The impact of water rights trading practice on water resources utilization efficiency in Sichuan Province

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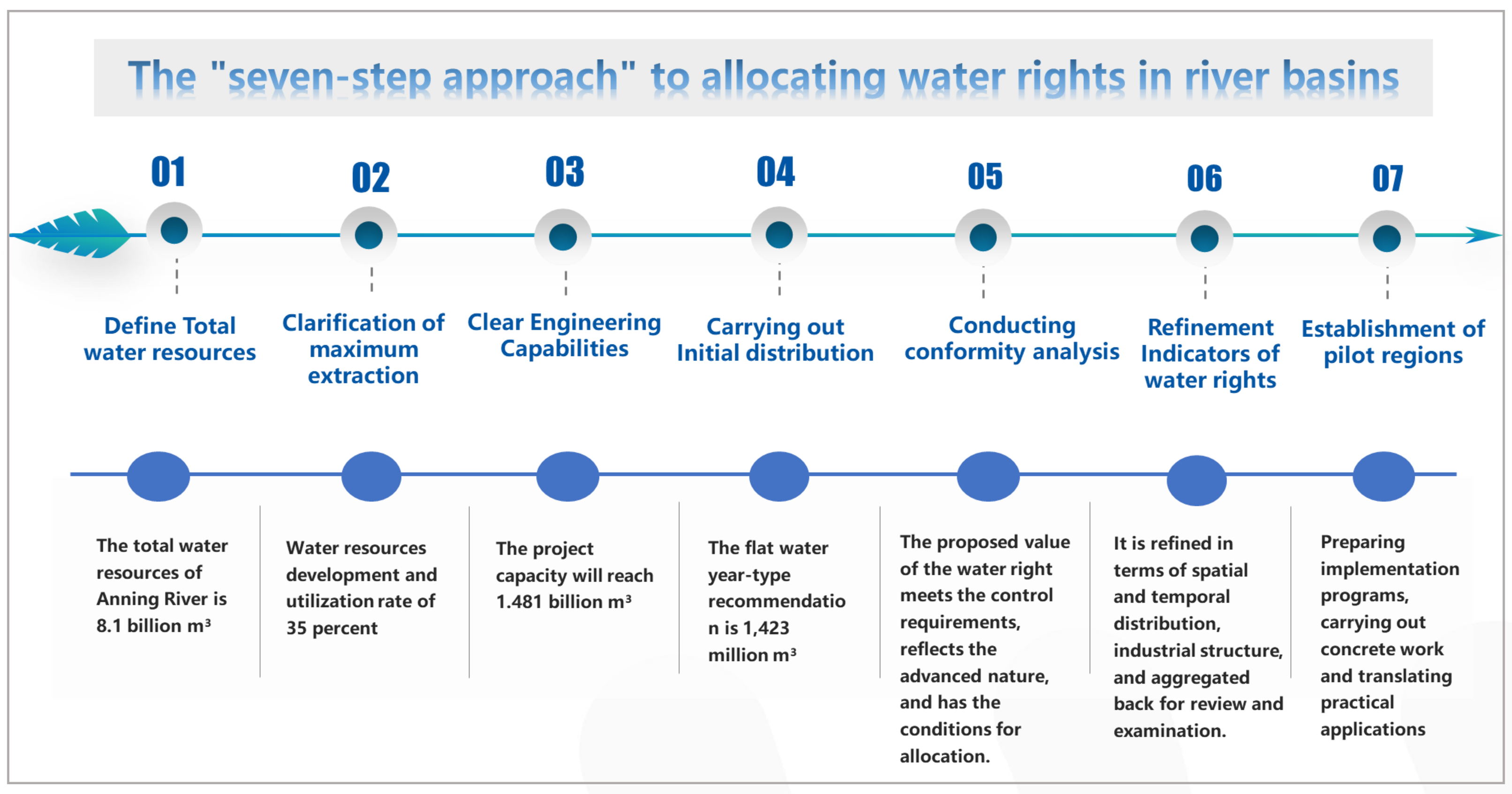
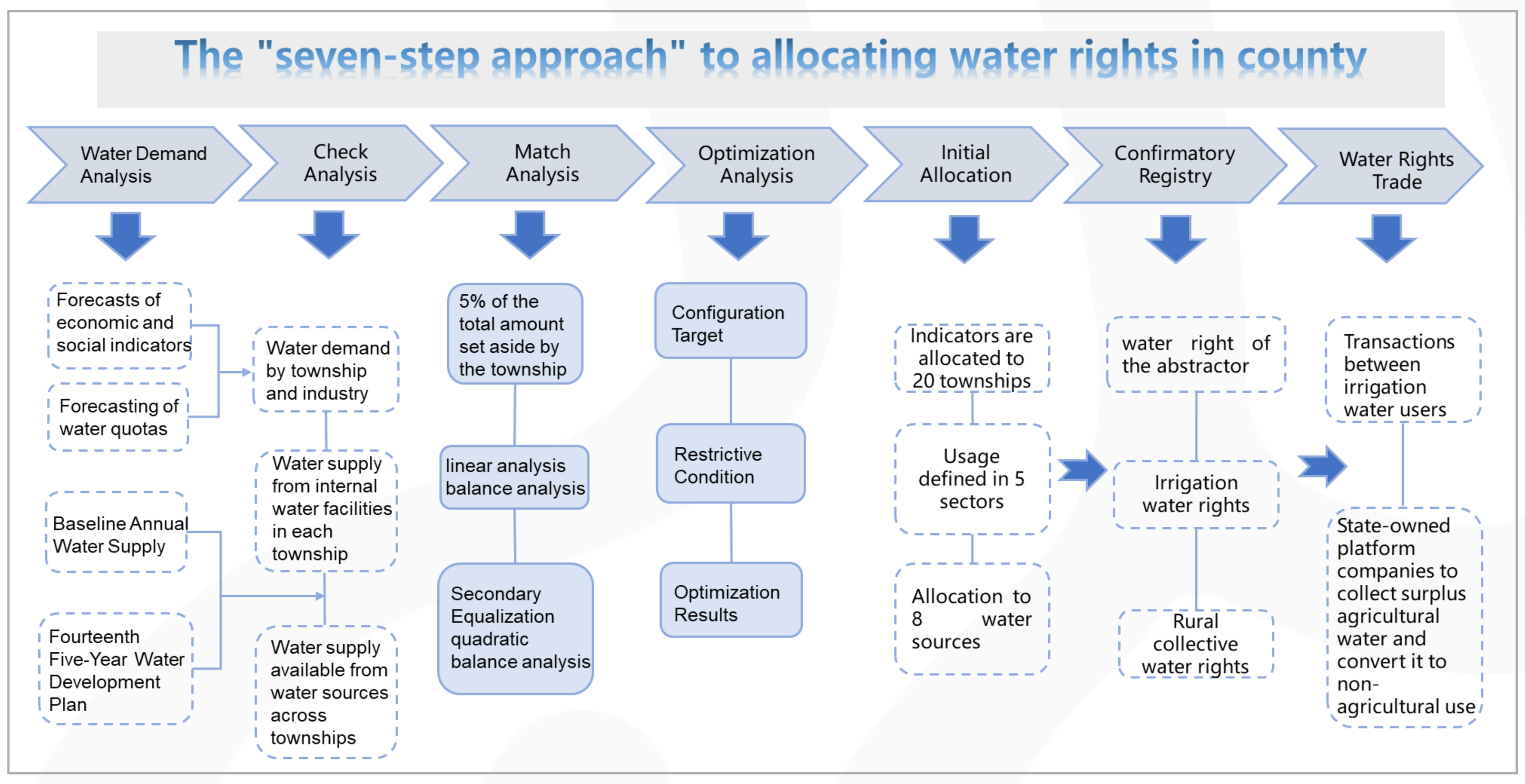
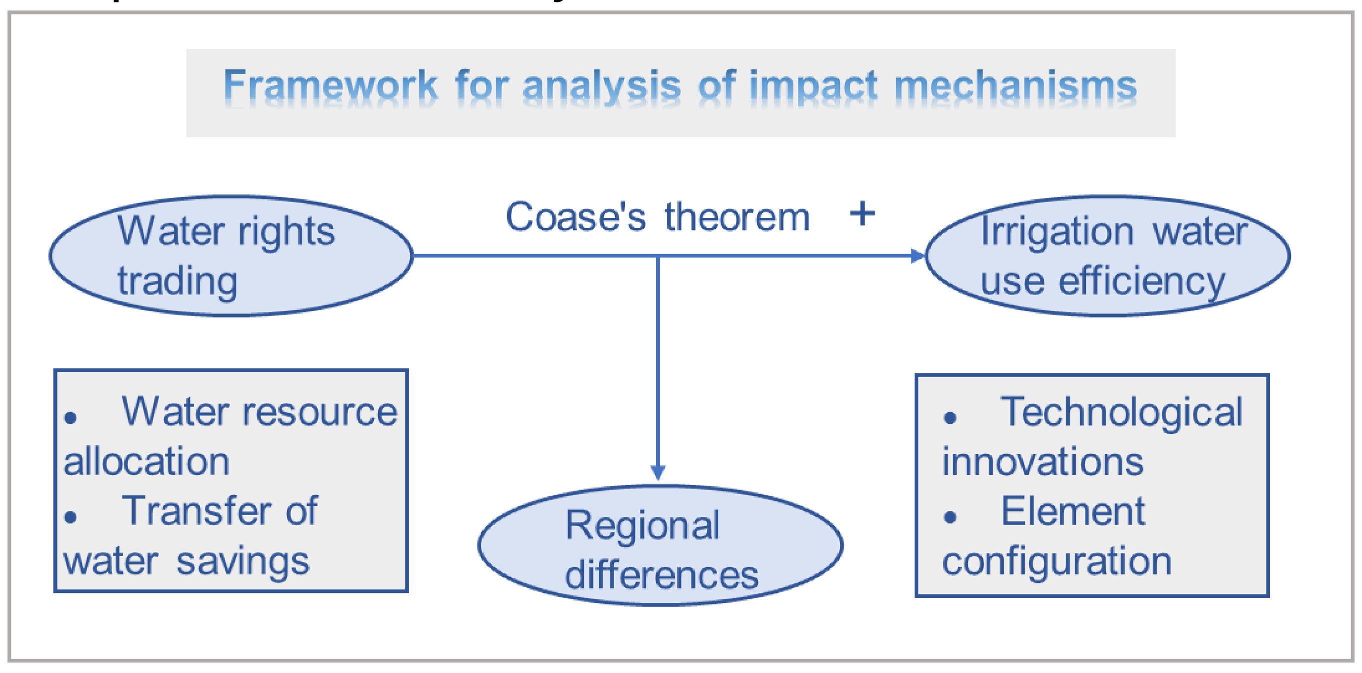
Objectives

- Irrigation water use is a crucial aspect of agricultural production. However, the limited nature of water resources is increasingly emphasized, leading to inefficient water use and water wastage. This phenomenon is particularly prominent in water-abundant regions such as Sichuan Province. As a flexible and efficient way to allocate water resources, water rights trading has attracted more and more attention. This thesis aims to explore the impact of water rights trading on irrigation water use efficiency through theoretical analysis and empirical research.
- With regard to the construction of the water rights system in Sichuan Province, the initial water rights of different regions and different water abstractors and water users have been clarified. A preliminary system for initial allocation of water rights has been established. It has carried out the construction of a system for the registration of water resources, the design of a system for approving the nature of water use and conversion, and the scheduling of water rights. Different regions, different industries, different water users, etc. piloted the trading of water rights between different subjects. Water rights trading has been completed in Chengdu City, Leshan City, Ziyang City, Luzhou City and other areas, and market instruments have been used to improve the efficiency of water resources utilization.







Methods

SBM-DEA

In this study, the SBM—DEA model was used to measure the irrigation water use efficiency as follows:

$$\min\left(\theta\text{-}\varepsilon\left(e_1^T S^- + e_2^T S^+\right)\right) \quad (1)$$

$$s.t.\begin{cases} \sum_{k=1}^{n} X_k \lambda_k + S^- = \theta X_j \\ \sum_{k=1}^{n} Y_k \lambda_k - S^+ = Y_j \\ \lambda_k \geq 0, k = 1, \cdots, n \\ S^+ \geq 0, S^- \geq 0 \end{cases} \quad (2)$$

Irrigation water use efficiency is the ratio of the farmer's optimal irrigation water input to the actual value of irrigation water use, with the following formula:

$$IWE_i = \frac{IWC_i - S_{w,i}}{IWR_i} \quad (3)$$

Where: IWEi is the irrigation water use efficiency of farmer i; IWCi is the actual irrigation water use of farmer i; Sw,i is the calculated slack in the irrigation water input of farmer i. The difference of IWRi minus Sw,i is the optimal irrigation water input.

DID（Difference-in-Differences Model）

In order to assess the impact of water rights trading policies on irrigation water use efficiency in Sichuan Province, this paper uses a double difference model (DID). Some districts were included in the pilot and others were not. In this paper, the farmers in the pilot areas that have implemented the water rights trading policy as the "treatment group" and the areas that are not included in the pilot as the "control group" are used to estimate the DID model. The model was set up as follows:

$$IWE_i = \alpha_0 + \alpha_1 Area_i \times Time_t + \alpha_2 X_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad (4)$$

i and t denote pilot area and time, respectively; IWEit is the explanatory variable irrigation water use efficiency; Areai is a dummy variable for pilot area; timet is a dummy variable for time; Xit is a control variable; μi and ηt denote the pilot area fixed effect and year fixed effect, respectively; εit is a random error term; α0 is a fixed-intercept term; α1 reflects the policy effect of the water trading mechanism on the irrigation water use efficiency, and α2 is the coefficients of the control variables.

Table1 Ordinary panel difference-in-difference regression results

Variables	(1)	(2)
Area×Time	0.084*** (4.15)	0.077*** (3.85)
Control Variables	Yes	Yes
_Cons	0.410*** (29.4)	0.396*** (40.04)
Time fixed effect	No	Yes
Province fixed effects	Yes	Yes

Table2 Ordinary panel difference-in-difference regression results

Variables	(3) Central	(4) South	(5) West
Area×Time	0.068** (2.01)	0.094*** (2.79)	0.022*** (2.06)
Control Variables	Yes	Yes	Yes
_Cons	0.272** (2.54)	0.153** (2.05)	0.309** (3.21)
R^2	0.598	0.436	0.612

Note: ***、*** indicates significant at the 1% 、5%level respectively, values outside parentheses are regression coefficients, and values in parentheses are t-values.

Conclusions

- Water rights trading has a significant impact on agricultural water use efficiency. The enhancement of irrigation water use efficiency by water rights trading in the pilot region lies roughly between 0.077 and 0.084.
- There is significant regional heterogeneity in the impact of the water rights trading mechanism on irrigation water use efficiency. Water rights trading has the greatest utility in improving irrigation water use efficiency in the southern region, followed by the central region, and the smallest in the western region.