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Determinants of Farmers' Acceptance of the Volumetric Pricing Policy for Irrigation Water: An Empirical Study from China

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Abstract: Volumetric-based pricing for irrigation water was introduced as part of a comprehensive reform of agricultural water prices in China. However, operational deficiencies and farmers' lack of willingness to adopt the volumetric pricing policy (VPP) hinder the coordinated implementation of the reform. To address these practical challenges, we employed a binary logistic regression model to analyse farmers' acceptance of the VPP for agricultural irrigation water usage in Suqian City, Jiangsu Province. A variable set was formed by selecting potential variables from four types of influencing factors: the subject (water users), the object (water supply departments), natural condition factors, and social condition factors. Our results revealed seven factors that determine whether farmers accept the VPP: irrigation water measurement at the water inlet of a lateral canal, the irrigation water-saving rewards scale, enforcement efforts of charging by volume, the irrigation water source type, the use of agricultural water-saving for trade, financial investment in water-saving technology, and the level of irrigation water pricing. We determined the degree of influence of the seven determining factors, among which the irrigation water-saving rewards scale and enforcement efforts of charging by volume most influence farmers' decisions on the VPP for irrigation water. The results of this study can be used as a reference for innovation of the agricultural water-saving system in Suqian City, optimisation of an accurate fiscal subsidy scale, quantification of irrigation water rights, optimisation of the measurement facility layout, and effective implementation of agricultural water rights trading. More broadly, this study provides a valuable reference for solving the difficulties faced in the comprehensive reform of agricultural water pricing in China, which includes irrigation water pricing mechanisms, management systems, subsidy mechanisms, and water-saving incentive measures.

Keywords: water price mechanism; charge by volume; irrigation water measurement; policy regulation; China's comprehensive reform of agricultural water price; agricultural water-saving

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Citation: Fang, X.; Zhu, Y. Determinants of Farmers' Acceptance of the Volumetric Pricing Policy for Irrigation Water: An Empirical Study from China. *Water* **2024**, *16*, 1243. https://doi.org/10.3390/w16091243

Academic Editor: Haijun Liu

Received: 3 April 2024
Revised: 20 April 2024
Accepted: 23 April 2024
Published: 26 April 2024

1. Introduction

Agriculture is a major water user worldwide, with approximately 70% of global freshwater consumption attributed to agriculture [1]. Especially in China, with a population of 1.4 billion, agriculture is key in ensuring national food security and welfare [2]. However, China is one of 13 countries facing severe water scarcity worldwide, with its per capita water resources only accounting for a quarter of the global average [3]. Under the pressure of climate change, population rise, and economic growth, China's water resources and irrigated agriculture face even more severe challenges [4–6]; thus, the issue of agricultural water conservation must be urgently addressed.

Introducing water prices is crucial to encouraging farmers to use irrigation water more effectively, promoting innovation in water management practices, and achieving agricultural water conservation [7,8]. Cost recovery is the most common motivation for introducing irrigation water pricing in various countries [9]. Several developed countries, including the United States, France, Australia, and the United Kingdom, established water rights laws and implemented comprehensive agricultural water pricing management systems and models earlier than many others. These countries based their irrigation water pricing on the principle of cost recovery, and they have developed well-established systems for managing water resources for agriculture [10–13]. However, due to the limitations of economic development, many developing countries, such as India, Pakistan, and Indonesia, find it difficult to implement cost recovery pricing and instead set irrigation water prices based on farmers' purchasing power, with water prices far below water's costs [14,15]. Level of economic development is not the only factor affecting irrigation water pricing. For example, the eastern and western states of the United States of America implement different pricing models according to the influence of climate and water resource endowments [13]. Therefore, various natural, economic, legal, and institutional factors make it impossible for countries to adopt a uniform irrigation water pricing model [16] or reach a consensus on ideal water prices [17]. Additionally, changes in the economic development level, laws, systems, or demand for agricultural products will lead to countries making corresponding adjustments or reforms to agricultural water prices. Establishing an appropriate irrigation water pricing mechanism based on the local conditions in China is crucial to saving water, ensuring food security, and improving water management.

Over the past few decades, substantial population growth in China has increased the need to ensure food security by stabilising and encouraging agricultural development. Based on this premise, agricultural irrigation in China has been supplied on a non-profit basis, and the price of irrigation water paid by farmers is very low, accounting for only approximately 35% of the supply cost [18]. This makes it difficult to implement a cost-based pricing model. The contradiction between the price of irrigation water and the cost of its supply directly leads to the poor operation of farmland water conservancy projects, which affects the quality of agricultural water supply services, leads to low water use efficiency in agriculture, and causes farmers to lack awareness about water conservation [19]. In 2016, the Chinese government issued "Opinions on Promoting Comprehensive Reform of Agricultural Water Prices", which proposed the reform direction of total volume control and quota management and a settlement method based on "charge by unit". "Volume-based pricing" refers to charging irrigation water users based on the amount of water used, a policy aimed at the previous policy of "charging based on irrigated area and crop type" in China. It is also a term used in normative documents related to water pricing reform in China. From the perspective of water pricing, "charge by volume" essentially means pricing based on the volume of water used. To ensure consistency with previous research, we will use the term "volumetric pricing policy" (VPP) throughout the study.

The VPP links water fees to the amount of water used by agricultural users, which can effectively promote water-saving awareness and motivate users to improve water use efficiency. This policy also aligns better with the water pricing principles advocated by the World Food Program in EU countries [20]. However, the low willingness of irrigation users to accept the VPP in China creates difficulties for the coordinated promotion of measures such as quota management, precision subsidies, progressive pricing, water-saving incentives, and other relevant measures in the comprehensive reform of agricultural water prices. The audit results released by the Chinese National Audit Office in 2022 for the first batch of completed reform tasks in Jiangsu Province revealed key issues in the implementation of the VPP for agricultural water use, inadequate use of metering facilities, the non-execution of progressive pricing, and unclear water-saving effects. Firstly, unwillingness to adopt the VPP hinders the coordinated implementation of comprehensive agricultural water price reform measures. Secondly, adopting the VPP for agricultural irrigation water requires certain conditions to be met, and the relevant institutional measures may have operational limitations. However, research on Chinese farmers' willingness to pay for agricultural water prices [19] shows that farmers are not unwilling to pay for water; indeed, their willingness to pay is often higher than the current water price, as farmers are accustomed to paying based on the irrigated area. Therefore, the possible reasons for such issues should be analysed in detail. Such research has substantial practical value for tackling the problems limiting China's comprehensive reform of agricultural water prices.

The VPP is based on the principle that irrigation water charges increase with water usage, which conforms to the price leverage concept of water conservation management [21]. VPPs not only incentivise water-saving and improve water use efficiency [22] but also promote the construction of water supply projects and facilities through price adjustments, which can effectively increase the guaranteed water supply [23] and has been widely applied in countries such as Australia, the United Kingdom, France, Israel, Jordan, Mexico, Morocco, Spain, the United States, Hungary, Poland, and the Czech Republic for the management of agricultural irrigation water [24,25]. Practical applications have also shown that implementing VPPs requires the corresponding conditions to be met and existing constraints to be overcome. The main condition for implementing VPPs is that individual water users should have independent water meters that meet the relevant standards and are recognised by the users. This is necessary for accurately measuring individual water usage [20,26,27]. However, installing measurement systems can be costly and requires consideration of factors such as the crop type, planting area, or land value, which is why non-VPPs may be easier to implement than VPPs [28]. Its constraining limitations are mainly manifested according to two aspects. First, the VPP often requires setting different volume quotas for individual farmers, and the determination of these quotas must consider various factors, such as specific farming systems, crop structures, climate conditions, and hydrological resources, which makes the process more complex and rigorous [29]. The second constraint is that volumetric pricing imposes higher demands on water users in terms of irrigation quality; however, optimisation of the irrigation water supply infrastructure, implementation of refined maintenance and management, and dynamic and effective scheduling of water sources require substantial investment [21]. Thus, meeting the measurement conditions and overcoming the constraint limitations imply increased costs and water prices. When the water price exceeds the farmer's ability to pay or the increased water price exceeds the increased irrigation benefits, farmers are unwilling to accept the VPP [26]. In areas without legislation to regulate groundwater extraction, this can cause excessive and uncontrolled groundwater extraction and lead to external impacts on the ecological environment [20,30,31]. Therefore, "irrigation area pricing" benefits from rationality, whereas the VPP benefits from fairness and efficiency. However, if the policy objective is to recover irrigation water costs, the VPP may lead to an increase in water prices, which is an unacceptable pricing scheme for farmers [32]. To address the practical challenges encountered by the VPP in China, it is necessary to quantitatively analyse why water users (farmers) may not accept this pricing method.

Clarifying the constraining factors of the VPP is key to resolving the pricing mechanism dilemma for irrigation water use and improving water use management, targeted subsidies, and water-saving incentives. Furthermore, statistical analysis is crucial to provide evidence of the challenges and pressures facing the VPP and the low acceptance of charging by volume from farmers. Therefore, the aim of this study is to use statistical analysis to reveal the reasons for the challenges faced by the VPP, as part of China's agricultural water pricing reform, by quantifying the relationship between the factors influencing the VPP and farmers' acceptance toward the VPP. Specifically, this study has the following three aims: (1) analyse the factors influencing the VPP for agricultural irrigation water in China; (2) employ a binary logistic regression model to identify the determinant factors influencing farmers' acceptance of the VPP; (3) use the quantitative analysis results to discuss the degree of influence of the determinant factors and propose feasible suggestions for optimising the VPP in China.

2. Description of Comprehensive Agricultural Water Pricing Reform in China

The Chinese government launched a comprehensive agricultural water pricing reform policy in 2016 promoting agricultural water conservation, building on 10 years of exploration (2004–2013) and two years of pilot projects (2014–2015). The plan was to establish an efficient agricultural water-saving system supported by engineering facilities, effective price leverage, significant water conservation effects, and an overall agricultural water price that would meet the operational and maintenance requirements within approximately 10 years (three to five years in developed regions) [33]. The reform includes six core elements (quota control, water supply metering, water pricing mechanism, reward regulations, water management organisation, and long-term management and protection), four conditional elements (property rights reform, water rights allocation, water abstraction permits, and planting structure), three guarantee elements (leadership system, water-saving investment, and publicity and guidance), and three performance elements (water fee collection rate, reform area, and water-saving effect) [34].

Since the comprehensive reform of agricultural water pricing was fully implemented in China in 2016, more than seven years of practical application have shown that the policy can effectively promote agricultural water conservation [35]. However, several constraints and problems exist. First, the progress of the reform exhibits significant regional disparities, with unbalanced promotion among the three regions of eastern, central, and western China [36]. Second, the facility measurement process has limitations, such as unsuitable measurement conditions, instrument lifespans, and maintenance costs [37]. Third, the funding for targeted subsidies is inadequate, which hinders the construction of a long-term mechanism [38]. Fourth, the operating expenses of water management organisations are difficult to implement, and their operational efficiency is low [39]. Fifth, the assessment method does not reflect county-level differences. The national government cannot apply it according to surface-level policies at the provincial level [40]. Sixth, the national policy for comprehensive agricultural water pricing reform encounters problems such as unclear responsibility for water conservation control and complicated operational methods [33]. Seventh, the method and measures for water conservation responsibility assessment based on electricity consumption have not been fully implemented in lift irrigation areas [41]. Although methods for addressing the problems mentioned above have been stipulated in the relevant reform documents, the overall effectiveness of their implementation has substantial room for improvement.

3. Materials and Methods

3.1. Study Area

3.1.1. Geographic and Hydrological Conditions

The study area is in Suqian City in northern Jiangsu Province, China. This area represents the intersection of the Huaihai Economic Zone, the Coastal Economic Belt, and the Yangtze River Economic Belt. It contains three counties (Shuyang, Siyang, and Sihong) and two districts (Suyu and Sucheng), which are collectively referred to as "three counties and two districts". The area is rich in water resources, with two lakes (Hongze Lake and Luoma Lake) and three rivers (the Grand Canal, the Huai River, and the Yi River) serving as the main water sources. Additionally, the Eastern Route Waterway of the South-to-North Water Diversion Project runs north–south through the study area, making it a significant hub for water resource utilisation. To build a city with strong water conservancy, efforts have been made to integrate project water conservancy, resource water conservancy, and ecological water conservancy through reform. This has effectively strengthened the functions of water conservancy infrastructure and resource utilisation, including flood control and drainage, agricultural irrigation, ecological water replenishment, and soil and water conservation.

3.1.2. Reasons for the Pilot and Effectiveness of the Reform

Suqian is a major agricultural city and a major water conservancy city, with high investment in agricultural infrastructure. The investment intensity of only three projects, including high-standard farmland construction, water-saving renovation of large and medium-sized irrigation areas, and subsidies for key counties with 100 billion catties of grain, has reached 0.77 $ per m^2 (a unit of area measurement used in China, corresponding to 666.7 m^2). According to its relatively robust agricultural infrastructure, unique river–lake water network structure, and the water rights constraint of transiting water resources from the South-to-North Water Diversion Project's eastern route, the city became the first to undertake the national agricultural water price comprehensive reform pilot demonstration task in 2014. During the pilot demonstration period, which focused on the reform path of "water-use classification, measurement zoning, household settlement, and effective delivery of subsidies" [42], the city took the lead in implementing the "electricity-to-water conversion" measurement method using irrigation pump stations as control units, as well as the "fee-price integration" charging method based on large-scale land transfer households as settlement units. Suqian also completed the pilot demonstration tasks of quota control, water price regulation, water use metering, targeted subsidies, water-saving incentives, and long-term management and protection.

3.1.3. Specific Issues and Obstacles to Promoting the Reform

During the continuous promotion of comprehensive agricultural water price reform in Suqian, individual factors such as the large-scale and weak economic foundation of the reform, as well as the incomplete adaptation of macro reform policies, have constrained the mechanisms for water pricing, incentives, management and maintenance, and water use management. As a result, the sustainability of these four mechanisms has been insufficient, and "shortcomings constraints" have been constantly evident. The reasons for these typical problems are as follows. Firstly, effective control measures in water use are lacking in lift irrigation areas, which account for more than 85% of the effective irrigation area and are the focus of comprehensive agricultural water pricing reform and key areas for agricultural water conservation. Due to diversification of the property rights to irrigation pump stations, decentralised management responsibilities, and weak process management, the water conservation responsibilities stipulated by the reform policy cannot be closely implemented. Secondly, charging based on the volume measured at the water inlet of a lateral canal is inadequately implemented in artesian irrigation areas. The water inlet of a lateral canal is a key node in farmland irrigation at which it is reasonable to implement agricultural irrigation water metering. The irrigation below the water inlet of a lateral canal features "homogeneous irrigation", and a lack of water-saving awareness among individual households regarding water usage is exhibited in this context, resulting in agricultural irrigation water fees being calculated by volume per household only being a formality and them essentially being charged based on irrigation area [41]. Consequently, charging based on the volume measured at the water inlet of the lateral canal is rendered ineffective. Thirdly, the funding for targeted subsidies and water-saving rewards is insufficient. Because of the financial income situation at the county level, the funding available for county-level comprehensive agricultural water pricing reform is limited, which makes it difficult to establish a sound long-term mechanism for reform results.

3.2. Survey and Data Acquisition

The research data were collected using on-site surveys conducted in the study area from January 2021 to October 2022. A questionnaire survey method was adopted, conducted on a household basis, as well as face-to-face interviews. A two-stage cluster random sampling technique was used to select the sample. In the first step, the sample size was allocated to the "three counties and two districts" in the study area based on the proportion of effective agricultural irrigation areas. A total of 430 questionnaires were distributed (130 in Shuyang County, 80 in Siyang County, 90 in Sihong County, 70 in Suyu District, and 60 in Sucheng District) using this weight, of which 372 valid questionnaires were returned (104 in Shuyang County, 68 in Siyang County, 87 in Sihong County, 61 in Suyu District, and 52 in Sucheng District). In the second step, farmers were randomly selected from each selected cluster (sample county or sample district). The survey questionnaire related to the farmers' acceptance of the VPP and potential influencing factors. Potential influencing factors were classified into four types: subject factors, object factors, natural condition factors, and social condition factors.

3.3. Selection of Potential Influencing Factors

The selection of potential influencing factors is crucial when using a binary logistic regression model to explore the important factors that affect the acceptance of the VPP among farmers. The VPP is a system comprising multiple elements and links that interact, including irrigation engineering construction, irrigation water quota control, irrigation water metering, cost accounting and price setting, and supporting policies for water pricing mechanisms. As the VPP reflects the balance of interests between the supply and demand sides, namely the buyer–seller relationship between the supply and demand sides, the influencing factors on both the supply and demand sides are classified into object and subject factors. Moreover, as water resources are natural and social commodities, the buyer–seller relationship between the supply and demand sides depends on the price and the natural and social conditions. Therefore, analysis of the operation of a water pricing mechanism based on the concept of water consumption should consider the interests and relevant conditional constraints of the four parties involved; that is, the subject (water users), the object (water supply departments), and the natural and social conditions. A total of 19 potential influencing factors were selected, as shown in Table 1.

The subject factors refer to the potential influencing factors determined from the farmers' perspective. Price affordability is the most direct impact on the farmers. "Proportion of water fees to household income" and "proportion of water fees to agricultural income", reflecting the wealth status of the water-using households, were selected as the potential influencing factors. The critical values of these variables were set according to the average value of the proportion of water fees to household income (0.5%) in the study area. "Level of education" and "level of understanding of the VPP" were also selected, reflecting the cultural level of the water-using households. Moreover, "irrigation water usage", reflecting the water-saving awareness of the water-using households, was chosen.

The object factors refer to the potential influencing factors determined from the perspective of the water supply department. The scientific layout of the measurement points, whether irrigation facilities and funding support sustainable water supply, and whether the water pricing policy helps reduce farmers' water expenses are all potential factors that may affect farmers' acceptance of the VPP. Therefore, "irrigation gate-based irrigation water measurement" with terminal control accuracy, "investment intensity in irrigation projects", and "implementation of engineering water diversion" were also selected as potential factors influencing the VPP. The intensity of investment in irrigation projects refers to the ratio of the total investment in new, renovated, and expanded irrigation projects to the effective irrigated area. Based on a statistical data analysis in the study area, the 2021 investment intensity is 0.96 $ per m^2; based on this, we set the variable value of "irrigation project investment intensity". Moreover, water-saving rewards can reduce the pressure of water price increases; metering and charging policies are comprehensive guarantee measures; and implementing these policies requires enforcement measures. Therefore, "irrigation water-saving rewards scale", "implementation of supporting policies for metering and charging", and "enforcement efforts for charge by volume" were all selected as potential influencing factors.

The supply and demand of water resources are constrained by natural conditions. Therefore, "irrigation water source type" and "actual irrigated area", respectively, affecting the supply and demand for water resources, were selected. The variable value for "actual irrigated area" was determined based on the research findings in the study area (889 m^2 per capita of arable land, calculated as 2667 m^2 per household with an average of three persons). The irrigation water source type was divided into unified and self-supplied water sources. Self-supplied water sources refer to ponds and wells built by households or collectives.

Table 1. Variables and assignment of potential influencing factors.

Variables	Notation	Variable Assignment
Farmers' acceptance of the VVP	Y	1 if Acceptance, 0 Otherwise
Subject factors		
Proportion of water fees to household income	X1	1 if <0.5%, 2 if ≥0.5%
Proportion of water fees to agricultural income	X2	1 if <0.5%, 2 if ≥0.5%
Level of education	X3	1 if Primary, 2 if Secondary; 3 if Higher
Level of understanding of the VPP	X4	1 if No or low-level, 2 if Moderate-level, 3 if High-level
Irrigation water usage	X5	1 if ≤ Within the quota, 2 if Over quota
Object factors		
Irrigation water measurement at the water inlet of lateral canal	X6	1 if Metering using hydraulic structures, 2 if Metering using instruments and facilities, 3 if Metering by "electricity converted into water"
Irrigation project investment intensity	X7	1 if ≤1.04 $ per m^2, 2 if >1.04 $ per m^2
Implementation of water diversion engineering	X8	1 if Non-implementation (due to lack of water source or high cost of water diversion), 2 if Implementation
Irrigation water-saving rewards scale	X9	1 if Low reward (or no reward), 2 if High reward (that can compensate for water-saving costs)
Implementation of supporting policies for metering and charging	X10	1 if Non-implementation, 2 if Implementation
Enforcement efforts for charge by volume	X11	1 if No or low enforcement effort, 2 if Strong enforcement effort
Natural condition factors		
Actual irrigated area	X12	1 if ≤2667 m^2,2 if >2667 m^2
Irrigation water source type	X13	1 if Unified water source, 2 if Self-supplied water sources
Social condition factors		
Financial investment in water-saving technologies	X14	1 if No investment, 2 if There is investment
Use of agricultural water-saving for trade	X15	1 if No or little trading, 2 if Large trading with significant economic benefits
Level of financial subsidies for agricultural water prices	X16	1 if No or few financial subsidies, 2 if Financial subsidies for water price difference
Level of irrigation water prices	X17	1 if Less than or equal to operation and maintenance costs, 2 if Higher than operation and maintenance costs
Irrigation water guarantee rate [1]	X18	1 if ≤50%, 2 if 50%–75%, 3 if ≥75%
Convenience of payment for farmers	X19	1 if Inconvenient, 2 if Convenient

Notes: [1] Irrigation water guarantee rate: $P = m/(n + 1) \times 100\%$. M is the number of years in which the designed irrigation water consumption has been fully met, and n is the total number of years calculated (based on calendar year method, with a series of no less than 15 years).

The supply and demand of water resources are constrained by economic and social conditions, and policy conditions in particular. Relevant research conclusions and policy arrangements also confirm the influence of social conditions. For example, farmers hope to possess, sell, and transfer legally recognised water rights for a certain volume of water [27], and subsidy policies are significantly positively correlated with WTP [43]. China's comprehensive agricultural water pricing reform policy also specifically regulates the water supply guarantee rates, "one-vote system" settlement methods, and water prices that are not lower than the operational maintenance costs. Therefore, "financial investment in water-saving technologies", "use of agricultural water-saving for trading", "level of financial subsidy for agricultural water prices", "irrigation water guarantee rate", "level of irrigation water prices", and "convenience of payment for farmers" were selected as the social conditioning factors.

3.4. Binary Logistic Regression Model

A binary logistic regression model was employed in this study to investigate the determinants of farmers' acceptance of the VPP. The binary logistic regression model is a regression analysis model that considers binary response variables and is highly effective in analysing micro-level individual decision-making behaviour and driving factors [9,44,45]. This model is an appropriate tool for determining the factors influencing farmers' acceptance of the VPP, a binary response variable. The binary logistic model assumes that the cumulative distribution function of the explanatory variable residuals follows a logistic distribution [46]. Y represents the binary dependent variable, indicating whether or not farmers accept the VPP, with Y = 1 if farmers accept the VPP and Y = 0 if they do not. X1, X2, X3, . . ., X19 are independent variables representing the potential influencing factors selected in the preliminary stage, with their corresponding values shown in Table 1. In this study, regression models were established through statistical analysis using SPSS statistical software, with the mathematical expression for the binary logistic regression model [47] as follows:

$$P = \frac{e^{f(x)}}{1 + e^{f(x)}} \tag{1}$$

$$1 - P = \frac{e^{f(x)}}{1 + e^{f(x)}} \tag{2}$$

$$Ln\left[\frac{p_i}{1 - p_i}\right] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i + \varepsilon \tag{3}$$

Here, α is a constant term, i refers to the given farmer, β_i represents the parameters affecting the acceptance of the VPP, P is the probability of farmers accepting the VPP, $1 - P$ is the probability of farmers not accepting the VPP, x_i represents the factors that affect whether farmers accept the VPP, and $Ln\left[\frac{p}{1-p}\right]$ represents the logarithm of the odds ratio in favour of accepting the VPP. In the results, B, Sig, and Exp(B) represent the regression coefficient, the significance level (p-value) of the regression coefficient, and the occurrence probability, respectively. When B is positive, the independent variable positively impacts the dependent variable; when B is negative, the independent variable negatively impacts the dependent variable.

In the binary logistic regression model, all the independent variables were created as dummy variables and expressed by defining their categorical meanings. The frequency and percentage of all the variables were obtained through descriptive statistics and used to analyse the overall characteristics of VPP acceptance (Y) and the potential factors (X_i) among farmers. The chi-square test was used to determine the significance between the potential factors and the farmers' acceptance of the VPP [48]. Furthermore, the percentage derived from cross-tabulating the potential factors and acceptance situations was used to identify specific differences. Additionally, a variance inflation factor (VIF) test was performed before the binary logistic regression analysis was conducted to check for multicollinearity [49,50]. A VIF value between the variables greater than 10 indicates high collinearity between the variables, which means that they cannot be included in the same model simultaneously. Conversely, a VIF value of below 10 supports the selection of these independent variables. The tolerance values for each independent variable also support this point, as they were all above the traditional cut-off point of tolerance greater than 0.10, indicating no multicollinearity.

4. Results

4.1. Characteristics of Farmers' Acceptance of the VPP

According to the survey results, we calculated the proportion of farmers who agreed to the VPP. Only 29.6% of 372 farmers accepted the VPP, while 70.4% did not, indicating a low level of acceptance among the farmers. The survey results are consistent with the resistance and difficulties reflected in the actual implementation of the comprehensive agricultural water price reform.

4.2. Characteristics of Potential Factors Influencing on the VPP

Tables 2–5 show the characteristics of four potential factors that affect farmers' acceptance of the VPP, including the frequency and proportion of different categories, the frequency and proportion of acceptance and nonacceptance in different categories, and the results of the chi-square test between the influencing factors and acceptance status.

Table 2. Statistical analysis results for subject factors.

Variables	Nonacceptance (n = 262)		Acceptance (n = 110)		Total (n = 372)		Sig.	X^2
	f	(%)	f	(%)	f	(%)		
Proportion of water fees to household income								
<0.5%	220	70.1	94	29.9	314	84.4	0.719	0.129
≥0.5%	42	70.4	16	27.6	58	15.6		
Proportion of water fees to agricultural income								
<0.5%	162	66.9	80	33.1	242	65.1	0.044 *	4.045
≥0.5%	100	76.9	30	23.1	130	34.9		
Level of education								
Primary	79	68.2	37	33.8	116	31.2	0.539	1.235
Secondary	155	70.5	65	29.5	203	59.1		
higher	28	77.8	8	22.2	53	9.7		
Level of understanding of the VPP								
A little knowledge	83	71.6	33	26.4	116	31.2	0.746	0.586
Some knowledge	144	70.9	59	28.9	203	54.6		
A lot of knowledge	35	66.0	18	34.0	53	14.2		
Irrigation water usage								
Within the quota	99	64.3	55	35.7	154	41.4	0.029 *	4.764
Over quota	163	74.8	55	25.2	218	58.6		

Notes: * denotes significance at a 95% confidence level ($p < 0.05$).

Table 3. Statistical analysis results for object factors.

Variables	Nonacceptance (n = 262)		Acceptance (n = 110)		Total (n = 372)		Sig.	X^2
	f	(%)	f	(%)	f	(%)		
Irrigation water measurement at the water inlet of lateral canal								
Metering using hydraulic structures	128	78.1	36	21.9	164	44.1	0.004 **	11.117
Metering using instruments and facilities	35	74.5	12	25.5	47	12.6		
Metering by "electricity converted into water"	99	61.5	62	38.5	161	43.3		

Table 3. *Cont.*

Variables	Nonacceptance (n = 262)		Acceptance (n = 110)		Total (n = 372)		Sig.	X^2
	f	(%)	f	(%)	f	(%)		
Irrigation project investment intensity								
≤1.04 $ per m^2	188	71.2	76	29.8	264	71.0	0.605	0.267
>1.04 $ per m^2	74	68.5	34	31.5	108	29.0		
Implementation of water diversion engineering								
Non-implementation	88	66.2	45	33.8	133	35.8	0.179	1.808
Implementation	175	72.8	65	27.2	239	64.2		
Irrigation water-saving rewards scale								
Low reward	207	82.1	45	17.9	252	67.7	0.000 ***	51.460
High reward	55	45.8	65	54.2	120	32.3		
Implementation of supporting policies for metering and charging								
Non-implementation	183	72.3	70	27.7	253	68.0	0.241	1.374
Implementation	79	66.4	40	33.6	119	32.0		
Enforcement effort for charge by volume								
No or low enforcement effort	218	79.3	57	20.7	275	73.9	0.000 ***	39.597
Strong enforcement effort	44	45.4	53	54.6	97	26.1		

Notes: ** denotes significance at a 99% confidence level ($p < 0.01$). *** denotes significance at 99.9% confidence level ($p < 0.001$).

Table 4. Statistical analysis results for natural condition factors.

Variables	Nonacceptance (n = 262)		Acceptance (n = 110)		Total (n = 372)		Sig.	X^2
	f	(%)	f	(%)	f	(%)		
Actual irrigated area								
≤4 mu	209	70.8	86	29.2	295	79.3	0.730	0.119
>4 mu	53	68.8	24	31.2	77	20.7		
Irrigation water source type								
Unified water source	241	76.4	75	23.6	318	85.5	0.000 ***	37.679
Self-supplied water sources	19	35.2	35	64.8	54	14.5		

Notes: *** denotes significance at 99.9% confidence level ($p < 0.001$).

Table 5. Statistical analysis results for social condition factors.

Variables	Nonacceptance (n = 262)		Acceptance (n = 110)		Total (n = 372)		Sig.	X^2
	f	(%)	f	(%)	f	(%)		
Financial investment in water-saving technologies								
No investment	236	76.4	73	23.6	309	83.1	0.000 ***	30.967
There is investment	26	41.3	37	58.7	63	16.9		
Use of agricultural water-saving for trade								
Little or no trading	241	73.3	88	26.7	329	88.4	0.001 **	10.885
Large trading with significant economic benefits	21	48.8	22	51.2	43	11.6		

Table 5. *Cont.*

Variables	Nonacceptance (n = 262)		Acceptance (n = 110)		Total (n = 372)		Sig.	X^2
	f	(%)	f	(%)	f	(%)		
Level of financial subsidies for agricultural water prices								
No or few financial subsidies	242	72.0	94	28.0	336	90.3	0.040 *	4.234
Financial subsidies for water price difference	20	55.6	16	44.4	36	9.7		
Level of irrigation water prices								
Less than or equal to operation and maintenance costs	147	62.0	90	38.0	237	63.7	0.000 ***	22.152
Higher than operation and maintenance costs	115	85.2	20	14.8	135	36.3		
Irrigation water guarantee rate								
≤50%	28	75.7	9	24.3	37	9.9	0.244	2.821
50–75%	216	71.1	88	18.9	304	81.7		
≥75%	18	58.1	13	41.9	31	8.3		
Convenience of payment for farmers								
Inconvenient	32	65.3	17	34.7	49	13.2	0.399	0.711
Convenient	230	71.2	93	28.8	323	86.8		

Notes: * denotes significance at a 95% confidence level ($p < 0.05$). ** denotes significance at a 99% confidence level ($p < 0.01$). *** denotes significance at 99.9% confidence level ($p < 0.001$).

4.2.1. Characteristics of the Subject Factors

Table 2 presents the statistical analysis results for the five factors related to the subject of irrigation water users. The results show that in 84.4% of the surveyed households, irrigation water fees accounted for less than 0.5% of their income, whereas for 15.6% of households, they accounted for more than 0.5%. This indicates that most households can afford the irrigation water fees based on their economic income. Water fees accounted for less than 5% of agricultural income for 65.1% of the surveyed households. Thus, for most farmers, water expenses only account for a small portion of their household or agricultural income. As the rural economy diversifies and rural–urban integration advances, agricultural income is no longer the sole source of income for farmers, with other sources of income accounting for a higher proportion. In terms of education level, the survey found that most of the farmers had secondary education, at 59.1% of the total, followed by primary education only (31.2%) and tertiary education (9.7%). According to the survey results regarding the farmers' understanding of the VPP, 54.6% had a general understanding, whereas 31.2% did not. Only a small portion (14.2%) of the farmers were clear about the specific regulations, such as the meaning, implementation method, and supporting policies of the VPP. Statistics on irrigation water usage showed that 58.6% of the farmers exceeded the quota for water usage. This indicates that most farmers lack water-saving awareness and do not act appropriately.

The chi-square test results for the subject factors influencing acceptance of the VPP revealed a significant correlation between the proportion of water fees to agricultural income ($p < 0.05$) and irrigation water use ($p < 0.05$) and acceptance of the VPP. Compared to farmers whose water fees accounted for more than 5% of their agricultural income, those whose water fees accounted for less than 5% of their agricultural income (33.1%) had a higher acceptance rate of the VPP by 10 percentage points. The proportion of farmers who exceeded the water quota and did not accept the VPP (74.8%) was significantly higher than that of farmers who used water within the quota (64.3%). The other three subject factors included the proportion of water fees to the farmers' income, level of education, and level of understanding of the VPP; however, these factors did not result in a statistically significant difference in VPP acceptance ($p > 0.05$). That is, a higher income, a higher education level, and a greater understanding of the VPP did not improve farmers' acceptance of the VPP.

4.2.2. Characteristics of the Object Factors

Table 3 displays the statistical analysis results for the six irrigation water object factors. The three types of irrigation water measurements at the water inlets of lateral canals (metering using hydraulic structures, using instruments and facilities, and by "electricity converted into water") were used in 44.1%, 12.6%, and 43.3% of the surveyed households, respectively. Instrumental measurements were rarely used. The intensity of investment in irrigation projects was divided into two categories: less than or equal to 1.04 \$ per m^2 and greater than 1.04 \$ per m^2. The irrigation project investment intensity for most of the farmers (71%) was less than 1.04 \$ per m^2.

Regarding water diversion engineering, 64.2% of households had already built a water diversion system for their farmland, whereas 35.8% had not yet achieved this due to a lack of water sources or the high cost of water diversion. This indicates that there is still room to improve the water supply infrastructure. Only 32.3% of the surveyed farmers received high irrigation water-saving rewards that could compensate for their water-saving costs. Only 32% of households were covered by the implementation of the supporting policy of metering and charging, indicating substantial room for improvement. According to the survey results on the investigation and punishment efforts for charging by volume, most of the farmers (73.9%) had not received any investigation and punishment or had only received low punishment. This indicates that administrative management measures have not been effectively implemented or have not yet produced actual results.

The chi-square test results for the irrigation water object factors influencing the acceptance of the VPP showed a significant association between the irrigation water measurement at the water inlets of lateral canals ($p < 0.01$), the irrigation water-saving rewards scale ($p < 0.001$), and the enforcement effort for charging by volume ($p < 0.001$) and the acceptance of the VPP. The proportion of households accepting the VPP in the group using "electricity for water" metering was 38.5%, which was significantly higher than that in the metering group using instrumentation (25.5%) and the metering group using hydraulic structures (21.9%). The proportion of VPP acceptance in the group with larger irrigation water-saving rewards to compensate for the cost of water-saving (54.2%) was significantly higher than that in the group with smaller water-saving rewards (17.9%). Stronger enforcement of volumetric pricing through metering also showed a higher contribution to the acceptance of the VPP. The proportion of households accepting the VPP was significantly higher in the group where metering was enforced (54.6%) than in the group without enforcement (20.7%). Two factors (irrigation project investment intensity and the implementation of supporting policies for metering and charging) did not show a statistically significant correlation with VPP acceptance ($p > 0.05$).

4.2.3. Characteristics of the Natural Condition Factors

The natural geographic conditions directly affect the actual irrigation area and the type of irrigation water source. Table 4 shows that 79.3% of the surveyed households had an irrigation area of less than 2667 m^2, whereas 20.7% had an irrigation area greater than 2667 m^2. This indicates that there is still a gap in land transfer and concentrated cultivation in the study area. Moreover, 85.5% of households used a unified irrigation water source, whereas only 14.5% used self-supplied water sources. This indicates that irrigation water sources have a relatively high level of guarantee.

The two groups with different irrigation areas ($\leq$2667 m^2 and >2667 m^2) had similar VPP acceptance rates, at 29.2% and 31.2%, respectively, and the difference was not statistically significant ($p > 0.05$). This may be because both for the original fee based on an area policy and the reformed fee based on a water volume policy, irrigation area has a positive effect on water charges. The chi-square test results on the association between irrigation water source type and VPP acceptance showed a significant correlation ($p < 0.001$). The proportion of farmers who accepted the VPP in the group with self-supplied water sources was 64.8%, much higher than that of farmers who used a unified water source.

4.2.4. Characteristics of the Social Condition Factors

Table 5 presents the statistical results for six social factors. The proportion of fiscal investment in water-saving technology was only 16.9%. The proportion of agricultural water-saving used for trade and producing significant economic benefits was 11.6%. The proportion of households receiving fiscal subsidies for their agricultural water costs (with the price difference subsidised by the government) was only 9.7%. These results indicated the need to leverage targeted subsidies from the government further. The price of irrigation water was mostly (63.7%) lower than the operation and maintenance costs, indicating that a low water price cannot effectively sustain the sound operation of agricultural water supply projects. With the improvement of rural transportation facilities and information systems, the vast majority (86.8%) of the farmers found it convenient to pay the fees, indicating that the payment conditions for agricultural irrigation water were met.

The chi-square test results for the association between the social and economic factors and VPP acceptance showed a significant correlation ($p < 0.001$) between VPP acceptance and four factors: the financial investment in water-saving technology, the use of agricultural water-saving in trading, the level of fiscal subsidies for agricultural water prices, and the level of irrigation water prices. The group that received financial investment in water-saving technologies had a much higher acceptance rate of the VPP (58.7%) than the group that did not receive such investment (23.6%). The group that used agricultural water for trading had a higher rate of VPP acceptance than the group without government subsidies. The group with greater government subsidies for agricultural water prices also had a higher acceptance rate. Among the group that paid more for water than their operation and maintenance costs, only 14.8% of the farmers accepted the VPP, whereas 38% of the farmers in the group paying less for water than their operation and maintenance costs accepted the VPP. The differences in the irrigation water guarantee rate and the convenience of farmers' payment methods did not have a statistically significant correlation ($p > 0.05$) with VPP acceptance.

4.3. Determinants of Farmers' Acceptance of the VPP

A binary logistic regression model was used to test the predictive ability of selected variables, comprising the subject, object, natural, and social factors, for the irrigation households' acceptance of the VPP. The model included the 19 independent variables (19 potential influencing factors) in Table 1, which were used for preliminary hypothesis analysis to test for multicollinearity. Each independent variable's tolerance values and VIF were higher than the conventional cut-off point of 0.1 for tolerance and lower than the critical value of 10, indicating the absence of multicollinearity.

The results of the binary logistic regression model are shown in Table 6. The Hosmer–Lemeshow goodness-of-fit test results showed that $p = 0.841$, much greater than 0.05, indicating that the model's predicted and observed values fit well at an acceptable level. The likelihood ratio chi-square test of the model indicated a significance value of less than 0.05, with a chi-square statistic of 179.791, suggesting that the regression model, including all its predictive factors, has statistical significance. Therefore, the explanatory variables in the model are significantly related to farmers' acceptance of the VPP; the selected explanatory variables are appropriate for predicting the dependent variable. The model explained 38.3% (Cox and Snell R-squared) and 54.5% (Nagelkerke R-squared) of the variance in the farmers' acceptance, correctly classifying 82.5% of them. All these tests indicated that the model is reliable.

According to Table 6, the *p*-values for the irrigation water-saving rewards scale, the enforcement efforts for charging by volume, the irrigation water source type, and financial investment in water-saving technologies were all less than 0.001; the *p*-values for the use of agricultural water-saving for trade and the irrigation water pricing level were all less than

0.01; and the *p*-values for irrigation water measurement at the water inlet of lateral canals were less than 0.05. These seven variables can help predict farmers' acceptance of the VPP, as they play a decisive role in determining such acceptance. The *p*-values for the remaining 12 explanatory variables were greater than 0.05, indicating that they did not significantly explain the farmers' acceptance of the VPP.

Table 6. Determinants of farmers' acceptance of VPP: parameter estimates from logistic regression model.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Subject factors								
Proportion of water fees to household income	0.107	0.471	0.051	1	0.821	1.112	0.442	2.800
Proportion of water fees to agricultural income	−0.261	0.362	0.519	1	0.471	0.770	0.379	1.567
Level of education			0.001	2	0.999			
Level of education (secondary)	−0.010	0.365	0.001	1	0.979	0.990	0.484	2.026
Level of education (higher)	−0.016	0.608	0.001	1	0.978	0.984	0.299	3.236
Level of understanding of the VPP			1.220	2	0.543			
Level of understanding of the VPP (moderate-level)	0.352	0.363	0.945	1	0.331	1.423	0.699	2.895
Level of understanding of the VPP (high-level)	−0.010	0.494	0.000	1	0.983	0.990	0.376	2.607
Irrigation water usage	−0.570	0.322	3.141	1	0.076	0.566	0.301	1.062
Object factors								
Irrigation water measurement at the water inlet of lateral canal			7.162	2	0.028 *			
Irrigation water measurement at the water inlet of lateral canal (metering using instruments and facilities)	0.662	0.534	1.541	1	0.215	1.939	0.681	5.520
Irrigation water measurement at the water inlet of lateral canal (metering by "electricity converted into water")	0.952	0.358	7.072	1	0.008	2.591	1.285	5.227
Irrigation project investment intensity	−0.035	0.335	0.011	1	0.917	0.966	0.501	1.861
Implementation of water diversion engineering	−0.146	0.329	0.198	1	0.656	0.864	0.453	1.646
Irrigation water-saving rewards scale	1.919	0.327	34.487	1	0.000 ***	6.814	3.591	12.928
Implementation of supporting policies for metering and charging	0.374	0.340	1.213	1	0.271	1.454	0.747	2.829
Enforcement efforts for charge by volume	1.921	0.352	29.712	1	0.000 ***	6.827	3.422	13.620
Natural condition factors								
Actual irrigated area	0.212	0.385	0.304	1	0.581	1.237	0.581	2.632
Irrigation water source type	1.759	0.420	17.577	1	0.000 ***	5.809	2.552	13.224

Table 6. *Cont.*

Variables	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Social condition factors								
Financial investment in water-saving technologies	1.548	0.384	16.236	1	0.000 ***	4.704	2.215	9.989
Use of agricultural water-saving for trading	1.372	0.461	8.842	1	0.003 **	3.944	1.596	9.745
Level of financial subsidies for agricultural water prices	0.279	0.573	0.237	1	0.627	1.322	0.430	4.065
Level of irrigation water prices	−1.187	0.372	10.194	1	0.001 **	0.305	0.147	0.632
Irrigation water guarantee rate			1.836	2	0.399			
Irrigation water guarantee rate (50–75%)	0.408	0.546	0.558	1	0.455	1.504	0.516	4.384
Irrigation water guarantee rate (≥75%)	0.938	0.704	1.778	1	0.182	2.555	0.644	10.145
Convenience of payment for farmers	−0.122	0.450	0.073	1	0.786	0.885	0.367	2.137
Constant	−3.456	0.935	13.656	1	0.000	0.032		

Notes: B: beta coefficients; S.E.: stand error; Exp(B): odds ratio (OR); *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; C.I.: confidence interval.

The subject factors did not show statistical significance in predicting the acceptance of the VPP. This indicates that factors such as agricultural or household income, education level, understanding of the VPP, and irrigation water usage do not have a significant impact on the acceptance of the VPP.

According to the object factors related to the supply side, variables including the intensity of investment in irrigation projects, the implementation of water diversion engineering, and the implementation of supporting policies for metering and charging were not statistically significant factors for predicting the acceptance of the VPP; that is, they did not play a decisive role in whether the farmers accepted the VPP. The coefficient for the irrigation water metering method ("metering by electricity conversion") was positive, with an odds ratio of 2.591, indicating that if the water supplier adopts the "metering by electricity conversion" method, the probability of farmers accepting the VPP will increase by 1.591 times. This suggests that farmers have more trust in the "metering by electricity conversion" method than in metering methods that rely on waterworks or instruments. According to the coefficient and odds ratio for the irrigation water-saving reward, when the water supply side provided a high water-saving reward, the probability of the farmers accepting the VPP was 6.814 times higher than that for those receiving no or low rewards. This suggests that water-saving rewards have an important motivating effect on farmers' acceptance of the VPP. Furthermore, according to the coefficient and odds ratio for the enforcement effort for charging by volume, the farmers were 6.827 times more likely to accept the VPP when there was substantial effort in enforcing charging by volume than when there was only nominal enforcement or none. This indicates that farmers' acceptance of the VPP significantly depends on the enforcement effort of charging by volume.

Regarding the natural environmental factors, the actual irrigated area did not have a decisive influence on whether the farmers accepted the VPP. In contrast, the type of irrigation water source did have a determining effect on VPP acceptance. The odds ratio for this variable (OR = 5.809) indicated that, compared to farmers under uniform canal irrigation conditions, those with self-provided water sources were significantly more likely (5.809 times) to accept the VPP.

Among the social factors, the variables of financial subsidies for agricultural water prices, the extent of an irrigation water guarantee, and the ease of farmer payment did not have a determining effect on whether the farmers accepted the VPP. In contrast, financial investment in water-saving technologies was positively associated with the odds of farmer acceptance (OR = 4.704), indicating that financial investment in water-saving technologies can increase the likelihood of farmers' acceptance by 4.704 times. This suggests that government investment in water-saving technologies has a promoting effect on farmers' acceptance of the VPP. The coefficient of using agricultural water-saving for trading was positive, with an odds ratio of 3.944. Thus, when agricultural water-saving was used for transactions, the probability of the farmers accepting the VPP was increased by 3.944 times. In other words, the economic benefits of using agricultural water-saving for transactions can incentivise farmers to accept the VPP. The coefficient of the irrigation water price level was negative, with an odds ratio of 0.305. This indicates that when the water price was greater than the operation and maintenance costs, the probability of farmers accepting the VPP decreased to 0.305 times when the water price was less than the operation and maintenance costs. This suggests that high water prices are one of the constraining factors that leads to farmers' unwillingness to accept the VPP.

5. Discussion

5.1. Farmers' Acceptance of the VPP

International organisations such as the World Bank and the Organization for Economic Co-operation and Development have supported agricultural water price leveraging as an irrigation policy tool. It has also been included in China's water legislation [4]. "Volume-based pricing" is a widely applied agricultural water pricing policy [22,51] that directly links the amount paid to the actual amount of water used, which can encourage farmers to save water and improve the efficiency of their water resource utilisation. It is also a fundamental policy in China's current comprehensive reform of agricultural water prices. Farmers are the main targets of water price reform, and the comprehensive reform of agricultural water prices depends on their acceptance of the VPP.

In this study, we conducted a survey and statistical analysis of the comprehensive reform of agricultural water pricing in Suqian City, Jiangsu Province. The results showed that only 29.6% of the surveyed farmers supported the VPP. The low level of acceptance of the VPP among farmers has constrained the coordinated promotion of the comprehensive reform of agricultural water pricing. This finding confirms some typical problems already experienced during reform in China, such as unclear responsibilities for water conservation control, complicated system operation methods [34], the insufficient sustainability of the related mechanisms, inadequate regulation of the fees and prices, insufficiently detailed water conservation effects, and excessive emphasis on assessment based on volume and price, leading to the virtualisation of reform measures [41]. These problems need to be addressed to consolidate and deepen reform achievements and innovate coordination and promotion methods. Additionally, despite the lack of previous survey reports on VPP acceptance on the part of farmers, many studies have discussed the VPP's implementation difficulties. It is believed that the high requirements of measurement technology and irrigation facilities in the VPP are important factors contributing to the implementation difficulties, which then lead to costs related to the irrigation facilities, measurement, management, and maintenance [20,21,26–28].

An increase in costs leading to a rise in water prices may stimulate farmers to conserve water. However, many empirical studies have shown that a VPP that has a water-saving effect may lead to the opposite result [52]. A study conducted in the agricultural Mediterranean region of southern Italy found that the adoption of volumetric pricing stimulated high water prices, which then led to an increase in groundwater extraction [20]; farmers only needed to pay for the cost of pumping groundwater because there was no charge for groundwater irrigation. Thus, volumetric pricing has the potential to stimulate illegal groundwater extraction. Moreover, high water pricing policies for agricultural irrigation may also lead to more serious consequences. In relatively poor or extremely dry areas, volumetric pricing based on cost recovery may exacerbate poverty or lead to irrigation abandonment and the discontinuation of agricultural production [51]. Therefore, for China to achieve coordinated progress in the comprehensive reform of agricultural water pricing, it is necessary to base the policy on the supply and demand of agricultural water resources and tailor it to the local conditions, time, and people. Thus, it is important to optimise the VPP for agricultural irrigation water from the perspective of farmers' acceptance, as discussed in this study.

5.2. Impact of the Subject on the Farmers' Acceptance of the VPP

From the perspective of the subject (water users) of the water price reform, i.e., farmers, five potential influencing factors were selected in this study (the proportion of water fees to household income, the proportion of water fees to agricultural income, the level of education of the farmers, the degree of understanding of metering charges, and whether an excessive irrigation water quota is used). These five variables reflected the characteristics of the farmers' education level, income level, and water-saving awareness. Many studies have shown that these characteristics are important factors affecting the willingness of farmers to pay for water prices [53–61]. However, the results of this study show that these five variables do not significantly impact farmers' willingness to accept the VPP. This suggests that although the VPP means cost recovery and higher water prices, farmers' degree of acceptance of the VPP is not solely determined by the level of water prices.

According to the actual situation in the study area, the subject factors do not have a significant impact on VPP acceptance for the following reasons. Firstly, Suqian City in the study area is in Jiangsu Province, a developed area of China, where the superior planting agricultural production conditions, determined by the water system and water engineering facilities, and relatively high agricultural and non-agricultural income of farmers generally result in a small proportion of water fees to income. Secondly, Suqian City was one of the first pilot areas for the comprehensive agricultural water price reform in China; thus, it has a high level of recognition of water resources as commodities and a high degree of self-discipline and institutional adaptability in paying agricultural irrigation fees. Thirdly, Suqian City belongs to the plain river network area, which boasts complete water systems and sufficient water resources, and the irrigation water quota is set relatively high.

5.3. Impact of the Object on Farmers' Acceptance of the VPP

From the perspective of the object (water supply side) in water price reform, we selected six potential influencing factors as the objects of analysis. We found that three of them significantly impacted the willingness of water users to accept volumetric pricing. The three factors are the measurement method for irrigation water, the scale of water-saving rewards for irrigation, and enforcement efforts for charging by volume.

Metering of irrigation water usage is a basic technical requirement for the implementation of the VPP [27]; thus, the installation of water meters for each water user is a basic requirement for the VPP [26]. In India, pricing policies based on water volume have not yet been implemented because of the lack of water metering infrastructure [58]. Some studies have proposed using pre-paid water meters to measure irrigation water use, which is highly effective for saving water, improving productivity and the economic benefits, and reducing the negative environmental impacts of irrigation [22]. However, the use of water meters for measurement has some practical issues, such as limitations in the measurement conditions for low-lift pump stations, limitations in the service life of the measurement instruments, limitations in later operation and maintenance expenses, and a lack of recognition of the measurement results by farmers [37]. As a result, the metering rate in the research area is only 12.6%. "Electricity-based water metering" refers to the method of measuring irrigation water usage by directly obtaining the electricity usage from an electricity meter installed by the power supply department and converting it into water usage. This approach has advantages such as ease of operation, acceptance by farmers, and wide adaptability [37]. As a result, the "electricity-based water metering" rate in the study area is 43.3%, second only to the metering using hydraulic structures rate (44.1%). The main reasons farmers using "electricity conversion to water" tend to accept the VPP are because the accuracy of the water measurement results is objectively guaranteed, and payments based on electricity measurement provide a practical constraint.

Relying solely on the VPP may not influence farmers' water use behaviour in terms of water conservation and may even stimulate farmers to illegally extract groundwater or even steal water [28]. Establishing incentives is necessary to foster farmers' self-discipline and water-saving awareness [62], and it is also an important aspect of China's agricultural water price reform [63]. The reasons why the scale of irrigation water-saving rewards and efforts in enforcing charging by volume have a significant impact on farmers' willingness to accept the VPP are threefold. Firstly, farmers clearly understand the high levels of irrigation water usage and realise the potential for water conservation in current irrigation practices. However, implementing each water-saving measure requires a certain amount of financial investment, with the current water-saving rewards representing one such measure financed by the government. When the reward scale is insufficient to cover the costs of implementing water-saving measures, farmers will hold a negative attitude toward the VPP. Secondly, the VPP is an innovative policy reform that needs to be implemented through administrative measures, such as administrative investigation, supervision, and audit supervision of the VPP's implementation. Whether these administrative measures are implemented and the degree to which they are implemented directly affect the performance of the VPP. Thirdly, if the two measures of water-saving rewards and administrative enforcement are implemented effectively, they will have different impacts on the following three variables: the implementation of the water diversion project, the intensity of investment in irrigation projects, and the implementation of supporting policies for metering and charging. This indicates that the two variables of the irrigation water-saving rewards scale and the intensity of enforcing charging by volume have guiding and regulatory effects. This also suggests that the three variables of the implementation of the water diversion project, the intensity of investment in irrigation projects, and the implementation of supporting policies for metering and charging have complementary connotations and causal relationships with the three significant influencing variables of irrigation water measurement, the irrigation water-saving rewards scale, and the intensity of enforcing charging by volume.

5.4. Impact of the Natural Conditions on Farmers' Acceptance of the VPP

From the perspective of natural conditions, we selected two potential influencing factors to study the determinants of VPP acceptance by the farmers: actual irrigated area and irrigation water source type. It was found that the irrigation water source type exhibited a significant impact on their acceptance. Some studies have discussed the relationship between irrigation water sources and the willingness to pay for irrigation water, which provides a reference for this study. A study on the WTP for surface water irrigation in areas where groundwater resources are scarce found that farmers had a higher WTP because of their greater need for surface water irrigation [29]. Another report found that farmers who solely use groundwater as their water source demonstrate a higher WTP than farmers who use both surface water and groundwater because the price of using groundwater for irrigation is non-existent [64]. These studies have all found that the type of irrigation water source farmers depend on affects their WTP for irrigation water. Although our study focuses on the acceptance of the VPP instead of WTP, the findings reflect a consistent underlying theme.

Here, it was found that farmers who use self-supplied water sources significantly support the VPP. This is because farmers who use self-supplied water sources do not need to pay for irrigation water, so they appear to accept the VPP; however, this acceptance is not true acceptance but rather indifference. On the contrary, farmers who use unified surface water irrigation mostly do not accept the VPP. They depend highly on surface water resources and need to pay for surface water irrigation. These farmers are very concerned about the rationality of the new water pricing policy. Against a context of rising water charges after the water price reform, insufficient understanding of the volumetric pricing method, and incomplete supporting policies for the VPP, farmers are prone to be resistant to the new water pricing policy. This finding suggests that the VPP has a potentially stimulating effect on farmers' groundwater extraction. This is consistent with previous research findings [20,30,31].

The actual irrigated area does not have a significant impact, mainly because the irrigation facilities in the study area, Suqian City, are laid out in large or medium-sized irrigation districts, and the water conditions in the irrigation area are "homogeneous", resulting in a lack of concern for the actual irrigated area.

5.5. Impact of the Social Conditions on Farmers' Acceptance of the VPP

Six factors were selected from the perspective of the social conditions that influence water price reform. Among them, three factors (whether agricultural water-saving can be traded, government investment in water-saving technologies, and the level of irrigation water prices) have been found to have significant impacts. Water rights trading, as a means of using market mechanisms to allocate water resources, is defined in terms of the water volume and facilitates supply–demand equilibrium [51]. When the water-saving rewards are not sufficient to compensate for the water-saving investments, farmers are more inclined to exchange the surplus water rights generated by water-saving measures for compensation for water-saving investments. This reflects farmers' desire to implement VPP measures to obtain the income opportunities generated by water-saving behaviour. The promotion and application of agricultural water-saving technologies and equipment require high investment. Although farmers do not pay much attention to the ratio of input to output, they have shown significant interest in government investment in water-saving technology because the national government is the main channel for investing in agricultural water-saving technology and equipment, from which farmers hope to gain potential benefits. Farmers are most directly and sensitively affected by irrigation water price level changes. Studies have shown that when irrigation water fees exceed the operation and maintenance costs, the probability that farmers will not accept the VPP increases significantly. Thus, a requirement for farmers to accept the VPP is that the water price must be transparent. When the fee is too high and corresponding services to farmers cannot be provided, the VPP may be misunderstood as a new billing technology rather than a new pricing method that must be adopted to improve water supply services and promote water conservation [27].

Agricultural production is subject to factors such as natural conditions and production cycles, which makes agricultural output unstable. From the perspective of increasing their income, farmers expect that implementing the VPP will not increase the cost of irrigation water and reduce stable income. They do not pay much attention to whether the payment process is convenient. The study area, Suqian City, is a large agricultural city. To continue to promote agricultural productivity, farmers' income, and agricultural efficiency, financial investment in water infrastructure at all levels occurs mainly in the form of engineering investment; the irrigation water guarantee rate thereby meets the needs of agricultural production. The financial subsidies for agricultural water prices are weak in promoting the comprehensive reform of agricultural water prices. This is the fundamental reason why farmers do not pay much attention to financial subsidies for agricultural water prices and irrigation water guarantee rates.

6. Conclusions and Recommendations

In this study, farmers' acceptance of the VPP for agricultural irrigation water was investigated and analysed in Suqian City, China, against the background of comprehensive agricultural water price reform. Considering that VPP acceptance is a process with complex interactions between the subject (water users) and the object (water supply departments) of acceptance and the surrounding natural and social conditions, 19 potential influencing factors were chosen. A binary logistic regression model was constructed to determine the elements behind farmers' acceptance of the VPP. Seven determining factors were innovatively extracted, including irrigation water measurement at the water inlet of lateral canals, the irrigation water-saving rewards scale, efforts in enforcing charging by volume, the irrigation water source type, the use of agricultural water-saving for trade, financial investment in water-saving technology, and the level of irrigation water prices.

To ensure that the relevant measures of the VPP can effectively support the achievement of water-saving goals, we propose the following recommendations. Firstly, implementation of the VPP must adhere to the principles of the geographical characteristics, water resource conditions, and human qualities. Given the irrigation characteristics of the plain river network area in the research area of Suqian City, the metering and charging policy should be further refined and interpreted as "implementing metering using the irrigation areas controlled by the water inlet of the lateral canal and assessing charging by water usage quotas" to strengthen the operability of the existing metering and charging policy. Secondly, water-saving incentives must be implemented. The water-saving quantity used to calculate the amount of reward must have an appropriate degree of accuracy; that is, it must be consistent with the crop water consumption quota standards designed in the reform, the acquisition of natural precipitation, the water consumption calculation methods, and the funding sources and scale to avoid asymmetric rewards and punishments, which may result in unfairness. Thirdly, to support the further development of water-saving agriculture with weak economic characteristics, the government should increase public investment in water-saving technology, equipment, and facilities. Fourth, encouraging effective water rights trading can convert farmers' pursuit of income from water-saving opportunities into a policy response to the VPP. Fifth, it is crucial to clarify the responsibilities and authorities of the relevant departments and increase inspection and audit supervision from an administrative inspection and audit perspective. Sixth, differentiated water pricing policies and subsidy measures can be implemented for irrigation areas with self-supplied water sources to reflect water fairness, thereby supporting the rationality and smooth implementation of the VPP. Finally, increasing the price of agricultural irrigation water must be coordinated with policies such as complementary agricultural water-saving rewards and precise financial subsidies.

Author Contributions: Conceptualization, X.F.; methodology, X.F.; software, X.F.; formal analysis, X.F.; investigation, X.F. and Y.Z.; resources, X.F.; writing—original draft preparation, X.F.; writing—review and editing, X.F. and Y.Z.; supervision, X.F. and Y.Z.; funding acquisition, X.F. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the National Natural Science Foundation of China (No. 41871313) and the Natural Science Foundation of Jiangsu Province (BK20161118).

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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