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Full Length Research Paper

Exploring Farmers' Knowledge Gaps and Their Impact on Demand for Seed and Irrigation Technologies in Nigeria: A Comprehensive Assessment

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In Sub-Sahara African countries like Nigeria where the substitutability of agricultural inputs tend to be low, policies that directly improve access to deficient inputs (“input-specific” policies) may be more effective than other policies that improve access to all inputs but to a lesser extent (“general” policies). This study uniquely assesses how input-specific policies were distinguished from general policies among selected studies on seed and irrigation technologies in Nigeria. Findings indicate that significant knowledge gaps might exist in Nigeria for “input-specific” information and in different ways for each seed and irrigation technologies. Key implications on future research were discussed.

Key words: Nigeria, seed, irrigation, input substitutability, technology adoption.

INTRODUCTION

The adoption of modern agricultural inputs has been considered slow in Sub-Sahara African (SSA) countries including Nigeria. Among others, lack of access to complementary inputs is often one of the constraints (Feder et al., 1985). The lack of complementary inputs, for example irrigation technology for improved seeds or vice versa, can cause low adoption of these inputs if production function is in Leontief shape, in which the production is determined by the minimum level of either inputs used (Leontief, 1941). Such constraint becomes more binding if farmers lack access to efficient markets for various inputs so that surplus inputs can be traded easily with deficient inputs. In Nigeria, the substitutability of inputs, for example between seed and irrigation, is still low. In spite of modern development in breeding nutrient efficient maize varieties, higher yields still depend on adequate water supply (Idinoba et al., 2004). Inputs markets are imperfect with high transaction costs for irrigation pump (Takeshima et al., 2010) and there is lack of timeliness in seed delivery (particularly at the planting time) to farmers (Longtau, 2003; Manyong et al., 2003; Odoemenem and Obinne, 2010; Omonona, 2006; Saka et al., 2005). Majority of farmers in Nigeria are still significantly poor with little access to credit or insurance and their liquidity constraints often limit their ability to best exploit market conditions to purchase needed inputs. Consequently, farmers cannot easily exchange extra improved seed with access to irrigation water, nor vice versa. There seems, however, little distinction of policies that are more effective under the environment where different inputs are less substitutable due to the nature of production technology or the conditions of input markets.

This paper attempts to classify the major policy suggestions and empirical information in Nigeria on the adoption of seed and irrigation technologies into “general policies” and “input specific policies”. Here “input specific policies” directly raise the accessibility of deficient inputs, while “general policies” have more neutral effects on various inputs so that access to both deficient and surplus inputs are raised but lesser extent. As is indicated in this paper, when the production inputs are less substitutable, input specific policies can be relatively more important than general policies. In such case, empirical information can be more useful if it addresses constraints specific to particular inputs instead of constraints generally applicable to many inputs but to lower extent. This paper then assesses the potential research questions that can be useful in raising the adoption of improved seed and irrigation technologies where these technologies are barely substitutable.

SIMPLE CONCEPTUAL FRAMEWORK ON INPUTS SUBSTITUTABILITY AND EFFECTS OF POLICY

Policies for seed and irrigation can reduce the marginal cost or increase the marginal return of each of one unit of seed and irrigation technology. Input-specific policies only affect the cost or return of the corresponding input but not the other inputs. Here briefly illustrates how substitutability between inputs can make the input-specific policy more / less effective than the general policy. Suppose a farmer's production function is $q = f(s(x, y), r(x, z), w)$ where production q is a function of seed quantity s, irrigation investment r, and other factors w. Furthermore s and r are determined by the policies specific to each input (y for seed and z for irrigation) and x that affects both seed and irrigation technology. For convenience, x, y and z are policies that affect farmers' access to s quantity of seed and r quantity of irrigation. We then consider the production functions with three different levels of input substitutability;

Perfectly substitutable: $q = \alpha s(x, y) + \beta r(x, z)$ (1)

Cobb-Douglas: $q = s^{\delta}(x, y)\, r^{\varepsilon}(x, z)$ (2)

Perfect complements (Leontief form): $q = min\ (\lambda s(x, y), \mu r(x, z))$ (3)

In which α, β, δ, ε, λ and μ are all positive scalars. Now we examine the effect of policy x, y and z. Marginal effects of x, y, z on q corresponding to (1) through (3) are then:

(1) $q_x = \alpha s_x + \beta r_x$; $q_y = \alpha s_y$; $q_z = \beta r_z$ (4)

(2) $q_x = q(\delta/s \cdot s_x + \varepsilon/r \cdot r_x)$; $q_y = q(\delta/s \cdot s_y)$; $q_z = q(\varepsilon /r \cdot r_x)$ (5)

(3) If $\lambda s > \mu r$; $q_x = \mu r_x$; $q_y = 0$; $q_z = \mu r_z$; If $\lambda s < \mu r$, $q_x = \lambda s_x$; $q_y = \lambda s_y$; $q_z = 0$ (6)

In which q_x and q_y in (4) are illustrated in the arrows in the isoquant on Figure 1a, while q_x and q_y in (6) are in Figure 1b. Now imagine a situation in which general policy x and input-specific policy y or z yield the same increase in production in (1). That is,

$q_y = q_z = q_x \alpha s_y = \beta r_z = \alpha s_x + \beta r_x$ (7)

In (7), since x is a general policy and therefore s_x, $r_x > 0$. We then have $s_y > s_x$ and $r_z > r_x$. Meanwhile, if $s_y > s_x$ and $r_z > r_x$, from (6), $q_x = \mu r_x < q_z = \mu r_z$ when $\lambda s > \mu r$, and $q_x = \lambda s_x < q_y = \lambda s_y$ when $\lambda s < \mu r$. Thus, even when the general policy x has the same production growth impact as input specific policies y or z under perfect substitutability, x has less impact than y or z under no substitutability. Similarly, if $s_y = s_x$ and $r_z = r_x$, while x has more impact than y or z under perfect substitution production function, x has only the same impact as input-specific policies under Leontief form production function. When inputs are less substitutable, general policy x may be less effective than the input specific policies. The conceptual framework here underscores the importance of distinguishing input specific policies from general policies.

EXAMPLES BY SEED AND IRRIGATION TECHNOLOGIES IN NIGERIA

Here categorizes suggested policies found in seed and irrigation-related empirical studies in Nigeria into general and specific groups and identifies categories with relative knowledge gaps. The studies reviewed are by no means exhaustive, and seed related studies are only on major crops in Nigeria (rice, maize and cowpea). The reviewed studies, however, still represent the major empirical literature discussing characteristics of Nigerian farmers' demand for improved seeds and irrigation technologies.

Framework

Most of the suggested policies for seed and irrigation technologies in the main Nigerian literature are categorized in two steps (Table 1). They are first categorized based on the types of factors, that is agro-ecological, socio-economic, risk, transaction costs and regulatory issues. Possible policies relevant to each category of factors, which include not only those suggested in the studies but also issues that need to be addressed in the studies but have not been done so, are then grouped into general and input-specific categories. Policies described in Table 1 aim to raise the expected return, lower the expected costs of each technology and reduce uncertainty in such return and costs. For example, climatic conditions, soil or topography of plots affects the return of currently grown varieties, potential return from improved varieties, and farmers demand for improved varieties given its difference from current varieties. These factors also affect the rainfall risk, which then affects the potential return from irrigation. Examples of general policies for these factors include developing weather insurance, support for soil amendment practices, or fertilizer applications that raise the return from both seed and irrigation. Meanwhile, seed specific policies include development of appropriate varieties that suit particular climatic conditions or soil conditions, and irrigation specific policies include supporting the research on the

Table 1. Key policy goal relevant to each area (the italic texts show the possible issues or policies that are not analyzed by studies reviewed).

Factors		General (*X*)	Seed (*Y*)	Irrigation (*Z*)
Agro-ecological	Climate	Weather insurance	Development of varieties.	*Rainfall risk and demand for irrigation.*
	Soil	Support for soil amendment. Fertilizer application.		
	Other natural environment (pests, weeds, wild fire)	Training of farmers on appropriate production practice.	Development of variety. *Research on the patterns ofwildfire,forecast system.*	Training of farmers on assessment of water resources. *Easier access to public information of water body (locations, depth of aquifer).*
Socio-economic	Output market	Price support, stabilization. Support to processing facility/storage	Development of varieties. Determinants of variety changes. Encourage subsequent replacement.	*Price of certain crops during the dry season.*
	Own input prices	Support for public institutions/private companies	*Farmers' ability to reproduce seed every production cycle.*	Demand for spare parts *Increasing scale, financial support for initial outlay.*
	Complementary inputs	Labor – training/educations Gender-targeted intervention. Credit.	Improve seed storage facility. *Improved access to chemicals used for seed preservation/storage.*	*Water - farmers' perceptions on costs due to water sharing, water quality (salinity, acidity, nitrogen), water rights, conflict resolution.* Land – ownership, tenure, fragmentation, land transactions; Labor - training on irrigation schedule, mulching organic matter, deep tillage etc. Cheaper fuel.
Risks		*Productivity risk.* *More research on farmers' perceptions of such risks.*	*Loss of stock – wild fire, bush burning, pest, theft, civil conflict.*	Groundwater quality; depletion of aquifer;
		Development of appropriate insurance system.	*Break down of resistance.*	*Break down of equipment (pump etc).*
Transactions costs		Support for disseminating information on better crop management technology.	Information on seed attributes, appropriate seed use.	Impact of transaction costs on the adoption of irrigation technology, identification of factors to reduce such cost. *Information on availability, accessibility and operation of equipments.*
Regulation		Policy principle. Increase capacity to certify, guarantee the quality of seed/irrigation equipments.	*Bettercertification for seed, traders.* *Patent, intellectual property rights.*	Farmers' rights to quality water, conflict resolution etc; regulate water use based on recharge pattern of aquifer.

effects of rainfall risk on farmers' demand for irrigation. Development of appropriate varieties is considered mostly a seed specific policy, because it typically raises the marginal productivity per unit of seeds, but leave the

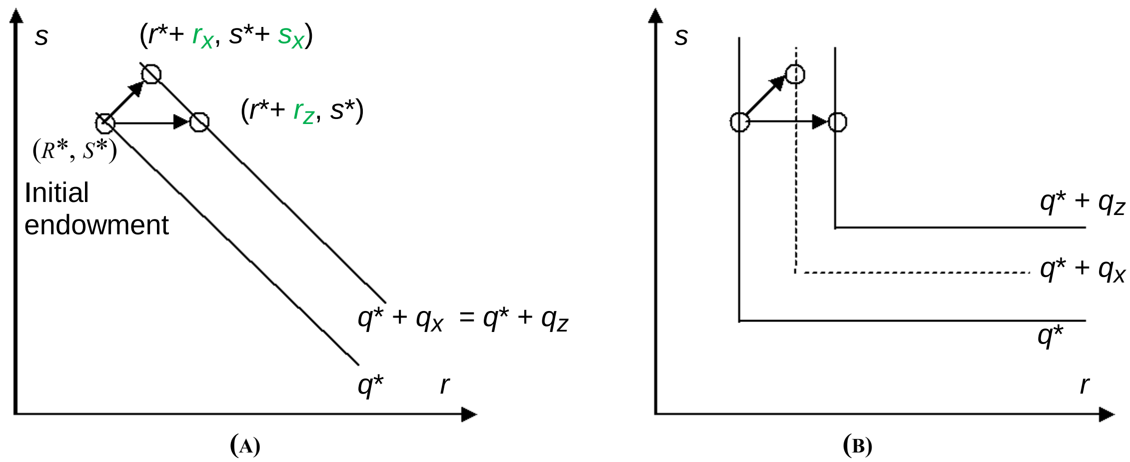

Figure 1a. Effect of general policy and specific policy under high substitutability of inputs. b). Effect of general policy and specific policy under low substitutability of inputs.

marginal productivity of a unit of water relatively unchanged. Policies relevant for other factors are grouped in similar ways in the rest of Table 1. The grouping in Table 1 provides a good framework for us to assess the level of empirical information on general and input-specific policies, in a systematic and comprehensive manner in the face of the complex sets of major factors affecting African farmers' demands for agricultural inputs.

Most importantly, key differences in general policy and input-specific policies conceptualized in Figure 1 become clearer with examples listed in Table 1. Many of the general policies, either development of insurance systems, training of farmers, output price support, increased supply of other complementary inputs, may have limited impacts on the productivity growth if substitutability between seed and irrigation is low. In such case, input-specific policies that more directly affect the cost and return of these technologies become important.

SUMMARY OF LITERATURE

Two important findings are discussed. First, there are categories where the empirical studies are relatively scarce for seed compared to irrigation technologies, or vice versa. Such categories constitute important knowledge gaps and often ignored if only general policies are sought but input-specific are not. Secondly, when two inputs are looked at separately, general policies are often suggested without distinction from input-specific policies. It becomes more difficult for policy makers to tell which policies may be more effective in environment with different substitutability of inputs. Regarding the first issue, seed specific policies and empirical information are relatively abundant in certain categories in Nigeria. Development of appropriate varieties, which is relatively more seed specific, is suggested by many studies across various categories (Akande, 2007; Dalton, 2004; Ekeleme et al., 2009; Kormawa et al., 2002; Lawal et al., 2005; Manyong et al., 2000; National Agricultural Seed Council of Nigeria, personal communication; Saka et al., 2005). Some studies have focused on improving the seed storage facility (Adejumo and Raji, 2007). These are relatively specific to seed as farmers often save seed for use in the next planting season. The transactions costs associated with diffusion of new varieties are also widely discussed (Sabo and Zira, 2009; Horna et al., 2007; Saka et al., 2005; Oladele and Somorin, 2008). For irrigation, few studies in Nigeria have addressed the issues that are counterpart to aforementioned issues with relatively abundant seed-specific policy suggestions. For example, few studies ask irrigation specific agro-ecological questions such as the impact of rainfall risks on demand for irrigation, farmers' knowledge of water body and the impact of such information.

Similarly, only a few studies asked potentially irrigation specific questions regarding transaction costs (Takeshima et al., 2010). Conversely, irrigation specific policies or empirical information are relatively abundant in the category of own input prices (Kimmage, 1991; Orubu, 2006). The importance of land tenure system is commonly raised (Etkin, 2002; Fu et al., 2010; Oramah, 1996). The importance of training farmers for appropriate irrigation system is also emphasized (Graham et al., 2006; Ogunjimi and Adekalu, 2002; Ramalan and Nwokeocha, 2000). Risks associated with quality of ground water (Ibe and Agbamu, 1999; Lynch et al., 2001; Mashi and Alhassan, 2007) depletion of aquifer (Kay, 2001) are often discussed. The importance of proper regulation and enforcement has also been suggested (Acharya, 2004; Goes, 1999; Orubu, 2006; Tarhule and Woo, 1997). Few counterpart questions, however, have been addressed and policies suggested for seed in Nigeria. Few studies discuss the link between seed price and seed demand considering farmers' ability to reproduce seed, or the effect of public sector participation in the production costs of self-pollinating crops which tend to be recycled over several production seasons. The effect of various risks (wild fire, bush burning, pests and civil strife) on seed demand has rarely been studied in Nigeria. In addition, the questions associated with regulation, such as farmers' preferences on certain seed sources due to lack of certification, or the effect of patent and intellectual property rights on seed variety development, have rarely been estimated empirically. Secondly, as was mentioned above, general policies are often suggested without distinction from input-specific policies.

Various studies in Nigeria suggested relatively general policies. They include improved availability of other complimentary inputs including fertilizer (Effiong and Ibia, 2009; Kebbeh et al., 2003; Kormawa et al., 2002; Oyekale and Idjesa, 2009), agro-chemicals (Kormawa et al., 2002; Pasquini et al., 2004), or credit (Kebbeh et al., 2003; Kormawa et al., 2002). Many studies emphasize the support for training on improved use of inputs (Adekalu et al., 2009; Alene and Manyong, 2006; Alene and Manyong, 2007; Graham et al., 2006; Idinoba et al., 2004; Okunade, 2007; Oyekale and Idjesa, 2009; Sabo and Zira, 2009; Saka et al., 2005). Supports are also emphasized for gender-targeted support (Adeoti, 2006), general public support for private companies (Adejobi et al., 2005), or information dissemination of better crop managemnt (Alene and Manyong, 2006; Coulibaly et al., 2008). Many of these studies, however, neither provide more seed or irrigation specific policies, nor clearly distinguish general policies from specific policies which can be important depending on the substitutability of the seed and irrigation technologies.

DISCUSSION AND CONCLUSIONS

Two key research implications are drawn from the findings earlier, which can guide an important direction for future empirical research analyzing SSA farmers' demand for modern agricultural inputs. First, the findings suggest that, when empirical studies focus on just one of either seed or irrigation technologies but not both of them, many issues that are supposed to be common to both inputs are actually studied for only one of the inputs. For example, in Table 1, while climatic conditions and soil conditions can be important agro-ecological factors that can affect the demand for both inputs, these conditions are addressed only in seed related studies in Nigeria. By comparing two inputs in the same framework as in Table 1, questions unasked for particular inputs while they should be conceptually relevant are identified. Such "unasked but should be asked" questions actually constitutes large portion of knowledge gaps. Categories of issues addressed and studied are quite different between seed and irrigation technologies in Nigeria, while not much discussion has been made about why there are such differences. For example while some areas can be considered irrelevant to certain inputs, very few empirical studies actually point that out. Secondly, input-specific issues can be visible only when comparing the particular input to the other inputs. More efforts are needed in focusing on such input-specific issues when analyzing farmers' demand for certain agricultural inputs.

Examples of such input-specific characteristics include reproducibility, recyclability, and susceptibility to various natural and man-made risks other than rainfall, scale neutrality, which are currently often ignored in the empirical studies in Nigeria. Challenges in focusing on the input-specific characteristics of particular inputs can be in one way overcome by putting more efforts in analyzing multiple inputs at the same time with the aim of comparing the differences across these inputs. Overall, the issues discussed in this paper reflect the important challenges faced by the research on technology adoptions by African farmers, and possibly with the designing of appropriate policies. This paper presented an example which indicates that, input specific constraints need to be identified appropriately by not only analyzing the input itself but also by using frameworks that analyze similar issues for complementary inputs. Such needs call for not only more support for empirical research but also more dialogue between research communities focusing on different inputs, such as seeds and irrigation that are currently relatively separated not only among the domestic research communities in SSA countries but also at the international level.

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