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Empowerment and Agricultural Production

Evidence from Rural Households in Niger

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ABSTRACT

Niger is a landlocked Sahelian country, two-thirds of which is in the Sahara desert, with only one-eighth of the land considered arable. Nevertheless, more than 90 percent of Niger's labor force is employed in agriculture, which is predominantly subsistence oriented. Since the great famines of the 1970s and 1980s, the country has pursued agrarian intensification through technological change to address challenges to the food security situation. However, this approach has failed to recognize that the main characteristic of the Sahelian part of West Africa is the intricate complexity of the social, environmental, and economic dimensions that differentially affect male and female rural dwellers. One example is the patrilineal tenure system, which under increased population pressure has led to the exclusion of women and youth from agriculture in some areas. The Women's Empowerment in Agriculture Index (WEAI) indicates that access to land is one important dimension of empowerment. In order to assess the role of empowerment in agricultural production, we use new household- and individual-level WEAI data from Niger and regression analysis. Our results show that empowerment is important for agricultural production and that households in which adult individuals are more empowered are more productive. This means that other and possibly more effective pathways to agrarian intensification exist and important agricultural productivity gains could be made by empowering men and women in rural households.

Keywords: smallholders, empowerment, West Africa, regression analysis, gender

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1. INTRODUCTION

Niger is a landlocked Sahelian country covering an area of 1.27 million square kilometers, of which two-thirds are located in the Saharan zone. The Nigerien population, which stood at 19 million in 2014, combines the highest fertility rate in the world and the lowest human development index with one of the lowest levels of income per capita (World Bank 2015). Since the great famines of the 1970s and 1980s, challenges to the food security situation in the Sahel have been at the heart of research to develop policies on agriculture. The international attention devoted to famine and food shortages in Niger has culminated in a call for agricultural change involving Green Revolution plant varieties, chemical fertilizer, irrigation, mechanized equipment, and fossil fuel energy (Stone, Netting, and Stone 1990). However, this approach to agrarian intensification is rather technology focused, and the related research appears to be characterized by overused shortcuts and simplifications describing this rapidly evolving environment. In reality, the main characteristic of the Sahelian part of West Africa is the intricate complexity of the social, environmental, and economic dimensions that differentially affect rural populations. Though this can be said of many rural societies around the world, in the Sahel this complexity is enhanced by the harsh environmental conditions and by the important effects that social relationships have on the evolution of farming systems (Saqalli et al. 2011).

For the Sahelian rural population, the village (combined with its terroir) and the household are still the most important levels for the management of economic activities (Saqalli et al. 2011). The household can be considered as an institution that connects relatives through links of permanent mutual responsibility and in which an obedience/insubordination dialectic may occur between members and the head. In the household, roles and functions are thus under the control of a head, though this control may vary across households. It is considered as a strong norm that men should be the farm managers, using their dependents as labor, and although women could play a critical and potentially transformative role in agricultural and rural-sector growth, they face persistent obstacles and economic constraints that limit further inclusion in agriculture and rural development. Women are thought to be especially constrained beyond the cultivation of subsistence crops, such as sorghum and millet, in cash crops and other activities such as livestock rearing. Lack of access to extension, financial services, credit, and infrastructure impede their innovation in developing enterprises as well as their participation in modern value chains and trade. Understanding and addressing social-based constraints such as limited empowerment of women in agriculture and the behavior emanating from these constraints (Saqalli et al. 2011) could thus be another pathway to achieving agrarian intensification.

In this paper, we use new household- and individual-level data from Niger and regression analysis to assess the role of empowerment in agricultural production. Our results reveal that a linear variable coefficient model wherein human capital variables interact linearly with traditional inputs best describes our data. We find that empowerment can be considered as technology changing, significantly affecting slope coefficients and the intercept of a Cobb-Douglas production function. In particular, empowerment is found to positively affect the productivity of labor and equipment. Our results indicate that it is inappropriate to derive policy implications from evaluating the effects of human capital in agricultural production at the mean. In fact, differentiating households by their status as dual or as primarily female- or male-headed reveals that the productivity elasticity of empowerment is much larger for dual households, in which women are the least empowered.

2. BACKGROUND

More than 90 percent of Niger's labor force is employed in agriculture, which is predominantly subsistence oriented. Two-thirds of the country is in the Sahara desert and only one-eighth of the land is considered arable. Pastoralism is the main activity in the Sahelian zone south of the Sahara, while mixed farming systems with livestock keeping dominate in the higher-rainfall Sahelo-Sudanian and Sudanian zones in the south (Pender et al. 2008). In fact, livestock (cattle and smaller ruminants) constitutes one of the key foraging/manuring components for the sustainability of these systems (La Rovere et al. 2005). Millet is the most important food crop, occupying nearly half of the total harvested area in the country. However, most smallholders fail to produce enough food to meet household requirements. Economically, there is a strong correlation between changes in gross domestic product and the meteorological situation, demonstrating the extreme fragility of the economy and particularly the agricultural sector. This weakness, combined with the structural deficit in agricultural production to meet the needs of a fast-growing population generates an almost permanent situation of food insecurity (World Bank 2015). Male members of rural households tend to engage in seasonal migration to reduce consumption pressure on the millet stock, leaving more food for those who stay home, and to earn supplementary income. It has been estimated that more than 1 million men migrate each year (Guenguant, Banoin, and Quesnel 2002; Mounkaïla 2003). Most migrate each dry season, from October to May, to try to find work in the main employment and business centers of the countries bordering the gulf of Guinea, usually in small trade, tea selling, and other small-scale commercial activities (Reardon 1994; Timera 2001; Mounkaïla 2003).

Organization of Agricultural Production

Farming systems in the Maggia fossil valley of Birni N'Konni can be largely characterized as extensive agropastoral millet and legume based with gardening. The main cereals cultivated are pearl millet (Pennisetum glaucum L. Br.) and sorghum (Sorghum bicolor L. Moench), both often intercropped with cowpeas, a legume (Vigna unguiculata L. Walp). Agriculture tends to be managed in an extensive and risk-averse approach. Given the very low inherent soil fertility and the high spatial and temporal intra-annual and interannual rainfall variability, farmers tend to clear and sow more surface than they can manage and harvest for food security and tenure purposes. Parcels are scattered in the terroir, with varying distance to the village and varying soil quality. This spatial dispersion of fields is thought to help mitigate the effects of the rainfall spatial variability on crop yield (Loireau-Delabre 1998; Abdoulaye 2002). All cereals are sown after the first rains, in May or June. The main labor peak occurs during weeding in July. The main part of the cereals are harvested in September-October, but some short-cycle varieties, which require more labor and better soils, can be harvested in August (Saqalli et al. 2011).

Haoussa farm villages, such as the ones under study here, are built up around a core family group composed of agnatic kinfolk. The fundamental unit of residence, production, distribution, transmission, and reproduction is the *gida*. At a mature stage of the domestic cycle, the *gida* is a patrilocal multiple-family household of at least two generations' depth and comprising the conjugal family units (*iyali*) of the household head (*mai gida*) and his married sons and their children. Some wealthier *gida* include farm slaves (Netting, Wilk, and Arnould 1984). The *gida* is essentially a family farming unit, distinguished from other units by usufructary rights of tenure to dune and marsh lands, control of its own granary, and disposition of the labor power of its active members. The household head partitions the land into *gandu* (collective) and *gamana* (individual) parcels. Traditionally, men and women would work together on the *gandu* parcels while youth and wives would also work on their *gamana* plots about a day a week. The household head would store output from collective parcels and was obliged to use this stock for feeding and dressing household members, paying taxes, and defraying ceremonial expenses of the household (Netting, Wilk, and Arnould 1984). Individuals and younger conjugal members would feed themselves during the dry season using the output of their *gamana* plots. Women and younger members of relatively affluent households could also gain access to land by renting or purchasing plots. In the traditional setting, small households could overcome temporary or seasonal bottlenecks by calling in young men in the village to participate in a labor party (*gayya*), a form of interhousehold labor exchange. Upon the death of the head (or internal dispute), inheriting sons would not immediately divide the land but would continue to work together, with the eldest son assuming the role of *mai gida*. Eventually the patrimony would be divided into smaller family units among older brothers, and the younger brothers would have to clear new bush land when available. Increased population pressure and the resulting farm fragmentation in parts of Niger are posing important challenges to this traditional system of land allocation, and have caused *gandu* parcels to become increasingly smaller and household heads to begin cultivating the *gamana* land.

Empowerment in Rural Households

Empowerment has been defined as the expansion of people's ability to make strategic life choices, particularly in contexts where this ability had been denied to them (Kabeer 2001). In defining empowerment in agriculture, it is important to consider the ability to make decisions as well as access to the material and social resources needed to carry out those decisions (Alkire et al. 2013). An important contributor to empowerment in agriculture is thought to be a certain level of tenure security (Banerjee, Gertler and Ghatak 2002). In Niger, as discussed above, while customary law certainly prevents women and younger men from owning land and denies them the freedom to transfer it to their heirs (male or female), the traditional system of land allocation was relatively equitable insofar as it guaranteed women and youth access to land through the *gamana*. As long as this enabled them to produce "enough," they did not want any land from their family of origin and did not get involved in land inheritance claims. However, increased population pressure and increased farm fragmentation have led to progressive loss of the *gamana* for women and younger male household members, and a resulting reduction in their control over agricultural production. This reduction or, in some cases, complete loss of control is said to mark the beginning of the exclusion of women and youth from access to land (Diarra and Monimart 2006). Progressive loss of the *gamana* in areas of high pressure on land has led to a situation in which the distribution of inherited land is being contested and challenged on the basis of Koranic law. It has been argued for some parts of Niger that a generation of women has arisen who do not work the land, and that these women are particularly vulnerable and effectively excluded from all agriculture work. For these places, it seems that there is a defeminization of agriculture (Diarra and Monimart 2006). This suggestion is in line with recent findings of Palacios-Lopez, Christiaensen, and Kilic (2015) that the contribution of women to labor in agriculture in Niger is comparatively low, at only about 24 percent.

Empowerment and Agricultural Production

A growing body of empirical evidence suggests that increased empowerment could have positive effects on a number of important development outcomes, such as household agricultural productivity, food security, and nutrition security. Banerjee, Gertler, and Ghatak (2002) have shown that increased security of tenure has positive productivity impacts for rural households in West Bengal. For Côte d'Ivoire, Hoddinott and Haddad (1995) and Duflo and Udry (2004) found that increasing women's share of cash income significantly increases the share of the household budget allocated to food. Doss (2006) showed that in Ghana, increasing women's share of assets, particularly farmland, significantly increases budget shares on food expenditure. More recently, Sraboni and others (2014) examined the relationship between women's empowerment in agriculture and per capita calorie availability, dietary diversity, and adult body mass index for rural households in Bangladesh. Taking into account the potential endogeneity of empowerment, they found that increases in women's empowerment are positively associated with calorie availability and dietary diversity at the household level.

Here, we focus on the productive effects of improvements in general household-level empowerment. We take a slightly different approach from that of the studies above and treat empowerment as a human capital variable. *Human capital* refers to any aspect of a person that produces economic value and from which one cannot be separated the way one can be from physical or financial assets (Becker 1975). Human capital thus includes personal attributes such as health, nutrition status, knowledge, and skills. Ever since Schultz's (1961) seminal article, investments in human capital have been widely viewed as making a substantial contribution to economic growth, and studies at the microeconomic level have confirmed that human capital variables affect agricultural production (Croppenstedt and Muller 2000; Wouterse 2015), but to our knowledge there are no studies that measure and analyze the role of empowerment in smallholder production.

3. EMPIRICAL STRATEGY

In the field of microeconomics, studies have tended to assess the role of human capital in agriculture at the farm household level by estimating a stochastic frontier or production function with selected human capital indicators entering linearly and allowed to neutrally shift the production function (Croppenstedt and Muller 2000) while keeping coefficients on traditional inputs—land, labor, and capital—constant. However, the assumption of constant coefficients for traditional inputs in the presence of household-level variation in human capital variables may not be realistic. The macroeconomic literature has posited certain so-called environmental or contextual variables that not only affect the location of an economy on a given production function but also determine the choice of the implemented technique (Mundlak, Cavallo, and Domenech 1989; Fulginitti and Perrin 1993). This idea has been translated to the microeconomic level by Strauss (1986), for example, who allowed for a variable coefficient on labor in his study on nutrition and labor productivity in Sierra Leone. It could, however, still be considered restrictive to allow the human capital indicator to interact only with labor. A recent study in Burkina Faso has posited a farm household–level production function for which coefficients are variable and determined by human capital indicators (Wouterse 2015). In this log-linear, variable-coefficient specification, human capital variables—in this case, weight for height, formal education, and age of adult household members—were allowed to linearly affect productivity through interactions with all traditional input variables and production technologies, and returns on scale were not restricted to be the same across households. Results revealed that weight for height enhanced returns on land, and formal education enhanced the productivity of male labor.

Here we take a similar approach to assessing the role of empowerment in agricultural production. We initially posit the log-linear version of a constant-coefficient augmented Cobb-Douglas agricultural production function at the farm household level:

$$y = \alpha_0 + \sum_k z_k \alpha_k + \sum_i x_i \beta_i + u. \tag{1}$$

In (1), a farm household transforms inputs x_i—land, labor, fertilizer, and equipment expressed in logs—into the log of output, y—the aggregate of the quantity harvested of each crop. Land is measured at the household level by aggregating individual plot sizes. Rural Niger is characterized by a missing market for land, with rights largely assigned on a hereditary basis along patrilineal lines. Land size thus cannot be adjusted in the short run and may be considered as exogenous to the production process. Labor input is measured in days. Because paid hired labor is hardly used, this variable concerns only household members. Both labor and fertilizer are adjustable in the short run and therefore likely to be endogenous with production. Equipment comprises the current value of traction animals and all agricultural equipment—mainly plows and carts—to which we applied an annual depreciation rate of 10 percent. The value of equipment is assumed to be fixed in the short run.

In (1), z_k indicates human capital variables specific to the household—empowerment and formal education expressed in logs—that are included as additional factors of production and allowed to neutrally shift this function while all other coefficients are constant. Education is measured as the highest level of formal schooling received by an adult household member, in years, and empowerment is measured as the sum of the weighted inadequacy scores for the various indicators (excluding credit) averaged at the household level. Because empowerment and traditional variable inputs—labor and fertilizer—may be determined simultaneously with output, we use instrumental variables to identify our production function.

We subsequently formulate a linear variable coefficient model as proposed for human capital variables at the microeconomic level by Wouterse (2015):

$$y = \alpha_0 + \sum_k \alpha_k z_k + \sum_i x_i \beta_i + \sum_i \sum_k \beta_{ik} x_i z_k + \sum_i x_i u_i + u. \tag{2}$$

In (2), the βs represent variable output elasticities for each of the traditional input variables. Human capital variables determine these elasticities and thus affect the slope of the production function while also (still) neutrally shifting the intercept. Having estimated the two models described above, we assess the validity of their specification and assess the status of empowerment and education as technology-changing variables. We subsequently calculate production and productivity elasticities, where the latter are defined as in Fulginiti and Perrin (1993):

$$\frac{\partial y}{\partial z_k} = \sum_i \beta_{ik} x_i + \alpha_k. \qquad (3)$$

The effect of empowerment (and education) on agricultural productivity is thus summarized by (3).

4. DATA AND STUDY AREA

Data to estimate the various versions of the agricultural production function set out above were collected by the author during April–May 2015 for 500 randomly sampled households (and 769 adult individuals in these households) in 35 villages situated in three communes (Doguéraoua, Malbaza, and Tsernaoua) in the Maggia valley of the Birni N'Konni department in the Tahoua region. Birni N'Konni is situated in the southern part of the country and belongs to the Sahelo-Sudanese environment, which allows for rainfed agriculture. Individual-level data were collected using the Women's Empowerment in Agriculture Index (WEAI) survey tool (Alkire et al. 2012), and household-level data were collected using a standard agricultural household survey. The WEAI survey tool collects data from the primary male and female members of a household on five domains that are thought to make up empowerment: (1) decisions about agricultural production, (2) access to and decision making power about productive resources, (3) control of use of income, (4) leadership in the community, and (5) time allocation.

Households in our sample count 6.0 members on average, which is slightly below the national average in rural areas of 6.6 as recorded in *l'Enquete Nationale sur les Conditions de Vie: Des Ménages et l'Agriculture au Niger* (ECVMA) in 2011. This slightly smaller household size recorded in our data may be due to our perhaps more stringent definition of household members as those who fell under the care of the household head in terms of nutrition for more than three months during the past year. Polygamy is not very common, with about one-fifth of household heads in a polygamous marriage. Households are almost all of the Muslim faith and of Haoussa ethnicity, although there are also a few villages that contain more Touaregs. The main activity of sampled households is agriculture, in particular millet cultivation (often intercropped with sorghum or cowpeas) on plots of land that are cultivated under a system of customary land tenure, with plots managed by either the extended family or an individual. Households cultivate almost 6 hectares of land on average, subdivided into a few plots. Dry-season vegetable gardening is practiced only in places where wells, marshes, and valleys give access to shallow groundwater in thalweg fields.[1] In the Haoussa areas, men have been found to usually be garden managers (Saqalli et al. 2011). Onions and, to a lesser extent, tomatoes are cultivated in the off season in thalweg fields. Most households also hold some livestock, usually goats. For livestock, although the ownership distribution of such animals is said to be more "democratic"—that is, women and young men do own goats and sheep—the purchase of cattle is still unofficially restricted to men (Saqalli et al. 2011). Participation in the "exode" is a common activity, but only accessible to men, with one-fifth of households in our sample containing at least one migrant.

In terms of household types, about half of the sampled households contain both an adult male and an adult female, and slightly fewer than one-third contain only a female adult. In many cases these are households in which the male head of household has passed away. As a result of polygamy and large age gaps at marriage, far more women than men experience the death of a spouse at some point in their lives, frequently at a young age (Van de Walle 2013). Interestingly, there is a sizeable group of about 100 households that contain only an adult male. Upon closer inspection, a majority of adult males in these households are married, but quite a few households of this type are made up of unmarried men. In the former, the spouse may have been absent for a longer period at the time of the survey (enumerators did return after three days in case one respondent was absent), perhaps visiting relatives rather than having migrated, because participation in the "exode" is rare for women.

Table 4.1 depicts a breakdown of production variables by household type.

[1] The *thalweg* is the line of lowest elevation within a valley or watercourse.

Table 4.1 Household descriptive statistics

Variable	Dual (*N* = 271)	t-test[b]	Adult female only (*N* = 117)	t-test[c]	Adult male only (*N* = 92)	t-test[d]
Output (kg)	2,017.84	2.08	821.07	-1.27	1,290.72	1.11
	(6,033.30)[a]		(2,338.82)		(2,991.67)	
Output/ha	380.45	1.08	249.75	-0.51	320.72	0.46
	(1,004.87)		(923.61)		(827.46)	
Labor (days)	136.77	1.60	108.65	0.12	106.39	1.64
	(165.77)		(144.14)		(111.17)	
Fertilizer (kg)	43.61	1.84	22.46	-0.63	31.69	0.94
	(104.38)		(102.29)		(109.01)	
Land (ha)	6.77	3.09	3.92	-2.23	5.72	1.03
	(9.22)		(5.85)		(5.67)	
Equipment (FCFA)	125,618	3.99	48,902	-3.60	125,868	-0.01
	(193,246)		(116,899)		(190,453)	

Source: Author's survey
Notes: FCFA = CFA francs. [a] Standard deviation in parentheses. [b] Dual versus primary female households. [c] Primary female versus primary male households. [d] Primary male versus dual households.

From Table 4.1, we see that households containing only an adult female dispose of about half of the land available for cultivation, compared with dual households. We also see that these households are significantly less well-endowed in terms of equipment, which includes animals for traction. Not surprisingly, labor input is significantly lower for both types of primary households, which tend to be somewhat smaller at least in terms of the number of adults they contain.

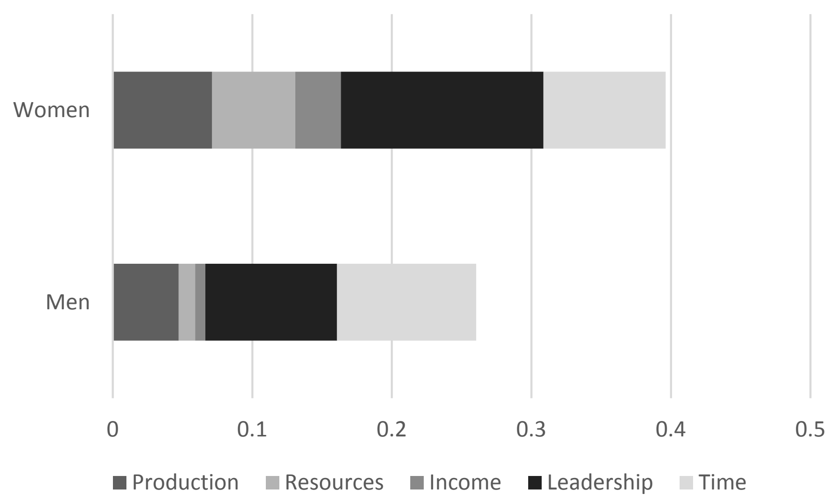
Table 4.2 shows unweighted scores for the various empowerment domains, where a value of 1 indicates complete inadequacy and a value of zero indicates complete adequacy in a domain. Female adults in households where male adults are also present are much less adequate in all domains compared with their male counterparts in the same household. Interestingly, these female adults are also more inadequate compared with their female counterparts in households where no male adults are present. Females in dual households are particularly inadequate in input on production decisions, asset ownership and input into asset decisions, and control over use of income. Females in adult female–only households are less adequately empowered compared with males in input on production decisions, control over use of income, and speaking in public, but are more adequate in autonomy. Females in both types of households are less adequate than men in the leadership domain due to their being rather uncomfortable speaking in public. Figure 4.1 shows the weighted contributions of the various domains to empowerment. We see that women are less empowered because they score particularly poorly in the leadership, resources, and income domains.

Table 4.2 Inadequacy scores by household type (unweighted)

Variable	Dual households		Adult female only	Adult male only
	Male	Female	Female	Male
Production				
Input on production decisions	0.00 (0.04)	0.77 (0.42)	0.26 (0.44)	0.01 (0.10)
Autonomy	0.50 (0.50)	0.42 (0.49)	0.34 (0.48)	0.42 (0.50)
Resources				
Asset ownership	0.26 (0.44)	0.62 (0.49)	0.33 (0.47)	0.17 (0.38)
Input on asset decisions	0.33 (0.47)	0.69 (0.46)	0.39 (0.49)	0.30 (0.46)
Income				
Control over use of income	0.06 (0.23)	0.71 (0.45)	0.25 (0.43)	0.01 (0.10)
Leadership				
Group membership	0.68 (0.47)	0.79 (0.41)	0.75 (0.43)	0.67 (0.47)
Speaking in public	0.27 (0.45)	0.69 (0.46)	0.67 (0.47)	0.16 (0.37)
Time				
Workload	0.11 (0.32)	0.23 (0.42)	0.15 (0.36)	0.04 (0.21)
Leisure	0.06 (0.24)	0.07 (0.25)	0.09 (0.29)	0.14 (0.35)
Empowerment	0.68 (0.16)	0.42 (0.17)	0.60 (0.14)	0.73 (0.10)

Source: Author's survey.

Figure 4.1 Contributors to inadequacy in empowerment



Source: Author's survey.

To calculate empowerment, we take 1 minus the sum of the inadequacy scores, which are weighted in such a way that each domain contributes one-fifth to overall empowerment.[2] Empowerment scores are given at the bottom of Table 4.2 and show that men in adult male–only households are the most adequate in terms of empowerment, closely followed by the adult male in a dual household. Women in dual households are the least empowered and are also much less empowered compared with their counterparts in adult female–only households. It should be noted that average empowerment in these dual households is actually lower than in the two other household types.

[2] We calculate empowerment as 1 minus the weighted sum of the inadequacy scores for the various indicators; the official WEAI also includes the degree of disempowerment for inadequate individuals and a gender parity index, which can only be calculated for dual households (Alkire et al. 2013).

In terms of education, our second human capital variable, according to our data the most highly educated adult member of the average household had received about two and a half years of formal schooling, with females having received significantly less than this. In Table 4.3, we report raw correlations between the average weighted adequacy in empowerment and both the level of formal education and the log of output. We see that both human capital indicators are significantly correlated with agricultural output and have the expected sign. It should also be noted that there is no significant correlation between education and empowerment.

Table 4.3 Raw correlations

Variable	All households	
	Ln output	Ln empowerment
Ln empowerment	0.13**	1.00
Ln formal education	0.10*	-0.02

Source: Author's survey.
Notes: *** significance at 1%, ** significance at 5%, * significance at 10%.

5. ESTIMATION STRATEGY

Identification

There are several difficulties with discerning causal links between empowerment and agricultural production in a regression framework. Empowerment is likely to be endogenous to the production process due to simultaneous effects. Though it may be intuitively appealing to believe that more empowered individuals are more productive, the direction of causality between empowerment and productivity is difficult to establish (Schultz 2003). Increased empowerment could lead to increased productivity, but it is equally possible that increased productivity leads to higher incomes, thereby improving an individual's status of empowerment (Garcia and Kennedy 1994).

Formal schooling of the most highly educated adult could also be endogenous with agricultural output due to simultaneous effects, although this source of bias is likely to be fairly small because the educational attainment of an adult has most likely taken place sometime in the past. In addition to the possible endogeneity of one of our human capital indicators, use of variable inputs such as labor and fertilizer is likely to be endogenous to the agricultural production process—that is, simultaneous effects may arise in which input quantities are adjusted in years of good rainfall.

To obtain consistent estimates in the presence of endogeneity, one may use instrumental variable methods in which the instruments are sufficiently correlated with the endogenous variables but strictly not correlated with agricultural output. To statistically control for potential endogeneity bias when estimating the relationship of morbidity, labor input, and fertilizer use with agricultural production, we postulate that empowerment, labor, and fertilizer use can be explained by household characteristics and village-level environmental variables. At the household level, we capture labor availability and empowerment through household composition variables, which are likely to affect asset ownership and decision making, and we capture labor and fertilizer demand through the number of plots the household cultivates. We also include time to nearest paved road from the homestead in minutes, and time to reach the nearest potable water source, which includes waiting time at the source. Increased time involved in water collection is likely to affect empowerment through adding to time poverty. Increased time to the nearest paved road could imply an increased burden when carrying out various household tasks. It could also indicate how isolated a household is, which may affect the way decisions are made within the household, although the nature of this relationship remains to be determined. At the village level, we also include the number of months per year the village is accessible by road, which may proxy for the availability of inputs in the village and also for isolation. We also include a dummy that takes the value of 1 if the village is affected by transhumance—long-distance herding activities. In these villages, herders exchange animal manure for grazing rights and milk for grain. Farmers may even have their livestock tended by these herders. Long-distance herding activities in the villages are expected to, among other things, reduce the need for labor for fertilization. Descriptives of our instrumental variables are given in Table 5.1.

Table 5.1 Excluded instruments

Variable	Mean	Standard deviation	Minimum	Maximum
Household level				
Number of plots	2.29	1.22	1	7
Number of adults (ages 15+)	2.67	1.38	1	12
Share of prime-age adults (19–40)	0.28	0.21	0	1
Time to paved road (minutes)	59.74	84.50	0	540
Time to nearest potable water source (minutes)	46.37	52.67	0	400
Village level				
Number of months village is accessible	3.97	2.91	0	9
Village affected by transhumance	0.93	0.25	0	1

Source: Author's survey.

As mentioned, an instrumental variable must satisfy two requirements: it must be both correlated with the included endogenous variable and orthogonal to the error process (Baum, Schaffer, and Stillman 2003). We test the former condition—relevance—by examining the fit of the first-stage regressions. The relevant test statistics here relate to the explanatory power of the excluded instruments in these regressions. We report the R-squared of the first-stage regression with the included instruments partialed out. This may also be expressed as the F-test of the joint significance of the excluded instruments in the first-stage regression. Following Baum, Schaffer, and Stillman (2007), we report the Kleibergen-Paap rk Wald F-statistic and the Stock-Yogo critical values to further test for weak instruments. For models with a single endogenous variable, these indicators are considered to be sufficiently informative. While existing only for independently and identically distributed (IID) error models, these statistics may still indicate weak instrument issues in non-IID cases (Baum, Schaffer, and Stillman 2007).

For the latter condition—validity—to hold, excluded instruments need to be orthogonal to the error in the second-stage regression. If we have more excluded instruments than included endogenous regressors, we can test whether our instruments are uncorrelated with the error process. For this test, the residuals from a two-stage least-squares regression are regressed on all exogenous variables: both included exogenous regressors and excluded instruments. Under the null hypothesis that all instruments are uncorrelated with the error, a Lagrange multiplier statistic of the $N \cdot R^2$ form has a large sample χ^2 (r) distribution, where *r* is the number of overidentifying restrictions or excess instruments. Rejection of the null hypothesis would cast doubt on our instrument set. We report the Hansen J-statistic and the associated p-value, which is the generalized method of moments equivalent of the Sargan test described above and robust to possible heteroskedasticity.

Turning to an instrumental variable (IV) estimation for the sake of consistency must be balanced against the inevitable loss of efficiency (Wooldridge 2003). This loss of efficiency can be justified only if the ordinary least squares (OLS) estimator is biased and inconsistent. We report the p-value of the Durbin version of the Durbin-Wu-Hausman test for endogeneity, which involves estimating our regressions via both OLS and IV approaches, and comparing the resulting coefficient vectors. Results are best interpreted not as a test for the endogeneity or exogeneity of regressors per se, but rather as a test of the consequence of employing different estimation methods on the same equation (Baum, Schaffer, and Stillman 2003).

When using predicted variables as regressors in second-stage parametric regressions, the reported standard errors are not valid because they do not take into consideration that the endogenous regressors have been estimated in the first stage (Wooldridge 2003; Baltagi 2002). We apply the method suggested by Murphy and Topel (2002) to calculate asymptotically correct standard errors (Baum 2006).

6. FINDINGS

First-stage regression results for fertilizer use, labor supply, and empowerment are given in Table A.1 in the appendix. Our various instruments are significant and have the expected sign. At the bottom of the table, we report the results of two tests for relevance and validity. If we apply the rule of thumb that for a single endogenous regressor a Kleibergen-Paap rk Wald F-statistic below 10 is cause for concern (Staiger and Stock 1997), we can confirm that our instrument set is appropriate. Using Stock-Yogo weak identification test critical values, we are able to reject weak identification more or less at 15 percent maximal IV relative bias. The p-value associated with the Hansen J-statistic is 0.46, indicating that we cannot reject the hypothesis that our instruments are orthogonal to the error in the second-stage equation.

Table 6.1 reports estimation results for the various specifications of the production function. Column (b) gives the IV estimation results of the augmented Cobb-Douglas production function instrumenting for fertilizer use, labor supply, and empowerment. We find that empowerment positively and significantly affects the quantity of agricultural output. In fact, an increase of 1 percent in average empowerment would increase the quantity of output by almost 1.5 percent. It is also important to note that formal education of the most highly educated adult in the household does not contribute to agricultural output and even has a negative sign. Although when returns on schooling in African agriculture are considered they are often assumed to exist, estimates of the returns from schooling in rural economies range widely from highly positive to negative (Taylor and Yunez-Naude 2000) and existing evidence on the impact of education on agricultural productivity in Africa is mixed (Appleton and Balihuta 1996). One reason for this variation may be that participation in formal education is low, particularly for older household members, making it difficult to collect sufficient observations to decipher any meaningful relationship between education and agricultural production. The second reason may be that formal education leads household members to become disengaged with agriculture through migration or increased nonfarm activities. Farm households may reap rewards from schooling by abandoning one activity in which returns from schooling may be limited in favor of a new activity in which the returns from schooling are high. Alternatively, they may continue producing traditional crops while diversifying into new activities in which the returns from schooling are high, provided that incentives for diversification (risk, scale effects) exist (Taylor and Yunez-Naude 2000).

Table 6.1 Estimation results

Variable	(a) Augmented log-linear OLS	(b) Augmented log-linear IV	(c) Variable coefficient model IV
Ln land	0.44 (0.09) [a]**	0.20 (0.12)*	0.25 (0.13)*
Ln labor[b]	0.18 (0.08)**	0.60 (0.24)**	0.43 (0.24)*
Ln fertilizer[b]	0.17 (0.04)**	0.23 (0.14)*	0.31 (0.14)**
Ln equipment	0.19 (0.05)**	0.14 (0.06)**	0.13 (0.06)**
Ln education	-0.07 (0.08)	-0.11 (0.09)	-0.09 (0.10)
Ln empowerment[b]	0.95 (0.23)**	1.48 (0.66)**	1.36 (0.67)**
R-squared	0.29	0.28	0.30
Ramsey RESET F-test (p-value)		3.00 (0.08)	0.95 (0.33)
N	480		

Source: Author's survey.
Notes: Community fixed effects not reported. IV = instrumental variables; OLS = ordinary least squares.[a] Robust standard errors in parentheses. [b] Predicted from first-stage regressions. ** significant at 5% level, * significant at 10% level.

In the augmented Cobb-Douglas function, which treats human capital variables simply as additional inputs, the coefficients on all inputs are restricted to be constant, and all households are assumed to operate on the same production function. However, a simple Ramsey RESET test, which assesses whether nonlinear combinations of the fitted values help explain the outcome (Ramsey 1969), on the IV version of the constant-coefficient production function yields a p-value of 0.08, suggesting that the model may be misspecified. In fact, we would do well to entertain the possibility that empowerment could affect the production technology itself. It is conceivable that more empowered farmers, for example those with higher tenure security, would be more inclined to look after their plots, for example, to better time their input application or even to be more adept at critically evaluating new and reportedly improved input varieties. Another example of empowerment would be membership in a producer organization—accounted for in the leadership component of empowerment—which provides access to information that allows farmers to distinguish more quickly between the systematic and random elements of productivity responses. We could thus pose the question whether these farmers may choose a different production technology—that is, whether empowerment (or formal education in this case) can be technology changing (Mundlak 1986; Fulginiti and Perrin 1993). If this is the case, we could still be underestimating the impact of empowerment on smallholder productivity.

Column (c) of Table 6.1 reports the coefficients calculated on the basis of estimation of our linear variable coefficient model. Estimation results of the variable coefficient model are given in Table A.2 in the appendix and reveal statistically significant interactions between traditional inputs and human capital variables. In particular, empowerment interacts positively with returns on labor and equipment, and negatively with returns on fertilizer. These findings, in combination with the general positive relationship between empowerment and productivity, suggest that empowerment contributes to increased returns on labor and equipment. One interpretation would be that tenure security and group membership, two important contributors to empowerment in our data, would enhance the efficiency with which labor is applied and equipment is used. The F-test for the joint significance of the slope interactions, reported at the bottom of Table A.2, confirms that empowerment can indeed be considered as technology changing, affecting the slope of the production function and the intercept. The Ramsey RESET test, reported at the bottom of Table 6.1, now has a p-value of 0.33, suggesting that our variable coefficient model is well specified.

A more broad interpretation of the validity of the variable coefficient model is that we can let go of the restrictive assumption that all households employ the same production technology and that human capital variables could be contributing to these different technologies. To better understand the household-level differences in technologies suggested by the variable coefficient model, we tabulate productivity elasticities for our human capital variables and estimated elasticities for traditional inputs by household type. Results—displayed in Table 6.2—show that there are important differences in production and productivity elasticities due to variations in human capital. It needs to be noted that the elasticity for education is consistently negative across household types, suggesting that increased formal education would actually lead to a deterioration in output. Returns on empowerment strongly differ across household groups and are highest for dual households, in which, as we saw before, women are much less empowered.

Table 6.2 Productivity and production elasticities for technology-changing variables

Household type	Dual	Adult female only	Adult male only
Productivity elasticity for human capital variables			
Empowerment	1.55 (2.08)[a]	1.08 (2.08)	1.16 (1.86)
Education	-0.08 (0.13)	-0.06 (0.14)	-0.14 (0.13)
Production elasticity for traditional input variables			
Land	0.26 (0.21)	0.25 (0.20)	0.18 (0.25)
Labor	0.41 (0.36)	0.43 (0.34)	0.55 (0.42)
Fertilizer	0.33 (0.22)	0.28 (0.22)	0.22 (0.24)
Equipment	0.11 (0.07)	0.16 (0.13)	0.18 (0.13)
Returns on scale	1.11	1.12	1.13

Source: Author's survey
Note: [a] Standard deviations in parentheses.

When we consider the production elasticities of traditional inputs, we see that although returns on scale are similar, high empowerment in adult male–only households contributes to their higher productivity of labor and equipment. For adult female–only households, we find higher returns on equipment but not labor. In combination, these findings suggest that empowerment matters for agricultural production and most strongly for dual households, where women are much less adequate in terms of access to resources, among other things. Improvements in empowerment, for example through increased group membership or more secure tenure, should contribute to increased returns on labor and equipment, thereby contributing to agrarian intensification.

7. CONCLUSION

Human capital variables play an important role in smallholder agricultural production. This paper has looked at the role of empowerment in the agricultural production of rural households in Niger. We collected data using a household survey and the WEAI survey tool in 500 households in the Tahoua region of Niger during April–May 2015. Recognizing the potential technology-changing effects of human capital variables and the endogeneity of empowerment, we have employed IV and a variable coefficient approach to demonstrate that returns on empowerment differ according to the type of household, defined as containing both a male and female adult, only a female adult, or only a male adult. Concretely, we have shown that empowerment can be considered as technology changing, significantly affecting the intercept and the slope of an agricultural production function. In particular, empowerment positively affects the productivity of labor and equipment but interacts negatively with returns on fertilizer.

Our results indicate that it is inappropriate to derive policy implications from evaluating the effects of empowerment in agricultural production at the mean. In fact, differentiating households by their status as dual or as primarily female- or male-headed reveals that the productivity elasticity of empowerment is much larger for dual households, in which women are the least empowered, primarily due to reduced control over assets and income, lower group membership, and less confidence. It follows that important agricultural productivity gains could be made by empowering in particular this group of women.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1 First-stage regression results

Variable	Fertilizer	Labor	Empowerment
Included instruments			
Land	0.05 (0.10)	0.29 (0.05)**	-0.01 (0.02)
Current value of equipment	0.24 (0.05)**	0.02 (0.03)	0.02 (0.01)**
Formal education	0.31 (0.09)**	0.02 (0.05)	0.01 (0.01)
Excluded instruments			
Share of prime-age adults	0.46 (0.34)	-0.60 (0.19)**	-0.15 (0.05)**
Number of adults	-0.20 (0.18)	0.21 (0.09)**	-0.09 (0.03)**
Number of plots	0.57 (0.08)**	0.33 (0.04)**	-0.00 (0.01)
Time to nearest road/100	0.19 (0.08)**	0.04 (0.04)	0.04 (0.01)**
Time to nearest potable water source/100	0.15 (0.15)	0.08 (0.09)	-0.12 (0.02)**
Village affected by transhumance	0.67 (0.25)**	-0.38 (0.13)**	-0.08 (0.03)**
Number of months village is accessible	-0.09 (0.03)**	0.02 (0.01)	0.02 (0.01)**
R-squared	0.34	0.41	0.14
Partial R-squared	0.09	0.11	0.12
Kleibergen-Paap rk Wald F-statistic	10.25	15.10	10.36
Stock-Yogo critical values			
10% maximal IV relative bias	19.86		
15% maximal IV relative bias	10.83		
20% maximal IV relative bias	6.77		
Hansen J-statistic (p-value)	3.61 (0.46)		
Durbin (score) $\chi^2(1)$ (p-value)	3.47 (0.02)		
Number of observations	480		

Source: Author's survey.
Notes: Robust standard errors in parentheses. Community fixed effects not reported. ** significant at 5% level, * significant at 10% level.

Table A.2 Estimation results from the linear interaction model

Variable	Linear	Education	Empowerment[b]
Ln land	-0.37 (0.64)[a]	-0.20 (0.13)	-1.39 (1.13)
Ln value of equipment	0.78 (0.25)**	0.03 (0.06)	1.30 (0.49)**
Ln fertilizer use[b]	-0.73 (0.49)	-0.11 (0.10)	-2.07 (0.87)**
Ln labor[b]	1.61 (0.88)*	0.32 (0.18)*	2.57 (1.53)*
Intercepts	-7.20 (3.73)*	-1.34 (0.90)	-18.03 (6.92)
R-squared	0.30		
Breusch-Pagan test for heteroskedasticity $\chi^2(1) = 0.97$, prob > χ^2 = 0.33			
F-test of random effects on intercept F(2,461) = 3.88, prob > F = 0.03			
F-test of random effects on coefficients F(8,461) = 2.16, prob > F = 0.03			

Source: Author's survey.
Notes: Community fixed effects not reported. [a] Robust standard errors in parentheses. [b] Predicted values from first-stage regression. ** significant at 5% level, * significant at 10% level.

REFERENCES

Abdoulaye, T. 2002. “Farm-Level Analysis of Agricultural Technological Change: Inorganic Fertilizer Use on Dryland in Western Niger.” PhD dissertation, Purdue University, West Lafayette, IN, US.

Alkire, S., R. Meinzen-Dick, A. Peterman, A. R. Quisumbing, G. Seymour, and A. Vaz. 2012 *The Women’s Empowerment in Agriculture Index.* Discussion Paper 01240. Washington, DC: International Food Policy Research Institute.

Alkire, S., H. Malapit, R. Meinzen-Dick, A. Peterman, A. Quisumbing, G. Seymour, and A. Vaz. 2013. *Instructional Guide on the Women’s Empowerment in Agriculture Index*. Washington, DC: International Food Policy Research Institute.

Appleton, S., and A. Balihuta. 1996. “Education and Agricultural Productivity: Evidence from Uganda.” *Journal of International Development* 8 (3): 415–444.

Baltagi, B. H. 2002. *Econometrics*. Berlin: Springer-Verlag

Banerjee, A. V., P. J. Gertler, and M. Ghatak. 2002. “Empowerment and Efficiency: Tenancy Reform in West Bengal.” *Journal of Political Economy* 110 (2): 239–280.

Baum, C. 2006. *An Introduction to Modern Econometrics Using Stata*. College Station, TX, US: Stata Press.

Baum, C., M. E. Schaffer, and S. Stillman. 2003. *Instrumental Variables and GMM: Estimation and Testing*. Working paper 545. Boston: Boston College.

———. 2007. “Enhanced Routines for Instrumental Variables / Generalized Method of Moments Estimation and Testing.” *Stata Journal* 7 (4): 465–506.

Becker, G. 1975. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, 2nd edition. New York: Columbia University Press.

Croppenstedt, A., and C. Muller. 2000. “The Impact of Farmers’ Health and Nutritional Status on Their Productivity and Efficiency: Evidence from Ethiopia.” *Economic Development and Cultural Change* 48 (3): 475–502.

Diarra, M, and M, Monimart. 2006. *Landless Women, Hopeless Women? Gender, Land and Decentralisation in Niger*. Drylands Issue Paper 143. London: International Institute for Environment and Development.

Doss, C. 2006. “The Effects of Intrahousehold Property Ownership on Expenditure Patterns in Ghana.” *Journal of African Economies* 15 (1): 149–180.

Duflo, E., and C. Udry. 2004. *Intrahousehold Resource Allocation in Côte d’Ivoire: Social Norms, Separate Accounts, and Consumption Choices*. Working Paper 10498. Cambridge, MA, US: National Bureau of Economic Research.

Fulginiti, L., and R. Perrin. 1993. “Prices and Productivity in Agriculture.” *Review of Economics and Statistics* 75 (3): 471–482.

Garcia, A., and M. Kennedy. 1994. “Assessing the Linkages between Low Body Mass Index and Morbidity in Adults: Evidence from Four Developing Countries.” *European Journal of Clinical Nutrition* 48 (3): S90–S97.

Guenguant, J.-P., M. Banoin, and A. Quesnel. 2002. “Dynamique des Populations, Disponibilités en Terres et Adaptation des Régimes Fonciers: Le Cas du Niger.” In *Développement Durable*, edited by F. Gendreau and M. Lututala, Chapter 3. Rome: Food and Agriculture Organization of the United Nations.

Hoddinott, J., and L. Haddad. 1995. “Does Female Income Share Influence Household Expenditures? Evidence from Côte d'Ivoire.” *Oxford Bulletin of Economics and Statistics* 57 (1): 77–96.

Kabeer, N. 2001. “Conflicts over Credit: Re-evaluating the Empowerment Potential of Loans to Women in Rural Bangladesh.” *World Development* 29 (1): 63–84.

La Rovere, R., P. Hiernaux, H. Van Keulen, J. B. Schiere, and J. A. Szonyi. 2005. "Co-evolutionary Scenarios of Intensification and Privatization of Resource Use in Rural Communities of South-Western Niger." *Agricultural Systems* 83 (3): 251–276.

Li, Q., and S. Wang. 1998. "A Simple Consistent Bootstrap Test for a Parametric Regression Function." *Journal of Econometrics* 87:145–165.

Loireau-Delabre, M. 1998. "Espaces Ressources Usages: Spatialisation des Interactions Dynamiques entre les Systèmes Sociaux et Ecologiques au Sahel Nigerien, Site de Banizoumbou, Niger." PhD dissertation. Montpellier, France: Université Montpellier 3.

Mounkaïla, H. 2003. "De la Migration Circulaire à l'Abandon du Territoire Local dans le Zarmaganda (Niger)." *Revue Européenne des Migrations Internationales* 18 (2): 161–187.

Mundlak Y. 1986. "Endogenous Technology and the Measurement of Productivity." In: *Agricultural Productivity: Measurement and Explanation,* edited by S. M. Capalbo, J. M. Antle, Chapter 11. Washington DC, International Food Policy Research Institute.

Mundlak, Y., D. Cavallo, and R. Domenech. 1989. *Agriculture and Economic Growth in Argentina, 1913–84.* Research Report 86. Washington, DC: International Food Policy Research Institute.

Murphy, K., and R. Topel. 2002. "Estimation and Inference in Two-Step Econometric Models." *Journal of Business and Economics Statistics* 20 (1): 88–97.

Netting, R. M., R. R. Wilk, and E. J. Arnould. 1984. *Households: Comparative and Historical Studies of the Domestic Group*. Berkeley, CA, US: University of California Press.

Palacios-Lopez, A., L. Christiaensen, and T. Kilic. 2015. *How Much of the Labor in African Agriculture Is Provided by Women?* Policy Research Working Paper 7282. Washington, DC: World Bank.

Pender, J., T. Abdoulaye, J. Ndjeunga, B. Gerard, and E. Kato. 2008. *Impacts of Inventory Credit, Input Supply Shops, and Fertilizer Microdosing in the Drylands of Niger*. Washington, DC: International Food Policy Research Institute.

Ramsey, J. B. 1969. "Tests for Specification Errors in Classical Linear Least Squares Regression Analysis." *Journal of the Royal Statistical Society B* 31 (2): 350–371.

Reardon, T. 1994. "La Diversification des Revenus au Sahel et Ses Liens Éventuels avec la Gestion des Ressources Naturelles par les Agriculteurs." In *Promotion de Systèmes Agricoles Durables dans les Pays d'Afrique Soudano Sahélienne*, edited by M. Benoît-Cattin, 65–77. Rome: Food and Agriculture Organization.

Saqalli, M., B. Gérard, C. L. Bielders, and P. Defourny. 2011. "Targeting Rural Development Interventions: Empirical Agent-Based Modeling in Nigerien Villages." *Agricultural Systems* 104 (4): 354–364.

Schultz, T. 1961. "Investment in Human Capital." *American Economic Review* 51 (1): 1–17.

———. 2003. *Wage Rentals for Reproducible Human Capital: Evidence from Ghana and the Ivory Coast.* Economic Growth Center Discussion Paper 868. New Haven, CT, US: Yale University.

Sraboni, E., H. J. Malapit, A. R. Quisumbing, and A. U. Ahmed. 2014. "Women's Empowerment in Agriculture: What Role for Food Security in Bangladesh?" *World Development* 61: 11–52.

Staiger, D., and J. H. Stock. 1997. "Instrumental Variables Regression with Weak Instruments." *Econometrica* 65 (3): 557–586.

Stone, G. D., R. M. Netting, and M. P. Stone. 1990. "Seasonality, Labor Scheduling, and Agricultural Intensification in the Nigerian Savanna." *American Anthropologist* 92 (1): 7–23.

Strauss, J. 1986. "Does Better Nutrition Raise Farm Productivity?" *Journal of Political Economy* 94 (2): 297–320.

Taylor, J. E., and A. Yunez-Naude. 2000. "The Returns from Schooling in a Diversified Rural Economy." *American Journal of Agricultural Economics* 82: 287–297.

Timera, M. 2001. "Les Migrations des Jeunes Sahéliens: Affirmation de Soi et Émancipation." In *Les Jeunes: Hantise de l'Espace Public dans les Sociétés du Sud?,* edited by R. Collignon and M. Diouf, 37–49. Paris: Karthala.

Van de Walle, D. 2013. "Lasting Welfare Effects of Widowhood in Mali." *World Development* 51: 1–19.

Wooldridge, J. M. 2003. *Introductory Econometrics: A Modern Approach*, 2nd ed. New York: Thomson Learning.

World Bank. 2015. World Development Indicators: Niger. Accessed on May 29. http://data.worldbank.org/country/niger.

Wouterse, F. 2015. "Can Human Capital Variables Be Technology Changing? An Empirical Test for Rural Households in Burkina Faso." *Journal of Productivity Analysis* 44 (2): 1–16.

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