A re-examination of the impact of irrigation on rice production in Benin: An application of the endogenous switching model

Gbetondji Melaine Armel Nonvide

University of Abomey-Calavi, Benin

ABSTRACT

Irrigation offers important opportunities for enhancing crop yield and production in developing countries. This paper provides a re-examination of the impact of irrigation on rice production in Benin. It employed an endogenous switching model to account for bias due to observable and unobservable factors. The results indicated that the age of the farmer, gender, education, extension services, credit, access to media, ownership of mobile phone, off-farm income, and distance from home to irrigation scheme are factors affecting the probability of the adoption of irrigation. The results also revealed that adoption of irrigation is positively associated with rice productivity improvement. Farm variables such as soil fertility, labor, and fertilizer and herbicide application have a positive effect on rice productivity. Other variables increasing the rice yield were: education, credit, off-farm income, and access to media. These findings suggest that investments in irrigation should be accompanied by the provision of institutional support measures and complementary farm inputs to enhance the impact of irrigation on rice production.

Introduction

Although food security remains one of the higher priorities of the Government of Benin, national food crop production is still insufficient to satisfy the food need of the population. Each year, food deficiency is compensated by imports, with milled rice imports to Benin increasing from 115,000 t in 2002 to 350,000 t in 2013 (United State Department of Agriculture [USDA], 2016). Over the same period the total population has increased annually at a growth rate of 3.5 percent from 6,769,914 in 2002 to 9,983,884 in 2013 and the population growth and dietary changes together have led to an increase in the demand for food, which is a global trend supported by studies on food security (Hanjra & Qureshi, 2010). One way to face the challenge of growth in food demand and reduce food import dependency is to increase agricultural production and productivity. Rice production in Benin increased at an annual rate of 11 percent between 2000 and 2014, while the total area harvested increased at 8 percent (Food and Agriculture Organization [FAO], 2016). This shows that bulk of the gains in food production came from area expansion, also supported by other studies (Abro, Alemu, & Hanjra, 2014; Hanjra, Ferede, & Gutta, 2009). As land resources are limited, the alternative is to increase the output per hectare through adoption of new agricultural practices and technologies. In regard to this, irrigation has been proved as an important tool for agricultural yield improvement (Carruthers, Rosegrant, & Seckler, 1997; Domenech & Ringler, 2013; FAO, 2003; Hanjra, Noble, Langan, & Lautze, 2017; Huang, Rozelle, Huang, Lohmar, & Wang, 2006). The development of irrigation contributes by increasing returns to smallholder farmers in terms of achieving higher yields and revenues from crop production (Hanjra et al., 2009; Hussain & Hanjra, 2004).
Investments in irrigation in Benin started in 1960. As a consequence, the total land developed for irrigation purposes has increased from 3,932 ha in 1975 to 9,724 ha in 1990, and to 23,040 ha in 2008 (FAO, 2014). This represents less than 8 percent of the potential irrigable land (322,000 ha) and approximately 0.8 percent of the total cultivated area in Benin. The irrigated crops are rice, sugarcane, vegetables, roots, and tubers (Ministère de l’Agriculture, de l’élevage et de la pêche [MAEP], 2009). Rice occupied about half of the total irrigated land in 2008 (FAO, 2014). This shows the importance of rice in Benin’s agricultural development policy. Indeed, the need for irrigation development to achieve high agricultural yields is clearly expressed and defined in the Plan Stratégique de Relance du Secteur Agricole (PSRSA) of Benin 2011–2015, which defines the guidelines for improving the use of irrigation facilities in the country. These policies undertaken by the Government for promoting food crop production in Benin led to an increase in rice production from 4,000 t in 1970 to 72,960 t in 2007 and to 234,145 t in 2015; however, the objective of the rice policy to be self-sufficient in rice production by 2015 was not met. National rice production in 2015 was far below the target of 600,000 t needed in Benin for self-sufficiency in rice production. Hence, studies analyzing the impact of adoption of irrigation remain vital for sound policies to support future interventions promoting the development of irrigation in Benin.

This study provides support for continuing investments in irrigation development in Benin. A review of previous studies indicates the positive impact of irrigation on crop yield, food security, and poverty (Bacha, Namara, Bogale, & Tesfaye, 2011; Carruthers et al., 1997; Domenec & Ringler, 2013; FAO, 2003; Hanjra & Gichuki, 2008; Huang et al., 2006; Hussain & Hanjra, 2003; Namara et al., 2010). Other studies have shown that impacts of investments in irrigation on crop productivity and poverty reduction are greater where institutional support measures and complementary policies and infrastructure are available (Fan, Hazell, & Throat, 2000; Hanjra et al., 2009; Hussain & Hanjra, 2003, 2004; Nguyen, Phung, Ta, & Tran, 2017). This study aimed to quantify the effect of irrigation adoption on rice production in the specific context of Benin. It complements earlier studies about the impacts of irrigation development. It also offers a re-examination of the impact of irrigation on rice yield in Benin. Indeed, a previous study (Nonvide, 2017) has shown that the contribution of irrigation in rice productivity improvement in Benin varies between 55 and 60 percent. By employing a Heckman model of selection, the study by Nonvide (2017) does not account for the unobserved factors (farmers’ motivation, ability, among others) which may affect the adoption process. This paper builds on previous analysis (Nonvide, 2017) and employs an endogenous switching model which controls bias due to both observable and unobservable factors. The advantage of the endogenous switching model is the use of full information maximum likelihood to simultaneously estimate the selection and outcomes equations. It can also be used to compare the expected outcomes under actual and counterfactual cases (Asfaw, Shiferaw, Simtowe, & Lipper, 2012; Carter & Milon, 2005; Di Falco, Veronesi, & Yesuf, 2011).

Material and Methods

Study Area and Sampling Design

The study was conducted in the municipality of Malanville, Benin. The climate is Sudano-Sahelian with only one rainy season from May to October. The municipality benefits from a low rainfall between 700 mm and 1000 mm. It experiences high levels of food insecurity (35%) and poverty (42.5%) with the majority of its inhabitants involved in subsistence agriculture and other activities such as fishing, livestock rearing, small business, trade, and crafts (Institut National de la Statistique et de l’Analyse Economique [INSAE], 2013). Maize, rice, millet, sorghum, cotton, and vegetables are the major crops grown. The municipality of Malanville is the largest rice-producing zone in Benin. Among the rice irrigation schemes developed by the State, the scheme in Malanville is the most important in terms of size, cropping season, and yield per farmer. The scheme covers 516 ha of which 400 ha were used in 2015. Rice is the only crop grown under the scheme with 1,054 farmers in 2015. The irrigated land size per farmer ranges from 0.25 ha to 2 ha.

The survey covered four districts out of the five in the municipality. District selection was based on the criteria of production and distance to the irrigation scheme. In each of the four districts selected, two villages (one high and one low rice-producing village) were purposively selected. A proportional sampling technique was employed to select the irrigators because they were grouped in 20–100 people. Those practicing rainfed farming were selected within the eight villages covered by the survey. Based on the list of rice farmers, provided by the Chief of the village, a random sample of 90 was obtained from each high rice-producing village. Similarly, 45 farmers were selected in each low rice-producing village. In total, 690 rice producers consisting of 150 irrigators and 540 farmers using rainfed techniques were interviewed from April to June, 2015.

Methods of Analysis

This study was built on the expected utility maximization theory. Under the expected utility framework, farmers adopt irrigation only when this could provide them with an expected utility greater than is the case without it. In line with this, farmers’ direct expectation in irrigation participation is the increase in crop yield. The study employed the endogenous switching regression model to achieve an unbiased estimate of irrigation’s impact on rice production per hectare, accounting for possible endogeneity of the adoption decision due to unobserved characteristics of farmers. The endogenous switching model involves separate estimations for subgroups of irrigators and rainfed farmers. Therefore, irrigation adoption becomes the selection criterion indicating the regime faced by the farmers. The irrigation adoption function is defined as:

$$D_i = \alpha Z_i + \mu_i \quad (1)$$

with $i = 1$ for irrigators and 0 for rainfed farmers, $Z_i$ is a vector of farmers and farm characteristics influencing the
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