ratio of rural non-agricultural employment labor to agricultural labor for the province i in the year t, reflecting non-agricultural employment level of province i; $X_{5i(t-1)}$ denotes vegetable consumer price index for the province i in the t-1 year, reflecting market demand of vegetable; X_{6it} is the per capita vegetable output for the province i in the t-1 year, reflecting comparative benefit of vegetable production; X_{7it} is the substandard road mileage for the province i in the t-1 year, reflecting traffic infrastructure construction; X_8 is time, reflecting sci-tech development level; X_9 denotes imlementation of priority distribution planning policy for agricultural products in 2003; μ_i refers to stochastic error. Except dummy variables and the year, the values of other explanatory variables are log values to weaken heteroskedasticity possibly arising out of regression.

3.2.4 Model regression results. (1) Regression and test of traditional panel data models. With the aid of Stata12.1 software, using panel data, we made an empirical analysis. Firstly, we used OLS method to make relevant regression and test. The output results are listed in Table 4.

Table 1 Results of mixed regression

Variable	Coefficient	Standard deviation	p value
Constant term	1.1943	0.1763	0.0000
Natural condition	–0.0001	0.0003	0.7530
Irrigation condition	0.0093	0.0011	0.0000
Knowledge spillover	0.0011	0.0012	0.3750
Non-agricultural employment	–0.0066	0.0017	0.0000
Market demand	0.0027	0.0016	0.0930
Comparative benefit	0.0059	0.0011	0.0000
Traffic infrastructure	0.0010	0.0001	0.0000
Sc-tech progress	–0.0020	0.0007	0.0060
Policy support	–0.0006	0.0001	0.0000

Results indicate that the evaluation effect of influence factors of vegetable production distribution is excellent. Coefficient and symbol of most explanatory variables are consistent with the hypothesis models; each explanatory variable is also significant in overall effect on dependent variables; Wald Chi-square value of

regression is 355.98, showing significant regression results.

(ii) Regression and test of stochastic and fixed effect panel data models. Considering fixed and stochastic effects of panel data, it is necessary to make regression analysis on fixed effect and stochastic effect of panel data and select more stable analysis model as the final results of empirical test.

Table 2 Regression results of stochastic and fixed effects

Variable	Stochastic effect			Fixed effect		
	Coefficient	Standard deviation	*p* value	Coefficient	Standard deviation	*p* value
Constant term	1.1943	0.1763	0.0000	1.1817	0.1736	0.0000
Natural condition	−0.0001	0.0003	0.7530	−0.0001	0.0003	0.7530
Irrigation condition	0.0093	0.0011	0.0000	0.0068	0.0012	0.0000
Knowledge spillover	0.0011	0.0012	0.3750	0.0009	0.0012	0.4510
Non-agricultural employment	−0.0066	0.0017	0.0000	−0.0070	0.0017	0.0000
Market demand	0.0027	0.0016	0.0930	0.0027	0.0016	0.0910
Comparative benefit	0.0059	0.0011	0.0000	0.0078	0.0001	0.0000
Traffic infrastructure	0.0010	0.0001	0.0000	0.0095	0.0001	0.0000
Sc-tech progress	−0.0020	0.0007	0.0060	−0.0015	0.0007	0.0290
Policy support	−0.0006	0.0001	0.0000	−0.0006	0.0001	0.0000

(iii) Hausman test. Error term of panel data model includes two parts: one is related to individual observation unit (all factors influencing explained variables but not changing with time), and the other is unobservable factors with cross-section changing with time. For such unobservable effect, it is essential to see whether its corresponding factor is related to explanatory variables observed in the model. If it is related, it is fixed effect; otherwise, it is stochastic effect. For this, it is feasible to use Hausman test to check hypothesis. Results of Hausman test indicate that ch2(7) is 18.73, *p* value is 0.0276, strongly rejecting stochastic effect hypothesis, so it should be fixed effect model.

3.2.4 Analysis of model results. Model results of individual fixed effect indicate that estimation effect of vegetable production distribution factors is excellent. Coefficient and symbol of most explanatory variables are consistent with the hypothesis models; Wald Chi-square value of regression is 23816.05; each explanatory variable is also significant in overall effect on the equation.

(i) Influence of natural condition on vegetable production distribution. Different from our expectation, the influence coefficient p value of natural condition on vegetable production distribution is 0.753, not significant. This is possibly because with social and economic development, and technological progress and development of modern transportation, the natural risk resisting capacity and long-distance transportation ability of vegetable production are gradually rising, and the dependence on natural environment is reducing.

(ii) Influence of irrigation condition on vegetable production distribution. The influence coefficient of irrigation condition on vegetable production is positive, and *p* value is 0, passing the significance test. This is consistent with our hypothesis. Most fresh vegetables are hydrophilic crop, not suitable for long distance transportation, highly dependent on irrigation and water conservancy projects. Therefore, development of agricultural infrastructure can promote vegetable production and improvement of agricultural infrastructure is also favorable for formation and development of vegetable production.

(iii) Influence of knowledge spillover on vegetable production distribution. The influence coefficient of knowledge spillover on vegetable production is positive, consistent with the previous hypothesis but not passing the significance test. Vegetable production in China experiences movement from suburban vegetable production to agricultural area vegetable production. In well-developed area of planting industry, experience accumulation and technology spillover greatly promote vegetable production. However, in areas with higher per unit area yield of grain crops, there will be competition with vegetable in planting industry. Possibly both actions are offset, knowledge spillover is not significant in development of vegetable production.

(iv) The influence of non-agricultural employment opportunity on vegetable production distribution. The influence coefficient of non-agricultural employment opportunity on vegetable production distribution is negative. This is consistent with previous hypothesis and passes significance test. Non-agricultural employment opportunities provide farmers with more choices and stimulate them to leave farmland. This plays an important influence on structure of agricultural industry. In areas with more non-agricultural employment opportunities, there are higher opportunity costs for engaging in agricultural production, less agricultural labor, so the negative influence on development of agricultural production is significant.

(v) Influence of regional market demand on vegetable production distribution. The influence coefficient of regional market demand on vegetable production distribution is positive and significant at 10% level. In the process of vegetable production, market demand can stimulate expansion of vegetable production. The moderate significant level is possibly because areas with higher consumer price index are economically developed areas where they are relatively developed secondary and tertiary industries, while the primary industry especially planting industry is small in scale. But this result still reflects that regional market demand exerts pos-

itive effect on development of vegetable production.

(vi) Influence of comparative benefit on vegetable production distribution. The influence coefficient of comparative benefit on vegetable production distribution is positive and passes significance test. Economic benefit is a decisive basis for farmers selecting agricultural production. In vegetable production, areas with higher per capita vegetable output have higher vegetable production efficiency. With higher efficiency, vegetable production can obtain higher comparative benefits. Such economic benefit will promote expansion of production scale and boost development of vegetable production.

(vii) Influence of traffic condition on vegetable production distribution. The influence of traffic condition on vegetable production distribution is positively significant. In other words, developed traffic will provide excellent transportation for vegetable production. In this study, we selected substandard road mileage as road data. This can not only reflect actual situation of road conditions in rural areas, but also avoid disturbance of many grades of roads in economically developed areas. Development of substandard roads will provide convenient transportation services for vegetable production and will be favorable for development of regional vegetable production.

(viii) Influence of sci-tech progress on vegetable production distribution. In this model, sci-tech progress fails to exert positive effect on development of vegetable production. This is worth discussing. With elapse of time, the development level of vegetable production in provinces declines. In this study, we adopted data of 1995 – 2012. Just like analysis in time-space characteristics, due to influence of industry structural adjustment and transformation of vegetable production from quantity growth to quality growth, the development of vegetable production declines in recent decade. Besides, due to influence of agricultural structure, constantly progressing agricultural science and technology will be mainly used in major crops, rather than in vegetable production.

(ix) Influence of agricultural policy on vegetable production distribution. Agricultural policy exerts significant influence on development of vegetable production. This is consistent with hypothesis model. In other words, active agricultural policy promotes development of vegetable production, while negative agricultural policy impedes development of vegetable production, and such action is significant. In this model, priority distribution plan of agricultural products exerts a great impact to vegetable distribution. In the adjustment of agricultural products, the proportion of vegetable production in most provinces slowly declines, and more economic crops are planted. For example, *Regional Distribution Plan of National Priority Agricultural Products* 2003 – 2017 proposed 11 varieties of crops and priority regions, including special wheat, corn, high oil soybean, cotton, double low rapeseed, double high sugarcane, apple, beef cattle, mutton sheep, milk, and aquatic products. Priority development of agricultural products forms high competitive relationship with vegetable production. Outwardly, it promotes regional distribution of priority agricultural products. In fact, it poses challenge to priority distribution and production distribution to vegetable development.

4 Policy recommendations

4.1 Attaching importance to agriculture industrial distribution, building main characteristic and specialized vegetable production areas, and developing vegetable production related industries Firstly, it is recommended to adjust agricultural development idea, attach importance to production distribution, and improve distribution of vegetable production. Since the reform and opening-up, vegetable production area rapidly expands, but regional difference is obvious. This indicates that there is still a large space to be lifted for vegetable industry distribution. Therefore, it is required to value distribution of vegetable production, change the "large and overall" situation of agricultural production, and promote vegetable production to development in priority areas.

Secondly, it is recommended to build main characteristic and specialized vegetable production areas in accordance with regional situations, to ensure quality of main vegetable production areas. Vast in territory, there are great differences in natural and economic environment of main vegetable production areas. Thus, it is recommended to build main characteristic and specialized vegetable production areas in accordance with regional industrial foundation, market condition, and ecological environment, and establish priority agricultural product economic belt, which is an effective path for development of modern agriculture.

Finally, it is recommended to develop vegetable production related industries, boost economic driving and radiation force of vegetable production. Specifically, it is recommended to strengthen spatial connection drive and radiation force of vegetable production, take main vegetable production areas as center, connect national agriculture industrial development plan, and establish cross-regional vegetable production economic belt.

4.2 Improving vegetable production condition and enhancing infrastructure construction Initial distribution of vegetable production depends on match degree of natural condition and production condition of vegetable varieties. However, economic graphical condition can adjust and optimize vegetable production distribution. Therefore, in the process of promoting development of agriculture industrial distribution, it is recommended to value construction of rural water conservancy projects, especially vegetable production infrastructure, raise vegetable production anti-disaster ability, enhance rural road construction, and provide convenience for vegetable production and transportation. Also, it is proposed to combine local resource endowment and industrial effect according to principle of comparative advantages.

4.3 Establishing vegetable production insurance system to stabilize expected income of farmers Non-agricultural employment affects action of farmers' vegetable production through economic income. Vegetable production is also faced with natural risk and market risk. In the context of globalization of vegetable

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Table 3 Model estimation results of the factors influencing farmers' demand for agricultural socialized production services

Explanatory variables	Information service	Financial service	Technical service	Production material supply service
Gender	0.406***		0.634***	
Agricultural land area	0.008*			0.008*
Number of farming labor				0.150*
Proportion of agricultural income	0.607***	0.872***	0.273**	0.184*
Whether farmers have the migrant experience	0.301**	0.309**	0.388***	0.270**
Whether farmers have received skill training		0.291*		
Constant	-1.123***	-1.410***	-1.567***	-1.229***

Note: * indicates a significant level of 10%; ** indicates a significant level of 5%; *** indicates a significant level of 1%; the blank indicates an insignificant level.

5.2 Policy recommendations (i) It is necessary to establish a grass-roots feedback mechanism for farmers' demand, and make the village committee serve as a bridge between farmers and government. (ii) It is necessary to selectively focus on the development of agricultural socialized service supply body. In this survey, 43% and 49% of farmers are satisfied or very satisfied with government departments and village collective, respectively, indicating that the current farmers trust the two service bodies. (iii) It is necessary to strengthen the integration of agricultural socialized service resources to improve service efficiency.

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production competition, it is required to keep competitive edge of vegetable production, and provide steady vegetable supply, so as to stabilize expected income of vegetable producers. Through establishing reasonable and scientific vegetable production insurance system, it is able to effectively reduce and mitigate risks, provide stable expected income for farmers, and alleviate impact arising out of non-agricultural employment opportunities to vegetable production.

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