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Exploring the Effects of Water Sector Investment In Economic Development in Iran

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Abstract

The aim of this study is to examine the effects of water sector investment on Iran economic development. In this study, in order to see the effects of water sector investment from production function [view] of Solo growth model (assuming constant return to scale), we use [data from] Economic Time Series Database of National Accounts in[sources as] Central Bank, Vice-Presidency for Strategic Planning and Supervision, and Iran Water Resources Management Co., which were gathered during 1980-2010. The amount of this effect is exploited from the model in question on four economic sectors in Iran; and its econometric method is Panel Data. The results show that continuing trend in population growth, indiscriminate use of resources and low efficiency intensify water shortages. Solo Growth Model (primary neo-classic one) for different sectors (agriculture, industry and mine, services, and petroleum sectors) in Iranian economy implies that the elasticity of water investment in agricultural sector is significant, and positive, with the amount of 1.3% and for the rest of the other sectors is non-significant. The investment effect of water sector for groundwater discharge is about 2.4 per cent which is significant; this maintains the important issue that by increasing investment, the amounts of water harvesting is not decreased. Conversely was happened for surface waters with the amount of about -2.7%. The elasticity of investment in water sector based on Solo Growth Model, justified for economic sectors of Iran with confidence coefficient of 66% is less than 1, about 0.02% in agricultural sector, and for the rest of the other sectors is negative and non-significant.

Keywords: water investment, economic development, investment elasticity, Solo growth model;

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1. Introduction

World economies are so divergent and hypogenous yet, each seeks for growth and development, because of advantages and benefits which is realized in this process. However, to attain a sustainable, high economic growth we should answer to the question that what factors determine the rate of economic growth? Or how and by means of what factors and policies the rate of economic growth can be influenced? Among many different factors which were effective in economic growth and development in Iran, water industry is crucial for its considerable achievements.

Water as a renewable resource and as a natural, economical, social and environmental commodity plays an exclusive role in economic growth. The first reason for expansion of water industry in Iran is exploiting its economical benefits. Regarding its importance in development of real sectors of the economy and its basic role in production and distribution process, water sector has a certain place in development plans of the country. Of the whole renewable, available waters (130 billion m^3) approximately 105 billion m^3 are surface flows, and the rest (25 billion m^3) penetrating flows as groundwater. There are 130 billion m^3 of water which can be extracted, however only 84% of it is used for agricultural applications in about 30% efficiency and the rest of the allocated water (70%) is wasted during transportation and consumption stages (Ettehad, 2002). These information show that this industry faced restrictions to exploit available resources in water sector. By recognizing these restrictions, and by fundamental research in every single ancillary activities of water industry, we will be able to use them for obtaining benefits in the industry.

This study is an attempt to do a research work in water industry of the country focused on the effects of water sector investment in economic development of Iran.

2. Theoretical Bases

In this study all information is gathered by library method. Time range of the information consists of data gathered in 1980-2010, [from resources] exploited from Economic Time Series Database of National Accounts in Central Bank, Vice-Presidency for Strategic Planning and Supervision, and Iran Water Resources Management Company. To represent a clearer picture from the position of water sector in national economy, one part of this research devoted to water sector portion in national production and investment, and in order to estimate the coefficient of economic growth elasticity in proportion to water sector production, we will suggest a regression model. We employ Gub-Douglas production function to explore the effects of water sector investment in economic development. Econometric method for exploring these impacts is Panel Data.

In the West development debates are focused on economic development and most important development problems focused on discussions about quantity of economic growth. In these theories it has been already assumed that quantity changes will be led to quality and organizational changes of the society. So, all efforts for dealing with development problems are focused on analyzing capital changes during a certain period of a time.

The reason for studying growth models in capital topic is that crucial variables in analyzing these models are capital and investment and the related issues. However theories and models in these fields are so widespread that hardly can we categorize them in a concise sector to explain them. The generalization of these theories is based on formulating the rules, which in long term are predominant over economic variables and parameters.

By constructing mathematical model, these theories try to anticipate changes in variables to study economic equilibrium conditions. What is an accepted premise in all these theories is the considerable importance of capital as development and growth factor. Therefore, the models employed in growth theories are rather seek for inventory changes in capital during a certain period of time and what factors really resulted in increase or decrease in investment are out of their economical analyses reach.

Hahn, one of the scholars of growth theorists maintains that theory of economic growth isn't that of history of the economy. In growth models, there is no class or advent of the middle class, no state or labor union; there is also no war or political problem so, growth theories and models separate growth path from the other evolutions of a society by separation of effective factors of investment and its stimulus on how the amounts of them change (Imani Rad, 1991).

As Robert Lucas (year?) mentioned "When we begin to think about economical growth, thinking will rest on other things."

In this article we represent Solo model that mostly is used by economists to study growth (Roomer, 2002). Solo model is the starting point for all growth analysis. By comparison of this model, we can understand the other models, even those which are basically different from this one. For understanding growth theories, it is essential to perceive the model. Furthermore, most of growth models used for developing countries set into Solo growth (1956) model frame.

The model used in this study is a production function of Solo growth (neo- classic) which is based on neo-classic basis. The production function here has these characteristics:

1. There is substitutability between labor and capital. Regarding the existence of the assumption, the amount of capital and labor required for production is determined. This means that in long term, economic situation approaches to an identical rate for capital and labor force (in case the technological progress doesn't happen). For this situation it is also required production per capita and real wages not to be increased.
2. Marginal productivity of labor and capital is descending.
3. Production function is a homogenous one order function therefore return to the scale is constant. Production function for justified Solo growth model is as follows:

$$\ln y_{lit} = \mu_{it} + \lambda_t + \alpha . \ln k_{lit} + \gamma \ln I_{wit} + (\alpha + \gamma + \beta - 1) \ln L_{it} + \varepsilon_{it}$$

In this function y_l is the amount of actual production, k_l amount of investment in different economic sectors, I_{wt} the amount of investment in water sector, L is occupational rate in different economic sectors. Symbol *ln* shows natural logarithm.

As we will see later, Solo growth model is considered as an important cornerstone to understand why some countries grow constantly and some other grow negligible.

3. Experimental literature review

Many studies have been done in this part which is an infrastructure component of economic studies. We will explain them by the following tables:

Table 1- The effect of infrastructures investments on economy

investment Elasticity Range	Areas	Not measured	Source
0/24	National	Total productivity of the production in infrastructures	Aschauer (1989)
0/27	National	Data elasticity in infrastructures	Duggal *et al*(1990)
1/000	National- short run	Supply elasticity in infrastructures	Demetriades and Mamuneas(2000)
1/030	National- long run		
2/8613	National- for industrial infrastructures	Relationship between infrastructures and rate of allocation	Bouhheas *et al* (2000)
Labor: 1/129 Capital: 0/026	National- short run	Elasticity of total supply in infrastructures	Demetriades and Hiens(2000)

Some of studies done in water sector are as followed:

Table 2- investment elasticity of infrastructures for water and waste water

Investment Elasticity Range	Areas	Not measured	Source
0/011	48 states	Net stock of water and waste water infrastructures on GSP	Evans and Kerras (1994)

0/1686	National	Net stock of water and waste water infrastructures	Moomaw *et al*(1995)
0/0003 to 0/2467 0/0567 to 0/2452 0/3312 to 0/0434 0/3045 to 0/0991	northwestern north central southern Western		
0/0004	National	Real costs of water and waste water on industrial productions indicator	Batina (1998)
0/00856 (1) [0/00579 تا 01074] 0/1159 (2) [0/01233 تا 0/00473] 0/01239 (3) [0/05814 تا 0/01673]	National	Investment on system of infrastructures of water and waste water supply 1) private GDP 2) private investment 3) private occupation	Pereira (2000)
0/0129	National	Investment on system of private infrastructures of water and waste water supply	Pereira (2000)

Misheal (2005) in his study during 1966-2005 in OECD countries and the U.S. named "the effects of state's costs on economic growth" explained theoretical topics and reviewed international practical documents in countries decreased state's costs as a portion of national production drastically, and analyzed these reforms. By comparing developed countries to some American countries, he resulted that controlling costs would led to success of the countries and in this way the rate of economic growth accelerated.

Sulmaz Moslehi (2004) estimates optimum size of state and its effects on growth in 2001-2002. She generalized the Barrow's model for oil-producing countries and concluded that total indicator for disorders due to policymaking, arrangements and lack of effectiveness of state's activities on economic growth is significant and negative. Barrow's theory in the frame of a non-linear model is confirmed[†] and in a linear model, both of consumption and construction costs have a negative effect on growth. She also separated consumption costs into hygiene and education costs and reached to a positive and significant relation to growth, however other consumption costs conversely related to economic growth (other than hygiene and education).

Fereshteh Chalak (2007) in her study named "Dynamic analysis of state costs' effect on Iran economic growth" during 1997-2004 also addressed the issue. By using dynamic system method, she simulates macro variables and explored the effects of consumption and construction costs of the state on economic growth and other variables. First of all, by assuming 40% increase in government budget in ten-year periods in three different scenarios, she studied state's cost on economic growth and compared impact rate of consumption and construction costs of the state. Results show that although an increase in construction and consumption costs of the state lead to an increase in economic growth, this impact is greater for construction costs. It is also showed that financing the state by banknote printing would decrease the economic growth.

[††] There is a converse u shape relationship between total incumbency of the state and economical growth.

Another study named "water role in developing agriculture sector" is that of Hamid Reza Khalil Ababdi and Hamid Abrishami (2004), both scholars of University of Tehran.

The results of this study show that water sector is a fundamental and basic one which can be employed as a growth engine in economy. It can lead to growth of other sectors, especially agricultural sector, and its subordinate activities so that every unit investment (one million Rails in the price of the year 1998) on water sector would lead to both direct and indirect employment for 0.29 persons. Calculation of backward and forward linkage also showed that water sector is ranked eleventh in terms of backward linkage and that of forward linkage is ranked sixth.
A study was done by "T. H." (2008) in headquarters of water administration of ministry of public affairs, named "Correlation between Investment in the Water Sector and Economic Growth of Developing Countries" consists of analyzing around both relationship between rainfall and economic growth and that of investment in water sector and economic development.
Standard deviation analysis of time series in 22 African developing countries consists of rainfall, national budget in financing water and hygiene sector, official development aids for all economic sectors, official development aids in infrastructures of water and GDP per capita.
The analyses show that there is no significant relationship between deviation from mean rainfall and GDP per capita, and the reason must be sought in historical, social, political and economical backgrounds. In all 22 African countries, there were also a linear significant relationship between national budget in financing water and hygiene sector and GDP per capita. Likewise, in 17 out of 22 African countries there were a significant relationship between development aids for all sectors and GDP per capita. Meanwhile, in 16 African countries out of 22 in linear egression, there were no significant relationship between official aids for water infrastructures and GDP per capita. However, it showed a linear significant relationship between financing water and hygiene sector and GDP per capita in all 22 African countries, and national budget in financing water and hygiene sector had a multifold impact on GDP per capita in comparison to official development aids.

4. The effect of water sector investment on different economic sectors

In this part, the effect of water investment on different economic sectors in the form of a full logarithmic equation for years 1980 to 2010 is explored. The model used in this estimation is Panel Data model which is assessed using Fixed Effect method. The reason why we use Fixed Effects method is that the number of cross-sections (economic sectors) in this model is less than estimated coefficients therefore Panel Data model cannot be estimated by using Random Effect method and Hausman testing is not relevant in this case. The results of estimates done on the basis of economic growth for each sector are as followed:

$$LOG(Y\_AGRIC) = -21.29693267 + 1.35169778628*LOG(L\_AGRIC) + 0.142664131058*LOG(K\_AGRIC) + 1.2954612039*LOG(IW\_AGRIC) + [AR(1)=0.872525370271]$$

$$LOG(Y\_INDUS) = -11.89759833 + 1.35169778628*LOG(L\_INDUS) + 0.142664131058*LOG(K\_INDUS) + 0.10366744113*LOG(IW\_INDUS) + [AR(1)=0.872525370271]$$

$$LOG(Y\_SERVI) = -15.87030906 + 1.35169778628*LOG(L\_SERVI) + 0.142664131058*LOG(K\_SERVI) + 0.587705206468*LOG(IW\_SERVI) + [AR(1)=0.872525370271]$$

$$LOG(Y\_OIL) = -26.09668286 + 1.35169778628*LOG(L\_OIL) + 0.142664131058*LOG(K\_OIL) + 2.38314303547*LOG(IW\_OIL) + [AR(1)=0.872525370271]$$

The original forms of equations show that the effect of investment and labor on development growth in each sector is positive and significant. The effect of investment in water sector on various sectors of agriculture, industry, service, and petroleum has different results as showed in the table below:

Table3. Exploring investment effect of water sector on various economic sectors

Coefficients impacts of water investment on each sector	Various economic sectors
1.295461*	Agriculture
0.103667	Industry
0.587705	Service
2.383143	Petroleum

Source: calculations of the researcher

*indicates significance coefficients in 90% confidence level

As expected, the effect of water investment on agriculture is positive and significant and its elasticity is more than 1 about 1.3% which indicates the high sensitivity of agricultural products to investment in water sector. This means that increasing 1% investment in water sector will increase economic growth in agriculture sector up to 1.3%. Regarding 93% of water consumption is used in agriculture sector, the results are acceptable. Investment effect coefficients in water sector on industry, service, and petroleum are non-significant. The justified coefficient correlation of this model is 0.99 and that of its long-sighted Watson is 2.05 which show the fitness of the model. The calculated result of elasticity is almost consistent with Demetridis and Mines' long term supply production elasticity infrastructures in national level. As the estimated model is full logarithmic, it is expected that this model is static and the graph of correlation test related to residual model confirms it.
This is in accordance with Solmaz Moslehi's study who stated that for industry, mine and petroleum sectors, in linear models, both of construction and consumption costs have a negative impact on growth; and it is in line with Mirzaee and Abrishami's ideas for agriculture sector. However it agrees with Sayeh Miri *et al* for agriculture sector but doesn't confirm the [results of the] other sectors.

5. Exploring investment effect on water sector by using the approach of justified Solo model

In this part investment effect in water sector, total investment (without considering investment on water sector) and labor force of Iran economic growth in a full logarithmic equation for years 1980 to 2010 is explored. Before testing for stability of the variable, unit root test is done for variables. As it was said before, unit root test based on Panel data is stronger than unit root test of time series. The model employed here is Panel data model which is assessed by using Fixed Effects method. The reason why we use Fixed Effects method is that the number of cross sections (economic sectors) of the model is less than assessed coefficients. Therefore, by using random effect, Panel Data model cannot be assessed and in this way, doing Hausman test is not relevant here.
The model used in this estimation is ARIMA model. The assessed results based on Solo economic growth model for each sector is as followed:

- *Substituted Coefficients*

- YL_AGRIC = -1.372894632 + 0.49538498597*L1_AGRIC + 1.90495384281e-05*KL1_AGRIC + 0.022732940078*IWL_AGRIC + [AR(1)=0.824236110838]
- YL_INDUS = -1.420988104 + 0.49538498597*L1_INDUS + 1.90495384281e-05*KL1_INDUS - 0.0219672719695*IWL_INDUS + [AR(1)=0.824236110838]
- YL_SERVI = -1.453140212 + 0.49538498597*L1_SERVI + 1.90495384281e-05*KL1_SERVI - 0.000387307490397*IWL_SERVI + [AR(1)=0.824236110838]
- YL_OIL = 0.577447814 + 0.49538498597*L1_OIL + 1.90495384281e-05*KL1_OIL - 0.0621463849712*IWL_OIL + [AR(1)=0.824236110838]
- YL_TOTAL = -2.296673181 + 0.49538498597*L1_TOTAL + 1.90495384281e-05*KL1_TOTAL - 0.0281669866246*IWL_TOTAL + [AR(1)=0.824236110838]

The original form of each part of equations show that the effect of investment and labor force (its logarithm already has taken, and labor force before estimation of the model, is justified on the basis of index 10000) on economic growth for each sector is positive and significant which is consistent with portions obtained from previous studies for Iran economy. The effect of investment in water sector on various sectors of agriculture, industry, service and petroleum has different results represented in table below:

table4 – exploring the investment effect in water sector on various economic sectors

Coefficient impacts of water investment for each sector	Economic sectors
*0.022733	Agriculture
-0.021967	Industry
-0.000387	Service

-0.062146	petroleum

Source: calculation of the researcher
*indicates significance of the coefficients at 66%confidence level

According to the estimation, Dickey Fuller test of unit root test has been done for every single sectors of the economy [and showed that] the equation is of sufficient reliability. This indicates the existence of short term relationship between dependent and independent variables and after co-integration test with $P<0.05$, it is confirmed that this is expressing the long term relationship between variables.
As was expected, the effect of water investment on agriculture sector is positive and its elasticity is about 0.19% which is less than 1. Coefficient investment effect in water sector for industry, service and petroleum sectors is non-significant. Justified coefficient correlation of the model is 0.99 and its Durbin - Watson is 2.14 indicating good fitness of the model; and the value obtained is close to the amount of elasticity of Moa *et al* (year?) studies about net reserve infrastructures of water and wastewater. As the assessed model is full logarithmic, it is expected for this model to be static and the graph of correlation test related to residual of the model confirm it.

Table 5 the amount of water investment (public and private sector) in 1980-2010

(figures in billions of Rails)

Shares(%)	Annual investment mean	The amount invested	Sectors
62	12015	372468	Public
38	7457	231165	Private
100	19472	603633	Total

Source: researcher's calculations
Total amount of investment in Iran economy during 31 years under study was 2,925,649 billion Rails from which the share of water was about 21% i.e. 603,363 billion Rails and the share of public sector investment was around 12.7% of total investment. The investment indicates that most of the investments are made in dams and there is no logical relationship between dams and the sub-networks. The amount of investment in sub-networks is about 15,737 billion Rails during these 31 years which is around 0.026% of total investment in water sector and shows the important issue that there is no a reasonable priority in water sector investment.

Table 6 – the results of Pedroni co-integration (accumulation) test

Test statistic	Statistic value	Probability level
Panel v-Statistic	-1.492006	0.9322
Panel rho-Statistic	-1.400244	0.0807
Panel PP-Statistic	-2.624289	0.0043
Panel ADF-Statistic	-2.884879	0.0020
Group rho-Statistic	-0.577054	0.2820
Group PP-Statistic	-3.284123	0.0005
Group ADF-Statistic	-3.342500	0.0004

Source: calculations of the researcher
In this part, typically, the ideas of T.H. Musouvir (2009) about the relationship between water investment and economic development is confirmed and shows that this relationship between the amount of budget and water financing in some parts of the economy is a linear one and significant. It also confirms the ideas of Elisa Gatto and Matteo Loczafame (2005) about growth in agricultural sector indirectly.

6. Exploring the effect of water sector investment on harvesting groundwater aquifer

To do this study, we employ a full logarithmic model. As expected, by negative water harvesting from groundwater aquifers, the amount of water sector investment had no effect on harvest reduction and the results of the model confirms it. The estimated coefficients in the model used are as showed in table below:

Table 7- exploring the effect of water sector investment on harvesting groundwater

Estimated coefficients	Variables
-8.297657	Intercept
2.387640**	Harvesting groundwater aquifer

Source: calculations of the researcher
** indicates the significance of coefficients in 95% confidence level

According to the information, fluctuations in level of groundwater aquifers and changes in reservoir volume of water extracted from 1966 to 1999, and decline curves in groundwater level of "underground aquifers" show a downward trend and confirm the above model.

1. **Exploring the effect of water sector investment on surface waters**

To do this, we used a full logarithmic model. Coefficient effect of water sector investment on surface flowing waters was extracted as a negative number and its significance level was low (this coefficient can be interpreted as significant in 83% confidence level). The result indicates that some factors other than investment should be noticed such as climate changes or the volume of rainfall and also entrance of boundary waters should be noticed as affecting variables. The estimated coefficients of the model are as in table 8.

Table 8- exploring the effect of water sector investment on surface waters

Estimated coefficients	Variables
33.46464**	Intercept
-2.733768	Harvesting from underground water

Source: calculations of the researcher
**indicates coefficient significance in 95% confidence level

Conclusion

Due to the low rainfalls and inappropriate distribution of the time and location of it in our country, Iran is among the most arid and semiarid climates of the world. The situation is getting worse due to population growth, expansion of urbanization, development of economic sectors such as agriculture and industry, and ever increasing demand for water.

The purpose of this study was to explore the effects of water sector investment on economic development in Iran. Findings of this study are represented as follows:

1. Despite inherent limitations and inappropriate distribution of water in Iran, utilization of this worthy and non-renewable and expensive resource in terms of investment, is in a very low efficiency.
1. Continued population growth in the country, will decrease the average per capita renewable water for entrancing in water stressed periods and then to facing with water crisis.
2. Continuation of indiscriminate use of water resources and low efficiency will exacerbate water shortage.
3. The estimated Solo model in the basis of primary neo-classic one for different economic sectors (agriculture, industry, mine, service and petroleum) indicates that elasticity of water investment on agriculture sector is significant and positive, and its value is about 1/3% and is non-significant for the rest of the other sectors.
4. The estimated Solo model in the basis of primary neo-classic one for groundwater discharges shows that the amount of investment in water sector has no effect on decreasing of water harvesting of underground aquifers. The value in this model is around 2.4% and is -2.7% for surface waters with confidence level of 95%.

5. The justified Solo growth model for different economic sectors of Iran indicates that the elasticity of water investment on agriculture sector is less than 1, 0.02%, with confidence coefficient level of 66% and is negative for the rest of the other sectors.
6. Water harvesting of underground aquifers is exceeded its limitations.
7. Most of the dams constructed have not any sufficient initial and/or sub-networks.
8. Drinking and agricultural water tariff rates are so low and cannot be substituted by depreciated assets.
9. The volume of water sector investment in 31 years mounted to 603,633 billion Rails, from which public share was 62% and that of private sector was 38%.
10. The amount of physical capital in constant prices of the period under study was 603,633 billion Rails from which the share of water sector investment on base price of year 2006 amounted to about 21% and portion of public sector was 12.73%.

To reduce and compensate the costs due to water crisis, here we offer some solutions and suggestions which may be useful:

1. Pay more attention to the effects of global climate changes and its impact on reducing rainfalls and surface flows during ten-year drought in Iran.
2. Pay more attention to increase in population growth rate during recent three decades in respect to developing countries, and more demand for drinking water, hygiene, services, and water demand in sectors such as agriculture, and industry, and growth in welfare and hygiene and increase in consumption per capita.
3. Pay more attention to limitations of water harvesting from underground resources. The consumption share of the whole country in this part is 70% and this requires to pay attention to the effects of land subsidence, reducing underground water reservoirs and pollution increase, influx of salt water and substitution of it in underground water so that major plains of the country faced to negative balance in water potential.
4. Implementation of irrigation and drainage networks based on modern irrigation methods in accordance with dam construction plans helps to increase the efficiency of irrigation and enhance production per hectare.
5. Using agricultural, industrial, and household wastewaters and raw sewages by treatment plans in order to recycle and reuse of the water.
6. Harvesting and control of surface water basins which are possessed in common (in border lines) and performing the required utilization.

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