Simulations the cultivation of legumes instead of wheat and barley and examining its economic effects

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ABSTRACT

This study Simulate the cultivation of legumes instead of wheat and barley and examining the impacts it on aggregate water use, output, land rent, land under culture, total rent and shadow price of water in downstream lands of Yengejeh Dam in Neyshabur. This is an exploratory study in nature which was conducted through a questionnaire survey in 2015-2016. The population of this research is all farmers who use the water of Yengejeh dam to irrigate their lands. By Using Cochran formula, 139 wheat and barley farmers selected as the sample of this research randomly. A scenario of legumes crops such as peas, beans and lentils that have different price in the competitive and monopolist water market was developed by assimilation algorithm. According to the market situation of water in the region which is almost similar to monopolist water market, the results showed that cultivation of legume instead of wheat increase amount water used, production, total rent and shadow price of water. But it decreases land under culture in the study area. Scenario results of cultivation of legume instead of barley showed that with cultivation of legume instead of barley the amount of product produced, land rent under, total rate and shadow price of water reduces. But it increased the land under culture in the study area. Therefore, the cultivation of legumes instead of wheat has better economic effects because it provided optimal resource allocation.

Key words: Competitive market, Legume, Monopolist market, Optimal resource allocation, Products Market.

INTRODUCTION

Water management has been called the most significant challenge of the 21st century. Most water is publicly provided by vertically integrated state utilities because the distribution of water is characterized by increasing returns to scale. Various studies have shown that public ownership and management of water have led to serious inefficiencies including weak incentives to reduce costs, implement marginal cost pricing or maintain water systems” (Cowen and Cowen, 1998. (Water reform has often meant the creation of markets at the downstream end where water users may buy and sell water as well as the management of generation and distribution facilities. However, market behavior downstream is closely linked to the upstream generation and distribution of water. Market power may occur at the supply, distribution or end-use stage. The organizational structure in any given micro-market affects the performance of the system as a whole. The focus of this paper is the integrated analysis of the microstructure of such markets in which the overall effect of market power in any one segment of the market can be examined. water demand management is supposed to move towards developing those contemporary perspectives which are in harmony with the objectives of sustainability development of water resources. It also must consider controlling the extent of water exploitation through growing highly efficient products (Chakravorty et al, 2008). In competitive water market management, the totally competitive (or decentralized) behavior would work. Farmers buy water from the supplier by the utility of the marginal cost and choose the optimum amount of water and the farm production. In such case, farmers do not invest in transferring water to the farm, because the maximization problem is independent of ‘x’. However, in case of monopolist water management, the water monopoly buy water from the water development section by its marginal cost or develop the water production capacity in the region. The monopoly optimally invests in transferring water to the farm and choose the product and price maximizing the benefit (Chakravorty and Umetsu, 2003).

Simulations with stylized data suggest that institutions with market power in generation and end-use generate significantly higher welfare than the distribution monopoly and business-as-usual regime. However, the distribution monopoly maximizes service area coverage. Using the same amount of water, it serves twice the geographical area than an output cartel. If the policy objective

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is maximizing the service area and bringing more consumers to the grid, the distribution monopoly may be preferred even though it produces lower economic welfare. It may be the regime of choice in water scarce regions. The analysis suggests that proposals for intervention in water markets must be informed by the choice of an appropriate institutional delivery system. Which institution performs better depends upon the conditions in each of the micro-markets and their inter linkages through technology.

Yengejeh Dam is located in village of Yengejeh and in Sarvelayat, Neyshabur. The agricultural lands of the downstream is 5262 hectare. Due to scarcity of resources (water limitation, the surface under culture, production cost, etc.), this question is raised that if farmers in the studied area decide to plant, products with higher prices, such as legumes, instead of wheat and barley cultivating these products in a competitive water market has higher economic effects or monopolistic water market. And, considering the water market in the study area, can the cultivation of these products be recommended to farmers? To answer these questions, the following hypotheses are developed:

1- Cultivation of legume instead of wheat and barley increases water used by monopolist water market.  
2- Cultivation of legume instead of wheat and barley production increases under monopolist water market.  
3- Cultivation of legume instead of wheat and barley increases land rent under monopolist water market.  
4- Cultivation of legume instead of wheat and barley increases the land under culture in the monopolist water market.  
5- Cultivation of legume instead of wheat and barley increases the total rent in the monopolist water market.  
6- Cultivation of legume instead of wheat and barley increases the shadow price of water in the monopolist water market.

MATERIALS AND METHODS

The information was gathered by questionnaire and field method to test the research hypotheses in 2015-2016 year. The statistical population included 341 farmers feeding their farms from this dam. Using Cochran formula, a sample of 139 farmers was selected that this sample was selected from the statistical population randomly.

Research method: The model consider here is a more general form of the one developed by Chakravorty, et al. (1995). Water is supplied by the utility from a point source (e.g., a dam) into a canal. Identical firms are located over a continuum on either side of the canal on land of uniform quality. Firms at location x draw water from the canal, where x is distance measured from the source. Let r = 0 be the opportunity rent per unit area of agricultural land. Define α to be the constant width of the project area.

Let z denote the amount of water supplied from the source. The cost of supplying z units of water is g(z).

The quantity of water delivered (per unit land area) to a firm at location x is q(x). The fraction of water lost in conveyance per unit length of canal is given by the function α(x). Let z(x) be the residual quantity of water flowing in the canal through location x. Then: 

\[ z(x) = q(x) \alpha - a(x) z(x) \]  

Let X be the length of the canal. Then 

\[ z = \int_0^X \left[ q(x) \alpha + a(x) z(x) \right] dx. \]  

The loss function a(x) depends on k(x), defined as the maintenance expenditures per unit surface area of the canal. 

\[ a(x) = a_0 - m(k(x)). \]  

Let I(x) denote firm-specific investment in water conservation. Then h(I) gives the proportion of water delivered that actually reaches the plant. Also let e(x) = qh(I) where e(x) is “effective water,” i.e., the amount of water actually applied to the crop. Then the production technology for each firm is given by f(e). Let Y be the aggregate output from the project. It is then given by

\[ Y = \int_0^X f(e) \alpha \, dx. \]  

Define the total cost of producing a given output level Y at C(Y) which can then be expressed as 

\[ C(Y) = g(Y) + \int_0^X \left[ k(v(z)) + (l(x) + r) \alpha \right] dx. \]  

The utility chooses control functions q(x), I(x), k(x), and values for X and z that maximize aggregate net benefits from the project as follows:

Minimize \( g(z) + \int_0^X [k(v(z)) + (l(x) + r) \alpha] \, dx \) 

Subject to

\[ Z(x) = q(x) \alpha - a(x) z(x) \]  

\[ Y'(x) = f(e) \alpha \]  

\[ q(x) \geq 0, I(x) \geq 0, k(x) \geq 0, z(x) \geq 0, \]  

\[ Z(x) \geq 0, X \geq 0, X \text{ free.} \]  

Then the Hamiltonian and corresponding Lagrangian are:

\[ H = k(V) + (I + r) \alpha + \lambda - \lambda_1 (q + AZ) - \lambda_2 f(e) \alpha \]  

\[ L = H(x) - \lambda_3 z. \]  

The necessary conditions for a solution to problem (6a)-(6e) are

\[ (\lambda - \lambda_1 f'(h)(l)) \alpha \leq 0 \leq 0 \text{ if } q > 0 \]  

\[ (1 - \lambda_1 f'(h)(l)) \alpha \leq 0 \leq 0 \text{ if } l > 0 \]  

\[ V(x) \lambda_2 \leq \lambda_2 \]  

\[ \lambda_1(x) = 0 \]  

\[ \lambda_2 = C(X) \]  

\[ \lambda_3(x) \geq 0 \Rightarrow \text{if } f(z) > 0 \]  

\[ \lambda_4(0) = g'(z) \]  

\[ \lambda_5(X) - \lambda_1(X) \beta = 0 \]  

\[ L(x) = 0. \]  

In the above, \( \lambda(x) \) is interpreted as the shadow price of delivered water at location x.

At the project boundary X, (17) gives:
\[ L(X) = k(X)w(z(X)) + [I(X) - r] \alpha + \lambda(X)q(X) \alpha + az(X) - \lambda f(e(X)) \alpha - \lambda(X)z(X) = 0. \]

Substituting \( z(X) = 0 \) and \( v(0) = 0 \) and rearranging, yields

\[ \lambda f(e(X)) - I(X) - \lambda q(X) = r \]

Which implies that net benefits from expanding the land area by one unit must equal the opportunity rent of land, \( r \). Thus the equilibrium value of \( X \) is inversely related to \( r \). If \( r = 0 \) (land is in infinite supply), that would imply a greater project area. If \( r \) increased with \( x \) because say, the downstream locations were closer to an urban center, then \( X \) would be smaller.

The monopolist is \( C^*(Y) \). Monopoly output \( Y_m \) is chosen to maximize profits \( \Pi^m \) as follows:

Maximize \( \Pi^m = pY - C^*(Y) \)

And \( Y_m \) solves

\[ MR(Y) - C^*(Y) = 0 \]

\[ MR'(Y) - C^''(Y) < 0 \]

Where \( p \) is the output price of the agricultural commodity. Let \( p \) be the output price under monopoly. Then \( p_m = U'(Y_m) \).

Let the corresponding cost function under a water market be \( C^w(Y) \). Purely competitive (or decentralized) behavior will result when individual farmers act competitively. Farmers purchase water from the water utility at its marginal cost at source, and choose optimal amounts of water and on-farm technology. The optimization problem for a farmer at location ‘\( x \)’ is given by

Maximize \( \pi^w = \left[p f(qh(I)) - \lambda \alpha - k q, I, k \right] \)

Where \( \pi^w \) represents competitive profits at ‘\( x \)’. It is clear from (23) that in a decentralized, competitive regime, the individual farmer will not invest in conveyance, and since the maximization problem is independent of ‘\( x \)’, conveyance expenditures under competition are zero at each ‘\( x \)’. Let us denote the cost function for aggregate output under competition as \( C_w(Y) \). Equilibrium aggregate output \( Y_w \) and price \( P_w \) in competition are then obtained as follows:

\[ Y_w \in \arg\max U(Y) - C_w(Y) \]

And solves

\[ U'(Y) - C_w'(Y) = 0 \]

\[ U''(Y) - C_w''(Y) < 0. \]

A computer algorithm was written that starts by assuming an initial value of output price \( P \) and \( z_0 \) and computes \( \lambda \) from (15). At \( x = 0 \), (10) gives \( m'(k) \). By iterating on \( k \), we compute \( k(x) \) that satisfies (33), and (32) gives \( a(x) \). Knowing \( \lambda \) (0), (8) and (9) used simultaneously yield \( I(x), q(x) \) and thus \( e(x) \), \( y(x) \) and \( R(x) \) respectively. Next, when \( x = 1 \), using a (0) and \( \lambda \) (0) in the solution to (11) gives \( \lambda \) (1), and \( z(1) \) is obtained from (1) by subtracting the water already used up previously. Again, \( \lambda \) (1) and \( z(1) \) give \( k(1) \) from (10) and the cycle is repeated to give \( q(1), I(1), \) etc...

The process is continued with increasing values of \( x \) until exhaustion of \( z_0 \) terminates the cycle, and a new value of \( z_0 \) is assumed. Aggregate land rents are calculated for each \( z \) by summing over \( R(x) \) and aggregate rents to water are computed similarly. The algorithm selects the value of \( z_0 \) that minimizes total cost (given by (6(a)). For each price \( P \), the corresponding \( Y \) is computed to generate the supply function. The equilibrium is computed by solving the supply and demand equations jointly. The algorithm was modified suitably for the competitive, monopoly solutions.

**RESULTS AND DISCUSSION**

Scenario results of cultivation of legume instead of wheat in the study area showed that in monopolist system, water shadow price increased with cultivation of legume instead of wheat. As a result, farmers showed more inclination to invest in water transfer. Therefore, the remaining water in the channel increased. Therefore, the amount of water delivered to the farm to be increased (Table 1). However, in competitive market, due to a reduction in the water remaining in canal, the water reaching farm and used by plants also decreased (Table 2). Therefore, the first hypothesis, i.e. cultivation of legume instead of wheat and barley increases water used in monopolist water market is approved for wheat product.

**Table 1:** Changes in product price and its effect on resources allocation under monopolist market in 2015-2016

<table>
<thead>
<tr>
<th>Product</th>
<th>Product price (Toman/Kg)</th>
<th>Production amount (Kg)</th>
<th>Shadow price of water (Toman/m³)</th>
<th>Water delivered to farm (m³/H)</th>
<th>Land rent (Toman/H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1100</td>
<td>40127.76</td>
<td>48.53</td>
<td>2706.47</td>
<td>285115.27</td>
</tr>
<tr>
<td>Peas</td>
<td>2100</td>
<td>5742.63</td>
<td>49.84</td>
<td>2760.34</td>
<td>501365.54</td>
</tr>
<tr>
<td>Beans</td>
<td>5100</td>
<td>5848.21</td>
<td>52.23</td>
<td>2906.34</td>
<td>1150676.44</td>
</tr>
<tr>
<td>Lentils</td>
<td>8000</td>
<td>6649.04</td>
<td>54.20</td>
<td>3045.29</td>
<td>1778445.43</td>
</tr>
</tbody>
</table>

Resource: Research Findings

**Table 2:** Changes in product price and its effect on resources allocation under competitive market in 2015-2016

<table>
<thead>
<tr>
<th>Product</th>
<th>Product price (Toman/Kg)</th>
<th>Production amount (Kg)</th>
<th>Shadow price of water (Toman/m³)</th>
<th>Water delivered to farm (m³/H)</th>
<th>Land rent (Toman/H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1100</td>
<td>4415.21</td>
<td>43.75</td>
<td>4742</td>
<td>925016.7</td>
</tr>
<tr>
<td>Peas</td>
<td>2100</td>
<td>3222.20</td>
<td>43.75</td>
<td>2790.69</td>
<td>485770.77</td>
</tr>
<tr>
<td>Beans</td>
<td>5100</td>
<td>3137.19</td>
<td>43.75</td>
<td>2337.65</td>
<td>201556.78</td>
</tr>
<tr>
<td>Lentils</td>
<td>8000</td>
<td>2137.14</td>
<td>43.75</td>
<td>1284.85</td>
<td>129441.08</td>
</tr>
</tbody>
</table>

Resource: Research Findings
In monopolist water market, as the water reaching farm and absorbed by plant increases, therefore, amount of produced product increases (Table 1). Therefore, the second hypothesis, i.e. cultivation of legume instead of wheat and barley increases production under monopolist water market is approved for wheat product.

In monopolist water market, the land rent increased with cultivation of legume instead of wheat (Table 1). In competitive market, though, land rent decreases (Table 2) therefore it can be concluded The third hypothesis states that cultivation of legume instead of wheat and barley increases land under culture in monopolist water market is approved for wheat product.

In monopolist system, increasing land rent makes farmers produce more in smaller surfaces under culture (Table 1) but in competitive market, increased land under culture forces farmers to increase their production (Table 2). Accordingly, The fourth hypothesis, i.e. cultivation of legume instead of wheat and barley increases the land under culture in monopolist water market, is not approved for wheat product.

Higher rent for each hectare, in monopolist water market, increases the total rent rate (Table 1) however, in the competitive market, the total rate decrease with the land rent (Table 2). Therefore, the fifth hypothesis, i.e. cultivation of legume instead of wheat increases the total rent in the monopolist water market is approved for wheat product.

With the increase in the amount of product produced in the monopoly market, the willingness to pay per cubic meter of water on the farm has increased, so the price of shadow of water has increased, thus the sixth hypothesis of the research that states cultivation of legume instead of wheat and barley increases the shadow price of water in the monopolist water market is approved for wheat product.

Scenario results of cultivation of legume instead of barley in the study area showed that in monopoly water market, with cultivation of legume instead of barley the amount of product produced reduced in per hectare. Therefore, the second hypothesis, i.e. cultivation of legume instead of wheat and barley increases production under monopolist water market is not approved for barley product.

Reduction in the amount of manufactured products means that the farmer has used less water. Therefore, reduced the cost of production and supply of water for agriculture also leads to reduction of shadow price of water for agriculture. Also, the volume of water flowing in the channel is decreased due to reduced agricultural use of water and causes the reduced incentive of farmers to invest in water delivery to the farm that result of it is increase in the amount of water losses in the transmission path. Thereby reducing the amount of residual water in the channel and thus reduced the amount of water that reaches the farm and plant will be used (Table 3). Therefore, the first hypothesis, i.e. cultivation of legume instead of wheat and barley increases water used by monopolist water market is not approved for barley product.

By reducing the amount of the products, rent per hectare of land reduced (Table 3). Therefore the third hypothesis, i.e. cultivation of legume instead of wheat and barley increases land rent under the monopolist water market is not approved for barley product.

So in the monopoly water market, the farmer tries to increase the amount of his crop with more cultivation. Therefore the fifth hypothesis i.e. cultivation of legume instead of wheat and barley increases the land under culture in the monopolist water market is approved for barley product.

However, in the monopolist water market, the total rate decrease with the land rent (Table 3). The fifth hypothesis, i.e. cultivation of legume instead of wheat and barley increases the total rent in the monopolist water market is not approved for barley product.

By reducing the amount of product produced in the monopoly market, the willingness to pay each cubic meter of water from the farmer has decreased, so the shadow price of the water has decreased, thus the sixth hypothesis of the research, which states cultivation of legume instead of wheat and barley increases the shadow price of water in the monopolist water market is not approved for barley product.

As the water market in the region is monopolist, the following findings are presented for farmers:

Results showed that cultivation of legume instead of wheat lead farmers invest in water transfer. This prevents from water loss in the distribution rout and transferring to the farm. In monopolist water market, cultivation of legume instead of wheat increases water reaching farm and consumed by plants which also increases the amount of produced product. In monopolist water market, if farmers cultivate

Table 3: Changes in product price and its effect on resources allocation under monopolist market in 2015-2016

<table>
<thead>
<tr>
<th>Product</th>
<th>Product price (Toman/Kg)</th>
<th>Production amount (Kg)</th>
<th>Shadow price of water (Toman/m³)</th>
<th>Water delivered to farm (m³/H)</th>
<th>Land rent (Toman/H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>1000</td>
<td>5735.04</td>
<td>22.53</td>
<td>3654.89</td>
<td>529628.73</td>
</tr>
<tr>
<td>Peas</td>
<td>2100</td>
<td>4989.65</td>
<td>22.51</td>
<td>3201.43</td>
<td>483053.80</td>
</tr>
<tr>
<td>Beans</td>
<td>5100</td>
<td>4441.34</td>
<td>22.49</td>
<td>2614.2</td>
<td>361053.321</td>
</tr>
<tr>
<td>Lentils</td>
<td>8000</td>
<td>3558.41</td>
<td>22.48</td>
<td>1891.10</td>
<td>240419.46</td>
</tr>
</tbody>
</table>

Resource: Research Findings
Table 4: Changes in product price and its effect on resources allocation under competitive market in 2015-2016

<table>
<thead>
<tr>
<th>Product</th>
<th>Product price (Toman/Kg)</th>
<th>Production amount (Kg)</th>
<th>Shadow price of water (Toman/m³)</th>
<th>Water delivered to farm (m³/H)</th>
<th>Land rent (Toman/H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>1000</td>
<td>5735.04</td>
<td>37.9</td>
<td>2423.5</td>
<td>365217.43</td>
</tr>
<tr>
<td>Peas</td>
<td>2100</td>
<td>6213.52</td>
<td>37.9</td>
<td>4711.48</td>
<td>401242.13</td>
</tr>
<tr>
<td>Beans</td>
<td>5100</td>
<td>7587.06</td>
<td>37.9</td>
<td>5707.9</td>
<td>620303.34</td>
</tr>
<tr>
<td>Lentils</td>
<td>8000</td>
<td>7867.49</td>
<td>37.9</td>
<td>6320.9</td>
<td>786749.28</td>
</tr>
</tbody>
</table>

Resource: Research Findings

legume instead of wheat, they should consider the chance of renting each hectare. They try to increase their capacity and production power by decreasing land in order to increase gross profits. This results in the reduction of total rent, especially for farmers whose farmlands are mostly rented.

The results showed that if barley farmers replace cultivation of legume instead of barley that has higher price than the barley, because of the decline in shadow price of water, the more water is used. Therefore, according to the market situation of water in the study region is almost like monopoly water market, cannot be recommended cultivate legume instead of barley that their price are higher than the barley. The results showed that if farmers replace cultivation of legume instead of barley, because of irreducible shadow price of water and increase the opportunity cost of rent per hectare of land, will try to increase their yields using less water and less acreage.

Practical Suggestion based on Research Findings:
1-Regarding results, the loss ratio in transferring route decreases and the amount of water reaching farm and absorbed by plants increases. Wheat farmers can be suggested cultivate legume instead of wheat.
2-Wheat farmers can be suggested cultivate legume instead of wheat. This increases production capacity and gross profits.
3-Wheat farmers try to reduce lands because of higher rent per hectare. Therefore, regarding the limited lands and higher cost of water supply and irrigation, farmers are suggested to cultivate legume instead of wheat.
4-Given that the market situation of water in the region cannot be recommended to barley farmers growing these legumes instead of barley unless the water market in the region is almost “like competitive water market. In other words, water rights leased in this area at a price determined that reflecting the cost of local evaluation operations people’s organizations be formed in the region that these organizations manage water distribution in the area and monitor water usage and quotas and their own roughing and interests monitoring is based on the power that the law has given them.

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REFERENCES