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Analytical investigation of the effects of dam construction on the productivity and efficiency of farmers

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ABSTRACT

Under drought conditions, by constructing dams, water resource management prevents the flow of water and helps sustain groundwater resources in the long run. On the other hand, dam construction affects the level and the patterns of cultivation, employment, rural livelihoods, and the productivity and efficiency of farmers. Given this approach, the effects of Baft dam construction on the efficiency and productivity of downstream agricultural land was studied in 2014. In order to achieve this objective, two groups of farmers were selected and evaluated; those that use Baft dam water, or the treatment group (80 farmers), and those who do not use the dam water, the control group (45 farmers). Tornqvists-Theil (TTP) index, Stochastic Frontier Analysis (SFA) and Matching method was used to analyze the information related to the two groups. The results revealed that the efficiency and the average of the Total Factor Productivity (TFP) of the treatment group is larger than control group. However, the difference between the average productivity of agricultural units in the treatment and control groups was not significant. Based on the cultivation of the farmers' products and experience in the two groups, the higher technical efficiency in the treatment group compared to the control group was related to scale efficiency. This fact has been confirmed by using the matching method. The results also revealed that the population of the treatment group increased from 145 to 431, with a growth of 197% after the dam construction. But the population of the control villages reduced from 147 to 116 people, a 27% decrease.

1. Introduction

Iran is classified as an arid and semi-arid region, with an average rainfall of 250 mm per year and an average annual rainfall of 413 billion cubic meters. In addition to being dry, Iran is also prone to drought. The combination of these two factors has led the average rate of water in Iran to be reduced by 7000 cubic meters, 50 years ago, to 1900 cubic meters per capita in 2009. Considering the rate of population growth, it is expected that the water rate will reach 1300 cubic meters in 2025 (Saedi, 2012). Although most parts of the country face water shortages, the issue is more important in some provinces of Iran. The Kerman province in southeastern Iran, with an area of 175,069 square kilometers, is the largest province of Iran and has a dry and arid climate. The average rainfall in the province is about 145 mm per year, which is 58% of the average annual precipitation in Iran. The average volume of rainfall in Kerman is about 25 billion cubic meters per year, of which a significant percentage is unavailable due to runoff (Shahidasht and Abbasnezhad, 2010). In order to optimally manage water under such conditions, the construction of dams, storage and the timely use of seasonal and non-seasonal rivers not only prevents the loss of a significant amount of flowing water, but also helps sustain groundwater resources in the long run (Saedi, 2012).

The Baft storage dam was among the most important dams in

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Kerman province that operated in 2009. Although the dam was constructed to provide a drinking, industrial and agricultural water supply, its water is actually only used for agriculture (Water and Wastewater Organization of Kerman Province, 2011). A major issue that affects whether a dam is built are the consequences of these projects and their effects on the residents that live downstream of the dam. In fact, these dams affect households living in border villages which, in turn, affects the level and patterns of cultivation, employment and rural livelihoods, rural to urban migration, and the productivity and efficiency of the farmers (Heidari, 2012).

So far at a national level, several studies have been conducted on the economic, social and environmental impacts of dam construction. Khoshraftar Moghadam (2009) in Iran analyzed the economic effects of the Tabarak – Ghochan dam on the villages downstream the dam. The results of this study indicated that the construction of the Tabarak – Ghochan dam led to a boost in the agricultural activities and services in the downstream villages and increased the diversity of economic activities among villagers; it also had a significant effect on employment and the development of new jobs in downstream rural areas. Moreover, Rahmati and Nazarian (2010) analyzed the economic, social and environmental impacts of the settlements affected by the construction of the Gotvand Olia and Karoon dams. The findings of this study indicated that the villages and agricultural lands behind the dams were subject to many negative social and economic effects and that the consequences were two times greater for rural communities. Similarly, Saedi (2012) examined the economic outcome of the Taleghan dam and found that its construction has affected the land use, land prices, rural livelihood, and availability of employment opportunities. Afshari and Ebrahimi (2013) also analyzed the socio-economic and ecological effects of the construction of the Hana dam. The results of this study showed that allocating all of the water behind the dam to the agricultural sector has increased the area of land under cultivation, improved farmers' income, and increased downstream land values.

Globally, Aguirre (2005) analyzed the socio-economic effects of the construction of the Chixoy dam in Guatemala. The results indicated that due to its construction, many agricultural, forestry and husbandry lands have become inundated and the residents have gradually lost their jobs. Furthermore, Rempel et al. (2005) examined the economic effects of small sand dams on the agriculture in Kenya. The results of the study showed that the construction of such dams in the areas under investigation increased in agricultural productivity, saved time irrigating, and, lastly, changed the pattern of crops that resulted in the tendency to grow new crops. Bohlen and Lewis (2008) also investigated the economic impacts of dam construction in the USA. The results of this study indicated that the construction of dams in the USA plays an important role in the development of human societies in different parts of America and that it had significant benefits for downstream residents as well. Pauw et al. (2008) evaluated the socio-economic effects of the construction of small dams on the seasonal sand rivers in Kenya. Their results showed that the construction of these dams significantly affected the area under cultivation, the agricultural production, and farmers' incomes. The results of this study also revealed that non-farm income was higher for those who had access to the dam water than for those with no access. Similarly, Mudzengi (2012) analyzed the socio-economic impacts of the construction of the SIYA dam in Mazungunye, Zimbabwe. According to the results of this study, the construction of the SIYA dam has helped the farmers produce an agricultural boom under poor weather conditions.

The analysis of the internal and external studies showed that the focus of the previous studies was mainly on three aspects, including the economic, social and environmental impacts of dams' construction. In terms of economic issues, the benefits and costs of these dams have been usually studied. Nevertheless, the analysis of the economic effects of dam construction on the efficiency and productivity of farmers have not been considered in previous studies is. When farmers only have access to scarce water supplies, the amount and the combination of this input is different in terms of their theoretical optimal levels. By constructing dams, these resources can be used more efficiently. Dams also affect productivity and efficiency by increasing farmers' access to water inputs. Consequently, easier access to water resources may lead to larger farm units and, therefore, reduce production cost and increase the technical efficiency of the units by creating economic efficiency. Accordingly, knowing the effects of dam construction on the productivity and efficiency of the surrounding societies and regions is important to the design policies that aim to make the areas more sustainable. It will also help stimulate the development and implementation of prevention oriented governmental policies, the empowerment of the affected regions and will improve rural livelihoods and educational programmes. Knowing all this, the aim of this study was to investigate the effects of the construction of the Baft dam on the efficiency and productivity of downstream farmers.

Accordingly, the paper is divided into three remaining sections. Section 2 provides background information on the Baft dam, the econometric techniques, and the data that were employed in this study. Section 3 is the results and discussion of the expressed. The final section summarizes the main findings of the paper and states the implications that they have on policy.

2. Methods and materials

In order to achieve the objectives in this section, first some background information about the Baft dam are presented. Followed by the methods used in the study, including the TTP index, SFA, and the matching method, which are discussed in detail. Fig. 1 displays the description of the methodology used in the manuscript. Accordingly, productivity and efficiency are calculated using the TTP index and the SFA model. Then, in order to analyze the effects of the dam on downstream farmers' productivity and efficiency, the matching method is used. Within the matching method two groups of farmers were selected, and in order to help, covariates were evaluated. It should be noted that the first group is the one that has access to the dam water (the treatment group) and that the second group consists of those who have no access to the dam water (the control group).

2.1. Baft dam characteristics

The Baft dam is situated 160 km southwest of Kerman province, a distance of 4 km from the city of Baft and is located on the Baft river. It is worth noting that the Baft river flows from north to south and due to its topographic conditions, the water level is lower than the agricultural land downstream of the river. The Baft dam is an earth dam with a clay core with a crest 1137 m long, a width of 10 m, and a height of 5.62 m above the river bed. The river stores 40 million cubic meters of water annually. According to the available statistics, the maximum and minimum annual river discharge volume of Baft at the entrance gate are respectively 145.5 and 5.1 cubic meters, whereas the annual river discharge coefficient of variation is about 80%. It should be noted that the dominant pattern of the area before the dam consisted of grains, which was strongly affected by water scarcity and droughts. The area downstream of the Baft dam is made up of about 270 ha of cultivated land, 230 ha of gardens, and 1618 and 1700 ha of fallow lands and natural resources, respectively; which, in the case where they have access to