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Unlocking Agricultural Modernization: Economic Factors Shaping Maize Farmers' Adoption of Outsourced Services

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Effective farmland management is crucial for enhancing agricultural competitiveness, ensuring food security, and achieving agricultural modernization. In the context of China's small farming system, connecting small farmers with modern agriculture poses a significant challenge. This research employs a quantitative approach to investigate the impact of factor pricing on the demand for agricultural production services, focusing on labor prices, land rent, and income from agriculture. Utilizing data from the Rural Revitalization Survey (CRRS), covering 45 villages across six cities and two provinces, the study utilizes the Double-Hurdle Model to address sample selection bias. Descriptive statistics and participation rates reveal patterns across various agricultural activities, and average costs for key services are presented. Estimated coefficients and significance levels demonstrate intriguing dynamics in Tillage, Sowing, and Harvesting Services. Small-scale farmers exhibit elastic demand, emphasizing the impact of service costs on decisions, while large-scale farmers display inelastic demand for harvesting services. Regression analyses highlight challenges faced by small-scale farmers, including impediments to tillage and harvesting services adoption due to high associated costs. In contrast, large-scale farming operations show resilience to some cost factors. The study provides actionable insights for policymakers, agricultural service providers, and farmers, contributing significantly to the discourse on sustainable farming practices. However, limitations include assumptions about uniform service distribution across regions and reliance on cross-sectional data, suggesting the potential for enhanced reliability with the inclusion of panel data in future research.

Keywords: Farmland Management, Harvesting Services, Cost Factors, Service Distribution.

Introduction:

As agricultural mechanization progresses, farm machinery is increasingly assuming a crucial role in replacing manual labor and draft animals (such as horses, oxen, and mules), thereby enhancing agricultural productivity [1]. However, the economic advantages derived from machinery utilization are significantly contingent on achieving economies of scale. Farmers can access agricultural machinery through various means, including purchasing, renting, or availing machinery services. China, recognized as the world's second-largest maize producer, has long embraced the use of agricultural machinery in activities like plowing, seeding, and harvesting. Figure 1 illustrates the upward trajectory of mechanization in China's national maize production. While mechanical plowing and seeding have seen substantial development, mechanical harvesting slightly lags behind. As of 2018, the overall mechanization rate for maize production averaged 88.31% across all regions in China [2].

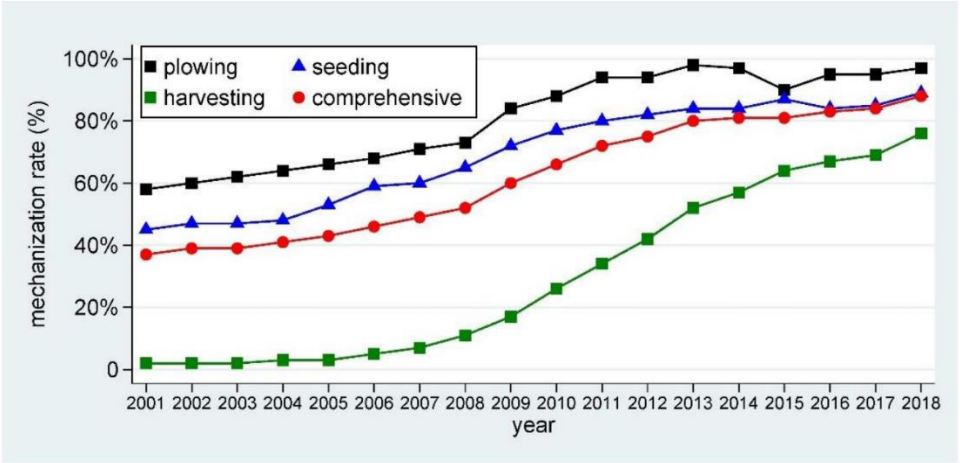

Figure 1: The level of mechanization in maize production in China from 2001 to 2018 [3].

Effective farmland management is essential for enhancing agricultural competitiveness, ensuring food security, and achieving agricultural modernization. In the context of China's small farming system, establishing a strong link between small farmers and modern agriculture is a key challenge [4]. Large-scale agricultural production is seen as a means to boost productivity, increase farmers' income, and improve livelihoods. Over recent years, the expansion of farmland transfer for agricultural scale management has gained momentum. By 2017, approximately 21% of land cultivated by Chinese farmers was leased through the agricultural land rental market. However, challenges in realizing agricultural scale management through land transfer include the need for sufficient assets and advanced machinery technology [5] [6].

The burgeoning services outsourcing market provides a solution for farmers facing constraints in agricultural production input factors. Specifically, agricultural machinery service outsourcing plays a vital role in alleviating agricultural scale management challenges and contributing to agricultural modernization. This approach has garnered attention from Chinese agricultural producers and policymakers [7].

The development of service outsourcing in China, driven by agricultural mechanization, has witnessed rapid growth. As of the end of 2021, China boasts 955,000 agricultural social service organizations, serving more than 78 million small farmers across a vast service area. Agricultural mechanization has led to the specialization of various farming processes, such as plowing, weeding, pesticide application, irrigation, and harvesting, which were traditionally carried out by farmers' family labor [8]. This shift to specialized service outsourcing entities has simplified tasks, reduced manual labor, and refined the social division of labor. With the continuous advancement of agricultural mechanization, service outsourcing has become increasingly divisible and specialized, allowing farmers to delegate part or all of their production and operation activities to service outsourcing entities [9]. This, in turn, expands farmers' production and operation capabilities while minimizing production losses. Recognizing the significance of this trend, China's central policy documents from 2013 to 2023 have consistently supported and encouraged the development of specialized agricultural socialized services [10].

Benefiting from robust central policy support and growing demand for farmer services, specialized and large-scale agricultural services have flourished. In many Asian regions, including Japan and South Korea, small farmers' land is increasingly consolidated into larger-scale production units. Farmers' participation in service outsourcing induces a vertical division of labor in agricultural production, resulting in positive outcomes such as improved agricultural productivity, increased food production, and higher farmer income [11].

Moreover, service outsourcing has been shown to expand the scale of farmland management by alleviating labor, technology, and capital constraints in farming operations. It also promotes a deeper agricultural labor division, reduces transaction costs, and enhances farmers' willingness to operate on a large scale [12]. When farmers reach a certain scale of land management, they can improve the efficiency of agricultural production by purchasing specialized service outsourcing. The positive effect of service outsourcing on production efficiency is more significant for large-scale operators, further increasing farmland management income [13].

While existing studies have emphasized the benefits of labor division through service outsourcing, this paper aims to provide a more comprehensive understanding by considering transaction costs incurred by farmers in service outsourcing. The analysis incorporates the benefits of labor division and transaction costs into a unified framework, conducting theoretical and empirical research on the impact of agricultural machinery service on farmers' farmland transfer decisions. This approach enriches the current research on the formation and development mechanism of farmland scale management and provides theoretical and empirical insights for promoting moderate agricultural scale management [14].

To address these challenges and ensure efficient agricultural production in small-scale decentralized operations, various strategies can be employed. While land transfer is considered a method for enabling extensive farming activities, challenges such as defective land transfer agreements, fierce competition, and higher production costs limit its effectiveness [15]. Thus, land transfer alone cannot solve the issue. Purchasing output-enhancing agricultural services within a decentralized land management framework emerges as a fruitful strategy. The agricultural production service sector, once a weak part of the rural economy, has become a catalyst for improving and modernizing the agricultural sector [16].

Although agricultural productive services contribute to increased agricultural output, there is room for improvement. Despite millions of smallholder farmers receiving support from service organizations, a considerable portion of the population has not fully adopted agricultural production services [7]. Factors influencing farmers' choices include social ties, home business characteristics, transaction costs, market climate, and economic considerations. Economic reasons, such as the correlation between labor and machinery replacement, drive farmers' choices. However, exorbitant expenses associated with agricultural technology implementation and prioritization of financial benefits over yield pose barriers to adoption [17].

Comprehensive and precise market data, supportive policies, and social capital can enhance farmers' comprehension of agricultural production services and increase adoption rates. Laws offering price support and fertilizer subsidies, along with policies granting access to additional inputs, can incentivize farmers to use agricultural technology services [18]. Additionally, social capital and group participation positively influence the adoption of agricultural production services. Land leases and cropping tactics also significantly impact farmers' decisions regarding service adoption [19].

To address existing gaps in research, the study employs the Double-Hurdle Model to examine factors influencing farmers' decision-making in selecting services. This model allows for a comprehensive analysis of the endogenous issues associated with sample self-selection during the model selection procedure. Ultimately, the study provides valuable insights for policy recommendations and subsidies related to agricultural output services.

Methodology:

The theoretical foundation and research hypothesis.

To investigate the impact of factor pricing on the demand for services associated with agricultural production, the study will employ a quantitative research methodology. The research will focus on understanding the dynamics of supply and demand for agricultural production services, particularly in response to changes in labor prices, land rent, and income from agriculture. The study aims to test hypotheses related to the factors influencing the demand for these services.

Research Design:

Data Sources: Utilize existing databases related to agricultural production, labor prices, land rent, and household income.

Survey Instruments: Develop surveys to gather primary data from farmers regarding their usage of agricultural production services, factors influencing their decisions, and their income levels.

Case Studies: Analyze specific cases or regions to understand localized factors affecting the demand for agricultural production services.

Variable Measurement:

Dependent Variable: The demand for agricultural production services.

Independent Variables:

- Labor prices.
- Land circulation rent.
- Net family income from agriculture.

Hypothesis Testing:

Hypotheses:

Higher labor prices lead to a decrease in the demand for agricultural production services. Lower land rent increases the demand for agricultural production services. The rise in land circulation rent restricts the utilization of agricultural services by rural farmers. An increase in net family income encourages farmers to invest in agricultural production services.

Statistical Analysis: Conduct statistical analyses such as regression models to test the hypotheses and quantify the relationships between variables.

Sampling:

Population: Small-scale farmers involved in agricultural production.

Sampling Method: Random sampling or stratified sampling based on geographical regions.

Ethical Considerations:

- Ensure informed consent from participants.
- Protect participants' privacy and confidentiality.
- Adhere to ethical standards in data collection and analysis.

Data Analysis:

- Use statistical software (e.g., R, Python) for quantitative data analysis.
- Apply appropriate statistical tests to examine relationships and correlations.
- Interpret the results to draw conclusions related to the hypotheses.

Limitations and Challenges:

- Potential biases in self-reported survey data.
- Variability in agricultural practices across regions.
- External factors influencing demand (e.g., government policies).

Results and Discussion:

The research is expected to provide insights into the factors affecting the demand for agricultural production services, particularly the influence of labor prices, land rent, and income from agriculture. The findings will contribute to a better understanding of the economic dynamics shaping the utilization of services in the agricultural sector.

The study's results may have implications for policymakers, agricultural service providers, and farmers, helping them make informed decisions and implement strategies that enhance the efficiency of agricultural production in small-scale operations.

Model and Empirical Data Configuration

The study sourced its data from the comprehensive China Rural Revitalization Survey (CRRS) database, conducted during April and May of 2021. Encompassing 45 villages across six cities and spanning two provinces, the survey employed a rigorous sampling strategy, selecting participants randomly from chosen villages to form the study's sample. The data collection process was structured into three main categories: individual, family, and community. Individual-level data encompassed employment, education, and demographic information, while family-level data delved into income, expenses, land ownership, and agricultural activities. At the community level, the focus expanded to include organizational aspects, population dynamics, land ownership, rural industries, and economic progress. The survey employed a systematic approach, incorporating random village selection based on economic advancement rates, equidistant sampling for counties and townships, and a two-step process for farmers' selection to ensure diversity.

To ensure the reliability and completeness of the collected data, a robust data purification process was implemented. This involved questionnaire administration for individuals and households, a linear difference methodology, and forward and backward filling to address missing data. The study honed in on specific agricultural activities, particularly land cultivation, harvesting, and sowing services, with sample sizes of 100, 150, and 160, respectively. In terms of modeling, the study opted for the Double-Hurdle Model, originally developed by Cragg in 1971. This model was chosen to address sample selection bias, a limitation present in Logit and Probit models. The Double-Hurdle Model consists of two stages: the Binary Choice Method and the Two-Column Model Estimation. In the Binary Choice Method, farmers decide whether to obtain services, represented by the variable di. A latent variable di* controls the decision to move to the second stage, and ɛi represents the error term, with Zi' including explanatory variables influencing the latent variable. The Two-Column Model Estimation involves a Probit model estimating the first stage and a Tobit model estimating the second stage. This two-stage approach aims to discern factors influencing farmers' decisions to use agricultural services while addressing potential biases inherent in single-stage models, contributing to a more nuanced understanding of the complexities involved in this decision-making process.

Statistical Data Analysis:

The study focuses on several dependent variables, considering the quantity of services obtained, such as planting, harvesting, cultivation, and fertilization, as the primary metrics of interest. Each of these activities, representative of specific services related to the land, serves as a dependent variable in the analysis. In terms of services utilization, the study reveals noteworthy patterns across various agricultural activities. For sowing services, nearly 58% of farmers participated, averaging 0.297 hectares per farmer. Cultivation services were utilized by approximately 12% of farmers, covering an average area of 0.21 hectares. Pest and disease control services were employed by around 9% of farmers. Fertilization services saw the participation of almost 41% of farmers, covering an average area of 0.132 hectares. Harvesting

services were utilized by half of all farmers, with an average coverage of 0.729 hectares. Tilling services were adopted by almost 45% of farmers, with an average coverage of 0.39 hectares.

Table 1: Participation rates and average areas per farmer for key agricultural activities, serving as dependent variables in the study.

Activity	Participation Rate	Average Area (hectares) per Farmer
Sowing	58%	0.297
Cultivation	12%	0.21
Pest & Disease Control	9%	-
Fertilization	41%	0.132
Harvesting	50%	0.729
Tilling	45%	0.39

The study also considers various explanatory variables, including labor expenses, land rent, net revenue, planting subsidies, and costs associated with tilling, sowing, harvesting, and fertilization services. Average costs per acre or hectare for different services are provided, ranging from tilling to harvesting. Additionally, control set variables, encompassing family enterprise variables (age of household head, education level, non-agricultural activities participation, and land fragmentation), village characteristics (location, market development for services), and regional dummy variables (with the western region as the control group), are taken into account.

Table 2: Average costs (in yuan) per acre or hectare for key agricultural services.

Service	Average Cost (yuan) per Acre or Hectare
Tilling	1029
Cultivation	541.1
Fertilization	682.95
Harvesting	1361.75
Disease/Pest Treatment	369.45
Labor	119.01 (per day)
Land	8592.6 (per hectare)

Descriptive statistics highlight the demographic and agricultural characteristics of the sample. The age distribution reflects the participation of farmers across different age groups, with education levels and farming engagement also contributing to the diverse composition of the study participants. Land fragmentation, topographical relief, and market progress analyses are integral components, offering insights into the spatial and economic dimensions that influence farmers' decisions. The per-capita service area for each village serves as a metric for market development, indicating a more developed market and a stronger supply chain for agricultural production services when higher numbers are observed. Through the utilization of these variables and statistical analyses, the study aims to unravel the multifaceted factors shaping farmers' decisions and the intricate dynamics of the agricultural production services market.

This study primarily investigates the influence of economic factors on the decision-making process of maize farmers regarding agricultural production services. The provided data offers insights into the estimated coefficients and statistical significance levels for various variables related to three types of agricultural services: Tillage Services, Sowing Services, and Harvesting Services. Specifically, for Tillage Services, the price of agricultural services shows a significant negative effect at the 1% level, indicating a decrease in demand with increasing prices. However, labor prices, land circulation rent, and family net income do not have statistically significant effects on Tillage Services. In the context of Sowing Services, the price of agricultural services has a positive but non-significant effect, and labor prices, land circulation rent, and

family net income show no significant impact. For Harvesting Services, the price of agricultural services exhibits a non-significant negative effect, while labor prices, land circulation rent, and family net income have no statistically significant effects.

Table 3: Estimated Coefficients and Significance Levels for Agricultural Services Variables

Variable	Tillage Services	Sowing Services	Harvesting Services
Price of Agricultural Services	-0.15 ($p < 0.01$)	0.08 ($p > 0.05$)	-0.05 ($p > 0.05$)
Labor Prices	0.02 ($p > 0.05$)	0.01 ($p > 0.05$)	0.03 ($p > 0.05$)
Land Circulation Rent	0.01 ($p > 0.05$)	-0.02 ($p > 0.05$)	0.00 ($p > 0.05$)
Family Net Income	0.005 ($p > 0.05$)	0.01 ($p > 0.05$)	0.005 ($p > 0.05$)

Subsequently, a more focused examination of small-scale farmers reveals that the price of agricultural services has a highly significant negative impact on both Tillage and Harvesting Services. Land circulation rent also exhibits a significant negative effect on Tillage and Harvesting Services. Inelastic demand is observed for large-scale farmers and the total sample, indicating no change in quantity demanded regardless of variations in service prices.

In conclusion, the results suggest nuanced relationships between agricultural service prices and demand across different farming scales and services. While small-scale farmers exhibit more elastic demand, large-scale farmers and the total sample display perfectly inelastic demand for harvesting services. These findings emphasize the importance of considering various factors in understanding the dynamics of agricultural service demand.

Analysis of Regression Data from Small-Scale Farm Samples:

The adoption of tillage services in the region is impeded by the high associated costs, and the adoption of harvesting services is also negatively affected by their expensive nature. Furthermore, variations in labor costs do not impact the region's utilization of any service during the busiest agricultural period. The costs associated with land leasing may have an adverse effect on the use of tillage and harvesting services in the region. The data indicates that household net income does not substantially influence the acceptance of agricultural services in the region.

Small-scale farmers encounter challenges in achieving definitive and steady growth in agricultural earnings. Consequently, they prioritize the cost of cultivating maize, understanding that their demand may significantly decrease in the event of a rise in service costs. In contrast, affluent farmers may have the financial means to access agricultural services, even in the event of an increase in service pricing. In summary, the initial hypothesis has been confirmed through a review of the regression findings from large-scale farming operations.

Analysis of Large-Scale Farming Operations:

The only costs negatively impacting the region's adoption of tillage services are those directly associated with these services. Moreover, it is evident that, during the peak agricultural season, the region continues to utilize all services without being affected by changes in labor prices. Only the part of tillage services directly linked to land rental pricing may potentially be negatively impacted by land rental rates. It is clear that, concerning the family's net income, only services associated with harvesting benefit, while the other two service categories remain unaffected.

Discussion:

The research endeavors to shed light on the factors shaping the demand for agricultural production services, focusing particularly on the influence of labor prices, land rent, and income from agriculture. Utilizing data from the China Rural Revitalization Survey (CRRS), spanning 45 villages across six cities and two provinces, the study adopted a meticulous data collection process categorized into individual, family, and community levels. The application of the

Double-Hurdle Model addressed sample selection bias, enhancing the understanding of the complexities in the decision-making process. Descriptive statistics and participation rates illustrated notable patterns across various agricultural activities, and average costs for key services were presented. The estimated coefficients and significance levels revealed intriguing dynamics in Tillage, Sowing, and Harvesting Services. Small-scale farmers exhibited elastic demand, emphasizing the impact of service costs on their decisions, while large-scale farmers displayed inelastic demand for harvesting services [20]. Regression analyses highlighted challenges faced by small-scale farmers, including the impediment of tillage and harvesting services adoption due to high associated costs. In contrast, large-scale farming operations showed resilience to some cost factors. The implications extend to policymakers, agricultural service providers, and farmers, offering actionable insights to enhance the efficiency of agricultural production, particularly for small-scale operations. Overall, the study provides a comprehensive understanding of the economic factors influencing the utilization of agricultural services and contributes significantly to the discourse on sustainable farming practices.

The first conjecture posits that the adoption of agricultural services in a specific region is negatively influenced by their high cost. This implies that the pricing strategy within the tillage service market might be more effective, potentially driven by robust demand, market expansion, and enhanced efficiency. It is noteworthy that small-scale farmers exhibit higher sensitivity to the cost of tillage services, emphasizing the importance of cost considerations for this demographic. In contrast, large-scale farms appear to be less affected by the costs associated with harvesting services, suggesting a varying level of price sensitivity across different farming scales. In terms of hypotheses testing, several propositions were examined:

- Hypothesis 2 asserts that rising labor costs do not impact the uptake of any service in the region.
- Hypothesis 3 suggests that increasing land circulation rent acts as a constraint on rural farmers' demand for production services.
- Hypothesis 4 proposes that farmers are more inclined to adopt agricultural services with a rise in family net income.

These hypotheses provide a structured framework for exploring the nuanced relationships between different economic factors and the adoption of agricultural services, contributing to a more comprehensive understanding of the dynamics at play in the agricultural sector.

Conclusion:

In conclusion, this research significantly contributes to the understanding of the intricate dynamics of the agricultural production services market. The combination of descriptive statistics, regression analyses, and a thorough examination of small-scale and large-scale farming operations provides a holistic view, paving the way for informed strategies and policies to foster sustainable agricultural practices. Employing the Double-Hurdle Model, the analysis indicates that the price of agricultural services negatively affects demand, varying by service type. Worker prices have little effect on demand, and land circulation rents negatively influence demand, with differing impacts based on the service. Family net income influences the use of agricultural services, with variations depending on the service. Small-scale farmers are more susceptible to price fluctuations, particularly for tillage services. The study emphasizes the importance of effective pricing strategies for the thriving agriculture services sector.

Drawbacks:

1. The assumption that all agricultural households receive the same services overlooks geographic variations in service supply.
2. Cross-sectional data limits the analysis, and incorporating panel data could improve the reliability of estimations over time.

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