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The Influence of Agricultural Production Mechanization on Grain Production Capacity and Efficiency

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Abstract: As an important production factor of grain production, agricultural machinery can effectively provide a theoretical basis for agricultural modernization development strategies by exploring its impact on grain production capacity and efficiency. This research starts from the two aspects of grain production capacity and grain production efficiency, takes rice, wheat, and corn as the research objects, and uses the C–D production function and Tobit model as the basis, respectively, to establish two impact models of production capacity and production efficiency. At the same time, according to the different emphases of the two models, this research designs different variable systems and finally uses the data from 2017 to 2021 for empirical analysis. The research results show that the influence coefficients of machinery service income and machinery power resource input on the total grain production capacity are 0.0976 and 0.0437, respectively, with a significant positive impact. At the same time, for rice crops, wheat crops, and corn crops, the amount of mechanization cost per mu has a significant positive impact on the yield capacity of crops, with impact coefficients of 0.0311, 0.0827, and 0.0233, respectively. The supply level of agricultural machinery services and the utilization rate of agricultural machinery services per mu have a significant positive impact on grain production efficiency. The impact coefficients of the supply level of agricultural machinery services per mu are 0.0192, 0.0587, and 0.0241, respectively. The impact coefficients of the agricultural machinery service utilization rate are 0.0059, 0.0148, and 0.0607, respectively, with a significant positive impact. It can be seen that agricultural production mechanization can effectively promote the improvement in grain production capacity and efficiency and promote the process of agricultural modernization. At present, most of the research on industrial mechanization services is biased toward the choice of agricultural mechanization services by farmers. However, this research has carried out the impact mechanism analysis from the perspective of time and space and the perspective of crops, rationalizing the impact mechanism of agricultural production capacity and agricultural production efficiency under agricultural mechanization.

Keywords: agriculture; mechanization; production capacity; production efficiency; C–D production function; Tobit model

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1. Introduction

The issue of food has always been an important global issue, especially in the immediate international situation, which has emerged in a more acute form, such as the food issue in the local situation in Ukraine [1]. Due to missing the time window for grain planting and the difficulty in the normal implementation of the grain export agreement, Ukraine is likely to be absent from the position of the world's food supplier in the near future, which will lead to the reduction in the world's food supply [2].In this situation, although global dispatching can solve certain problems, countries should also use such methods as agricultural mechanization to deal with the food problem [3]. In China, with the acceleration of theurbanization process, a large number of rural labor forces have been transferred to cities [4]. The problems of rural hollowing and aging of the rural labor force are increasingly serious, and the pressure on the structural transformation process of the agricultural production industry is increasing [5]. In this environment where the demand for agricultural labor is high, but the supply is weakening, the unit labor cost of agricultural production will continue to rise, and the structural shortage contradiction will also bring greater production pressure [6]. The mechanized production mode with high efficiency but a low cost has become an effective way to solve this contradiction. Through effective policy support and market support, agricultural mechanization can solve the contradiction between small-scale operations and large-scale operations [7]. On the other hand, agricultural mechanization is also conducive to breaking the constraints of capital and technology on agricultural operators [8]. As an effective form of labor factor transformation, agricultural production mechanization can solve the structural problems faced by the agricultural production industry from two aspects [9]. The first is to transform the production factors of traditional agricultural production from human production to mechanical production through agricultural production mechanization and solve the problem of hollow agricultural production caused by labor transfer [10]. On the other hand, more new production technologies can be introduced into the agricultural production field through agricultural production mechanization to achieve modern agricultural production increase and improve production efficiency from a technical perspective [11]. By analyzing the impact of agricultural production mechanization on grain production capacity and grain production capacity efficiency in agricultural production, this study explored the form and way of action of agricultural production mechanization in promoting agricultural production development and provided theoretical support for the development strategy of agricultural modernization.

2. Related Works

At present, the research on agricultural mechanization production is gradually deepening. From the perspective of crops, many studies have analyzed the changes in crop yield under the modern agricultural environment and the role of agricultural mechanization in it [12]. Gandasari (2021) analyzed the characteristics of the crop state in the agricultural production process as a research dimension and designed an innovative two-wheeled walking tractor and a new water pump system. The research results show that the innovative agricultural production system designed in the study can effectively reduce production costs while increasing output, effectively reduce the operational difficulty of agricultural production personnel, and improve production efficiency [13].Wu et al. (2021) took the degree of agricultural machinery input and the degree of grain output as the main research elements and established threshold regression and spatial effect analysis models. The results showed that the degree of agricultural production mechanization had a more obvious spatial spillover effect on grain output. Strategically improving the level of agricultural mechanization could effectively improve regional grain output and provide the possibility for the cross-regional cooperative operation of agricultural machinery [14]. Hilal et al. (2020) proposed a genetic algorithm-based identification model for wheat yield and straw-related variables to predict the yield of wheat main products and related agricultural by-products. The research results show that under the prediction of the model, the importance of fertilizer variables in wheat farms is 0.431 for phosphorus fertilizer, 0.327 for seed fertilizer, and 0.273 for nitrogen fertilizer, respectively [15]. It can be seen that the model can help agricultural growers to select more appropriate agricultural planting variables so as to obtain better agricultural production effects, Rahman et al. (2020) conducted in-depth discussions on the development trend of agricultural production mechanization in Bangladesh. The results show that the subsidy policy for agricultural mechanization projects is conducive to the formation of a benign market cycle for agricultural machinery manufacturers and agricultural producers [16]. At the same time, strengthening the popularization of agricultural machinery operation methods and the intelligent connection of agricultural machinery networks can improve the agricultural production effect and promote the development of agricultural modernization.Shaqiri and Vasa (2020) focused on comparing the economic characteristics of EU countries and carried out a systematic analysis of the agricultural mechanization in Kosovo. The research results show that for regions like Kosovo, with high agricultural employment levels and insufficient overall agricultural mechanization levels, agricultural subsidies should be increased to promote the development of agricultural mechanization, actively carry out agricultural mechanization service activities, and set up a mechanization service network [17]. It can be seen from the above studies that most of the studies have linked agricultural mechanization with agricultural production effects [18]. At the level of detail, they have studied the individual design of agricultural machinery and the prediction application of computerization. At the macro level, the development trend of mechanization and the affected factors of regional crop yield were studied. The perspective used in this study is similar to the macro perspective, but the impact is refined for each crop, and the analysis is also carried out from the perspective of time and space.

On the other hand, research on agricultural production capacity is also being enriched. Most of these studies focused on the analysis of the factors affecting the agricultural production capacity of the investigation team [19]. Mwanguhya and Ekere (2021) collected samples from 220 interviewees using random sampling techniques and used the Tobit model to conduct regression analysis on farmers' planting efficiency and economic characteristics. The research results show that the agricultural efficiency scores of cooperative farmers and non-cooperative farmers are significantly different, and the planting efficiency of farmers can be effectively improved by establishing a sound credit system and financial system [20]. Mile et al. (2021) explored Nigeria's agricultural expenditure and corresponding agricultural output, mainly using descriptive analysis methods, vector error tests, and variance decomposition methods. The research results show that there is a two-way relationship between Nigeria's agricultural expenditure and agricultural output during the forecast period. The establishment of a good agricultural credit system can promote the improvement in agricultural production efficiency and reduce farmers' poverty [21]. Ogundele and Ogundele (2020) studied the relationship between Nigeria's agricultural output and economic growth to determine the contribution of agricultural output to Nigeria's economic growth. The study used cointegration and vector error correction models for causal analysis. The research results show that the economic impact of agricultural output on economic growth is long-term and positive. As one of the major industries, it has played a certain supporting role in Nigeria's economic growth [22]. Mulu and Negessused (2020) the autoregressive distribution method to explore the impact of climate change on agricultural output and divided the impact into long-termand short-term impacts in the analysis process. The research results show that in the long run, the main climate-related variables have a significant impact on agricultural output, while in the short run, the impact of annual average rainfall is relatively significant, while the impact of average temperature is relatively insufficient [23]. It can be seen that the factors affecting agricultural production capacity include the agricultural financial system, climate factors, agricultural expenditure factors, planting efficiency factors, etc. [24]. At the present time of agricultural mechanization popularization, only analyzing a single factor is actually divorced from practical application. Therefore, this study combines different factors with agricultural mechanization and factors in the process of analyzing production capacity and production efficiency to form a comprehensive and practical analysis result.

To sum up, the current research on agricultural production capacity is mainly focused on specific agricultural production conditions in different regions, with more emphasis on the concept of specific regional analysis, while the research on agricultural mechanization focuses more on the new path of agricultural production brought about by technological development and policy support. This study also carries out the concept of the specific analysis of specific regions but divides the impact of agricultural mechanization on agricultural production into macro and micro perspectives for a more comprehensive analysis.

3. Model Design of the Impact of Agricultural Production Mechanization on Grain Production Capacity and Efficiency

3.1. Design of Production Capacity Model

When analyzing the impact of agricultural mechanization on grain production capacity and efficiency, the research mainly establishes models from the two perspectives of grain production capacity and production efficiency. At the same time, the macro panel data analysis and micro crop yield direction are used to analyze the model. On the one hand, this analysis method can more comprehensively analyze the force of agricultural mechanization. On the other hand, it can be analyzed from the perspective of main crop types, with a more comprehensive analysis and more emphasis on the impact path of mechanization. At the same time, the combination of the C–D production function and the Tobit model adopted in this study is more consistent with the research dimension and more feasible and scientific. In the context of agricultural mechanization, it is necessary to assume that agricultural producers are market-rational people and take the pursuit of agricultural production profits as the main goal [25]. This research also adopts this assumption, and the mechanized decision function of farmers is shown in Formula (1).

$$Z(R) = \begin{cases} 1, R = \Delta E(x_1, \ldots, x_n) - \Delta C(k_1, \ldots, k_m) > 0 \\ 0, R = \Delta E(x_1, \ldots, x_n) - \Delta C(k_1, \ldots, k_m) \leq 0 \end{cases} \tag{1}$$

In Formula (1), R is the expected profit increment of ΔE farmers, the expected income increment of ΔC farmers, the expected cost increase of x farmers, the variables that affect farmers' income, the variables k that affect farmers' costs, and Z the behavior of farmers choosing mechanized services. The production and management decision-making model of farmers under this assumption is shown in Formula (2).

$$MaxI = I_1 + I_2 + I_n - S - C \tag{2}$$

In Formula (2), I_1,I_2, and I_n represent the farmers' income from grain production and operation, other crops' production and operation income, and total non-agricultural income, respectively, whereas S represents the expenditure on purchasing mechanization services, and C represents the level of mechanization services in the area where the farmers are located. I_1 can be calculated as follows:

$$I_1 = \mathrm{f}_1(L_1, A_1, S_1) \tag{3}$$

In Formula (3), L_1 represents the labor force involved in grain production, A_1 is the grain planting area, and S_1 is the mechanization cost of grain production. I_2 can be calculated as follows:

$$I_2 = \mathrm{f}_2(L_2, A_2, S_2) \tag{4}$$

In Formula (4), L_2 represents the labor force involved in non-food production, A_2 is the non-food planting area, and S_2 is the mechanization cost of non-food production. The decision-making model for farmers' production goals isshown in Formula (5).

$$MaxI = Q \cdot Pq + I_n - C \tag{5}$$

In Formula (5), Pq represents the market grain price, and Q represents the grain output of a single household, which can be calculated as follows:

$$Q = \mathrm{f}(HL, HM, HF, A) \tag{6}$$

In Formula (6), HL can be calculated as follows:

$$HL = A_1 \times L \tag{7}$$

In Formula (7), A represents the grain planting area, and L represents the labor input per mu. HM can be calculated as follows:

$$HM = A_1 \times M \tag{8}$$

In Formula (8), M represents the input of agricultural machinery per mu. HF can be calculated as follows:

$$HF = A_1 \times F \tag{9}$$

In Formula (9), F represents the fertilizer input per mu. Under the combined effect of production decision-making and mechanization decision-making, the impact mechanism of agricultural mechanization services on grain production capacity is shown in Figure 1.

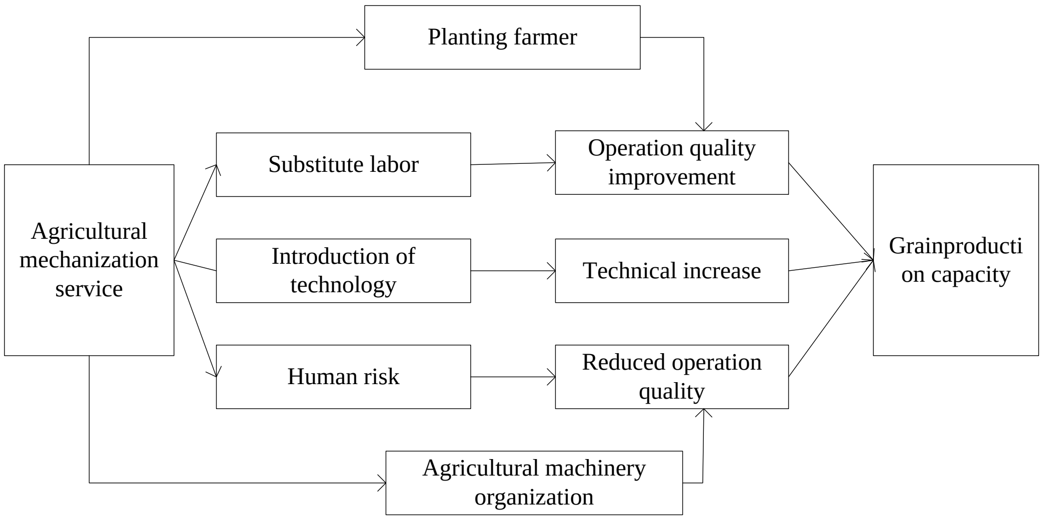

Figure 1. Impact mechanism of agricultural mechanization service on grain production capacity.

It can be seen from Figure 1 that agricultural mechanization services mainly affect food production capacity from three perspectives: replacing traditional labor, introducing new agricultural technologies, and generating human risks of mechanized technology [26]. In an ideal state, the first two factors will promote the improvement in the quality of agricultural production operations and achieve mechanized yield increases through technological development, while human risk may reduce the quality of operations [27]. When constructing the production capacity model, the research is constructed from the perspectives of the provincial panel and crop yield capacity. The provincial panel model is mainly designed based on the perspective of the C–D production function, as shown in Formula (10).

$$\ln y_{it} = \beta_0 + \beta_1 \ln m_{it} + \beta_2 \ln lab_{it} + \beta_3 \ln land_{it} + \beta_4 \ln \ln f_{it} + \beta_5 \ln dis_{it} + u \tag{10}$$

In Formula (10), y_{it}, m_{it}, lab_{it}, $land_{it}$ and $\ln f_{it}$, dis_{it} represent the total grain production capacity, the input of mechanical power resources, the input of labor, the input of land, the input of chemical fertilizer, and the degree of damage to crops, respectively, while the β values representthe parameters to be estimated, and u represents the interference items. The specific variables are shown in Table 1.

Table 1. Provincial panel data variables.

Variable Number	Variable Name	Variable Explanation	Variable Dimension	Maximum Value	Minimum	Average Value	Sample Size
A1	Total food production capacity	Total food output	Tons	6325	154	2077.55	315
A2	Mechanical power resource input	Total power of agricultural machinery * ratio of grain sown area	Ten thousand kilowatts	9071.74	143.31	2286.56	315
A3	Mechanical service revenue	Total income from agricultural machinery services * ratio of grain sown area	Billion	296.31	4.87	74.17	315
A4	Labor input	Number of agricultural employees * ratio of grain sown area	10,000 People	2105.42	76.82	716.74	315
A5	Land input	Grain sown area	Thousand hectares	11,764.35	376.71	4141.23	315
A6	Fertilizer input	Fertilizer usage * ratio of grain sown area	Tons	6.32	2.86	4.71	315
A7	Crop damage	Grain affected area/grain sown area	/	0.97	0.03	0.26	315

Note: * Indicates a multiplication sign.

The model based on crop yield capacity is also based on the C–D production function model, as shown in Formula (11).

$$\ln yr_{i,t} = \beta_0 + \beta_1 \ln mr_{i,t} + \beta_2 \ln lr_{i,t} + \beta_3 \ln fr_{i,t} + \beta_4 \ln kr_{i,t} + u_{i,t} \quad (11)$$

In Formula (11), yr, mr, lr, fr, and kr represent the output capacity per mu, the amount of mechanization cost, the amount of labor input, the amount of fertilizer input, and other costs, respectively. Here, i indicates the area, t is the time, and u is the interference item. The specific variables are shown in Table 2.

Table 2. Data variables of crop yield per unit area.

Crop Type	Variable Number	Variable Name	Variable Explanation	Variable Dimension	Maximum Value	Minimum	Average Value	Sample Size
Rice crops	B1	Rice yield per mu	Output of main products per mu of rice crops	Kilogram	718.21	274.41	492.45	300
	B2	Mechanization cost per mu of rice	Mechanized operation cost per mu of rice crops	Yuan	20.32	0.01	84.31	300
	B3	The amount of labor input per mu of rice	Labor usage per mu of rice crops	Day	26.71	3.04	9.81	300
	B4	Fertilizer input per mu of rice	Fertilizer usage per mu of rice crops	Kilogram	39.64	13.67	22.56	300
	B5	Other expenses per mu of rice	Other services and miscellaneous charges per acre of rice crops	Yuan	198.71	69.77	113.46	300

Table 2. *Cont.*

Crop Type	Variable Number	Variable Name	Variable Explanation	Variable Dimension	Maximum Value	Minimum	Average Value	Sample Size
Wheat crops	C1	Output capacity per mu of wheat	Output of main products per mu of wheat crops	Kilogram	495.26	100.81	341.37	190
	C2	Mechanization cost per mu of wheat	Mechanized operation cost per mu of wheat crops	Yuan	131.47	4.96	71.35	190
	C3	The amount of labor input per mu of wheat	Labor usage per mu of wheat crops	Day	14.27	0.27	7.21	190
	C4	Fertilizer input per mu of wheat	Fertilizer usage per mu of wheat crops	Kilogram	38.13	10.14	23.51	190
	C5	Other expenses per mu of wheat	Other services and miscellaneous charges per acre for wheat crops	Yuan	162.75	40.81	87.42	190
Corn crops	D1	Yield capacity per mu of corn	Main product output per mu of corn crops	Kilogram	691.61	231.76	457.43	245
	D2	Mechanization cost per mu of corn	Mechanized operation cost per mu of corn crops	Yuan	127.81	0.01	47.51	245
	D3	The amount of labor input per mu of corn	Corn crops labor usage per acre	Day	23.94	2.67	8.82	245
	D4	Fertilizer input per mu of corn	Fertilizer usage per mu of corn crops	Kilogram	33.87	13.81	23.91	245
	D5	Other expenses per mu of corn	Other services and miscellaneous charges per acre for corn crops	Yuan	182.42	17.94	77.23	245

3.2. Design of Production Efficiency Model

Food production efficiency refers to the degree of matching between the input of food production factors and the resulting food output [28]. The effect of socialized agricultural mechanization services on grain production efficiency is mainly reflected in two aspects, one is the reset of labor factors, and the other is the introduction of modern technology [29], as shown in Figure 2.

The research is mainly based on the Tobit model, and the model is constructed from the perspective of crop yield capacity. The crops are divided into three types: rice, wheat, and corn. For each crop type, separate indicators and models are established. The rice individual model is shown in Formula (12).

$$Ter_1 = \beta_0 + \beta_1 Mc_{i,t} + \beta_2 LnEdu_{i,t} + \beta_3 LnLandr_{i,t} + \beta_4 Dis_{i,t} + \beta_5 Irr_{i,t} + u_{i,t} \tag{12}$$

In Formula (12), Ter, Mc, Edu, $Landr$, Dis, and Irr represent rice production efficiency, mechanized water products, farmers' education level, rice planting scale, rice disaster status, and rice irrigation status, respectively. Edu is calculated as follows:

$$Edu = \frac{prs \cdot 6 + jms \cdot 9 + sms \cdot 12 + jc \cdot 15}{people} \tag{13}$$

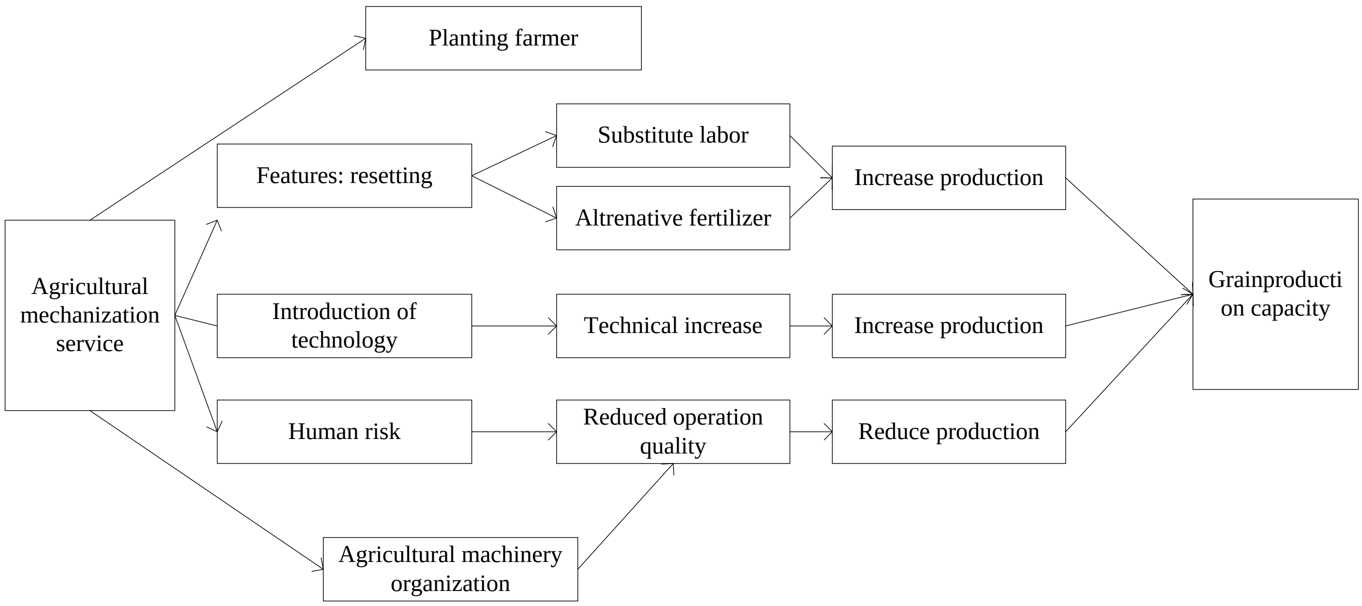

Figure 2. Impact mechanism of agricultural mechanization service on grain production efficiency.

In Formula (13), *people* represents the sample group aged six years and above, *prs* represents the number of groups with primary school education, *jms* represents the number of groups with junior high school education, *sms* represents the number of groups with high school education, and *jc* represents the number of groups withcollege education and above, respectively. The rice stand-alone model isshown in Formula (14).

$$Ter_2 = \beta_0 + \beta_1 Mc_{i,t} + \beta_2 LnEdu_{i,t} + \beta_3 LnLandrw_{i,t} + \beta_4 Dis_{i,t} + \beta_5 Irr_{i,t} + u_{i,t} \quad (14)$$

In Formula (14), *Landrw* represents the wheat planting scale. The separate model for the corn class isshown in Formula (15).

$$Ter_3 = \beta_0 + \beta_1 Mc_{i,t} + \beta_2 LnEdu_{i,t} + \beta_3 LnLandr\mathrm{c}_{i,t} + \beta_4 Dis_{i,t} + \beta_5 Irr_{i,t} + u_{i,t} \quad (15)$$

In Formula (15), *Landrw* represents the wheat planting scale. The specific variables are shown in Table 3.

Table 3. Production efficiency model data variables.

Crop Type	Variable Number	Variable Name	Variable Explanation	Variable Dimension	Maximum Value	Minimum	Average Value	Sample Size
Rice crops	E1	Rice production efficiency	Agricultural productivity of rice crops	/	0.9892	0.6261	0.8663	300
	E2	Agricultural machinery service supply level	Number of agricultural machinery employees per hectare of rice crop sown area	People	0.6453	0.0754	0.2827	300
	E3	Agricultural machinery service utilization	Agricultural machinery operation cost as a percentage of total service cost	%	0.4735	0.0001	0.2486	300

Table 3. *Cont.*

Crop Type	Variable Number	Variable Name	Variable Explanation	Variable Dimension	Maximum Value	Minimum	Average Value	Sample Size
	E4	Average years of education for farmers	Average years of education of rural residents	Year	8.2163	5.6349	7.3891	300
	E5	Percentage of farmers in basic education	Rural population with junior high school education or above in the total population	%	0.6953	0.2433	0.5346	300
	E6	Rice planting scale	Planting area of rice crops under a unit farmer	mu	9.2354	0.0731	2.1135	300
	E7	Disaster status of rice	Proportion of affected area of rice crops in planted area	%	0.9461	0.0257	0.2381	300
	E8	Rice irrigation status	Proportion of effective irrigated area of rice crops in planted area	%	0.6472	0.1532	0.3642	300
Wheat crops	F1	Wheat production efficiency	Agricultural productivity of wheat crops	/	0.9862	0.6172	0.8172	200
	F2	Agricultural machinery service supply level	Number of agricultural machinery employees per hectare of wheat crop sown area	people	0.6453	0.0813	0.3121	200
	F3	Agricultural machinery service utilization	Agricultural machinery operation cost as a percentage of total service cost	%	0.3871	0.0516	0.2453	200
	F4	Average years of education for farmers	Average years of education of rural residents	year	8.5271	5.6341	7.3542	200
	F5	Percentage of farmers in basic education	Rural population with junior high school education or above in the total population	%	0.6982	0.2532	0.5301	200
	F6	Wheat planting scale	Wheat crop planting area under unit farmer	mu	7.0347	0.2138	2.2794	200
	F7	Wheat disaster situation	Proportion of affected area of wheat crops in planted area	%	0.6776	0.0265	0.2543	200
	F8	Irrigation status of wheat	Proportion of effective irrigation area of wheat crops in planting area	%	0.9247	0.2341	0.4102	200

Table 3. *Cont.*

Crop Type	Variable Number	Variable Name	Variable Explanation	Variable Dimension	Maximum Value	Minimum	Average Value	Sample Size
corn crops	G1	corn production efficiency	Agricultural productivity of corn crops	/	0.9643	0.6152	0.7561	250
	G2	Agricultural machinery service supply level	The number of agricultural machinery employees per hectare of corn crop sown area	people	0.6452	0.0768	0.2953	250
	G3	Agricultural machinery service utilization	Agricultural machinery operation cost as a percentage of total service cost	%	0.2464	0.0000	0.0984	250
	G4	Average years of education for farmers	Average years of education of rural residents	year	8.5421	5.6342	0.7321	250
	G5	Percentage of farmers in basic education	Rural population with junior high school education or above in the total population	%	0.6983	0.2541	0.5223	250
	G6	corn planting scale	Corn crop planting area under a unit farmer	mu	16.6578	0.3452	3.0673	250
	G7	Disaster status of corn	Proportion of affected area of corn crops in planted area	%	0.6783	0.0164	0.2541	250
	G8	Irrigation status of corn	Proportion of effective irrigation area of corn crops in planting area	%	0.9217	0.1459	0.3842	250

4. Analysis of the Impact of Agricultural Production Mechanization on Grain Production Capacity and Efficiency

4.1. Analysis of the Impact of Agricultural Production Mechanization on Grain Production Capacity

When analyzing the impact of agricultural production mechanization on grain production capacity, the research will analyze from the perspectives of provincial panel data and crop yield capacity. The panel data is analyzed, and the basic data comes from the "China Statistical Yearbook". The specific results are shown in Table 4.

From Table 4, it can be seen that the fixed effects equation results are better. From the fixed effect equation, the influence coefficient of the input of mechanical power resources on the total grain production capacity is 0.0976, which is significant at the 1% level. The influence coefficient of machinery service income on the total grain production capacity is 0.0437, which is significant at the 5% level. This shows that the input of mechanical power resources has a significant positive impact on the total grain production capacity, and the income from mechanical services has a significant effect on the total grain production capacity. In the part of crop yield data analysis, this study also selected 2017 to 2021 as the research period, and the basic data came from the "National Agricultural Product Cost and Benefit Data Compilation". The specific results are shown in Table 5.

Table 4. Analysis of provincial panel data.

Variable Name	Numeric Type	Dynamic Variable Equation		Income Variable Equation	
		Fixed Effects	Random Effects	Fixed Effects	Random Effects
Mechanical power resource input	Coefficient value	0.0976	0.0843	/	/
	Significance level	1%	1%	/	/
Mechanical service revenue	Coefficient value	/	/	0.0437	0.0531
	Significance level	/	/	5%	1%
Labor input	Coefficient value	0.0223	−0.167	−0.0346	−0.0533
	Significance level	>10%	>10%	>10%	>10%
Land input	Coefficient value	0.3871	0.3581	0.4521	0.3841
	Significance level	1%	1%	1%	1%
Fertilizer input	Coefficient value	4265	0.5821	0.4726	0.6563
	Significance level	1%	1%	1%	1%
Crop damage	Coefficient value	−0.2413	−0.2527	−0.2543	−0.2641
	Significance level	1%	1%	1%	1%
Constant term	Coefficient value	1.2547	0.4832	1.5022	0.5607
	Significance level	1%	>10%	1%	5%
Hausman test	Coefficient value	13.24	/	16.52	/
	Significance level	5%	/	1%	/
F value	Coefficient value	105.14	/	82.91	/
	Significance level	1%	/	1%	/
VIF range		(1.17, 7.78)	(1.17, 7.78)	(1.19, 7.68)	(1.19, 7.68)
Sample size		315	315	315	315

Table 5. Analysis of crop yield per unit area.

Rice Crop Analysis				Wheat Crop Analysis				Analysis of Corn Crops			
Variable Name	Numeric Type	Model Analysis		Variable Name	Numeric Type	Model Analysis		Variable Name	Numeric Type	Model Analysis	
		Fixed Effects	Random Effects			Fixed Effects	Random Effects			Fixed Effects	Random Effects
Mechanization cost per mu of rice	Logarithm	0.0311	0.0338	Mechanization cost per mu of wheat	Logarithm	0.0827	0.0753	Mechanization cost per mu of corn	Logarithm	0.0233	0.0274
	Significance level	1%	1%		Significance level	1%	1%		Significance level	5%	1%
The amount of labor input per mu of rice	Logarithm	−0.0224	−0.0128	The amount of labor input per mu of wheat	Logarithm	−0.0332	−0.0511	The amount of labor input per mu of corn	Logarithm	−0.0762	−0.0735
	Significance level	>10%	>10%		Significance level	>10%	5%		Significance level	>10%	>10%
Fertilizer input per mu of rice	Logarithm	0.2781	0.2642	Fertilizer input per mu of wheat	Logarithm	0.2341	0.4032	Fertilizer input per mu of corn	Logarithm	0.2122	0.2342
	Significance level	1%	1%		Significance level	1%	1%		Significance level	1%	1%
Other expenses per mu of rice	Logarithm	0.1368	0.1783	Other expenses per mu of rice	Logarithm	0.1322	0.0261	Other expenses per mu of corn	Logarithm	0.0913	0.0957
	Significance level	1%	1%		Significance level	5%	>10%		Significance level	1%	1%
Constant term	Logarithm	4.6867	4.5704	Constant term	Logarithm	4.2781	4.2317	Constant term	Logarithm	5.2312	5.0524
	Significance level	1%	1%		Significance level	1%	1%		Significance level	1%	1%
Hausman test	Logarithm	8.46	/	Hausman test	Logarithm	48.33	/	Hausman test	Logarithm	15.34	/
	Significance level	10%	/		Significance level	1%	/		Significance level	5%	/
F test	Logarithm	42.73	/	F test	Logarithm	12.27	/	F test	Logarithm	19.41	/
	Significance level	1%	/		Significance level	1%	/		Significance level	1%	/
VIF test		(1.38, 2.57)	(1.38, 2.57)	VIF test		(1.36, 3.72)	(1.36, 3.72)	VIF test		(1.52, 2.43)	(1.52, 2.43)
Sample size		300	300	Sample size		190	190	Sample size		245	245

In Table 5, the Hausman test of the fixed effect is more significant, and the result is better. In terms of rice crops, the influence coefficient of the cost per mu of mechanization on the yield capacity of rice crops is 0.0311, and 1% water is significant; in terms of wheat crops, the influence coefficient of the cost per mu of mechanization on the yield capacity of rice crops is 0.0827, and 1% water quality is significant; for maize crops, the influence coefficient of the mechanization cost per mu on the yield capacity of rice crops is 0.0233, and 5 % water quality is significant. It can be seen that the amount of mechanization cost per mu has a significant positive impact on the yield per unit of the three crops.

4.2. Analysis of the Impact of Agricultural Production Mechanization on Grain Production Capacity

In the analysis of the impact of agricultural production mechanization on grain production capacity, the research is mainly analyzed from the perspective of crop yield capacity. The rice crop results areshown in Table 6.

Table 6. Data analysis of rice crops.

Variable Name	Numeric Type	Model Analysis	
		Supply Level Model	Utilization Model
Agricultural machinery service supply level	Logarithm	0.0192	/
	Significance level	1%	/
Agricultural machinery service utilization	Logarithm	/	0.0059
	Significance level	/	1%
Average years of education for farmers	Logarithm	−0.0053	/
	Significance level	5%	/
Percentage of farmers in basic education	Logarithm	/	−0.0069
	Significance level	/	1%
Rice planting scale	Logarithm	−0.0415	−0.0162
	Significance level	1%	1%
Disaster status of rice	Logarithm	−0.0076	−0.0061
	Significance level	1%	1%
Rice irrigation status	Logarithm	0.0234	0.0762
	Significance level	1%	1%
Constant term	Logarithm	0.9754	0.8973
	Significance level	1%	1%
LR test	Logarithm	1892.66	1807.92
	Significance level	1%	1%
VIF test		(1.16, 1.35)	(1.16, 1.35)
Sample size		300	300

In Table 6, the influence coefficient of agricultural machinery service supply level per mu on the production efficiency of rice crops is 0.0192, which is significant at the 1% level. The influence coefficient of agricultural machinery service utilization rate on rice crop production efficiency is 0.0059, which is significant at the 1% level. It can be seen that both the supply level of agricultural machinery services per mu and the utilization rate of agricultural machinery services have a significant positive impact on the production efficiency of rice crops. The wheat crop results are shown in Table 7.

Table 7. Data analysis of wheat crops.

Variable Name	Numeric Type	Model Analysis	
		Supply Level Model	Utilization Model
Agricultural machinery service supply level	Logarithm	0.0587	/
	Significance level	1%	/
Agricultural machinery service utilization	Logarithm	/	0.0148
	Significance level	/	5%
Average years of education for farmers	Logarithm	−0.1041	−0.1304
	Significance level	1%	1%
Percentage of farmers in basic education	Logarithm	/	/
	Significance level	/	/
Wheat planting scale	Logarithm	0.0097	0.0098
	Significance level	1%	1%
Wheat disaster situation	Logarithm	−0.0121	−0.0095
	Significance level	1%	1%
Irrigation status of wheat	Logarithm	0.0028	0.0173
	Significance level	>10%	1%

Table 7. *Cont.*

Variable Name	**Numeric Type**	**Model Analysis**	
		Supply Level Model	**Utilization Model**
Constant term	Logarithm	1.0461	0.9013
	Significance level	1%	1%
LR test	Logarithm	976.24	994.13
	Significance level	5%	1%
VIF test		(1.24, 1.73)	(1.24, 1.73)
Sample size		200	200

In Table 7, the influence coefficient of agricultural machinery service supply level per mu on the production efficiency of wheat crops is 0.0587, which is significant at the 1% level. The influence coefficient of agricultural machinery service utilization rate on the production efficiency of rice and wheat crops is 0.0148, which is significant at the 5% level. It can be seen that the supply level of agricultural machinery services per mu and the utilization rate of agricultural machinery services have a significant positive impact on the production efficiency of wheat crops. The corn crop results are shown in Table 8.

Table 8. Data analysis of corn crops.

Variable Name	**Numeric Type**	**Model Analysis**	
		Supply Level Model	**Utilization Model**
Agricultural machinery service supply level	Logarithm	0.0241	/
	Significance level	1%	/
Agricultural machinery service utilization	Logarithm	/	0.0607
	Significance level	/	1%
Average years of education for farmers	Logarithm	0.1087	/
	Significance level	1%	/
Percentage of farmers in basic education	Logarithm	/	0.0823
	Significance level	/	1%
Corn planting scale	Logarithm	−0.0141	−0.0211
	Significance level	1%	1%
Disaster status of corn	Logarithm	−0.0075	−0.0028
	Significance level	1%	1%
Irrigation status of corn	Logarithm	0.0036	0.0029
	Significance level	1%	1%
Constant term	Logarithm	0.4963	0.6587
	Significance level	1%	1%
LR test	Logarithm	1082.78	1093.43
	Significance level	1%	1%
VIF test		(1.34, 1.50)	(1.34, 1.50)
Sample size		250	250

In Table 8, the influence coefficient of agricultural machinery service supply level per mu on the production efficiency of maize crops is 0.0241, which is significant at the 1% level. The influence coefficient of agricultural machinery service utilization rate on the production efficiency of rice and corn crops is 0.0607, which is significant at the 1% level. It can be seen that the supply level of agricultural machinery services per mu and the utilization rate of agricultural machinery services have a significant positive impact on the production efficiency of corn crops. To sum up, for the three crops of rice, wheat, and corn, the level of agricultural machinery service supply per mu and the utilization rate of agricultural machinery services can significantly affect crop production efficiency, forming a positive driving effect. Although the research has carried out a more detailed analysis of the food production capacity and efficiency path of agricultural mechanization, agricultural mechanization is not the only factor affecting the food production capacity and efficiency, and the research lacks a more comprehensive analysis, which is also one of the future research directions.

5. Conclusions

In order to explore the influence of agricultural production mechanization on grain production capacity and efficiency, this research takes the C–D production function as the theoretical basis to establish the influence model of grain production capacity, and based on the Tobit model, establishes the influence model of grain efficiency capacity. This research uses provincial panel data and national agricultural product cost-benefit data from 2017 to 2021 as the data basis for empirical analysis. The research results show that in terms of grain production capacity, the amount of mechanical service income and the input of mechanical power resources have a significant positive impact on the total grain production capacity. The influence coefficients of the cost on the crop yield capacity are 0.0311, 0.0827, and 0.0233, respectively, and the positive effect is significant. In terms of the grain production efficiency for rice crops, wheat crops, and corn crops, the influence coefficients of agricultural machinery service supply level per mu are 0.0192, 0.0587, and 0.0241, respectively; the influence coefficients of agricultural machinery service utilization rate are 0.0059, 0.0148, and 0.0607, respectively, and the positive effect is significant. It can be seen that the mechanization of industrial production can simultaneously improve grain production capacity and efficiency and provide a material basis and technical support for the development of agricultural modernization.

Author Contributions: In this paper, X.L. (Xiangjuan Liu) put forward the research experiment: the research starts from the two aspects of grain production capacity and grain production efficiency, using the C–D production function and the Tobit model as the basis, respectively, to establish two impact models, and uses the data from 2017 to 2021 for empirical analysis. X.L. (Xibing Li) analyzed the data and helped with the constructive discussion. X.L. (Xiangjuan Liu) and X.L. (Xibing Li) made great contributions to manuscript preparation. All authors have read and agreed to the published version of the manuscript.

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