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RESEARCH PAPER

# Economic Evaluation of PPP in the Water Sector: Financial CGE Approach

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## Abstract
Value for money assessment is used in Iran to select appropriate projects for partnership with the private sector by public-private partnership contracts. However, this method merely focuses on the direct effects on the project's level and ignores the economic and social impacts and indirect national and regional impacts. This method also is limited to selecting discount rates and tax position adjustments. It ignores both the benefits users receive from increasing the quality of services through public-private partnerships and the project's financing methods. So ignoring these problems can lead to significant errors in assessments. Therefore, the present paper aims to use a complementary approach to make decisions about investing by public-private partnership method in one of the country's infrastructures of water resources development. In this regard, the effect of building, financing, and operation of the desalination project and water transfer from the Persian Gulf to industry and mine sectors in the southeastern provinces of the country by a public-private partnership model and using the recursive dynamic FCGE model to Iran's economic growth simulate and compare it to the traditional procurement model. Based on the results, it has no economic justification if the project is financed in the traditional procurement model (through increasing tax revenues) and financed through public-private partnerships (through the capital market) without increasing the productivity rate. In other words, this project is economically justifiable only if implemented by a public-private partnership contract and increases productivity by at least 0.01% during the operation period.
**Keywords:** Financial Computable General Equilibrium Model, Traditional Procurement, Public-Private Partnerships, Value for Money, Non-conventional Water.
**JEL Classification:** C68, H57, L32, H43, Q25.

## Introduction

Investigating the implementation process of development projects in previous years indicates that the increase in semi-finished projects has been a permanent problem both in the period of increasing oil revenues and decreasing its.

In Iran, based on the Sixth Development Plan's detailed document, approximately 65% of the national capital asset acquisition projects were not completed by the government on time and the building period of these projects increased to 11 years. Estimations indicate that more than 4,000 billion Rial is needed to complete the projects pledged in the budget laws, which will take 10 years to finance in the most optimistic case (regardless of US sanctions). Therefore, in recent years, the policy orientations have changed towards developing private

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sector investment by the public-private partnership model (PPP). For example, the necessity to use the non-governmental sector to produce water or wastewater is mentioned in this document. Currently, the Planning and Budget Organization of Iran has introduced 302 national projects and 537 provincial projects eligible for participation for the year 2020, of which 66 projects are about the supply and development of water resources.

However, it has also been severely criticized despite the benefits such as on-time delivery with the budget approved for these projects, innovation in design, building, and management, and providing access to new capital sources that the use of this model brings. Microeconomic theories and historical evidence show that this model is sometimes much more expensive to use than the traditional procurement model (Chen et al., 2007).Because first, the private sector cannot manage the transferred risk like the public sector. On the other hand, due to the difference in risk capacity, the return paid to the private partner is higher than the interest rate on government debt. Therefore, if the project fails, it is very likely that the public sector will incur extraordinary costs to maintain public services.[1] Second, due to demand and future costs, these long-term contracts face uncertainty, but due to competitive pressures on project assignments, contractors may often be overly optimistic in estimating future costs, leading to renegotiations during the contract. The cost of tender, the costs of moral hazard and renegotiation of long-term contracts, the cost of monitoring the private sector's performance, and, in general, the transaction cost in such contracts are very high. Third, governments that are severely pressured in developing infrastructure and inexperienced in applying this model may respond to unrealistic requests from the private sector and, in some cases, pay too much to a private partner (Buffie et al., 2016). Eventually, since bundling task is one of the key features of this type of model, it is argued that when a private contractor is responsible for the construction and operation of a public facility, he or she will be willing to invest more in the building phase to reduce operating costs (Hoppe et al., 2011). But the economic effect of more investment in the building phase depends on the externalities it has on the quality of services during the operation period. If the externalities are positive, it means that operating costs are reduced by improving the quality of infrastructure, and the social welfare gained from the bundling task will increase. Thus, if the externalities are negative, it is better to use the same traditional procurement model (Iossa and Martimort, 2015).

Therefore, regarding the application of the PPP models in infrastructure, it is necessary to make accurate and comprehensive assessments.

Currently, Various method, such as cost-benefit analysis or value for money assessment (VFM), are used to decide on the project's implementation approach in the form of a traditional public procurement model or PPP, which has many critics. For example, Yescombe (2007) believes that cost-benefit analysis is only suitable for the economic justification of a project, regardless of what sector invests (private or public sector).This method also does not consider how to finance expenses and relies solely on the discount rate or economic rate of return. Selecting the profitability index and making risk-related adjustments is as problematic as calculating the discounted rate cash flow in this method.

Vickerman (2007) also mentions the limitations of this model for large projects due to asymmetric information. Besides, assessing a participatory project using the VFM analysis is insufficient because this analysis method shows greater efficiency and feasibility for PPP relative to the traditional procurement model. This method merely focuses on the direct effects on the project's level and ignores the economic and social impacts and indirect national and regional impacts and does not consider non-financial costs and benefits. This method can also not calculate the benefits of faster work time in the PPP model (Chen et al., 2017). Another challenge of using this method is that the private sector builder competes based on

1. Of course, proponents of this model continue to claim that the private sector manages the transferred risk, better and at lower cost than the public sector, therefore the value for money is improved.

the lowest cost of the life cycle, not the least upfront cost, to meet the goals of the public sector (as explicitly stated in the contract). It also does not consider the benefits that users receive from increasing the quality of services in the PPP method (Grimsey and Lewis, 2005). This method is limited to selecting discount rates and tax position adjustments.; Thus, traditional assessment methods can hardly calculate the distribution of the economic burden of infrastructure projects based on a series of financial commitments (e.g., project financing with user fees, project financing from tax, or private sector bond issuance). Thus, regardless of the financing methods of a project, evaluations can lead to significant errors (Yescombe, 2007).

Therefore, regarding the drawbacks of the above methods, using various general equilibrium models to investigate this issue has received much attention. Examples include Bayer (2009), Kim et al. (2016), Chen et al. (2017), and Buffie et al. (2017) noted although most of these studies have been done on transportation projects.

Therefore, this study aimed to design a dynamic recursive financial computable general equilibrium model to compare the impact of a PPP with a traditional procurement contract for the Iranian economy.

Currently, in Iran, only the VFM assessment method is used to choose an appropriate model to implement a project. Water supply and development projects are also one of the areas neglected in this category of studies in the world, in which the use of the PPP method, especially BOT and BOO concession contracts, is quite common, therefore, for the first time in this paper, by modeling water good as one of the factors of production in industry and mining sectors, this assessment is done by the new approach, which is considered as an innovation. In this paper, the national desalination and transfer water project to industries and mines in the country's southeastern provinces were selected for study as a sample of water resources development projects. Selecting this plan is because its impacts include several catchments in the Hormozgan, Kerman, and Yazd Provinces; therefore, its impact can be assessed at the national level.

The paper continues with the literature review discussed in section 2. Section 3 also presents a research methodology, including data and calibration, scenario simulation. In Section 4, the results obtained are interpreted, and finally, in Section 5, conclusion and policy recommendations for future analysis are provided.

## Literature Review

To date, no study has been conducted on the economic effect of applying a PPP contract on the seawater desalination and transfer project using computable general equilibrium models. Indeed, previous research has often been conducted only on the area of transportation. For example, Chen et al. (2017) evaluated PPP's socioeconomic effects of a highway construction project in Virginia, USA, (DBFOM model) using a dynamic computable general equilibrium model on the regional economy (by changing the gross products) and social welfare (by changing the households' income). In their analysis, economic-social consequences are investigated through the effects of capital expenditures in the highway infrastructure and tax shocks by considering three scenarios; namely, the lower-bound public sector comparator, the upper-bound public sector comparator scenario, and PPP. The results of the simulation showed that the PPP model created greater social welfare effects, compared with the traditional procurement model, due to the reduced tax burden caused by private sector financing.

Buffie et al. (2017) investigated the responses separately of macroeconomic variables in the PPP and own investment by the public sector using a dynamic general equilibrium model featuring private capital accumulation and labor market flexibility (full employment with

flexible wages and involuntary unemployment with efficiency wages). They discovered that externalities increase social returns in the PPP model 2-9 percent, relative to own investment by the government; depending on whether externalities function separately or in combination, and on whether PPP brings the advantage of fast construction or not.

Kim et al. (2016) analyzed the economic effects of an investment in transportation projects on the growth and distribution in Indonesia using a financial CGE model by considering various financing methods such as tax revenues, government bonds, and private sector financing. The results indicated that transportation projects financed with tax revenues had stronger effects on GDP, compared with other financing methods.

Kim and Bae (2015) assessed the effects of financing and operation of a highway on the economic growth of Korea using a financial CGE model. They examined two scenarios for the financing and operation of the project. In the first scenario, the project is financed by the government using tax incomes, and then finally operated by the government. In the second scenario a BOT (build, operate, and transfer) agreement is made by private sector, and the project is financed by the private sector by issuing private bonds and building in a two-year period. In the next step, the private sector operates the project for an eight-year period. The results of the simulation indicate that financing and operation by the private sector positively will affect the GDP of Korea if, and only if, the relative efficiency of the private sector during the operation period is at least 7% above that of the public sector.

Bayar (2009) assessed a road construction project in the Azores under a PPP using a recursive-dynamic CGE model. It was assumed that there was no outlay by the public sector from 2007 to 2012, but then the reimbursement of the debt to the private sector would be made by the government from 2012 to 2036 by increasing income taxes by 10% or decreasing the transfers to households by 10%.The outcomes of these scenarios were compared with the situation in which no road was constructed. The results indicated that the increase in the welfare level caused by the construction of the road was compensated by the reduction in welfare due to taxes, and practically, the project was deemed unviable.

Kim et al. (1998) investigated the impact of investment in the transportation infrastructure in Korea using a dynamic CGE model. The results of a counterfactual analysis showed that this policy affected economic growth in a positive way and had a negative effect on inflation. Infrastructure investment elasticity related to GDP, exports, private consumption, and inflation depends on institutional constraints on the domestic inflow of foreign capital and financing methods of infrastructure projects. If the legal constraints on the inflow of foreign capital to the private sector were canceled, the impact of investment in transportation projects on economic growth would be maximized. On the other hand, the impact of investment on inflation would be minimized if transportation investment expenditures were fully financed by tax incomes.

## Model Structure

In this paper, the economic impacts of applying a PPP contract in one of the projects for investment in water resource development infrastructures in Iran are compared to the traditional procurement approach.

For this purpose, a recursive dynamic financial CGE model is used for Iran’s economy over a 30-year period. Further, the project for desalination and transfer of the Persian Gulf inter-basin water to the Central Plateau, as one of the water supply development projects, is considered. A consortium including Gol-Gohar Mining and Industrial Company, Sarcheshmeh Copper Company, and Chadormalu Mining and Industrial Company, entitled Persian Gulf Water Supply Company, is responsible for building, financing, and operating this project. The reason for considering the project is that the domain of its effects involves several basins in Hormozgan, Kerman, and Yazd provinces, and its impact can be assessed at

the national level.

In this model, eight groups in the category of goods and services (agricultural, industrial, mining, electricity, water, building, transportation, and services), eight activities (agricultural, industrial and mining, electricity, water, building, transportation, and services) and five economic institutions (households, corporation, financial institutions, government, and the rest of the world) are organized.

Iran's economy is assumed to be a small open economy (price taker in the global economy), and there is an equilibrium in foreign trade and current accounts, investments and saving, and the government's budget, like in other CGE models. Moreover, there is equilibrium between the demand and supply of financial assets in the financial markets, i.e., it is assumed that equities are issued to the extent of the demand for buying them.

Moreover, following the Armington assumption, households and corporations consume Armington goods, i.e., combinations of domestically produced goods and imported goods, which are imperfect substitutes. On the supply side, producers also supply domestically produced goods in domestic markets or export them, and there is an imperfect substitution between domestically consumed goods and exported goods in this transformation process, as in the Armington assumption.

This model classifies the real side equations into three blocks; price block, production and trade block, and institutions block. On the financial side, the financial account of institutions is considered in five blocks; namely, households block, corporations block, government block, financial institutions block, and the rest of the world block. Equations related to the constraints of real and financial sides that guarantee the settlement condition for four markets, i.e., goods and services, factors, financial assets, and foreign exchange, are also incorporated in the system constraints block.

One of the challenges of water related CGE models is how to model water. Generally, water resources are divided into two groups. The first group includes water resources collected from dams, water transfer networks, and other resources that in some way human beings have contributed to their infrastructures, such as purification, exploitation, distribution, and relevant services. The second group comprises water streaming naturally in rivers, springs, and lakes with no human interference.

The first group is considered as a good by national accounting. In other words, water produced and some related activities, including collection, purification, and distribution, are considered in the first group. The second group, however, is invisible in the money cycle of the economy and the national accounting. In other words, water is not considered as an initial endowment and production factor because the water is not traded in the market (Yousefi, 2011). In this regard, in 2008, the United Nations proposed to design the SEEAW system to help economists analyze the relationship between the water sector and other macroeconomic and regional variables. However, in some countries such as Iran, this accounting system does not exist, or it is in its initial stages. For this reason, in many CGE models, such as the one used by Feng et al. (2007), first, the shadow price of water for different economic sectors is calculated by using the input-output table and linear programming method to incorporate water as a natural endowment (Chen and Yang, 2002; Liu and Chen, 2008), then, this price is multiplied by the volume of water consumed by sectors to obtain the tariff for water resources (the economic price of water) for each sector. These values are separated from the capital, which is a factor of value-added, and are in a distinct row of the social-accounting matrix. In the model, water is considered in the first group because this it is non-conventional water extracted from the Persian Gulf, purified by the desalination plant in Bandar-Abbas, and transferred to the industry and mine sectors in the country's southeast provinces of Yazd, Hormozgan and Kerman.

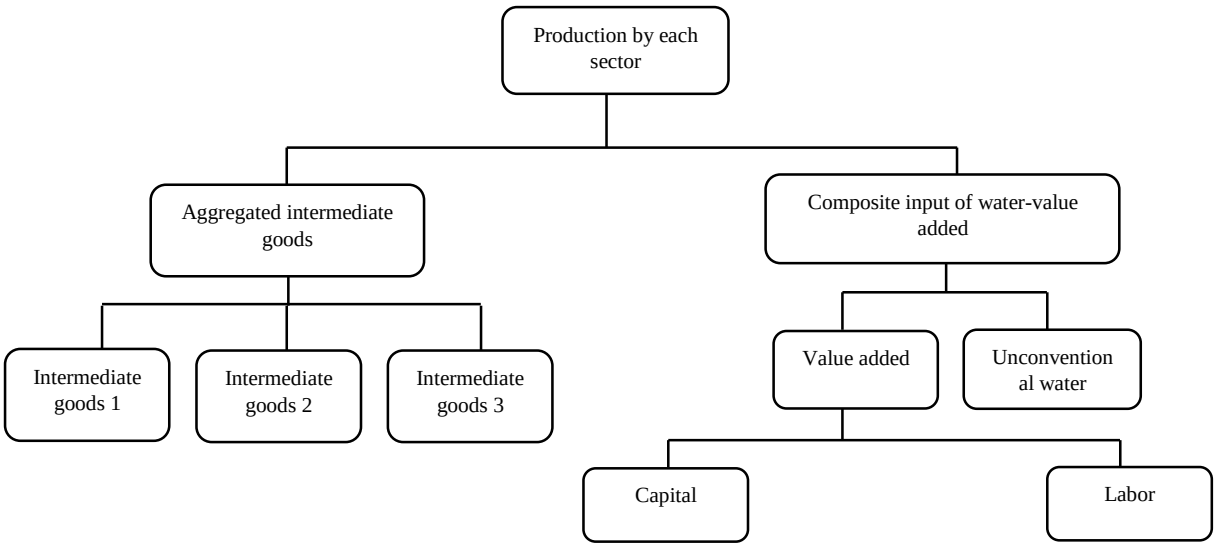


**Figure 1.** Production Technology
**Source**: Research finding.

On the other hand, water is one of the main factors of production in Gol-Gohar iron mines, Sarcheshmeh copper mines, and Cahdormalu iron ore mines and plays a major role in production like fossil energies.

Therefore, unconventional water, as a good, is combined with other production factors in different economic sectors with different elasticity.

Accordingly, on the real side of the model, the production sector comprises a two-layer structure in which in the first layer, the composite input value added-water (QKLW) and intermediate goods (QINTA) are combined based on a constant elasticity of substitution (CES) production function as follows:

$$QA_a = a_a^a.(\delta_a^a.QKLW_a^{-\rho_a^a} + (1-\delta_a^a).QINTA_a^{-\rho_a^a})^{\frac{1}{-\rho_a^a}} \quad (1)$$

$$\frac{QKLW_a}{QINTA_a} = \left[\frac{PINTA_a}{PKLW_a}.\frac{\delta_a^a}{(1-\delta_a^a)}\right]^{\frac{1}{1+\rho_a^a}} \quad (2)$$

In the second layer, on the one side, aggregate intermediate goods with zero elasticity of substitution (as a Leontief function) is composed of intermediate goods, and on the other side, the composite input of value added-water (QKLW) is organized by a constant elasticity of substitution function of water (QCW) and value-added (QVA) - a combination of labor and capital-as follows:

$$QKLW_a = a_a^{klw}.(\delta_a^{klw}.QVA_a^{-\rho_a^{klw}} + (1-\delta_a^{klw}).QCW_a^{-\rho_a^{klw}})^{\frac{1}{-\rho_a^{klw}}} \quad (3)$$

$$\frac{QVA_a}{QCW_a} = \left[\frac{PCW_a}{PVA_a}.\frac{\delta_a^{klw}}{(1-\delta_a^{klw})}\right]^{\frac{1}{1+\rho_a^{klw}}} \quad (4)$$

In the price block, the price of composite input of value added-water (PKLW) and the price of water (PCW) as an economic good are obtained as follows:

$$PA_a.QA_a = (PKLW_a.QKLW_a) + (PINTA_a.QINTA_a) \quad (5)$$

$$PKLW_a.QKLW_a = (PVA_a.QVA_a) + (PCW_a.QCW_a) \quad (6)$$

The equations for other real sides of the model have been taken from Lofgren et al. (2002) with some modifications regarding the structure of Iran's economy and the inclusion of the water function in the model.

On the financial side of the model, it is assumed that the total wealth of each institution (WE) is divided into real wealth and financial wealth. For simplify, financial wealth is divided into four groups; namely, cash and deposit, loan, bond, and equities.

In FCGE models, the behavior of the financial portfolio for economic institutions is specified by using financial portfolio optimizations or the analytical hierarchy process (AHP). In this model, AHP method (Kim, 2017) is used to specify the behavior of the financial portfolio for economic institutions.

Figure 2 presents the hierarchy tree. Return on assets is the main criterion to select the share of financial assets in the economic agents' financial portfolio.

Agents allocate their wealth (WEA) to either form a fixed capital (purchase of real assets) or supply it to demanders through financial assets. In other words, if the return on investment in forming a fixed asset (real sector) increases compared to the return on financial assets, one institution will purchase more real assets. Similarly, for the financial assets, if the equity return is higher than the rate of return on other competing assets, people will be encouraged to purchase more equity to increase their income.

In other words, the demand share for financial assets by the economic agent is calculated based on the return on capital according to the following equations; (G) represents the share of demand for real and financial assets, (RQ) stands for rate of return on equity, (RB) shows the rate of return on bonds, (RRC) is the rate of return on real assets, (RLOAN) is the rate of return on loan, and (RD) is the rate of return on deposits. Moreover, (RMR) represents the average rate of return on assets subjected to profit rate, (RMO) is the average rate of return on deposits and loans, (RMF) is the average rate of return on financial assets, $\varepsilon$ is the elasticity of substitution between financial assets, and $\psi$ is the shift parameter. All the rates of return are fixed.

$$\frac{G_{1,s}}{1-G_{1,s}} = \psi_{1,s} \cdot \left[\frac{1+RMF}{1+RRC}\right]^{\varepsilon_{1,s}} \quad (7)$$

$$\frac{G_{2,s}}{1-G_{2,s}} = \psi_{2,s} \cdot \left[\frac{1+RMR}{1+RQ}\right]^{\varepsilon_{2,s}} \quad (8)$$

$$\frac{G_{3,s}}{1-G_{3,s}} = \psi_{3,s} \cdot \left[\frac{1+RMO}{1+RB}\right]^{\varepsilon_{3,s}} \quad (9)$$

In the next stage, the demand for financial assets is specified based on the share variables by the following equations; (QRC) represents the demand for investment in real assets, (DEQT) is the demand for purchasing equity, (DBND) is the demand for buying bonds, (DDEP) is the demand for a deposit, and (DLOAN) shows the demand for loan by economic institutions.

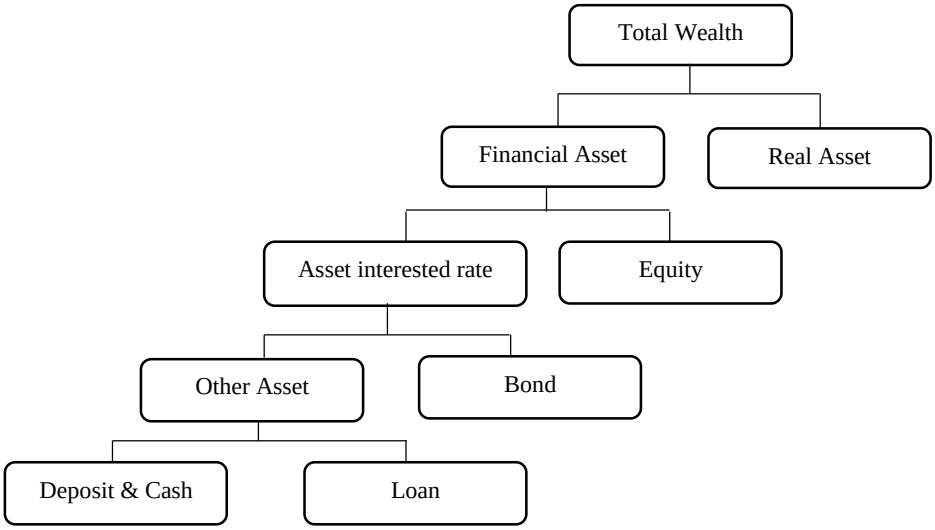


**Figure 2.** Hierarchy Tree
**Source**: Research finding.

$$\frac{G_{4,s}}{1-G_{4,s}} = \psi_{4,s} \cdot \left[\frac{1+RD}{1+RLOAN}\right]^{\varepsilon_{4,s}} \quad (10)$$

$$QRC_s = \left(1 - G_{1,s}\right).WE_s \quad (11)$$

$$DEQT_s = G_{1,s}.\left(1 - G_{2,s}\right).WE_s \quad (12)$$

$$DBND_s = G_{1,s}.G_{2,s}.\left(1 - G_{3,s}\right).WE_s \quad (13)$$

$$DDEP_s = G_{1,s}.G_{2,s}.G_{3,s}\left(1 - G_{4,s}\right).WE_s \quad (14)$$

$$DLOAN_s = G_{1,s}.G_{2,s}.G_{3,s}.G_{4,s}.WE_s \quad (15)$$

In the equations above, (WE) is the total wealth of each institution given by the sum of real and financial assets, as mentioned before. In other words:

$$WE_s = QRC_s + DEQT_s + DBND_s + DDEP_s + DLOAN_s \quad (16)$$

The total debt of each institution (BOR) is obtained from the sum of the total supply of financial assets, as follows:

$$BOR_s = SEQT_s + SBND_s + SDEP_s + SLOAN_s \quad (17)$$

Where (SEQT) is the supply of equities, (SBND) is the supply of bonds, (SDEP) is the supply of deposits, and (SLOAN) is the supply of loans. Here, it is assumed that the assets market is settled through quantitative adjustments, and the supply for each financial asset determines the level of demand of financial assets.

In other words, the conditions for equilibrium in financial markets are as follows:

$$\sum DEQT_s = \sum SEQT_s \quad (18)$$

$$\sum DBND_s = \sum SBND_s \quad (19)$$

$$\sum DDEP_s = \sum SDEP_s \quad (20)$$

$$\sum DLOAN_s = \sum SDLOAN_s \quad (21)$$

In this paper, dynamic equations related to capital accumulation, taken from Thurlow (2008), are included to adapt the model to a dynamic-recursive model. The labor supply is an exogenous variable and increased by a 1.1% growth rate but the capital supply is assumed to be an endogenous variable. Net capital accumulation in each period is obtained by adding the capital accumulation in the previous period to the net investment in the current period. We assume that there is a complete mobility of investment between the sectors over 30 years. Furthermore, the impact of changes in future expectations on flow capital accumulation and distribution is not incorporated in the model and future expectations are assumed to be the same as corresponding past observations to avoid excess complexity in the dynamic process.

*Data and Calibration*

Model calibration is the procedure of calculating unknown parameters applied to different functions of the model by pinning down the endogenous variables so that resolving the equations yields to the same initial equilibrium level of the data.

For this purpose, a set of information on initial values of variables and parameters is required. The initial values of the variables have been determined, in 1999, based on the social accounting matrix (SAM) of the Central Bank since this matrix is the only financial social accounting matrix (FSAM) in Iran, and other newer matrices have been provided only for the real economy.

The elasticity of the parameters used in the functions were extracted from other studies, as presented in Table 1, and then to prevent the occurrence of calibration error in different scenarios, the sensitivity of the results to changing these elasticity has been investigated. Depreciation rates also have been taken from Amini and Neshat (2005).

**Table 1.** The Elasticity of Substitution between the Parameters

| Elasticity | Value | Resource |
|---|---|---|
| Armington elasticity between imported goods and domestically produced goods | 3 | Torgensen (2003), EPAX model of Manzoor et al. (2010) |
| Elasticity of substitution between exported goods and domestically produced goods (CET) | 1 | EPAX model, Manzoor et al. (2010) |
| Elasticity between water and value-added (agricultural sector) | 0.1 | Feng et al. (2007) |
| Elasticity between water and value-added (services sector) | 0.75 | Feng et al. (2007) |
| Elasticity between water and value-added (water purification and collection) | 0.8 | Feng et al. (2007) (equivalent to low-intensive industries) |
| Elasticity between water and value-added (industries and mines) | 0.4 | Feng et al. (2007), (average of high-intensive industries with an elasticity of 0.3 and middle-intensive industries with an elasticity of 0.5) |
| Elasticity of substitution between production factors in the value-added layer | 0.8 | Standard model of Löfgren (2010) |
| Elasticity of substitution between goods | 6 | Standard model of Löfgren (2010) |
| Elasticity of substitution between financial assets in the financial portfolio formation function | 3 | Debowicz (2010) |

**Source**: Research finding.

In this model, government savings (the difference between government revenue and expenditure) is assumed to be endogenous variable in the government fiscal balance while all tax rates are fixed. In the current account balance, foreign savings (or the current account deficit) is assumed to be exogenous variable; hence, typically, the exchange rate should be flexible. But due to fact that the exchange rate in Iran is not floating, it is set as the numeraire. The macro closure for the capital account is also selected to be investment driven.

As noted by McDonald et al. (2005), investment expenditure is defined as an exogenous variable, also the investment adjustment is assumed to be an endogenous variable in order that changes in investment expenditure can further affect quantity of capital commodity rather than prices. The supply of production factors, such as labor as well as the supply of non-conventional water is a fixed and exogenous variable but capital supply is assumed to be an endogenous variable in the dynamic part of the model.

*Scenario Simulation*

The purpose of computable general equilibrium models is primarily for policy analysis and evaluation. Therefore after closing and specifying the model, in this section, the following scenarios are simulated by using the mixed complementarity problem (MCP) by the GAMS software.

**Scenario 1:** Building, financing, and operation by the traditional procurement model

In this scenario, it is assumed that investing and building the project are done by the public sector over a ten-year period. However, the project is implemented by the public sector through contracts such as the Turnkey contract (TKY), design-bid-built (DBB), or contract-manage (CM) approach by the private sector. Moreover, the public sector is responsible for financing the project and monitoring its building process, with the builder-contractor having no responsibility during the operation. The cost of building required for the project is estimated at 109 trillion Rial (with an exchange rate of 100,000 Rial per dollar), which is adjusted with respect to the exchange rates in the official market in the base year. Further, as in the Chen et al. (2017) study, the cost of building the project is considered with a 24% discount because in the traditional procurement model, the contractor does not undergo additional costs to increase the quality of the project, given that the contractor will not operate the project. On the other hand, the public sector has access to cheaper financial resources to manage the risk. The cost of building the project by the public sector is financed by the public budget by increasing tax rate. In other words, it is assumed that the tax rate will increase to the amount that the project need be financed in a ten-year period (the project building period). Indeed, in the building period, the economy experiences a shock of increasing investment expenditure and corporate tax rates simultaneously. This project has also been operated by the public sector during a 20-year period, which has increased the water supply to the industry and mining sectors to the amount of 650,000,000 $m^3$. Since the building, financing, and operation of the project are fulfilled by the traditional approach, and no additional cost is allocated to increase the productivity of the project, this parameter is predicted not to increase in the operation period.

**Scenario 2:** Building, financing, and operating of the project by a PPP model

In this scenario, it is assumed that the investment and building of the project are carried out in a seven-year period. In other words, since only one private consortium is responsible for building and operating the project in a specified period (30 years), the private consortium tends to conduct the project as fast as possible to benefit from more privileges in the operation period. The contract with this consortium may be of the types of BOO, BOT, and DBFO.

On the other hand, since this private consortium has sufficient motivation for increasing

the quality of infrastructures and does not have cheap financial resources to manage risk and uncertainty, unlike the public sector, it will face up to a 24% increase in building costs relative to the traditional public procurement model. Investment expenditure is assumed to be entirely financed through issuing equities in the capital market by the private sector.

Similar to the previous scenario, there is a water supply increase shock to the industry and mining sector to the amount of 650,000,000 $m^2$.

However, regarding the lack of time-series data or prior research on the difference between the productivities of the public sector and the private sector, four cases are assumed for the productivity parameter in this scenario.

In the case of B-1, the increase in cost during the building period is assumed to have no positive externalities. Therefore, in the operation period, the parameter related to production productivity will not increase. However, in the cases of B-2, B-3, and B-4, the increase in cost during the building period is assumed to have positive externalities, and the productivity parameter increases in these three scenarios by 0.01%, 0.02%, and 0.03%, respectively, in the industry and mining sectors.

## Results

The impacts of these scenarios on the GDP growth and other key economic variables are presented in Tables 2, 3, and respectively.

As the results show, infrastructure investment has short-term and long-run impacts on economic variables. The extent of its short-term effect depends on the size of investment expenditure and how the infrastructure is financed. Therefore, as seen in Table 2, the average GDP growth during the building period in the traditional procurement model is equal to 0.0021%, while in the PPP model is equal to 0.1012%. This is because of the impact of GDP growth caused by an increase in investment expenditures and demand-side stimulation, which in the traditional procurement model is decreased in response to increased corporate tax rates.

**Table 2.** Average GDP Growth (%)

| Year | Scenario 1 | Scenario 2 | | | |
|---|---|---|---|---|---|
| | A-1 | B-1 | B-2 | B-3 | B-4 |
| 1 | 0.0023 | 0.1014 | 0.1014 | 0.1014 | 0.1014 |
| 2 | 0.0022 | 0.1013 | 0.1013 | 0.1013 | 0.1013 |
| 3 | 0.0022 | 0.1013 | 0.1013 | 0.1013 | 0.1013 |
| 4 | 0.0022 | 0.1012 | 0.1012 | 0.1012 | 0.1012 |
| 5 | 0.0022 | 0.1012 | 0.1012 | 0.1012 | 0.1012 |
| 6 | 0.0021 | 0.1012 | 0.1012 | 0.1011 | 0.1012 |
| 7 | 0.0021 | 0.1011 | 0.1011 | 0.1011 | 0.1011 |
| 8 | 0.0021 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 9 | 0.0021 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 10 | 0.002 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 11 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 12 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 13 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 14 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 15 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 16 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 17 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 18 | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1397 |
| 19 | 0.0005 | 0.0005 | 0.0469 | 0.0932 | 0.1396 |

| Year | Scenario 1 | Scenario 2 | | | |
|---|---|---|---|---|---|
| | A-1 | B-1 | B-2 | B-3 | B-4 |
| 20 | 0.0005 | 0.0005 | 0.0469 | 0.0932 | 0.1396 |
| 21 | 0.0005 | 0.0005 | 0.0469 | 0.0932 | 0.1396 |
| 22 | 0.0005 | 0.0005 | 0.0468 | 0.0932 | 0.1396 |
| 23 | 0.0005 | 0.0005 | 0.0468 | 0.0932 | 0.1396 |
| 24 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| 25 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| 26 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| 27 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| 28 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| 29 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| 30 | 0.0004 | 0.0004 | 0.0468 | 0.0932 | 0.1396 |
| Average in the period of building | 0.0021 | 0.1012 | 0.1012 | 0.1012 | 0.1012 |
| Average in the period of operation | 0.0005 | 0.0005 | 0.0469 | 0.0933 | 0.1396 |
| Average in the whole period | 0.001 | 0.024 | 0.0596 | 0.0951 | 0.1307 |

**Source**: Research finding.

**Table 3.** Percentage of Change in Economic Variables (%)

| | | | Income | | | | Expenditure | | CPI |
|---|---|---|---|---|---|---|---|---|---|
| | | | H | E | B | GOV | GOV | H | |
| Scenario 1 | A-1 | Average in the building period | -0.034 | -0.017 | -0.042 | 0.209 | -0.001 | -0.052 | -0.0004 |
| | | Average in period of operation | 0.001 | 0.001 | 0.001 | 0 | 0 | 0.001 | 0.0001 |
| | | Average in the whole period | -0.011 | -0.005 | -0.013 | 0.07 | 0 | -0.017 | -0.0001 |
| Scenario 2 | B-1 | Average in the building period | 0.09 | 0.066 | 0.059 | 0.043 | 0.024 | 0.076 | 0.018 |
| | | Average in the operation period | 0.001 | 0.001 | 0.001 | 0 | 0 | 0.001 | 0 |
| | | Average in the whole period | 0.022 | 0.016 | 0.014 | 0.01 | 0.006 | 0.018 | 0.004 |
| | B-2 | Average in the building period | 0.09 | 0.066 | 0.059 | 0.043 | 0.024 | 0.076 | 0.018 |
| | | Average in the operation period | 0.072 | 0.062 | 0.082 | 0.03 | 0.014 | 0.085 | 0.013 |
| | | Average in the whole period | 0.076 | 0.063 | 0.076 | 0.033 | 0.016 | 0.083 | 0.014 |
| | B-3 | Average in the building period | 0.09 | 0.066 | 0.059 | 0.043 | 0.024 | 0.076 | 0.018 |
| | | Average in the operation period | 0.144 | 0.123 | 0.162 | 0.061 | 0.028 | 0.17 | 0.026 |
| | | Average in the whole period | 0.131 | 0.11 | 0.138 | 0.057 | 0.027 | 0.148 | 0.024 |
| | B-4 | Average in the building period | 0.09 | 0.066 | 0.059 | 0.043 | 0.024 | 0.076 | 0.018 |
| | | Average in the operation period | 0.215 | 0.184 | 0.243 | 0.091 | 0.042 | 0.254 | 0.039 |
| | | Average in the whole period | 0.186 | 0.156 | 0.2 | 0.08 | 0.038 | 0.212 | 0.034 |

GOV = Government, H= Household, E=Enterprises, B=bank and other financial institutions

**Source**: Research finding.

From the proponents' viewpoints of corporate tax, it is a tax on the corporates' profit, the demolition of which is less than the tax on other tax bases, and its tax burden is not transferred on the consumers and wage earners. On the other hand, Critics see it as a corporate income tax, which is like a tax on production factors and will have a negative effect on investment and production by increasing the cost of capital.

But the results indicate that in the project building period (short-term) with the traditional procurement model, the increase in corporate tax rates has led to a decrease in corporate income and consequently to financial institutions and households as part of the factors generated. The reduction in these sectors' incomes decreases the demand for all goods and services, thereby reducing the positive impact of investment on GDP.

However, the government's revenue is raised by increasing the tax rates, and the investment expenditure of the project is financed through the savings channel. However, during the project building period by the PPP model, increasing the equity issuance in the financial market causes the household income to increase through receiving profits from the purchase of equity.

This model assumes that the household enters this profit into the production process as working capital. Thus, contrary to the traditional procurement model, the private sector income increases, and consequently, the household consumption demand for goods and services increases. In other words, this financing method intensifies the positive impact of investment expenditures on the demand side. It also leads to an increase in the production of goods and services on the supply side, as seen in Table 4.

However, in the operation period, investment expenditures will lead to economic growth through three components: capital accumulation, increasing water supply, or increased productivity through increasing the efficiency and relative productivity of the private sector, which can be higher than the public sector.

**Table 4.** Percentage of Change in the Total Output

| Average percentage of change in the total output | | | Agriculture | Industry | Mining | Power | Water | Building | Transportation | Service |
|---|---|---|---|---|---|---|---|---|---|---|
| Scenario 1 | A-1 | building period | -0.014 | 0.034 | 0.024 | -0.023 | -0.024 | 0.085 | 0.008 | -0.02 |
| | | operation period | 0 | 0 | 0.001 | 0.001 | 0.002 | 0 | 0 | 0 |
| | | whole period | -0.004 | 0.011 | 0.008 | -0.007 | -0.007 | 0.028 | 0.003 | -0.006 |
| Scenario 2 | B-1 | building period | 0.01 | 0.09 | 0.03 | 0.01 | -0.03 | 0.09 | 0.01 | 0 |
| | | operation period | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | whole period | 0.01 | 0.03 | 0.01 | 0 | -0.01 | 0.03 | 0 | 0 |
| | B-2 | building period | 0.08 | 0.27 | 0.08 | 0.06 | -0.08 | 0.18 | 0.02 | 0.03 |
| | | operation period | 0.039 | 0.024 | 0.046 | 0.047 | 0 | -0.003 | 0.038 | 0.035 |
| | | whole period | 0.049 | 0.081 | 0.055 | 0.051 | -0.019 | 0.04 | 0.033 | 0.035 |
| | B-3 | building period | 0.08 | 0.27 | 0.08 | 0.06 | -0.08 | 0.18 | 0.02 | 0.03 |
| | | operation period | 0.078 | 0.048 | 0.093 | 0.094 | -0.002 | -0.006 | 0.075 | 0.071 |
| | | whole period | 0.078 | 0.099 | 0.09 | 0.086 | -0.02 | 0.038 | 0.061 | 0.062 |
| | B-4 | building period | 0.08 | 0.27 | 0.08 | 0.06 | -0.08 | 0.18 | 0.02 | 0.03 |
| | | operation period | 0.117 | 0.071 | 0.139 | 0.14 | -0.003 | -0.009 | 0.112 | 0.106 |
| | | whole period | 0.108 | 0.117 | 0.125 | 0.122 | -0.021 | 0.036 | 0.09 | 0.089 |

**Source**: Research finding.

In the traditional procurement model, which the construction contractor does not operate from the project, there is no expectation of increased productivity; therefore, the average GDP growth in this period will be 0.0005%. Regarding the longer building period in the traditional procurement model, compared with PPPs, this model's operation period is shorter than that in PPPs private, assumed 20 years. Therefore, the average GDP growth in the whole 30-year period (long-term period) is too small and equal to 0.001%.

However, In the PPP, since the private sector tends to benefit from the advantages of the project as soon as possible, the building period is shorter, but the operation period is longer, assumed 23 years (the total period for building and operation is 30 years in both models).

Moreover, if in the period of operation by the private sector, this sector's higher investment expenditure, such as scenario B-1, did not have positive externalities and did not lead to an increase in the productivity parameter, the average GDP growth in this period would be the same as the corresponding amount in the traditional procurement model and equal to 0.0005%. But if the costs increased during the building period had positive externalities and

led to an increase in the productivity parameter by 0.01%, 0.02%, and 0.03%, the economy would be faced a rise in the average GDP during the operation period by 0.093%, 0.046%, and 0.139%. The average GDP growth in the whole of the 30-year period is presented in Table 2.

Eventually, in this paper, like Kim et al. (2016), using the cost-benefit method can determine which model of building, financing, and operation (traditional procurement or PPP model) is economically justified. Here, the net present value of GDP changes is considered the benefit, and the net present value of investment expenditures is regarded as the cost. The discount rate also is assumed 7.2% for Iran, as in Abdoli (2009).

**Table 5.** Benefit-Cost Ratio

| Scenario | | Ratio |
|---|---|---|
| Scenario 1 | A-1 | 0.03 |
| Scenario 2 | B-1 | 0.37 |
| | B-2 | 1 |
| | B-3 | 1.66 |
| | B-4 | 2.31 |

**Source**: Research finding.

As seen in Table 5, the results show the building, financing, and operation of the Persian Gulf desalination and transfer water project to the Central Plateau only using a PPP contract and only if the productivity parameter is increased at least by 0.01% during the operation period, it has economic justification, and by increasing productivity, and only then the benefits of the project will outweigh its costs.

**Table 6.** Percentage of Change in Economic Variables with Various Elasticity Armington (%)

| Variables | Armington elasticity | A-1 | B-1 | B-2 | B-3 | B-4 |
|---|---|---|---|---|---|---|
| GDP | 3 | 0.001 | 0.024 | 0.060 | 0.095 | 0.131 |
| | 2.8 | 0.001 | 0.024 | 0.060 | 0.097 | 0.133 |
| | 3.2 | 0.001 | 0.024 | 0.059 | 0.094 | 0.128 |
| CPI | 3 | 0.000 | 0.004 | 0.014 | 0.024 | 0.034 |
| | 2.8 | 0.000 | 0.004 | 0.015 | 0.025 | 0.035 |
| | 3.2 | 0.000 | 0.004 | 0.014 | 0.024 | 0.033 |
| EG | 3 | 0.000 | 0.006 | 0.016 | 0.027 | 0.038 |
| | 2.8 | 0.000 | 0.006 | 0.017 | 0.028 | 0.039 |
| | 3.2 | 0.000 | 0.006 | 0.016 | 0.027 | 0.037 |
| YG | 3 | 0.070 | 0.010 | 0.033 | 0.057 | 0.080 |
| | 2.8 | 0.070 | 0.010 | 0.034 | 0.058 | 0.082 |
| | 3.2 | 0.070 | 0.010 | 0.033 | 0.055 | 0.078 |
| EH | 3 | -0.017 | 0.018 | 0.083 | 0.148 | 0.212 |
| | 2.8 | -0.016 | 0.018 | 0.084 | 0.151 | 0.217 |
| | 3.2 | -0.017 | 0.019 | 0.082 | 0.145 | 0.208 |
| YH | 3 | -0.011 | 0.022 | 0.076 | 0.131 | 0.186 |
| | 2.8 | -0.011 | 0.021 | 0.078 | 0.134 | 0.190 |
| | 3.2 | -0.011 | 0.022 | 0.075 | 0.129 | 0.182 |

EG= government expenditure, YG=government revenue, EH=household expenditure, YH=household income

**Source**: Research finding.

On the other hand, critics believe that the results of computable general equilibrium models are sensitive to the choice of parameters and depend significantly on the parameters' value. Therefore, all calculations were performed again by changing the values of two of the model's key parameters, including Armington and CET.

We conduct the sensitivity analysis for two of the model's key parameters, including Armington and CET. The findings, shown in Tables 6 and 7 indicate that the model results are not sensitive to parameters' choice. Of course, with increasing the productivity parameter, the sensitivity to changing the elasticity parameters increases too negligibly.

**Table 7.** Percentage of Change in Economic Variables with Various Elasticity CET (%)

| Variables | CET elasticity | A-1 | B-1 | B-2 | B-3 | B-4 |
|---|---|---|---|---|---|---|
| GDP | 1 | 0.001 | 0.024 | 0.060 | 0.095 | 0.131 |
| | 0.8 | 0.001 | 0.026 | 0.061 | 0.096 | 0.131 |
| | 1.2 | 0.001 | 0.022 | 0.058 | 0.094 | 0.130 |
| CPI | 1 | 0.000 | 0.004 | 0.014 | 0.024 | 0.034 |
| | 0.8 | 0.000 | 0.005 | 0.015 | 0.025 | 0.034 |
| | 1.2 | 0.000 | 0.004 | 0.014 | 0.024 | 0.034 |
| EG | 1 | 0.000 | 0.006 | 0.016 | 0.027 | 0.038 |
| | 0.8 | 0.000 | 0.006 | 0.017 | 0.028 | 0.038 |
| | 1.2 | 0.000 | 0.005 | 0.016 | 0.027 | 0.038 |
| YG | 1 | 0.070 | 0.010 | 0.033 | 0.057 | 0.080 |
| | 0.8 | 0.070 | 0.012 | 0.034 | 0.057 | 0.080 |
| | 1.2 | 0.070 | 0.009 | 0.033 | 0.056 | 0.079 |
| EH | 1 | -0.017 | 0.018 | 0.083 | 0.148 | 0.212 |
| | 0.8 | -0.017 | 0.022 | 0.085 | 0.149 | 0.213 |
| | 1.2 | -0.017 | 0.016 | 0.081 | 0.146 | 0.212 |
| YH | 1 | -0.011 | 0.022 | 0.076 | 0.131 | 0.186 |
| | 0.8 | -0.011 | 0.024 | 0.078 | 0.133 | 0.187 |
| | 1.2 | -0.011 | 0.019 | 0.075 | 0.130 | 0.186 |

EG= government expenditure, YG=government revenue, EH=household expenditure, YH=household income

**Source**: Research finding.

## Conclusions and Policy Recommendations

Investigating the trend of implementation of development projects in Iran over the past years shows that the government, as the main player providing public infrastructure, lacks sufficient financial, managerial, and technical capacity in this field.

The inefficient process of approving and executing development projects and the government's inability to complete infrastructure projects according to the schedule have imposed a massive volume of unfinished development projects on the national economy, which is why the government is highly willing to involve the private sector. In this regard, laws and regulations were adopted to encourage the private sector to enter into PPP contracts.

Of course, there is no guarantee that such partnerships will lead to truly desirable executive reforms. There is ample evidence worldwide that such contracts are much more expensive than traditional procurement models because the private sector often cannot manage risks like the public sector.

The long-term of these contracts, the existence of high political and economic risks, incomplete contracts, and asymmetric information have led to an increase in transaction costs and, consequently, the cost of using such contracts. Additionally, since the public sector is directly politically accountable for implementing such projects, it is likely that he/she will be constrained by the private sector and will have to pay more than before.

In this regard, it should be considered whether the higher productivity, efficiency, and higher speed of constructing a PPP project will compensate its higher cost.

In Iran, an assessment of government performance in participating private sector in development projects shows that the government has not succeeded. Because public sector officials must keep in mind that for various reasons, including political, legal, environmental, commercial, etc., it is not possible to execute all projects by participating private sector.

The private sector may also be reluctant to conduct the project due to perceived high risks or lack of technical, financial, or managerial capacity to execute it.

Moreover, although PPP contracts may cost more, they would be compensated through efficiency achievements. Also, changes in the operation and control of an infrastructure asset through PPP may not be sufficient to improve economic performance, unless conditions such as appropriate sector and market reforms and changes in the infrastructure's operational and managerial functioning are provided. The current regulations and laws also play a significant role in this failure**.**

Therefore, public sector officials' decision-making style to invest in new infrastructure and how to do it is essential. There are various criteria that the public sector can use to choose how to invest in new infrastructure (either through the public sector alone or in the form of PPP), such as cost-benefit analysis, VFM analysis, affordability, and balance sheet approach; But each of these methods alone is insufficient and has many disadvantages.

In Iran, the VFM assessment method is used to select appropriate projects for partnership with the private sector by PPP models.

VFM analysis is part of the initial study of the project in which information about the project costs and funding sources is identified and assessed; also, the allocation of project risks and other requirements and constraints of the project are determined.

Determining how to perform the project using the traditional procurement model or using the PPP model is one of such studies' results. But the criterion of VFM focuses only on the direct effects on the project's level and ignores the economic and social impacts and indirect national and regional impacts. This method is limited to selecting discount rates and tax position adjustments. This method is limited to selecting discount rates and tax position adjustments. It ignores both the benefits that users receive from increasing the quality of services through PPP and the project's financing methods. This is while ignoring these issues can lead to significant errors in assessments.

Therefore, the present paper aims at using a complementary method to make investment decisions with PPP model in one of the infrastructures of water resources development in the country. In this regard, the impact of building, financing, and operation of the desalination project and water transfer from the Persian Gulf to industries and mines in the southeastern provinces of the country by a PPP contract and using the recursive dynamic FCGE model to Iran's economic growth simulate and compare it to the traditional approach.

Based on the results, if the project is financed by the traditional public procurement model (with lower cost and longer duration) and using the country's general budget (from increasing tax revenues), it has no economic justification. Also, if this project is implemented by PPP models (with more cost and less time) and using the capital market's capacity, but spending this higher cost during building does not lead to increased productivity during operation, it also has no economic justification. However, only if this project is implemented using PPP models and increasing the productivity parameter by at least 0.01% during the operational period is economically justifiable.

By increasing the productivity rate, the benefits of this project will outweigh its costs. In other words, in this paper, the hypothesis of Iossa and Matrimort (2015) stating that only in the presence of positive externalities (the effect of costs that lead to increased efficiency and productivity during the operation period) bundling task (the PPP models) is preferred to unbundling task (the traditional procurement model), is implicitly approved.

Therefore, as seen using this method, decision-makers can consider the impact of increasing the quality or productivity resulting from private sector specialists' employment in analyzing the benefits and costs of projects. Therefore, it is suggested that government decision-makers make more precise decisions about selecting appropriate projects for private sector participation by using various models of computable general equilibrium and

simulating policies as a complementary and comprehensive method along with other methods. Eventually, this article assumes that the capital market finances the private sector. Therefore, in future research, financing the private sector can be considered from the National Development Fund or borrowing loans or foreign aids. In this article, the productivity parameter is considered a policy variable; therefore, it is suggested that this parameter be estimated in future research using historical data and be used in the model. Such research should also be conducted at the regional level, which was not possible due to the lack of the Financial-Regional Social Accounting Matrix in Iran.

Finally, risk analysis needs to be taken into account in the economic evaluation of the project because of the uncertainty in the financial markets and raw material prices in the sanction conditions in Iran.

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