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The Economic and Welfare Effects of Different irrigation Water Pricing Methods, Case Study of Khomein Plain in Markazi Province of Iran

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Abstract

The scarcity of water resources and supply resources limitation, have caused an increasing gap between water supply and demand specially in recent decades in almost all regions of the globe. One of the best known solutions proposed by the economists is using the different water pricing approaches thereby obtaining the optimal allocation and social justice. To this purpose, this paper uses the positive Mathematical Programming (PMP) and Econometric Mathematical Programming (EMP) in a comparative analysis to study the economic and welfare impacts of alternative water pricing approaches in the agricultural sector during agricultural period 2011/2012 in Khomein plain of Markazi province in Iran. Results show that the EMP can be a better alternative approach instead of PMP to better analyze of agricultural policies. According to the final outcomes, it is suggested to apply the block tariff in place of volumetric pricing method to reach the optimal allocation and promoting the water efficiency in the price range of 198 to 853 Rials.

Keywords:
Economic and welfare effects, Water pricing, Mathematical programming, Khomein plain

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INTRODUCTION

During recent decades, as for to population growth and improving life standards, water demand faced a dazzling speed. To deal with this, primarily, the strategy of discovering and exploiting new water resources came up. Increasing healthy and reliable water resources, producing more food and electricity and rural economic development were some of the benefits of this policy. It has to be mentioned that, nowadays, more than 70 percent of irrigation water is provided from fresh water and the increasing growth of this demand can be easily predicted (Jafari 2013). Extending the exploitation of non-renewable water resources has been one of the main approaches to provide with this increscent water demand in Iran. However, continuing the expansionist policies which were followed previously, due to impairment losses of species, ecosystems and water resources pollution are not possible any more. Additionally, the difficulty of finding new water resources and also the externalities of constructing huge water projects has increased the marginal cost of water extracting. To solve these problems, water management pattern with brand new policies like as concentrating on productivity improvement, managing the water demand and reallocating water between consumers as more suitable solutions are changing. A substantial number of studies show that governments, in order to reach the optimum allocation and rising water productivity used some policies like decentralization of irrigation water management, pricing systems, water laws and commercial plans (see Dinar and Maria, 2005; Johansson *et al.*, 2002; Tiwari and Dinar, 2002; Tsure, 2004; Roe, 2005; Veettil, 2011 for surveys). What emerges from these studies is that the relationship between variables and different existent characteristics in agricultural environment as the special irrigation type, water laws, structural frameworks and alternative cropping systems can affect the results significantly. The results of Liao *et al.* (2007), Frija *et al.* (2008), Herrera *et al.* (2004), Speelman *et al.* (2010 and 2011) mentioned that farmers willingness to pay could be influenced by environmental conditions and when water laws are not defined properly, it leads to inefficiency of water pricing systems, non-optimum water allocation, increasing trade-off costs and expenditures and finally inappropriate evaluation of water resources (Fragoso and Marques, 2013). More than 60 percent of Iran, Markazy province and particularly Khomein region have a dry and semi-dry climate. Khomein as a flat and talented agricultural region as for 240 mm annual rainfall and also increasing population growth as well as extending agricultural activities, faces rising water demand and contrary to its shortage. With considering the substantial relationship between water resources stock and rainfall, surveys show that despite the moderate and extreme drought happened during 2008 to 2011 in khomein region, annual exploitation from underground water resources increased 13.1 million m3 on average (Mosayebi and Maleki, 2012) which led to completely drying of 164 deep and shallow wells, 172 Ghanats, 57 natural fountains, 38 rivers and 13 soiled-dams. And also 349 deep and shallow wells, 79 Ghanats, 21 natural fountains, five rivers and 5 soiled-dams have 1 to 10 liters in second water that are so likely to get dried in the near future (Agricultural organization of Markazi province, 2012). Water has been regarded as a free commodity in Iran, historically. The act of pricing this scarce input and increasing the current prices encounters many problems. Currently water pricing in Iranian agricultural sector is done on the basis of "Justly Distribution of Water" law and regarding the underlying crop. As in this system, pricing is not based on water consumption volume; there is not enough motivation to efficient and economic allocation of water and its marginal return is often higher than the price and providing and distributing costs. The extension limitation of water resources and weak management companies with huge water losses make the applying of water demand-side policies as complementary inputs taxes or product taxes unavoidable. These policies have been investigated by different researchers in Iran. Hossain zad (2004) and Asadi *et al.* (2007) showed that as for low elasticity of water demand in agricultural sector of Iran, increasing the price of this input decreases the water demand slightly. So, the water price has to be increased substantially or alternative policies are to be introduced. But, it is to be noted that efficiency improvement and water allocation without suitable economic policies and instruments is not conceivable. Moreover, the result of a policy or its impact depends highly on the farmers' reaction to the applied policies. The farmers' reaction is depended on farm condition, individual attitudes and characteristics. It is not possible to examine alternative policies in laboratory conditions and the policy maker is seeking to get a good intuition about policy implications in agricultural sector and farmers' reaction to the policies. To this end, this paper is going to study the different water pricing methods impacts on water demand, water allocation among irrigated agricultural crops, farmers' revenue, costs and other inputs demand in Khomein plain. The rest of the article is organized as follows: In part twowe discuss he analytical framework. Part three, elaborates the data and empirical models. Part four presents the empirical results and discussion and finally in part five concludes.

Analytical framework

The water demand and supply

Generally, the demand for Irrigation water is come from the market demand of agricultural products. Suppose a farm with n products and an input of water, the profit is defined as:

$$\pi = \sum_{j=1}^{n} \left[p_j f_j \left(q_j \right) - w q_j \right]$$

$j = 1, 2, \ldots, n$ (1)

Where *fj(qj)=yj* is an ascending and strictly concave function, *j* is production yield, *pj* indicates the market price of *j-th* product and water price is shown by *w*. Essential prerequisite to maximize the profit is as

$$\frac{\partial \pi}{\partial q_i} = 0 \text{ or } f'\left(q_j\left(w\right)\right) = \frac{w}{p} \Rightarrow q_j\left(w\right) = f_j'^{-1}\left(w/p\right) \quad (2)$$

Where *qj(w)* shows the amount of entering water with price *w*. In other words, the water demand function of farmer is

$$q\left(w\right) = \sum_{j=1}^{n} q_j\left(w\right) = \sum_{j=1}^{n} f_j'^{-1}\left(w/p\right) \quad (3)$$

The individual water demand is specified by *qj(w)* and the aggregative water demand for all farmers is the sum of individual demands presented as

$$q\left(w\right) = \sum_{i}^{k} q_i\left(w\right) = \sum_{i=1}^{k} \sum_{j=1}^{n} f_{ij}'^{-1}\left(w/p\right) \quad (4)$$

Water demand could be measured with considering it as a free commodity and also with supposing it limited in x liter. Here, the thing which seems important is that we have to know the farmers willingness to pay for Δ unit more water. When they use water at *x* level, their revenue is *p*×*f(x)*. Expectedly, the additional income from using Δ unit more water is *p[f(x+*Δ*)-f(x)]*. The additional income *pf(x)* which is due to the little amount Δ, is indeed the maximum price that farmers are willing to pay for consuming additional units of irrigation water. This price is called Shadow price of water and its value is positive if the water constraint is binding. In other words, the problem of allocating the water between products can be solved by maximizing profit condition as:

$$\pi(p,x) = \max \sum_{j=1}^{n} p_j f_j\left(q_j\right)$$

$$s\,t \sum_{j=1}^{n} q_j \le x \quad (5)$$

Which its lagrangian form is as

$$\ell = p_j f_j\left(q_j\right) - \lambda\left[x - \sum_{j=1}^{n} q_j\right] \quad (6)$$

Where λ here is a coefficient of constraining factor of water, and shows the shadow price of it. This strategy can be applied for more inputs, variables, constraints, infinite puechased inputs and crops that use the water in their production process. In words, a combination of non-linear production functions with linear programming can be combined into a non-linear programming frame. Also, in both of these cases, the Irrigation water demand function could be obtained subject to maximizing the profit at different water levels which allows to obtain different allocative amounts of *qj* with shadow price of water λ. In the usual approach, the irrigation water demand can be extracted by regression analyzing of the observed information of water price and quantity. However, due to some problems like as unavailability of information and the variability of water price in small scales, this method causes imprecise estimations (Tsure, 2005).

Water pricing

The intersection between the non-decreasing marginal cost function and the descending slope derived from demand function determines the marginal cost of water. This happens In the great irrigation projects, when the average cost function is decreasing and the marginal cost curve placed under the average cost $(w^* < AC(w^*))$. Therefore, the real profit of supplier does not meet the fixed costs and in order to continue the activity in long-run, subsidies have got to be given to the suppliers. In the long-run, financing the suppliers' costs increases in order to cover their costs which often results in decreasing the average pricing costs. In this case, water price is set up following the exploited demand function and average cost. By the way, despite the farmer is able to return the overall water cost, but this policy is not efficient in the average pricing cost because it does not ensure the maximization of producer and farmers welfare. As it was mentioned by Tsure (2005), determining the water price by moving through the marginal cost curve toward the average cost could provide producers with positive profit and simultaneously decreases the farmers' profit. Since this decreasing profit is greater than that increasing profit, so the total welfare will experience a down fall by taking this method of pricing (Tsure, 2005). Hence, according to Tsure and Dinar (1997), water pricing on the basis of marginal cost can give the optimal water allocation but implementing this method requires some prohibitive operations like monitoring and management and collecting exact data. Thus, alternative water pricing methods are applied across the world including volumetric approach under which, the water costs are measured directly by estimating the water volume consumpted; input-output approach that irrigation water valuing is done based on products or inputs (except water) used in the production process ; regional method that water is priced on the basis of irrigation methods used in the region. Usually the differences in irrigation costs come as for the kind and amount of irrigation, irrigation method and irrigation season in a special region; blocking method in which variable volumetric tariffs are used proportional to an specified level of water consumption; two component tariff which usually comprises the pricing method based on marginal cost and annual fixed costs for water right (which has different values in each region depending on irrigation method); the last approach is the tax method in which water costs payments are considered according to the added value of the sown area which is caused by the irrigation water. Each of these water pricing methods, leads to different levels of welfare and net benefits and choosing one of them is based on the implementation costs which vary from one region to another as for the climatic issues, demographic, social structure, water rights, time and economic conditions. Thus, the pricing method is considered which has the most benefit. Without considering the implementation costs, one of the efficient approaches is the volumetric method. Tsure and Dinar (1997) compared the results of the volumetric and regional pricing methods. Results showed that if 7.5 percent of the outcome from water would used for operational expenditures, the regional pricing method has a much better return in comparison to the other approaches. Most notably, the supply and demand function and also the pricing methods based as the theoretical base of this paper are derived from Tsure (2000, 2005), Dinar (2000), Dinar and Maria (2005), Dinar and Mody (2004).

Positive mathematical programming (PMP) models

Recently, there appears an increasing interest to apply sort of generalized mathematical programming in agricultural sector. Heckely and Britz (2005) ratiocinate this interest by some reasons. First, an expanded range of political tools in addition to supportive policies based on pricing are come up. Also, as for to developing the multipurpose agriculture which is so important, it is more likely that with existing technical constraints, most of the old mathematical programming models give incoherent results. After presenting the positive mathematical programming by Howitt (1995) for calibration, it was applied in agriculture widely. Positive mathematical programming (PMP) was developed to overcome the difficulties of normative mathematical programming (Howitt, 1998). At most one concave profit function and the MC parameter as well in the non-linear variable cost function are used for PMP models. Therefore, this model is able to reproduce the observed situation and evaluate the policies and to suggest more reliable policies. The main model which was presented by Howitt (1995) had two components. The first component was a linear model with calibration constraints in order to build the dual value of resources and constraints and in the second component given obtained dual, calibration parameters (including MC as the coefficient of concave cost function(in the short-run as the coefficient of the non-linear profit function)) are estimated to maximize the model given the linear constraints. The main idea hidden in this method is using the dual values for non-linear calibration of the objective function in order to obtain the simple and exact basic situation observed data). Sabuhi *et al.* (2006) put it well"In order to specify the non-linear object function, each type of non-linear function which can set the marginal cost of preferential activities to their related prices in the level of observed activities, is possible to be utilized. So, in this study, for analyzing the policies we use the quadratic cost function which its general presentation is outlined in Heckely and Britz (2005), Henry *et al.* (2007) surveys. As it was shown in equations (1) and (11), these models show the maximum sum of farmers' surpluse.

$$\begin{aligned} &\max \pi = g\acute{m}l \qquad (7)\\ &\text{s.t}\\ &Al \leq b[\lambda]\\ &l \leq l^0 + \varepsilon[\rho]\\ &l \geq 0 \end{aligned}$$

Where π indicates the profit function in the short-run which is corresponding to the gross yield of farm in the short-run. *n* and *gm* present the vector of gross yield corresponding to each activity and the non-negative variable of sown area of each product, respectively; shows the technical coefficients matrix; *b* is the $m\times 1$ vector of available inputs (like land, water, labor and chemical fertilizer); indicates the $m\times 1$ vector of shadow prices for each input; ρ and l^0 present the $n\times 1$ vector of observed sown area for each product in the base year and the corresponding shadow price of it, respectively; ε is the littlest number as the calibration constraint which is used to prevent the linear dependency.

When ρj the the is determined then in the second step, using the PMP approach, the variables of non-linear cost function $C^v(l^0)$ are estimated in which the marginal cost of the activity $MC^v(l^0)$ has formed from two components: the known costs of activity *(c)* and the unknown marginal cost which are given below

$$MC^v = \frac{\partial c^v(l^0)}{\partial l} = d + Ql^0 = c + \rho \qquad (8)$$

Where Q and *d* are a $n\times 1$ positive, determined and symmetric vector of linear coefficients and the quadratic matrix of variable. To simplify, the diagonal elements of matrix Q as for the standard estimation approach from $qjj = \rho j / l_j^0$ for determining the quadratic function of costs are placed in the model below

$$\begin{aligned} &\max \pi = gm'l - \frac{1}{2} l'Ql \\ &s.t \qquad Al \leq b[\lambda], \qquad l \geq 0 \end{aligned} \qquad 0$$

The econometric mathematical programming (EMP) models

According to Heckely and Britz (2005), PMP approach faces some important limitations for instance the calibration constraints have to have the zero degree of freedom while this issue needs much of data or a so flexible functional form to cover all constraints. The other limitation is that different approaches to estimate the calibration parameters lead to considerable differences in simulation behavior. Buysse *et al.*, (2007) state that to obtain the more realistic simulation behavior, econometric programming models which can estimate the objective function and constraints given the external information are suitable alternatives for PMP models. The main axiom of this strategy using the lagrangian model is presented like below

$$\ell = gm'l - \frac{1}{2} l'Ql + \lambda(b - ul) \qquad (10)$$

If the land is the only fixed resource, then $A=u$ and *u* is a $n\times 1$ vector of the sum of them. The first optimization condition is

$$\frac{\partial \ell}{\partial l} = gm - Ql - \lambda u = 0$$
$$\frac{\partial \ell}{\partial \lambda} = b - ul = 0 \qquad (11)$$

Thus, the unknown parameters λ and Q can be estimated using some of econometric measures. In the case that the observed data are less than the parameters that has to be estimated, we face the *III-posed* situation. In this case, using the generalized Maximum Entropy (GME) the aforementioned situation can be solved (Golan *et al.*, 1996). Similar to Heckely and Wolf (2003) combining information related to land demand elasticity extracted from the sample, we can have a better estimation. The simple structure of the GME model constrained to the optimization conditions used in the programming model is

$$\max_{w_t, w^e, Q, l, \lambda} H(w_t, w^e) = -\sum_{t=1}^{T} w_t' \ln(w_t) - w^{e'} \ln(w^e)$$
$$s.t \qquad (12)$$
$$gm_t^0 - \lambda_t u - Q(l_t^0 - \varepsilon_t) = 0$$
$$u'(l_t^0 - \varepsilon_t) = b_t^0 \qquad (13)$$
$$\varepsilon_t = Vw_t = \sum_{s=1}^{2} \sigma_{jts} w_{jts} \qquad (14)$$
$$diag\left[E\right] = V^e w^e = diag\left[(Q^{-1} - Q^{-1}u (u'Q^{-1}u)^{-1} uQ^{-1})(\frac{\overline{gm^0}}{\overline{l^0}})\right] \qquad (15)$$
$$Q = LL', \qquad L = 0 \ \forall \ i \geq j \qquad (16)$$
$$\sum_{s=1}^{2} w_{jts} = 1, \qquad \sum_{s=1}^{2} w_{js}^{e} = 1 \qquad (17)$$

Where H is the entropy variable, w_t and w^{ε} are the probabilities values as for to the error and the estimated elasticity E; gm_t^0 and l_t^0 are vector of production marginal yield and the production physical amount for each observation t, respectively; λ is the shadow price of fixed resources (like land); Q is the symmetric positive and determined matrix of production marginal cost coefficients; V and V^{ε} are the known matrix of errors and supportive values of elasticity. Equation (12) indicates the maximum entropy; (13) is the first optimization condition; (14) and (15) allow to calculate the error term (ε_t) and elasticity (E) as for to the second optimization condition that the variable cost function has to be non-descending. (16) is included to ensure the concavity of variable cost function and being positive and determined of Q; (17) makes sure that the sum of the probabilities and elasticity are equal to unity.

The stochastic errors of each observation (ε_t) have zero mean and a standard deviation of σ_{jts}. To apply the GME approach, it was necessary to carry out re-parameterization of the error term as expected values of a probability distribution (Vw_t). This is calculated based on known values of standard deviation, which are spread by two support points (the n×n×2 V matrix). Incorporation of out of sample information through the use of priors on elasticities allows us to obtain more accurate estimates for the Q matrix. In our case the elasticity estimates (E) are given by the product between the n×n Jacobian matrix of the land demand functions $\{Q^{-1}-Q^{-1}u(u'Q^{-1}u)^{-1}u^{-1}\}$ and the mean of observed gross profit divided by the mean of observed land allocation to crop $(\frac{\overline{gm^0}}{\overline{l^0}})$. As for the error estimates, the elasticities (E) also have to be re-parameterized as the expected values of a probability distribution (we). In this case, for the central value of prior elasticities two support points were also considered and the values of standard deviations are bounded in the $n \times n \times 2V^e$ matrix (Fragoso and Marques, 2009).

After estimating the σ, Q, ε^t, w^e, wtvalues, the values are placed in the defined programming frame and it will be used to simulate the water pricing policies.

It is to be mentioned that in order to survey the different impacts of either of two EMP and PMP models on cropping pattern in this paper, after estimating the two models, we investigate the resulted diversity pattern. Genarally, for measuring the diversity of determined optimal cropping plans, regardless the different definitions that are presented for cropping diversity, we can measure it using two indexes including sown area and gross income. There exist Numerous indexes for calculating the diversity of a cropping plan. Shanon and bor, Simpson, Herfindal, Entropy and corrected concentration index are some of the most famouse indexes that are used to this end (Karbasi *et al.*, 2010). In this paper, we use Entropy Diversity index as it is used for large-scales like our case. This index is measured according to the following equation (Chang and Mishra, 2008):

$$EI = \sum_{i=1}^{i=n} \frac{X_i}{\sum_{i=1}^{i=n} X_i} \log\left(\frac{X_i}{\sum_{i=1}^{i=n} X_i}\right)^{-1} \qquad (18)$$

Where X_i indicates the sown area of the activity. In this equation, if the EI is greater than zero, the cropping diversity is high and if it is equal to zero or less than it, there is no cropping diversity.

Data

In the current study, Khomein plain accommodated 7543 farmers, was used as the underlying statistical population and in order to collect the data related to the quantity of inputs consumption required for producing crops which are included as: water, labor, machinery, chemical fertilizer and maure and herbicide were gathered through a three-stage stratified sampling and given the Cochran-Orcut formulation according to number of farmers in rural districts and villages over 2011-2012 agricul-

Table 1: Descriptive statistics of variables

variable	mean	SD	Min	max
Yield				
Irrigated wheat	3113.7	1840.5	200	8000
Dry wheat	1157	909	125	4000
Irrigated barely	2615	1421	200	7000
Dry barely	1411	852	2000	8000
Dry pea	370	250	150	1350
Bean	2568	889	1000	5000
Potato	19470	12890	3333	32000
Onion	5000	0	5000	5000
Alfalfa	8696	5658	750	20000
Irrigated corn	40000	0	40000	40000
Inputs				
Labor(rial)	360163.8	453615.4	19845.24	6775431
Chemical Fertilizer phospat(kg/ha)	136.2	33.6	63.5	171.9
Chemical Fertilizer azot(kg/ha)	199	68.8	83.3	318.8
Animal fertilizer(kg/ha)	5527	6208	0	14428
Herbicide(kg/ha)	0.683	0.589	0	1.7
Machinery (rial)	63269.5	74904.9	4328.1	984926.1
Irrigated wheat	4933.3	56.6	4820	5010
Dry wheat	4773.6	169.41	4560	4890
Irrigated barely	5944	198.8	5370	5948
Dry barely	5944	0	5944	5944
Dry pea	5850	0	5850	5850
Bean	37100	2325	36400	42000
Potato	2100	0	2100	2100
Onion	6000	0	6000	6000
Alfalfa	6500	3250	3180	7000
Irrigated corn	1000	0	1000	1000
Labor(hour)	5945.9	1164.6	4926.1	7215
Chemical fertilizer(kg)	118.4	84.7	68.9	216.4
Animal fertilizer(kg)	9.8	1.03	8.7	10.8
Herbicide(kg)	5627.6	1708.2	4926	7575
Machinery (hour)	6566.5	651.8	5911.3	7215

Source: Research findings

tural year, 36, 41, 30, 32, 39, 45 and 27 questionnaires were distributed among Chahar cheshme, Khoram dasht, Ashena khor, Hamze loo, Rastagh, Salehan and Gale zan (Totally 250 questionnaires) rural districts, respectively. Farmers of each village were chosen by systematic sampling method so that on the basis of farmers number and sample size related to each rural district, the sample of each village was determined. Also, the information related to the sown area and the production quantity of the under study region was derived from the Markazi province's Jihad-e-Agriculture organization data bank The descriptive statistics are reported in the Table 1.

RESULTS

The results are presented in two sections. The first section compares the results from PMP and EMP approaches using observed data aimed to choose a model which is able to explain the farmers' behavior in the best way. The second section is related to survey the alternative water pricing policies on water consumption, irrigated land area, farm profit and total welfare.

Results of EMP and PMP

Results of measuring the Entropy index for the PMP and the EMP models are showing that changing the cropping pattern is on the basis of reproducing the PMP model and also decreasing the diversity of cropping pattern is based on the EMP model reproduction. In the next step, as for which model predicts the farmers' behavior, we compare the results exploited from the PMP and EMP models with observed data. Also in the second section of the results, evaluation of the impact of alternative water pricing policies on water consumption, the irrigated area, farm profit and total welfare is discussed.

Irrigation water demand

Given that Evaluating the irrigation water demand and irrigated land area is not only beneficial for choosing the best policy analysis model but it can be used for creating pricing scenario assumptions which are essential for simulation. In order to survey and compare the EMP and PMP models in Figures 1 and 2 respectively, we evaluate the water demand quantity and the percentage of irrigated land versus the shadow price in either of the models.

As shown in Figure 1, the PMP pattern has a more flexible curve than EMP which indicates that the water constraint has a more considerable effect in PMP model for simulation of products substitution. This result is more obvious in figure 2 where the sown area is stated as a function of shadow price. Although, the EMP curvature is more than PMP, but it is a more suitable model to predict farmers' behavior regarding policy changes. Evaluating the irrigation water

Table 2: Comparative results of PMP and EMP models in comparison to the base year.

Activity	Sown area in the base year(Hectare)	Models PMP	 EMP	EMP-base
Irrigated wheat	8531	8531	8533	0.02
Dry wheat	9422	9422	9450	0.3
Irrigated barely	2708	2708	2700	-0.3
Dry barely	24	24	0	-100
Dry pea	151	151	157	0.03
Bean	3496	3496	3500	0.11
Potato	114	114	110	-3.51
Onion	266	266	293	10.5
Alfalfa	1494	1494	1498	0.27
Irrigated corn	35	35	0	-100
Total sown area	26241	26241	26241	0
Entropy Index	0.6576	0.6576	0.6572	-34
Water consumption('000 M3)	23558	23558	20106	-14.8
Dual value of land (Rial /hectare)	71685	71685	68385	-4.8

Source: Research findings

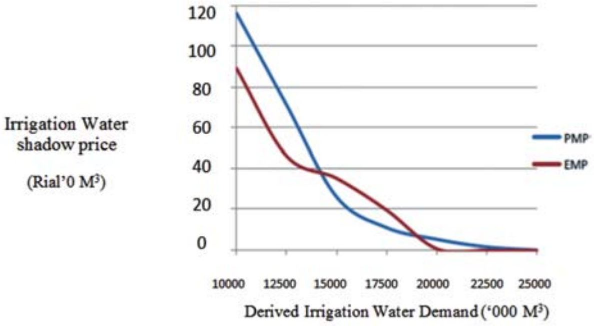

Figure 1: Derived Irrigation Water Demand from PMP and EMP models

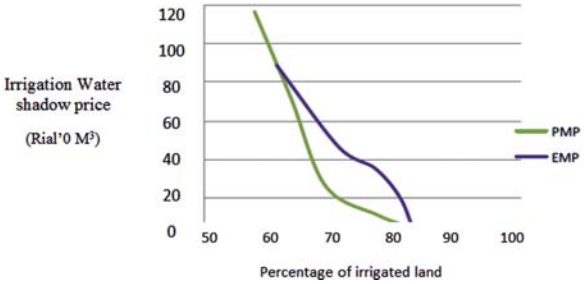

Figure 2: Percentage of irrigated land area from PMP and EMP models

demand and irrigated land area is not only beneficial to choose the best policy analysis model but it can be used for creating pricing scenario assumptions which are essential for simulation.

In the first part of demand curve i.e., 17500 to 25000 M3, The shadow price of water is in the range of 0 to 198 rials which have an elasticity of 0.008. In this price range, the changing percentage in water consumption is much less than the price changing percentage. In the second part of water demand curve i.e., 15000 to 17500 M3, price is in the range of 198.2 to 382 and the elasticity increases to 0.017 which means that more changing is expected from farmers regarding the price changes. In the third part and the availability range of 12500 to 15000 M3, price is between 382 and 420.3 and the elasticity comes out as 0.049. Interestingly, in the last part of demand curve, the elasticity increases to 0.108 which is the largest change in the consumption regarding to the price changes.

As for to the aforementioned results and the objective of this paper the simulation of the irrigation water pricing policies was done regarding the volumetric and the block tariff. In the volumetric tariff, simulation was done for 198, 382, 420.3 and 853.3 rials as optimal prices for each cubic meter of irrigation water. For the block method, the water costs were divided to three parts and in each part 50, 100 and 150 percent of water costs coverage was simulated.

Evaluation of the irrigation water pricing policies

In this section, the effect of water pricing policies on water consumption in all over the region,

Table 3: The water demand elasticity resulted from water demand for each shadow price.

Number	Water Demand	Water shadow price	Demand elasticity
1	17500-25000	0-198	0.008
2	15000-17500	198.2-382	0.017
3	12500-15000	382-420.3	0.049
4	10000-12500	420.3-853	0.108

Source: Research findings

Table 4:The economic effects of alternative irrigation water pricing policies using the EMP model

Policy	Welfare Changes	Sown area	Water consumption	Total Profit
Tariff 1	-24%	-16%	-8%	-1.5%
Tariff 2	-33%	-20%	-14%	-4%
Tariff 3	-42%	-38%	-19%	-25%
Tariff 4	-52.1%	-50%	-23%	-40%
Block Pricing	-30%	-17%	-21%	-26%

Source: Research findings

gross profit and total welfare of the society is tested. The final out comes are featured in the Table 4.

As featured in Table 4, total welfare (supplier plus consumer welfare) under the volumetric tariff of 198 rials, had the least reduction of 24% and in the second place, block tariff with 30 percent reduction proportional to the base year shows the least reduction in the total welfare. The distance between block and volumetric methods even exceeds 20 percent (for Tariff 4 case) which shows that generally, the block tariff provides a more satisfying total welfare level in comparison to the volumetric tariff. In the volumetric tariff of 198 rials, the water saving is 8% and in the block tariff, it reaches to 21%. As it is seen, the difference between these two policies in upper tariffs is negligible. The less reduction of farm profit is related to the tariffs of 198 and 382 rials for each cubic meter of volumetric method which shows 1.5% and 4% reduction, respectively. Considering the results, it can be said that in the lower tariffs, the block and volumetric tariffs effect on farm profit is almost identical but in the higher levels of pricing tariffs, the profit reduction in block tariff is less than volumetric one so that this difference in 420.3 and 853.3 rials for each cubic meter of water has 11% and 26% more reduction of profit. The sown area in the tariff of 198 rials for volumetric tariff is 84% and under block tariff is 83%. On the hand, attention has to be paid that increasing water price results in reducing the irrigated land areas thereby reducing the water consumption. Therefore, for this level of pricing tariff, block tariff allows to have a 3 percent water saving for 1 percent of reduction in the sown areas. Furthermore, placing 382, 420.3 and 853.3 tariffs will reduce the irrigated lands to 80, 62 and less than 50 percent, respectively.

CONCLUSION

In a brief summarizing, given the comparative results of the two models including Positive Mathematical Programming (PMP) and Econometric Mathematical programming (EMP) in reproducing the observed values and also the water demand and irrigated water amounts, it is understood that econometric mathematical programming model is more suitable and it is suggested to us this approach to better analyze the simulation of the effects of agricultural policies on farmers behavior. On the other hand, the simulation results show that pricing policies in irrigation sector are extremely affected by the local, structural and institutional situation. Also the pricing policies often are seeking objectives as economic efficiency, reducing costs, justice and resources conservation which are opposite to each other. The simulation analysis of alternative irrigation water pricing policies indicates that the block pricing policy is considerably capable to influence the allocation, efficiency improvement and water saving with taking into account of farmers' profit and the total welfare of suppliers and consumers. So, in order to sustaine the water resources and management and influencial reduction in irrigation water demand, it needs to incease the water price significantly but this plan will face serious reactions by beneficiaries of surface water and and also the policy makers and administrative authorities related to water issue. Given the afformantioned issues, there appears that for properly managing the water demand, they should go forward with accurate planning and scheduling the water price increasing (so that, the average water price approaches to long-run marginal cost companied with reforming the economic structure of the country) and consolidated which are likely to improve the irrigation water demand management. In this line, management and planning the water resources distribution and also correcting the water rules and presenting a suitable pattern of determining the rate of water price as block tarrif which is appropriate for the khomein region or other similar plains are the most influencial policies to reconstruct a progressive irrigation water managent system.

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