

# **Production structure and Cost efficiency of irrigated agriculture: A shadow cost approach**

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# Plan

- Introduction
- Theoretical approach
- Estimation and results
- Interpretation
- Implications and conclusion

# Introduction

- Water scarcity in Tunisia has become an increasing social and economic concern for both policy makers and water users.
- Considerable effort has been devoted over time to introduce policies aiming at increasing water efficiency based on the assertion that “more can be achieved with less water” through better management
- Better management usually refers to improvement of allocative and/or irrigation water efficiency.
- Improving allocative efficiency has been by far the most important factor for increasing farm income and conserving water waste.

# Concepts

- Technical inefficiencies arise when a given input mix is less than the maximum possible;
- Allocative inefficiencies arise when the input mix is not consistent with cost minimization.
- In other words, it is closely related to adequate **pricing of water** use for agricultural purposes,

# Theoretical background

- Distortions in relative price and hence on operating efficiency are due to existing constraints to observed market prices
- When farming is characterized by subsistence crops, farmers may be prevented from reaching the efficiency frontier as resources are allocated based on their marginal shadow values instead of the marginal value productivities. Therefore, inefficiency may arise from these differences.

# Shadow costs and relative price

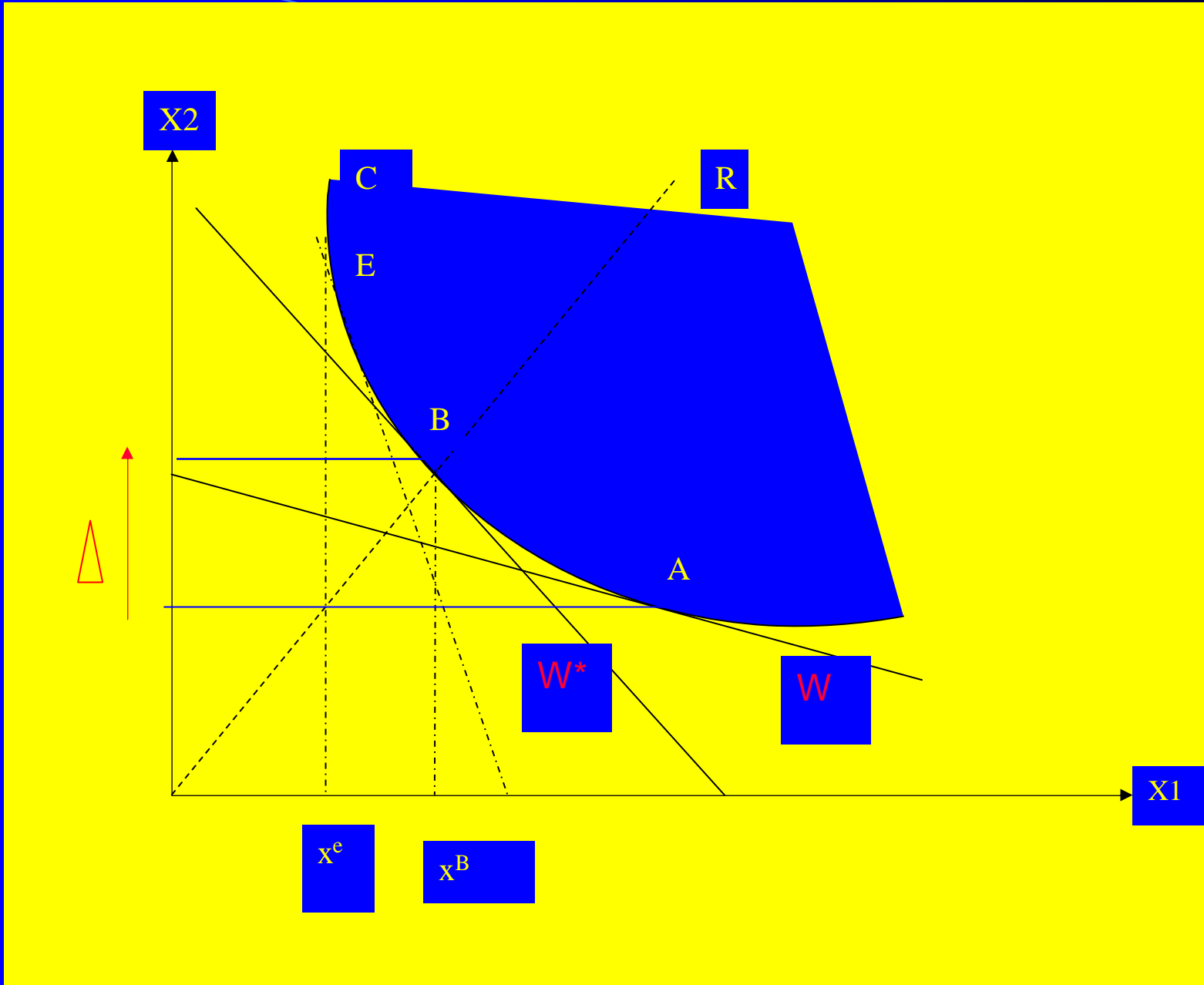
- First conditions for cost min:

$$\frac{P_i}{P_j} = \frac{f_i}{f_j}$$

- Suppose other constraints in the environment so that:

$$\frac{f_i}{f_j} = \frac{w_i}{w_j}$$

→ MRS=ratio of shadow or effective prices



- Although we cannot explicitly specify these constraints we however proceed by estimating parameters of shadow prices that allow us to determine the binding constraints and the magnitude of the divergence of shadow from market prices.
- An approximation of these shadow prices is:

$$w_i = k_i P_i$$

# Empirical model

- The shadow cost function is:

$$C_s = C_s(kP, y)$$

- This leads the actual cost function (log):

$$\ln c_a = \ln c_s + \ln \sum M_s (k_i)^{-1}$$

- And the actual cost share equations:

$$M_i^A = X_i P_i / C^A$$

# Estimation

- Based on four (4) factor inputs (capital, labor, intermediate inputs and water)
- Nonlinear cost function and associated factor share equations were estimated using LSQ (Nonlinear least squares) on TSP.

# Distortion factor (k)

- The distortion factor  $k$  could be input specific and estimates reflect only the mean cross sectional values
- It could also be modeled as a linear, exponential or quadratic specification of the hypothesized factors (in our case education, age, irrigation tech and water supply)

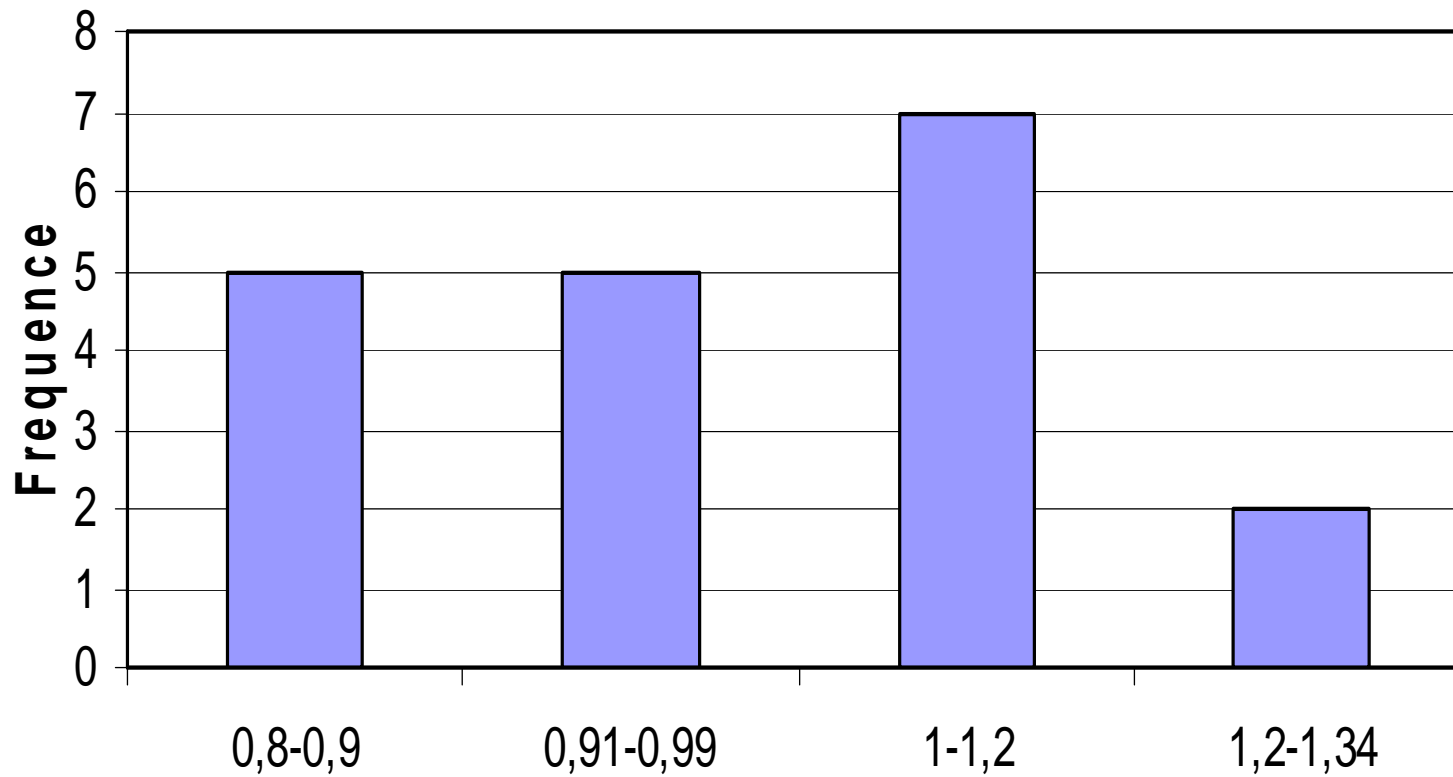
# Results: Jendouba

Parameter / variable	Restricted model	Unrestricted model
A (intercept)	-2.92*	-.81
B1 : L	1.27*	.22*
B2 : K	1.46*	1.27*
B3 : w	-0.18*	-.21*
B11: LL	0.02*	.062*
B22: KK	0.11*	.10*
B33: WW	0.81	.014*
B12: LK	-0.12*	-.01*
B13: LW	0.04*	-.029*
B23: KW	0.01*	.077*
C0: Y	1.29*	1.24*
CC: YY	-0.03*	-.053*
C1: YL	-0.05*	-.091*
C2: YK	-0.09*	-.02*
C3: YW	0.03*	.045*

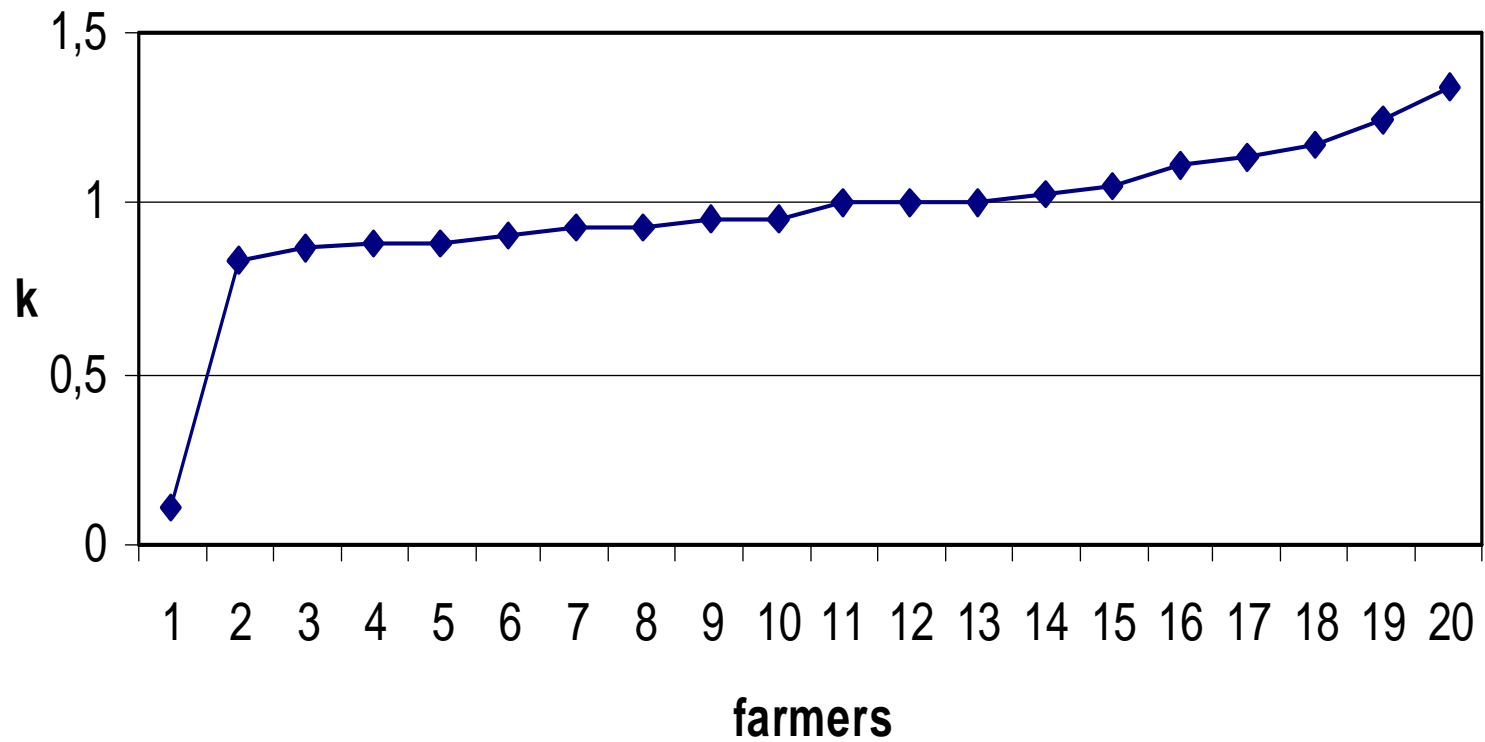
# Distortion factor: k

L1 (constant term)		.94*
L2 (education)		-.06*
L3 (irrigation system)		-.30*
L4 (age)		.006*
L5 (water supply)		-.103*
L6 (off farm income)		.000016*
Log likelihood	229.011	253.552
CONVERGENCE ACHIEVED (N° ITERATIONS)	618	720

## Cost inefficiency parameter (Jendouba)



### Price distortion coefficient for water (k) (Jendouba)



# Determinants of price inefficiencies

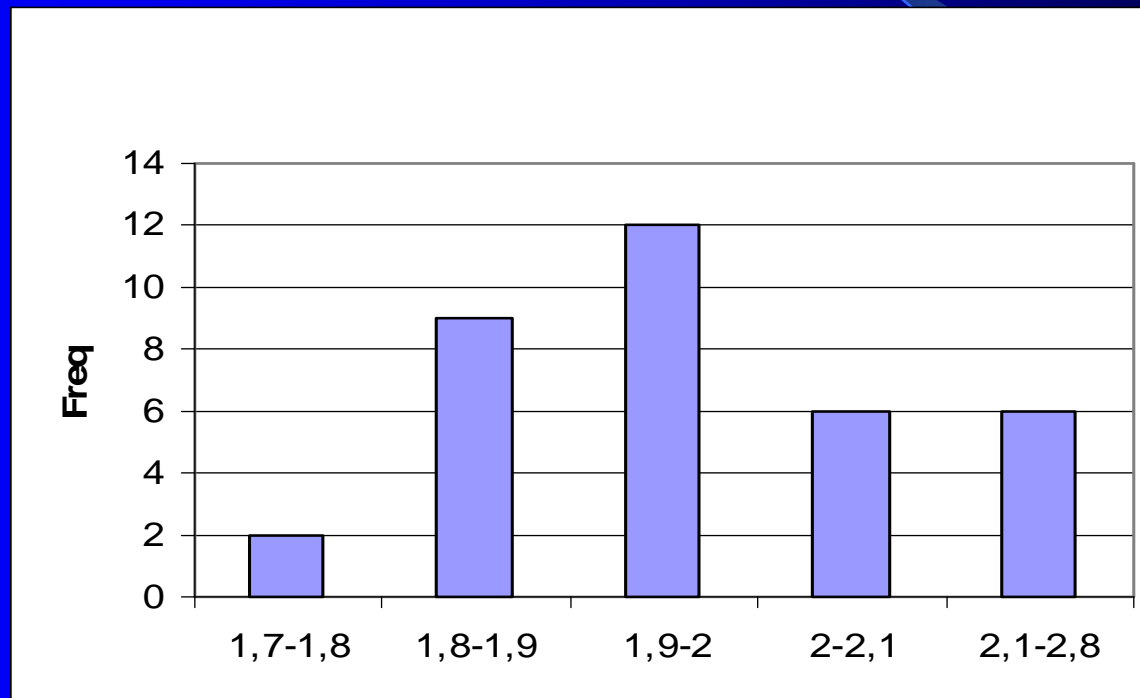
<b>(education)</b>	<b>categorical</b>	<b>-</b>
<b>(irrigation system)</b>	<b>Aspersion (%)</b>	<b>-</b>
<b>(age)</b>	<b>Continuous</b>	<b>+</b>
<b>(water supply)</b>	<b>Categorical (à la demande % par tour)</b>	<b>-</b>
<b>(off farm income)</b>	<b>Continuous</b>	<b>+</b>

# Results: Kairouan

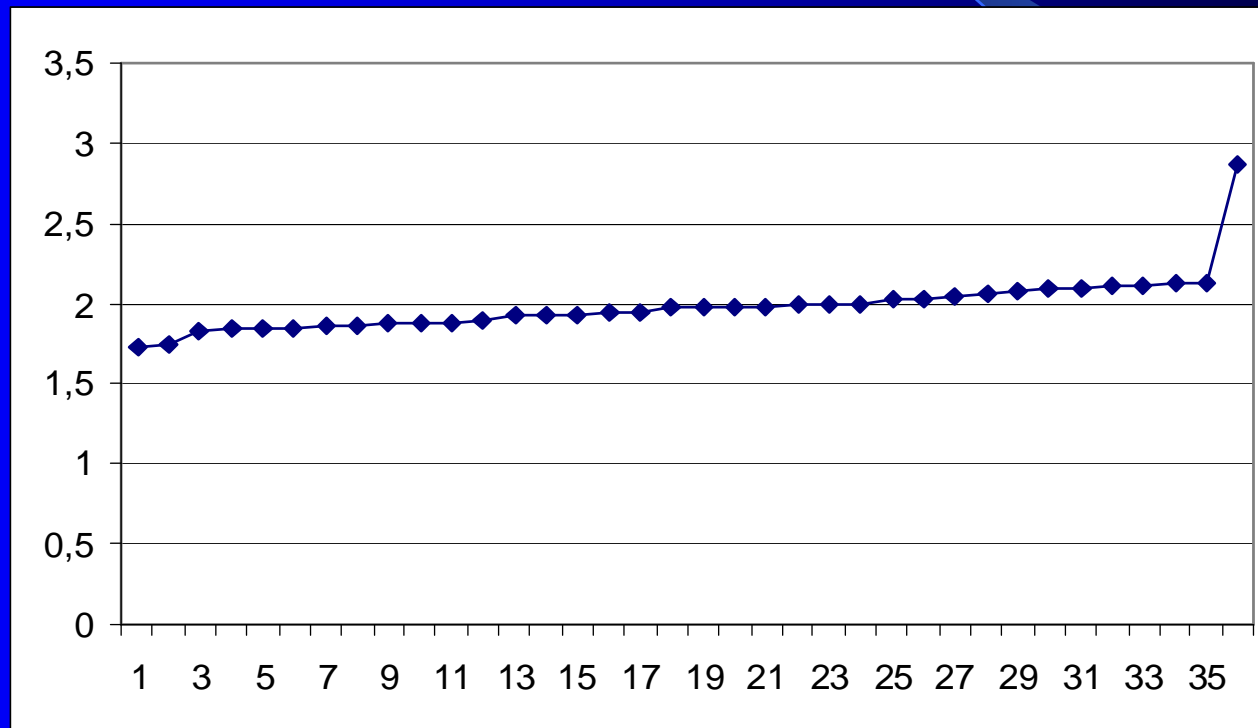
Parameter / variable	Restricted model	Unrestricted model
A (intercept)	.94 *	2.91*
B1 : L	.35 *	.30 *
B2 : K	.33 *	.77 *
B3 : w	-.069 *	-.63 *
B11: LL	.010 *	.057 *
B22: KK	.025 *	.116 *
B33: WW	-00.84	-.042*
B12: LK	.014 *	-.015*
B13: LW	.018 *	.0005
B23: KW	.041 *	.013 *
C0: Y	.238 *	-.15
CC: YY	.0048 *	.113 *
C1: YL	-.002	-.052*
C2: YK	.039 *	-.13 *
C3: YW	.018 *	.22 *

L1 (constant term)		1.53 *
L2 (education)		.005
L3 (irrigation system)		.26 *
L4 (age)		.008*
L5 (water supply)		-.07*
L6 (off farm income)		-.000012*
Log likelihood	419.7	411.87
CONVERGENCE ACHIEVED (N° ITERATIONS)	282	71

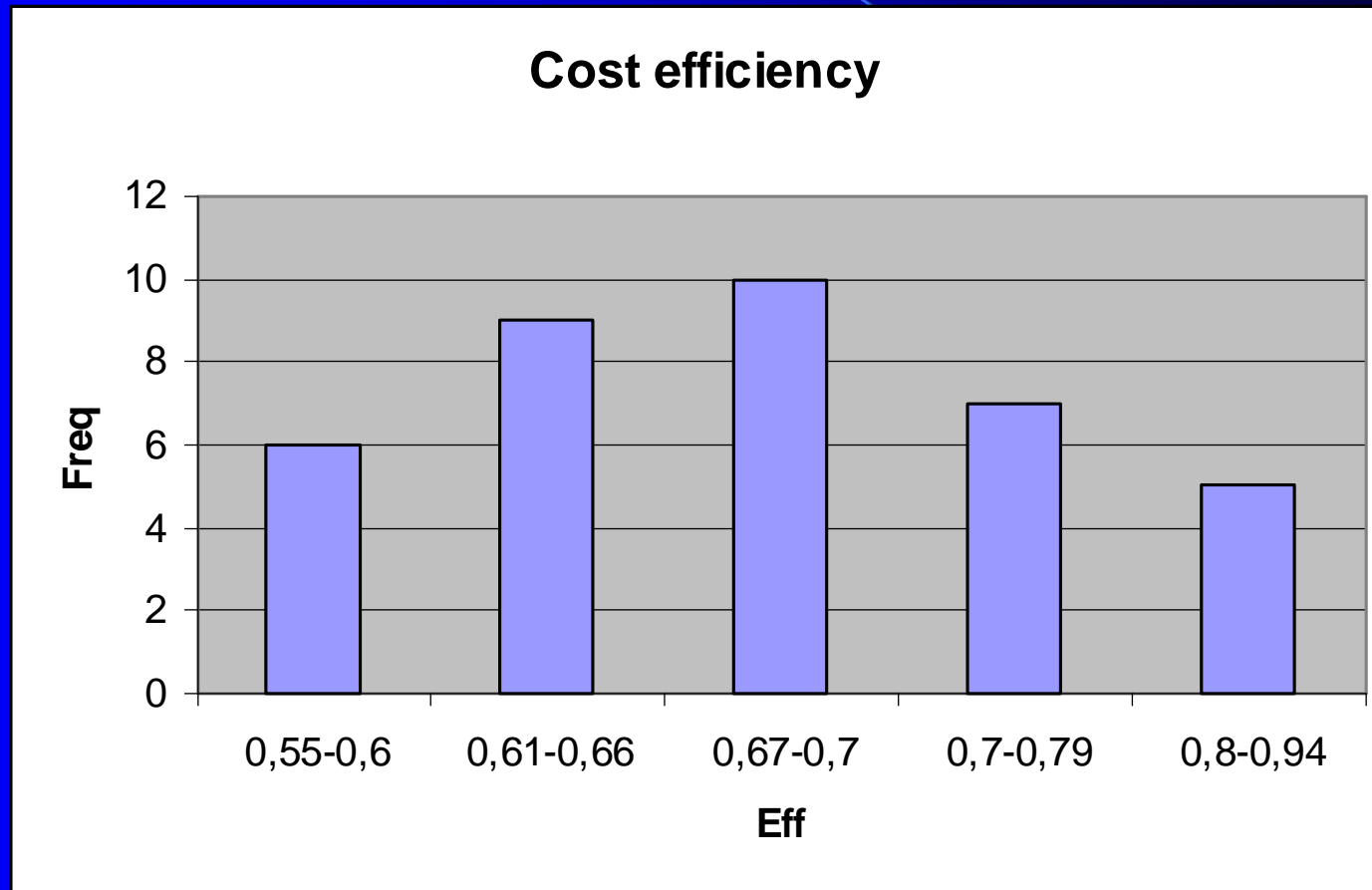
# Cost inefficiency parameter (Kairouan)



# Price distortion coefficient for water (k) (Kairouan)



# Cost efficiency: stochastic frontier approach



# Interpretation and implications

- $K$  different than 1 indicates the existence of relative price inefficiencies.
- $K > 1$  means existence of price distortions engendered by relative price inefficiencies and MRS exceeds the market price ration
- This may reveal the distortionary impact of water pricing (substitution).
- Education and water supply may reduce inefficiencies in Jendouba
- Water supply and off farm income are more significant in Kairouan