Detecting the Influencing Factors of Maize Production in China during 2009-2019

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ABSTRACT
The maize market in China has improved and the productivity of maize in China has increased through the past decade. We studied the influencing factors of maize production in China during 2009-2019 by multiple regression, including mechanization, planting area, drone application amount and price change. The result shows that among the four factors, only planting area has a significantly positive impact on maize production. We then made some prediction and offered some suggestion to the future development and researches of maize production based on our outcomes.

Keywords: *Multiple Regression Analysis, Dummy Variables, Mechanization, Planting Area, Drone Application Amount, Price Change*

1. INTRODUCTION

Maize is the second common kind of grain and plays a very important role in Chinese agricultural field. It can be used in many areas like feed, industrial processing, eating and so on. In the recent years, over half of maize has been used in feeding. China has planted maize since the 16th century. The development of maize production and the methods Chinese people used to improve maize production is widely studied [1]. However, we are curious about what and how factors or variables influenced the production of maize in recent decade and their degree of influence.

In *Evolution and Development of Maize Production Technology* in China, technological advance plays an important role in maize growing. Because of the new methods in growing maize, both quality and quantity of maize production have been improved. For example, scientists use hybridization to create new maize seeds. The goal of new maize seeds is to achieve high quantity and quality, density tolerance, strong adaptation and good comprehensive character. Mechanization has developed very greatly in the recent decade. In 2018, Chinese seeding mechanization arrived at as high as 97.33%. Chinese maize growing mechanization reached 88.73%. Maize harvesting mechanization was a little low at 75.85%. Some scholars have also proved the big effects brought by advanced technology in maize. Improving domestic maize breeding technology and introducing productive and low budget foreign maize seeds can improve Chinese maize product and self sufficiency rate.

Since Yuan Longping studied the first generation of hybrid rice, China has opened the era of hybrid breeding technology. With the efforts of generations of farmers, maize hybrids are constantly updated and hybridization technology is improving. Gradually, mechanical planting of maize and UAV plant protection have become popular and provide farmers with opportunities to grow more agricultural products which include maize. There were a lot of researchers who had already calculated the annual changes of maize yield. From 1949 to 2007, maize yield per hectare in China has increased by 4205. 1kg (437. 3%), with an annual increase of 85. 84kg·hm-2. The total yield was increased by 12. 3 times from 12. 418 million tons to 152. 310 million tons, of which the increase in yield per unit area accounted for 68. 4% and the expansion of planting area contributed 31. 6% [2]. In contrasting manner, we will update the indexes and outcomes to see the latest data.

The majority of articles only focus on effects of biological technology such as hybridization and transgenosis. Really few scholars do research with reference to advanced machines and drone technology. In this paper, we use the existing data of Chinese maize in the recent decade to give an analysis of the degree that how the technological factors affect production of maize. In addition, we will forecast the future development of maize product and give some suggestions to this industry. To be more precise, this paper is sectioned as follows: we will introduce the methods and models that

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we use to analyze the data. Then we will utilize several types of graphs to report and present our findings according to our analysis of data. After that there will be an explanation of the results and comparison with studies of other scholars. The next part is some other factors which cannot be calculated by data and influence of maize. In the end, we will illustrate the conclusion of the paper and state the future prediction.

2. Data and Approaches

2.1 Data

We select multiple regression analysis to find the correlation between every factor and maize production. The sample consists of annual production yield and the relative data of the factors. The sample period starts from 2009 and ends at 2019. After eliminating the vacancy value, we finally get the data of the degree to which each factor influences maize production, thus giving more favorable suggestions for future development. We select harvesting mechanization (the proportion that mechanical harvesting area takes up the whole planting area), planting area, drone amount of usage [3], and price change of maize among 2009 to 2019 as the variables.[4]

We calculated the maize production(Y), rate of harvesting mechanization(X1), planting area(X2), usage of drone(X3), and price change rate(X4) from 2009 to 2019. We did not put usage of drone in Table I because we set it as dummy variable, and it only had 0 and 1. From Fig. 1-4, the linear diagram of each variable's change per year, we can see that maize production was slowly increasing, which is the same as planting area, and very fast in harvesting mechanization. However, the change of price of maize was not obvious in this time period and only had a few fluctuations.

Table 1. Descriptive Statistics

	Mean	Max	Min
Y	23715.754	26499.22	17325.86
X1	0.511	0.8	0.19
X2	40277.814	44968.39	32948.34
X4	1.109	1.161	0.868

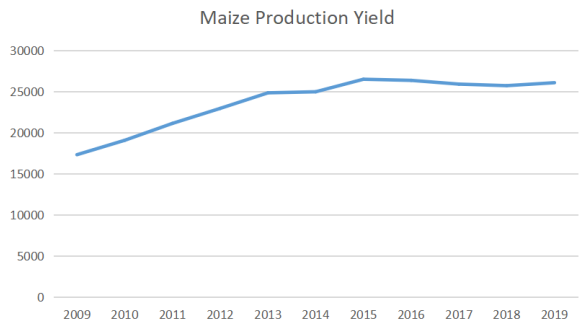

Figure 1. Maize production yield

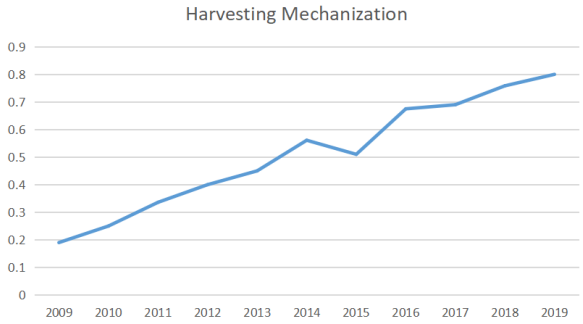

Figure 2. Harvesting mechanization

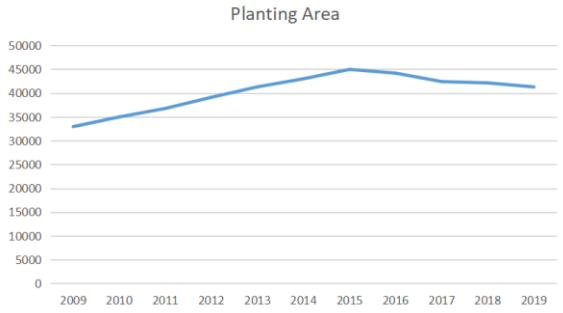

Figure 3. Planting area

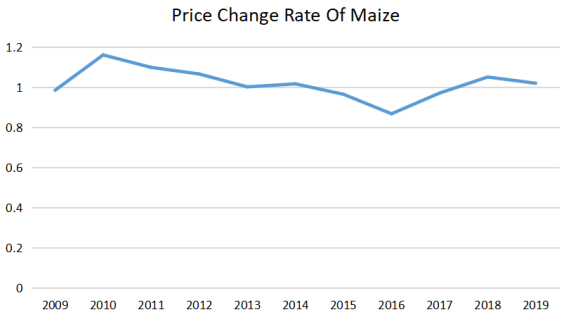

Figure 4. Price change rate of maize

2.2 Multiple regression

Linear multiple regression model illustrates the relationship between one dependent variable and over one independent variables. The function can be written as followed.

$$Y=\beta_0+\beta_1 X_1+\beta_2 X_2+\ldots+\beta_k X_k+\varepsilon \quad (1)$$

In this function, β_0 represents the population Y-intercept, which is a constant. K is the number of independent variables. ε is random error and it obeys normal distribution.

There is some researchers who already used this kind of method in this area [5]. We would like to use multiple regression analysis to see how variables can affect our object of study.

2.3 Dummy Variables

The Dummy variable is a kind of artificial variable and quantification of independent variables and it can make the description of questions more concise. Variable levels are always coded either 0 or 1.

In our analysis, we set X_3 as dummy variables. X_3 refers to the usage of drone, which is 0 before 2015 and 1 after 2016 because drones have been put into large scale use in Chinese agriculture since 2016 [6].

3. EXPERIMENT AND RESULTS

2.4 Hypothesis

We assume that every variable has a certain effect on the maize production and planting area effects the most. Therefore, our null hypothesis, H0, is β1=β2=β3=β4=0, and the alternative hypothesis, Hα, is that at least one β variable is not equal to 0. Our significant level is 0.95. If F-value is smaller than significant level, we can reject the null hypothesis; in contrast, if F-value is larger than significant level, we cannot reject the null hypothesis.

2.5 Experiment and Calculation

In order to understand every variable, mean has a determined function. The average is the most commonly used statistic in statistics and is used to indicate the central location of a relatively large concentration of observations in the data. Statistical averages are used to reflect the general level of the population of phenomena, or the central tendency of the distribution. Averages can be used to reflect the general and average level of a set of data, also be used to compare different sets of data in order to see the differences between the groups. The equation of mean can be expressed as: (A1+A2..+An)/N.

Then we need to determine the basic type of regression model, and then get the expression of regression equation through calculation. However, we used Excel to do multiple regression analysis to get more information. After that is the significance test of our multiple regression model. We did the correlation coefficient test to test the degree of linear correlation and F-value.

2.6 Results

The variance, Q1, Q3 and IQR are shown in Table II. We use variables to test whether the data is scattered or not. The bigger the variance is, the more scattered the data is. From Table 6, we can see that harvesting mechanization and price change rate of maize are not scattered.

TABLE 2. RESULTS OF MULTIPLE REGRESSION

	Maize production	Harvesting mechanization	Planting area	Price change rate of maize
variance	10162141.9	0.0424	15010629.5	0.00593
Q1	21131.6	0.336	36766.52	0.971
Q3	26078	0.69	42996.81	1.066
IQR	4946.4	0.354	6230.29	0.095

We did our analysis by Excel because it is more accurate than calculating by hand. Also the coefficient, P-value and significance F value. Our final multiple regression is:

$$Y=-4232.88 + 6019.32X1 + 0.59X2 - 428.77X3 + 1338.16X4 \quad (2)$$

Since significance F value is 2.4296E-05, which is not equal to 0.05, we rejected H0 that β1=β2=β3=β4=0. We judged whether the coefficient is significant by P-value or not. If P-value is less than 0.05, the coefficient is significant. From Table III, 0.00508933<0.05, so X2 is significant.

TABLE 3. COEFFICIENT AND P-VALUE

	Coefficients	P-value
X1	6019.31601	0.1654214
X2	0.58756562	0.00508933
X3	-428.76752	0.70802835
X4	1338.1577	0.71597181

2.7 Discussion

Maize production is gradually increasing and by our research, we use numbers to represent our factors affect the production quantity of maize. By comparing the

annual mean of each factors, we can see how they changed during the past decade, and by using multiple regression model, we know how they related with the maize production. In our research, we used multiple regression analysis to figure out the degree of influences of each variables which is harvesting mechanization, planting area, drone amount of usage and price changing rate. A phenomenon is often associated with multiple factors. It is more effective and practical to predict or estimate the dependent variable by the optimal combination of multiple independent variables than to use only one independent variable. Therefore, multiple linear regression is more practical than one linear regression.

Our research updated and concluded the resent maize production yield and the real-time data of variables that we think can influence our object of study in some extent. Therefore we hope our work can provide a picture of and help others to understand how maize production in China has developed and effected. In our outcomes, X2, which is harvesting mechanization, has the biggest significance. So we conclude that it influences the production of maize the most. However, since harvesting mechanization only changes less than 0.5 every year, the changing amount is not as big as we see.

In this research, many relative researches were studied and compared with our outcomes, providing many useful information and perspectives of choosing variables we need in our research [7] [8]. Our outcome fits well with what the researchers said in this paper. One variable we chose is the use of drone, and this idea comes from [9].

4. Other Influencing Factors Of Maize Production

There are also a lot of factors that affects production of maize. First, biological technology plays an important role in agriculture. New types of plant seeds have the ability to boost efficiency of growing and production. Some foreign countries have developed rapidly in recent years in researching advanced maize seeds especially genetically modified maize. In 2010, about 27000 thousand square hectometers of crop area used double superposition character strains or triple composition character strains, which took up over 40 percent of the whole American crop area.

At the same time, 16 countries used genetically modified maize. The total plant area of genetically modified maize arrived to 46000 thousand square hectometers in the world [5]. In the recent decades, the number of Chinese new maize has increased rapidly. In the ten years, hundreds of new maize have been developed every year. The most successful maize developed by China is Zhengdan 958 because of its high production and stable yield. Since 2000, the plant area of Zhengdan 958 has increased fast. The plant area of Zhengdan 958 exceeded 4000 square hectometers in both 2007 and 2008 in China.

However, Chinese biological technology development is just in the beginning, it is not ripe enough. Moreover, there are not enough research teams in China. To improve this situation, China researchers should learn some foreign technology and introduce foreign productive maize seeds. But we should not rely too much on foreign technology. We should develop our own technology like choosing local and foreign seeds and hybridize them together in order to gain more efficient seeds. In addition, Chinese government should increase the investment of biological technology and improve policies in this industry.

Natural factors like climate can also influence production of maize. Maize is thermop8o 30 degree is suitable for the growing of maize. If the temperature is too low, under 10 degrees, maize will grow very slowly. Since maize is short-day crop, the most suitable sunlight hour is 8 to 10 hours. Maize has strong photosynthetic capacity and high light saturation. Since the leaf area of maize is big, transpiration of maize is strong. During the growing period of maize, the most suitable precipitation is around 600 mm. Both drought and waterlogging have effects on the growing of maize. Since maize has strong root system and self-regulation, it absorbs water from soil. When meeting hot and dry weather, maize leaves curl up automatically in order to reduce transpiration. Although maize cannot wither easily, lack of water has bad effects on production and quality of maize. Deep and loose soil can satisfy the growth of maize. Farmers mostly choose rich black soil, chernozem, alluvium and thick meadow soil. The demanding of nitrogen, phosphorus, potassium, sulfur, calcium and magnesium are much bigger. Spring maize area of northeast China has similar condition with famous American maize area. The suitable temperature during growing seasons, big temperature difference, enough sunlight and precipitation in northeast China can satisfy the demand of maize growth. Northeast China has become the most productive maize area in China due to its flat terrain and rich soil. As the rise of climate, the plant area of late-maturing varieties is increasing. But sometimes production decreases because of chilling damage [5].

Maize also has influence on other products. Over half of maize is used in feeding. So if the price of maize decreases, price of feed grains made of maize reduces too. Maize is an important raw material of pig feed. When the price of maize decreases, cost of pork decreases. More pork can be produced with the same cost. We set pork production as Y, maize price change as X and used Excel to find the regression is Y=6435.92-1118.03X. We can see that when maize price increases, pork production decreases.

5. CONCLUSION

The demand of maize in the world is becoming more and more. Since then, most articles focus on some natural factors and biological technology that affect production of maize. However, as the development of advanced technology, some machines have more obvious effects on maize production.

This paper has researched several factors which change the production of maize in China. Different from other researches, we have used dummy variables. We use four variables, harvesting mechanization, planting area of maize, drone amount of usage and price change rate of maize. The annual sample cover the periods from 2009 to 2019. This article employs multiple regression, dummy variable and hypothesis test. All the results are calculated by Excel. The multiple regression is tested by P-value and significance F value. Our null hypothesis has been rejected since significance F value is not 0.05 and there is relationship between maize production and the four variables. The multiple regression shows that harvesting mechanization, planting area and maize price change rate have positive effects on production of maize. Only drone amount of usage shows a negative effect.

The findings revealed by multiple regression model are of potential importance to policy makers in terms of agriculture. It shows the importance of technological development. Government should pay attention to technological agriculture and advertise the advantages of advanced technology like high quality and production. They can also set some welfare to farmers to encourage their consumption of machines because some farmers may consider machine as expensive cost and do not want to buy. Moreover, some machines may damage the seeds and fruit of maize when working. Governments should put more investment in improving machines. Nevertheless, there are still some limitations in our work. The availability of database is limited, so we can't get every information, which may lead our outcomes to be not all-inclusive or representative. We can only find the data since 2009. But the harvesting mechanization in 2009 is already 0.19, the numbers before 2009 may be very little. So we consider our data is enough. In addition to this, our research result may be not suitable for every year because there may be some special cases. For example, COVID-19 epidemic since the beginning of 2020 has brought significant effects in almost all the industries all over the world. Another thing is that we conducted the analysis of research objectives over a specified period of time and had no much time to do deeper discoveries. The last thing is that the effecting variables are chosen by our personal well and is not absolutely objective. The conclusion doesn't include very aspects and details.

Further study will shed more light on agriculture connected to technology and biology. For future studies, we hope that there will be more information available for people to analysis and there will be more completed analysis and other variables that we didn't contain in this paper.

In the end we want to give some political advices: The government should set special policies to farmers, which can include more inclusive finance pilot reforms and launch unsecured, few-interest bearing and sustainable inclusive finance products. This can provide enough money to farmers in order to encourage them to have more planting areas and improve the production quantity.

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