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Estimation of the Demand Function of Water for the Industrial Sector Using Translog Cost Functions (Case Study: Zahedan City)

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ABSTRACT

The main objective of the current study was to estimate the demand function for water in the industrial sector of Zahedan city based on the methodology of duality premise. To this end, the trans-log cost function which is considered as a more robust framework for the analysis of production relationships was utilized to estimate the demand function of water in the industrial sector instead of using conventional production methods. This is an applied survey in which the trans-log cost function and the cost share equations using Iterative Seemingly Unrelated Regressions (ISUR) approach. After the estimation of the model, the production infrastructure technologies, the substitution and price elasticity were calculated and homothetic, constant return to scale and Cob-Douglas hypotheses for the production function were tested using Eviews software. The data of the study refer to 30 active production units located in the industrial clusters of the Zahedan city during the period from 2011 to 2012. Data were collected through questionnaires. The determination coefficient of the model was equal to 97 percent which indicated the goodness of fit. On the other hand, the results of the model estimation represented water as a non-elastic commodity because the price elasticity calculated for water was less than 1 (-0.07). Moreover, the calculated values for Allen-Uzawa and Morishima elasticities indicated a strong substitution relationship between water as a production input and machinery (6.69) and building (1.30) inputs. On the other hand, there was a weak substitution effect between water and land inputs (0.65) and a complementary relationship existed between water and labor inputs (-0.43). However, it should be mentioned that the homotheticity, constant returns to scale, and the Cob-Dagoulas form of the cost function hypotheses were rejected based on the Maximum Likelihood Ratio (Wald-Statistic).

1. Introduction

Water means life and without which no creature is able to survive. Wherever there is water, there also exists prosperity and economic boom. On the other hand, various utilizations of water come into action including drinking, swimming, washing and taking bath, irrigation, usage in industrial activities, power generation, transportation and boating, fishing, creating beautiful landscapes etc. Zahedan city, the capital of Sistan and Baluchestan Province, is considered one of the arid and water deficit regions in Iran in which the required water for drinking, industry and agriculture is provided through underground sources and collection of atmospheric precipitations and the overflows of water behind common dams in borders. However, Zahedan city lacks any surface water sources. The current paper attempted to estimate the demand for water in industrial sector through cost minimizing method using translog cost functions.

2. Literature review

Water is a scarce commodity which plays a multi-dimensional role in the economy:

1. As a final good which is consumed by the final consumer.
2. As an intermediary good which is applied in the production of other commodities.

Although water is considered one of the renewable energy resources, the volume of water resources is so limited all over the globe. Due to population growth, industrial development, higher levels of public health welfare, per capita renewable resources per capita is continuously declining. Moreover, the vital and effective role of water in all aspects of individual and social life of a community is so important that on the one hand, it is considered as the basis of for comprehensive

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development of a country and its population and on the other hand, water it has become as one of the important limitations for planners and policy makers in various regional, national, and transnational levels.

The idea originated from the dominant strategy of the world holds that water is designated as the origin of life. Therefore, due to the critical value of water and its vital effect on the development of human communities, it is extremely important and an inevitable task for any nation to recognizing recognize the need for to management, control, protection and optimal exploitation of the water resources in a particular certain area is extremely important and an inevitable task for any nation. Also, daily increasing the growing rate of water consumption of water in the Iran's industrial sector as the consequence of the impressive growth of this sector completely makes it imperative to shows the necessity of studying the water demand structure and identifying the water consumption channels. Consumption of water is consumed in various forms in the nature cycles has various forms. The most important forms include drinking, household consumptions, and agricultural, horticultural, industrial and mineral activities. However, Although the quantity of water consumed in the industrial sector is relatively small, it is vitally necessary to analyze water consumption structure because of the increase of in the industrial activities due to the demand pressure for the commodities produced in the industries, the industrialization of the country, the increasing level of urbanization and issues related to water pollution caused by industrial effluent and the analysis of the water consumption structure is vitally necessary in Iran. On the other hand, little research has been published in the field of industrial water use .

Sistan and Baluchistan province with an average annual rainfall of 110 mm per year and the average temperature of 22 to 37 ° C is one of the dry provinces of the country Iran due to that lack precipitation, lack of proper engineering, implementation of inappropriate projects and lack of proper management of water resources has always suffered the people of this province. The required water for drinking, industry and agriculture is provided through underground sources and collection of atmospheric precipitations and the overflows of water behind common dams in borders.

The total surface water in Sistan and Baluchistan province is around 4.8 billion m^3. About 3 billion m^3 comes from the border river in this province and only 1.8 billion m^3 is recoverable. On the other hand, the greatest value of exploitation in the province refers to the surface water flows. Generally, the estimation of the water demand makes it possible for planners and executives to be able to meet the needs of region local population for water consumption appropriately, especially in the industrial sector by paying enough attention to the sensitivity of demand with respect to variables influencing the demand for water including quality and the type of raw materials, production technology, the process used in the corresponding industry, the quality of the supplied products and the quantity of output and also the culture dominating the manufacturing unit or any other effective variable.

The study attempted to estimate the industry demand for water using the minimum cost approach. The corresponding function is affected by the performance of the manufacturing units (factories and workshops located in Zahedan industrial clusters) and it was an unrestricted function. In other words, initially because the functional form of the production function is was not already specified, the general form of the translog production function was used due to its capability for transformation to other forms of production functions in order to obtain the corresponding production function based on the results of the study and by taking into account the required assumptions into account.

As the basis of the current survey was based on the real performance of the production units, all the data about water consumption was were collected using questionnaires and the statistical population of the current survey included were active production units located in the industrial clusters of Zahedan city.

3. Empirical studies about demand for water

Despite the considerable volume of the studies conducted about the water consumption in the agricultural and household sectors, water demand in the industrial sector has been studied to lesser extent and there is a limited literature on the subject and the reason is attributed to the lower share of water consumption in the industrial sector. Babin *et al*. (1982) estimated the trans-log cost function for various manufacturing industries in the US (based on the type of the industry). They focused on the substitution possibilities between water and other productive inputs. The productive inputs included water, capital, active labor and non-active labor. The results of the study indicated that the share of water was greater than 1 percent in 3 three sectors of 7seven. They found that price elasticity of water ranges ranged from -0.14 for food industry to -0.66 for paper and wood industry. Moreover, they concluded that capital and labor were substitutes in all sectors, However, the substitution possibility with water and other inputs varies varied from one sector to another .

Zeigler and Bell (1984) estimated the demand for water using the average cost of water charges instead of the marginal costs. They investigated a sample including 26 elements in the Arkansas state, US. They estimated the cost function in a Cob-Douglas form. The results of the study indicated that the best specification can could be obtained when the average cost is used to estimate the demand function .

Williams and Suh (1986) attempted to estimate the industrial water demand based on from a quiet different point of view perspective. Data were aggregated over 120 municipalities of the USA in the year 1973. Industrial water demand was found to depend upon water price, the value of production, and the number of industrial connections in each municipality. Demand equations were estimated by ordinary least squares (OLS) using different price variables including water price and, the production value in each city. According to the price specifications, price elasticity varied from 0.44 to 0.97.

Renzetti (1988) studied the elasticity of industrial water consumption using a sample of 372 industrial firms of British Columbia, Canada by estimating a Cob-Douglas function. Four specific water inputs were distinguished in the study including water intake, recirculation, and treatment prior to discharge. On the other hand, four manufacturing subgroups were considered in the study: petrochemicals, heavy industry, forest industry, and light industry. Price elasticities estimated in the study vary varied from -0.54 in light industries to -0.12 in petrochemical industry. On the other hand, the share of water input costs in the petrochemical industry was less in the petrochemical industry than in light industry. Moreover, there were was a substitution relationship between water treatment prior to use and treatment prior to discharge and a complementary relationship between the water intake and recalculated water.

Renzetti (1992) also estimated the above model for a sample consisted of 2000 industrial firms in Canada. Their withdrawals represented 95% of total water used by the manufacturing industry. Seven industry sectors were studied including beverage, plastic and rubber, textile, paper and pulp, metals, minerals, and petroleum. According to the results of the study, price elasticities were significant in four of the seven industries: plastic and rubber -0.15, textile -0.33, paper and pulp -0.59 and minerals -0.32. The results of the study indicated that the water intake and the circulated water were substitutions.

Reynaud (2003) investigated the structure of the industrial water in France using trans-log cost functions. The study estimated the industrial demand for water and calculated the costs of productive inputs in the Gironde region in France by selecting a sample of 51 industrial firms during the period from 1994 to 1996 using the duality production theories, minimum costs, and iterative seemingly unrelated regression approach. As the cost functional form wasn't was not pre-specified and trans-log forms specifications are were flexible, the trans-log functions were used to estimate the model. The inputs considered in the study included: labor and three other water inputs (total water in the network, water for consumption and the purified water). The results of the study indicated that the industrial firms were sensitive with respect to the price of the water intake (inputs) and generally the price elasticity of network was quite low (-0.29), but it was greater than the price elasticity for household consumptions. On the other hand, price elasticities were different with respect to the type of the industry so that the price elasticity of the network was -0.095 in the alcohol industry and -0.374 in other classified industries including: chemical, food, advertisement, and service industries). Moreover, the results indicated that water and labor were substitutions while water and capital were complementary inputs. On the other hand, the water in the production network and the free water were substitutions and purified and free water were complements.

Kumar (2000) investigated the structure of demand for industrial water for a three- year period using a trans-log cost function for a sample consisted consisting of 93 industrial firms in India and calculated the sensitivity of water and the shadow price of water in the industrial sector. Inputs used in the estimation of the function included labor, capital, and water. The results of the model estimation indicated that the average shadow price of water was 7.21 rupees per kilo-liter and due to the diversity of industries, the shadow average price for the water varies varied between industries. The shadow average price per kilo-liter for petrochemicals was 30.54 for petrochemicals, and 1.40 for paper productions, 1.40, respectively. Moreover, water and capital were substantive inputs while water and labor were complements. However, the price elasticity (sensitivity) of the derived demand for water was greater (-1.11) than in comparison with other similar studies.

Sharzei and Ghetmiri (1996) studied the demand and the value of water using trans-log cost functions and estimated the demand for water and the substitution and price elasticity for huge industries in Fars province. The results of the study indicated that the calculated criterions didn't did not represent the same results for the degree of price elasticity for water demand in all industries. Therefore, using these criterions criteria in forecasting the effects of pricing policies in on the industrial sectors could be in doubt. The lack of accessibility to the four components of demand in the industry makes it impossible to forecast the effects of such policies on the saving of water.

Sharzei (2002) investigated the theoretical foundations of demand for water and checked the water intake structure in the industry using trans-log cost functions to analyze the demand for water in the industrial sector and the share of inputs. After representing the theoretical foundations of demand for water, a selection of 120 large industrial firms were chosen to investigate the structure of water consumption including ownership and value of products, type of consumption, disposal of industrial wastewater, and partial productivity. The results of the study indicated that:

1. Among the nine activities for the studied firms (chemicals, paper, cardboard and printing, wood and wooden products, metallic minerals, non-metallic minerals, machinery and equipment, food industry, textile and garments, miscellaneous), chemical industry with 17.7 percent of the total water consumption had the largest share of the total water consumption in the industries and paper, cardboard and printing with 1.7 percent of the total water consumption had the lowest share of water consumption.

1. Industrial water use for cooling purposes is higher than the other types of water consumption.
2. Industries with private sector ownership had less water consumption and had created greater value added than the state-owned industries .
3. Almost half of water consumption in the industry is disposed excreted as industrial wastewater.
4. Paper, cardboard and print industry had with the greatest partial productivity and non-metal industries had the lowest partial productivity.
5. One of the features in the water consumption in the industrial firms is the type of consumption. Due to various types of water consumption in the industry sector, the water consumption for cooling the machinery was 25 per cent, production 21 per cent and vapor production 15.9 per cent of the total water consumption, respectively. Using water for warming and cooling purposes only constitutes 4.7 percent of the total water consumption. As the water consumption for cooling the manufacturing machinery was greater than other water consumption types in the industry.

4. Model estimation

This was a practical study which used the trans-log cost functions and the cost share equations of the inputs. The data were collected by a questionnaire during the period from 2011 to 2012. The Eviews software was used to estimate the models of the study. The iterative seemingly unrelated regressions (ISUR) was applied for the estimation of the regression models. After the estimation of the value model Allen-Uzawa and Morishima substitution and elasticities were calculated and also the homothecity and constant return to scale and additional tests were conducted to make sure whether or not the production function is of Cob-Douglas form.

4.1. Model specifications

A production function was used to estimate the model; therefore, in the current study the production function was specified as follows (Jalaei and Sadqy, 2008):

$$Y= f(X_i) \quad i=L,T,H,Z,W \tag{1}$$

Where, Y represents the level of output and X_i shows the production factors. The production factors included labor, machinery, constructions, land, and water. The output quantity is limited by the production factors so that X, Y> 0. On the other hand, the concavity of the production function is satisfied. The other assumption is that the production function is that it can't be composited into the factors of production. It means that the marginal rate of substitution (MRS) between the production factors is independent of any external factor (Jalaei and Sadqy, 2008):

$$\frac{\partial}{\partial xw}\left(\frac{Fi}{Fj}\right)= 0 \ ,$$
$$Fi = \frac{\partial Fi}{\partial Xi} * \frac{Fi}{Fj} = \frac{MPPi}{MPPj} \tag{2}$$

Satisfying the continuity of the production function, the cost function can be obtained. For any production function, there is a cost function. It was assumed that the cost function was as follows:

$$C(P_i,Y) = min(P,X) = TC \tag{3}$$

So that C was the total cost and p_i represented the price of the production function.

The second order differential of the function can be calculated. On the other hand, the cost function is convex. P_j,Y>0 so that (Jalaei and Sadqy, 2008):

$$C = f\,(P_l,P_t,P_H,P_Z,P_W,y) \tag{4}$$

Where, P_l, P_T. P_H, P_Z, and P_W were the water price index, land, construction, machinery, and labor, respectively. Y shows the level of output and C is the total cost. The trans-log function in the current study was specified as follows (Jalaei and Sadqy, 2008):

$$\begin{aligned} lnc &= \alpha_0 + \alpha_1 \ln(p_H) + \alpha_2 \ln(p_L) + \alpha_3 \ln(p_T) + \alpha_4 \ln(p_Z) \\ &+ \alpha_5 \ln(p_W) + \beta_1(0.5)(ln(p_H)^2) + \beta_2 ln(p_H)ln(p_L) \\ &+ \beta_3 \ln(\mathrm{p_H})\ln(\mathrm{p_T}) + \cdots + \beta_{23}(0.5)(\ln(\mathrm{p_Z})^2) \\ &+ \beta_{24}\ln(p_Z)ln(p_W) + \beta_{25}(0.5)(ln(p_W)^2) + \delta_1\ln(\mathrm{Y}) \\ &+ \delta_2\ln(p_H)ln(Y) + \cdots + \delta_6 ln(p_W)ln(Y) \\ &+ \delta_7(ln(Y)^2) \end{aligned} \tag{5}$$

In order to satisfy the homogeneity assumption for the cost function with respect to factor price, the following restrictions were levied (Jalaei and Sadqy, 2008):

$$\sum\alpha_i=1 \ , \ B_{ij}=B_{ji} \ , \ \sum B_{ij}=\sum\delta_{iy}=0 \ , \ i,j=L,T,H,Z,W \tag{6}$$

The Shepherd lemma states that the conditional demand for the production factor is equal to the derivation of the cost function with respect to the price of that factor:

$$\frac{\partial lnc}{\partial lnpi} = \frac{p}{c} * \frac{\partial c}{\partial pi} = \frac{pixi}{c} = S_i \tag{7}$$

Therefore, the share of any production factor can be obtained by calculating the first order derivation of the equation (5) with respect to pi (Jalaei and Sadqy, 2008):

$$S_i=\alpha_i+\sum B_{ij} \quad LNP_j+\delta_{iy}LNY \tag{8}$$

Where, the share of any production factor can be written as follows (Jalaei and Sadqy, 2008):

$$S_L=\alpha_L+B_{LL}\,LNP_L+B_{LT}\,LNP_T+B_{LH}\,LNP_H+B_{LZ}NP_Z+B_{LW}\,LNP_W+\delta\,ly\,LNY \tag{9}$$

$S_T=\alpha_T+B_{TL}\,LNP_L+B_{TT}\,LNP_T+B_{TH}\,NP_H+B_{TZ}LNP_Z+B_{TW}\,LNP_W+\delta_{Ty}\,LNY$ (10)

$S_H=\alpha_H+B_{HL}LNP_L+B_{HT}LNP_T+B_{HH}LNP_H+B_{HZ}\,LNP_Z+B_{HW}\,LNP_W+\delta_{Hy}\,LNY$ (11)

$S_Z=\alpha_Z+B_{ZL}LNP_L+B_{ZT}\,LNP_T+B_{ZH}\,LNP_H+B_{ZZ}\,LNP_Z+B_{ZW}\,LNP_W+\delta_{Zy}\,LNY$ (12)

$S_W=\alpha_W+B_{WL}LNP_L+B_{WT}LNP_T+B_{WH}LNP_H+B_{WZ}LNP_Z+B_{WW}\,LNP_W+\delta_{Wy}\,LNY$ (13)

Thirty-eight coefficients should be estimated. Due to the existence of asymmetry condition, the number of parameters reduces to 28. The asymmetric coefficients are as follows (Jalaei and Sadqy, 2008):

$B_{LH}=B_{HL}$, $B_{HT}+B_{TH}$, $B_{TL}=B_{LT}$, $B_{ZH}=B_{HZ}$, $B_{ZL}=B_{LZ}$, $B_{ZT}=B_{TZ}$, $B_{WL}=B_{LW}$, $B_{WH}=B_{HW}$, $B_{WT}=B_{TW}$, $B_{WZ}=B_Z$ (14)

The trans-log cost function with respect to the factor price is homogenous of degree 1. Therefore, (Jalaei and Sadqy, 2008)

$$\begin{aligned}
&\alpha_l+\alpha_T+\alpha_H+\alpha_Z+\alpha_W=1\\
&B_{LL}+B_{LT}+B_{LH}+B_{LZ}+B_{LW}=0\\
&B_{TL}+B_{TT}+B_{TH}+B_{TZ}+B_{TW}=0 \qquad (15)\\
&B_{HL}+B_{HT}+B_{HH}+B_{HZ}+B_{HW}=0\\
&B_{ZL}+B_{ZT}+B_{ZH}+B_{ZZ}+B_{ZW}=0
\end{aligned}$$

The cost share equations has the feature that $\sum \text{Si}=1$, meaning that $\sum \text{PiXi}=\text{C}$.

As the equations for the share of inputs are related to each other, the ISUR method was used to estimate the model. In order to estimate the equations simultaneously, due to the homogeneity and asymmetry conditions (which states that the sum of the input costs are equal to 1), it was necessary to ignore one of the equations. Therefore, the information of one of the equations was redundant and could be omitted from the model.

First of all, in the logarithmic equation the share of all factors (except for the output level) was divided into the price of the land. In other words, *n-1* equations for the share of the costs had linear forms. Then in order to avoid the correlation between the equations, the number of equations was reduced from 5 to 4 equations. Therefore, the share of the input costs after the omission of the land input would be as follows (Jalaei and Sadqy, 2008):

$S_l=\alpha_L+B_{LL}LN(P_L/P_Z)+B_{LT}\,LN(P_T/P_Z)+B_{LH}\,LN(P_H/P_Z+B_{LW}\,LN(P_W/P_Z)+\delta_{ly}\,LNY$

$S_T=\alpha_T+B_{TL}LN(P_L/P_Z)+B_{TT}\,LN(P_T/P_Z)+B_{TH}\,LN(P_H/P_Z)+B_{TW}\,LN(P_W/P_Z)+\delta_{Ty}\,LNY$ $S_H=\alpha_H+B_{HL}LN(P_L/P_Z)+B_{HT}\,LN(P_T/P_Z)+B_{HH}\,LN(P_H/P_Z)+B_{HW}\,LN(P_W/P_Z)+\delta_{Hy}\,LNY$

$S_W=\alpha_W+B_{WL}LN(P_L/P_Z)+B_{WT}\,LN(P_T/P_Z)+B_{WH}\,LN(P_H/P_Z)+B_{WW}\,LN(P_W/P_Z)+\delta_{Wy}\,LNY$ (16)

After the estimation of (16) simultaneous system of equations by applying the restrictions of the equation (15) the coefficients of the share equations for the land input (Z) would be (Jalaei and Sadqy, 2008):

$$\begin{aligned}
&\alpha_Z=1-\alpha_L-\alpha_H-\alpha_T-\alpha_W\\
&B_{LZ}=-(B_{LL}+B_{LH}+B_{LT}+B_{LW})\\
&B_{TZ}=-(B_{TL}+B_{TH}+B_{TT}+B_{TW})\\
&B_{HZ}=-(B_{HL}+B_{HH}+B_{HT}+B_{HW}) \qquad (17)\\
&B_{WZ}=-(B_{WL}+B_{WH}+B_{WT}+B_{WW})\\
&B_{ZZ}=-(B_{ZL}+B_{ZH}+B_{ZT}+B_{ZW})
\end{aligned}$$

In order to increase the efficiency and calculate the coefficients of the output level, the total cost function was included to the cost share equations (16):

$$\begin{aligned}
&\ln\left(\frac{C}{p_Z}\right)\\
&=\alpha_0+\alpha_1\ln\left(\frac{p_H}{p_Z}\right)+\alpha_2\ln\left(\frac{p_L}{p_Z}\right)+\alpha_3\ln\left(\frac{p_T}{p_Z}\right)\\
&+\alpha_4\ln\left(\frac{p_W}{p_Z}\right)+\beta_1(0.5)(ln\left(\frac{p_H}{p_Z}\right)^2)+\beta_2 ln\left(\frac{p_H}{p_Z}\right)ln\left(\frac{p_L}{p_Z}\right)\\
&+\beta_3 ln\left(\frac{p_H}{p_Z}\right)ln\left(\frac{p_T}{p_Z}\right)+\cdots+\beta_{10}(0.5)(ln(p_W)^2)\\
&+\delta_1 ln(Y)+\delta_2 ln\left(\frac{p_H}{p_Z}\right)ln(Y)+\cdots+\delta_5 ln\left(\frac{p_W}{p_Z}\right)ln(Y)\\
&+\delta_6(ln(Y)^2) \qquad (18)
\end{aligned}$$

Using the ISUR, the system of equations was estimated by Eviews package and after the estimation of the model, three tests for homothecity, constant return to scale, and the Cob-Douglas form were conducted and the substitution and price elasticities of the production factors were calculated. The results of the estimation will be presented in the following.

4.2. Description of the variables for the estimation of the trans-log functions

The required information for the estimation of the cost function model included the quantity of production, the total cost paid for the output, the share of production factor from the total cost of the output, and finally the price of the production input. The inputs applied for the production process included labor, land, constructions, machinery, and water.

Due to the variety of the type of production unit activity and the variety of the produced output of the manufacturing units in order to calculate the cost share of the production inputs, it was necessary to have access to the quantity of the inputs used for the production of the output. Therefore, we describe the input costs (variables of the model) used in the production process in the following section.

4.2.1. The cost of the labor input

The cost of labor is equal to the sum of wages paid to workers in the period from 2011 to 2012 (the wages paid to workers were monthly).

4.2.2. The cost of the machinery

The cost of the machinery is equal to the sum of the average price paid for the use of machinery input located in the production unit during the relevant time period.

4.2.3. The cost of building

The cost of building is the price paid for purchasing or renting buildings and facilities existing in the production unit for the relevant time period.

4.2.4. The cost of land inputs

The input cost is the sum of the price paid for purchasing or leasing land to the production unit for the relevant time period.

4.2.5. The cost of the water

The cost of water is equal to the sum of the prices paid for water (piped water and sewage bills issued by firms) or purchased water in tankers).

It should be mentioned that all information about the costs and the amount of inputs applied in the production process was obtained by questionnaires from the manufacturing units.

5. The estimation of the model

As the main purpose of the current study was the estimation of the water demand in the industry sector, in order to estimate a model the initial information and the selection of a consistent model is necessary and inevitable (Jahani and Asghari, 2005). The data of the study refer to 30 active production units located in the industrial clusters of Zahedan city during the period from 2011 to 2012 using a questionnaire. Also, the Eviews software was used to estimate the model. On the other hand, the iterative seemingly unrelated regression (ISUR) was applied for the estimation of the regression models. As the cost functional form was not pre-specified and trans-log form specifications were flexible, the trans-log functions were used to estimate the model because it was assumed that the trans-log functions could appropriately represent the technology of production infrastructures.

6. Investigation and identification of manufacturing technology infrastructure:

In this study, no special technology was imposed on the production process that cause the predefined limits. For example, not only Cobb - Douglas production functions and CES substitution elasticity between factors of production were restricted to be constant over time (or in the case of Cobb-Douglas is equal to one) but also extension of these functions to more than two production inputs need to impose more limiting constraints about the possibility of substitution between factors of production. Imposing a final rate of substitution between production factors rejects the possibility of being complementary for any pair of inputs. Considering that the production function Cobb - Douglas and CES are not able to properly display technology infrastructures, economists did not have any choice but to seek to use flexible functional forms which are based on a few assumptions and therefore, make it possible to test basic assumptions of the theory.

Christensen *et al*. (1971) developed a logarithmic trans-log production function which limits the above production function and have considerable flexibility. The representation of flexible functions on the one hand and development and expansion of the duality theory on the other hand made it possible to empirically and easily analyze sophisticated technologies. Under perfect competition in the markets of output and production inputs, it is possible to extract a set of functions from profit functions (or minimize the costs) that the quantity demanded (or share of the cost) for each factor of production a linear function (linear or logarithmic) of the price of production inputs. The theory of duality ensures that the related equations for infrastructures of production technology are unique (Rezaei, 2007).

In order to determine the technology infrastructures by the Eviews software and the form of the trans-log function, some of the production features such as homotheticity, constant return to scale, and the Cobb-Douglas form of the production inputs were tested using statistical tests. As in the current study, the analysis of elasticities had great importance and Allen-Uzawa and Morishima elasticities were calculated (Rezaei, 2007).

6.1. Demand substitution elasticity

The substitution elasticity shows the sensitivity of a variable with respect to changes in other variables. In most empirical studies, the calculation of substitution elasticity is considered as the main objectives of the studies which are:

6.1.1. Allen-Uzawa substitution elasticity

6.1.2. Allen own and cross substitution elasticities

This kind of elasticity which is known as Allen and Uzawa substitution elasticity is used to classify any pair of inputs as substitutions or complements. According to Blackorby and Russel (1975), the Allen cross substitution elasticity shows the substitution degree between the two inputs. This elasticity can be defined as follows:

$$\theta ij = \frac{c(\partial 2c/\partial pi\partial pj)}{(\frac{\partial c}{\partial pj})(\frac{\partial c}{\partial pj})} = \frac{\partial (xi/\partial pi)c}{(\frac{\partial c}{\partial pi})(\frac{\partial c}{\partial pj})} \quad (19)$$

This type of elasticity can be calculated as follows for the trans-log cost functions:

$$\theta ii = \gamma ii_{i} + \frac{si(si-1)}{(si)2} \quad , \quad \theta ij = \frac{\gamma ij}{sisj} + 1 \quad \text{for } i \neq j \quad (20)$$

If the algebraic cross elasticity is positive, $\theta ij > 0$ indicating that there is a substitution relationship between the two inputs and if $\theta ij < 0$, there is a substitution relationship between the inputs. About the value of the Allen own elasticity, it is expected that the sign of such kind of elasticity be negative because the demand of any commodity (except for Giffen goods) has a reverse relationship with the price of the commodity.

6.1.3. Morishima substitution elasticity (MSE)

This kind of elasticity can be obtained by the logarithmic derivation of the ratio of inputs to the marginal rate of substitution or the ration of the input prices. According to Chambers, Blackorby and Russel, the Morishima substitution elasticity can be defined as follows:

$$\omega ij = \frac{\partial \ln (\frac{xi}{xj})}{\partial \ln (\frac{pi}{pj})} = \text{MSEij} \quad (21)$$

The positive (negative) value of this kind of elasticity shows that the inputs are substitutions (complements). According to Blackorby and Russel (1975)'s study, the Morishima substitution elasticity for the trans-log cost function can be defined as:

$$\omega ij = \varepsilon ij - \varepsilon jj \qquad \text{for } i \neq j \quad (22)$$

Morishima substitution elasticity represents comprehensive information about the relative share of the factors from the costs in response to the price of factors. This measure can be calculated as:

$$\delta ij = 1 - \omega ij \quad (23)$$

If the value of the Morishima substitution elasticity was less (greater) than 1, the relative share of the costs will be increasing (decreasing).

6.1.4. Price of demand

Another kind of elasticity is the own and cross elasticity for input demand that can be defined as:

$$\varepsilon ij = \frac{\partial lnxi}{\partial lnpj} = \frac{\partial xi}{\partial pj} \cdot \frac{pj}{xi} \quad (24)$$

In the tran-log cost functions, these types of elasticities can be computed as (Jahani and Asghari, 2005):

$$_{Ij} = \theta_{ij} s_j \qquad for \quad i \neq j \quad , \quad \mathcal{E}_{ii} = \theta_{ii} . s_i \mathcal{E} \quad (25)$$

Demand for the *i* th input is elastic, with low elasticity and non-elastic if the value of $\mathcal{E}_{ij}$ was greater, less than or equal to 1, respectively. Blackorby and Russel (1975) state that the Allen substitution elasticities do not provide any information about the degree of curvature of the same production curves and cannot be interpreted as the marginal rate of substitution. Moreover, Allen substitution elasticity provides little information. Morishima indicates that there is another measure for the substitution of the production factor that is known as the Morishima substitution elasticity.

7. Data and empirical results

The model suggested for the estimation of the demand for water and the identification of the production structure was a logarithmic total cost tran-log function which was estimated using ISUR. In order to estimate the model during the period 2011-2012, simultaneous equations 13, 12, 11, 10 and 9 will be estimated due to the imposed restrictions to the trans-log cost functions equations 11, 10, 9 and 13 and finally the coefficients of equation 12 were obtained.

The results of the estimation of total cost function were presented in table (1). These coefficients include the price of the labor, the square of the labor, the multiplication of machinery price and labor price, the multiplication of the water price and the labor, the square of the machinery price, the multiplication of machinery price and water price, the square of the water price, and the multiplication of labor and output quantity (the share of the labor is the production coefficient). The non-significance of the above coefficients (except for the multiplication of labor and output quantity) can be attributed to the assymetricity of the Hessian matrix if the total cost function in the share of inputs equation. On the other hand, the significance of most coefficients of the equation and the high value of the determination coefficient (equal to 97 per cent) will confirm the suitability of the estimation. In other words the determination coefficient of the model R^2=0.97 indicated the goodness of fit. It showed that 97 per cent of the variance of the dependent variable can be accounted for by the explanatory variables of the model. The determination coefficients of the relative ratio of labor, land, water, and building were 0.21, 0.48, 0.35 and 0.32, respectively.[2]

[2] The low value of the determination coefficient in the relative share of the inputs is due to the fact that trans-log models often provide weak results for the cost share equations.

Table (1): The results of the estimation of trans-log function

variables	Prob	t-statistic	Standard deviation	Coefficients
α_0	0.0004	5.52	11.87	65.57
α_1	0.0015	4.49	9.52	42.81
α_2	0.4088	0.86	6.93	6.00
α_3	0.0003	-5.63	5.97	-33.70
α_4	0.0029	-4.05	2.99	-12.13
β_1	0.0280	-2.61	2.25	-5.90
β_2	0.0243	-2.70	1.60	-4.34
β_3	0.0368	2.45	1.96	4.81
β_4	0.0000	8.56	0.45	3.89
β_5	0.5983	-0.54	4.48	-2.44
β_6	0.1819	1.44	4.02	5.82
β_7	0.2186	-1.32	1.14	-1.52
β_8	0.2509	-1.22	2.48	-3.04
β_9	0.0872	-1.91	1.41	-2.72
β_{10}	0.2280	-1.29	0.49	-0.64
δ_1	0.0000	-8.11	3.56	-28.96
δ_2	0.0043	-3.78	0.98	-3.73
δ_3	0.7118	-0.38	1.11	-0.42
δ_4	0.0003	5.61	0.59	3.35
δ_5	0.0038	3.87	0.48	1.88
δ_6	0.0000	8.18	0.32	2.64

The results of the estimation of the equation of the water cost share in the current study were as follows:

S_w=0.47+0.22p_h-0.51p_l+0.33p_t-0.07p_w-0.006y

The results of the model estimation indicated that the share of water cost had a positive relationship with the machinery and building price and a negative relationship with the price of the other inputs (labor, water, and the output quantity). In other words, the increase in the unit price of water as well as buildings and the use of machinery would increase the share of the water costs, and the increase in the labor price and output quantity would decrease the relative share of the water in the total costs.

S_w=-0.23+0.02P_h-0.02P_l+0.05P_t-0.02P_w+0.03Y

The coefficient of the relative ratio of labor from the total costs indicated a positive relationship between the share of the labor in the total cost paid to the production and the price of applying one unit machinery; but there was a negative relationship between the price of one unit labor force and water price. The results showed that the increase in the output quantity and the increase in the relative price of water decreased the relative share of the labor in the total cost paid to the production factors.

S_h=0.33-0.18P_h+0.31P_l-0.22P_t+0.06P_w+0.006Y

The coefficient of the relative share of the building in the total costs indicated a positive relationship between the share of the building paid to the production factors and the price of labor, water and produced output. There was a negative relationship between the relative share of the building in the total costs and one unit building and machinery. The results of the estimation stated that the relative share of the machinery price the relative share of the building decreases and the by the increase of the relative price of the labor the relative share of the building decreases.

S_t=0.42-0.06P_h+0.23P_l-0.17P_t+0.03P_w-0.03Y

The coefficient of the share of machinery service in the total costs paid to the production factors indicated a positive relationship between the share of machinery service in the total costs paid to the production factors and a negative relationship between share of machinery service in the total costs and one unit machinery and output. The results indicated that the relative share of the machinery service increases with labor price and the relative share of the machinery services decreases with the increase in the output price.

7.1. The test of homotheticity

The null hypothesis and the vs. can be defined as follow:

H_0=b $_{QL}$= b $_{QH}$=b $_{QZ}$=b $_{QT}$=b $_{QW}$=0
H_1 = all above variables aren't equal to zero

According to the results of the table (2) by comparing the value of χ^2 statistic with the critical value, the null hypothesis could not be rejected. Therefore, the homotheticity restriction could not be accepted. Therefore, the share of the production costs for any of the inputs is affected by the change of the output level.

Thus, the costs of some inputs will increase by changing the quantity of the output while the share of some costs will decrease.

7.2. The constant return to scale test

The null hypothesis and the vs can be defined as follow:

$H_0=\alpha_Q=1, b_{QQ}=b_{QL}=b_{QH}=b_{QZ}=b_{QT}=b_{QW}=0$
H_1=all above variables aren't equal to zero

According to the results presented in table (2), the null hypothesis could not be accepted by comparing the value of χ^2 statistic with the critical value and the productivity of the factors should be increasing or decreasing. Therefore, if the use of factors of production were doubled, the level of production would be more or less than twice.

Table 2: Test hypotheses about the various features of production technology

hypothesis	χ^2 statistic	χ^2 critical value	Degrees of freedom
Homotheticity	61.82	9.49	4
constant return to scale test	148.39	12.59	6
Cobb-douglas production function	222.81	26.29	16

7.3. The test for cobb-Douglas form of the production function

The null hypothesis and the vs hypothesis can be stated as follows:

$H_0=b_{QL}=b_{QH}=b_{QZ}=b_{QT}=b_{QW}=0$ Cobb-Douglas production function
H_1= tran-log production function

According to the results in table (2), the comparison of the calculated χ^2 statistic with the critical value indicated that the Cobb-Douglas cost function did not properly display the production structure in the studied region. Therefore, the trans-log form of the cost function was the acceptable form. Based on the results of the above tests we could calculate and interpret the substitution and price elasticities of the production inputs which showed the relationship between the variables and the estimated coefficients of the model. It should be mentioned that the calculated values for price and substitution elasticities between the inputs were presented in tables (3) and (4). As the main purpose of the current study was to estimate the demand for water, the main part of the analysis referred to the price and substitution elasticities of the water. According to the results of the estimation of the main model, the Allen and Uzawa own and cross elasticities for the inputs can be seen in table (3).

Table 3: The estimation of the own and cross elasticities of substitution inputs

	land	machinery	labor	building	water
Water	0.65	6.96	-0.43	1.30	-1.52
Building	0.052	-0.1	0.03	-0.31	
Labor	-7.5	16.67	-5		
Machinery	-10	-53			

As it can be seen in table (3), all Allen own and cross elasticities had the correct and expected negative sign ($\theta_{ii}<0$). According to the above information, the substitution elasticities of water with other inputs indicated that water, machinery and land were substituting and water and labor were complements. On the other hand, labor and machinery were substitutions and labor and machinery had complementary relationship. The complementary relationship between water and labor indicated that the increase in the labor price (the wage paid to the workers) decreased the demand for water input. Based on the industry and the type of the produced output and the amount of the water used, the increase in the labor input decreased the demand for water which indicated that the changes in the labor price did not have a significant effect on the demand for water.

The substitution effect between water and building, machinery and land indicated that the increase in machinery and building use increased the cost (price) of the water (the substitution elasticity of water greater than 1) and decreased the water use (the substitution elasticity of water less than 1). This is a good description for the strong relationship between water and other inputs (building and machinery). On the other hand, less than one partial elasticity of water and land indicated a weak degree of substitution between water and land. In other words it can be concluded that 1 per cent increase in the machinery, building and land increases the demand for water by more than 1 per cent (6.69 per cent with respect to the machinery and 1.30 per cent with respect to the building) and also increases the demand for water by less than 1 per cent with respect to land (0.65 per cent). The own and the cross elasticities for input demand were presented in table 4.

As it can be seen in table (5), all own elasticities had the correct and expected sign ($\varepsilon_{ii}<0$). In other words, there was a reverse relationship between price and quantity demanded. The results indicated that the absolute value of the price elasticity for building input was greater than other inputs (0.18), meaning that the sensitivity of the building demand with respect to its own price changes was greater than other inputs. Machinery, water, and labor were in the next ranks. The absolute value of the own price elasticity of all inputs were less than 1 and therefore, it can be concluded that the demand for all inputs were non-elastic. In other words, a certain per cent increase in the price of any inputs leads to the decrease of demand for that input less than the imposed change. The results about water indicated that although the price elasticity of water was negative and had the expected sign, the water price change cannot make any remarkable change in the demand for water.

The partial cross elasticities between water and building were very low (0.22). It indicated that the demand for water rises very low with the increase in the building price. Also 1 per cent increase in the price of the building increases the demand for water by 0.22 per cent. The value of cross elasticity between water and land was close to zero (0.3) which shows the sensitivity of the land demand with respect to water. In other words, 1 per cent increase in the price of land increases the demand for water by 0.06 per cent. The cross elasticity between water and labor indicated that there was a complementary relationship between these two inputs, but the greatest sensitivity was between water and these inputs (-0.51) which indicated that 1 per cent increase in the price of the labor decreased the demand for water by 0.51.

Table (4): The estimation of the own and cross elasticities of the production inputs

	Machinery	Labor	Building	Water
Water	0.33	-0.51	0.22	-0.07
Building	-0.21	0.3	-0.18	0.06
Labor	0.05	-0.02	0.02	-0.02
Machinery	-0.16	0.22	-0.06	0.32
Land	-0.03	-0.03	0.03	0.03

The values of the Morishima substitution elasticities are presented in table (5). It can be seen that the elasticity with respect to all production factors (inputs) was less than 1 which indicates the weak relationship between any pairs of the inputs. Thus, the substitution elasticity with respect to all inputs (except for the substitution elasticity of water with labor, building with machinery and land with labor) had positive signs. In other words, there was a complementary relation between water and labor, building or machinery and labor, and all other inputs were substitutions. The other interpretation of the Morishima substitution elasticity can be stated as follows. For example, if the ratio of water price to the machinery is increased by 1 per cent, the demand for the ratio of water to the machinery increases by 0.49 per cent and for building by 0.4 per cent.

Table (5): The estimation of the Morishima substitution elasticities

	Machinery	Labor	Building	Water
Water	0.49	-0.49	0.4	-
Building	-0.05	0.32	-	0.13
Labor	0.21	-	0.2	0.05
Machinery	-	0.24	0.12	0.39
Land	0.13	-0.01	0.21	0.1

We can obtain the changes in the relative cost of any production factor from the total production cost in response to the price changes of inputs. The results of the effects of the changes in the price of the production factors on the relative share of costs can be seen in the table (6).

Table (6): the effects of changes in the price of inputs on the share of costs

	Machinery	Labor	Building	Water
Water	0.51	1.49	0.6	-
Building	1.05	0.68	-	0.87
Labor	0.79	-	0.8	0.95
Machinery	-	0.76	0.88	0.61
Land	0.87	1.01	0.79	0.9

The high and positive elasticity of water and labor (1.49) showed that there was a significant increase in the share of water against labor in response to the larger increase of the water with respect to the water price. On the other hand, small and positive elasticity of water and machinery inputs (0.51) indicated that a significant increase in the share of the water against the machinery input in response to the small increase of the machinery price with respect to water price.

8. Conclusions

Recommendations can be provided as follows:

8.1. Executive recommendations

a) As the price elasticity of water was low and less than one, it seems that price policies can't have any effects in decreasing the demand for water or this reduction will be very small. Therefore, it is recommended to use non-price policies to decrease demand for water in the industrial sector.

b) As the substitution elasticity between water and other inputs was less than one, it seems that price policies can't have any effects in decreasing the demand for water. Therefore, it is recommended that due to the substitution and complementary relationship between water and other inputs using substitutionary inputs instead of water to decrease the demand for water.

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