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Analysis of Factors Influencing Adoption of Dairy Technologies In Western Kenya

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Abstract

Indicators of poverty in western Kenya show high poverty levels. The area has low dairy development yet the potential for dairy development is quite high. Dairy farming has the potential to reduce poverty by increasing incomes and reducing unemployment. This paper reports factor interrelationships in dairy adoption with a view to understanding factors that influence adoption. The binary probit model was used to analyse data from 1575 households. Contrary to findings from similar studies elsewhere, some factors had a negative association with adoption, thus unfolding a unique adoption process. The association between the factor interactive affects and technology adoption highlighted the importance of exploring factor interrelationships. The widely held conclusion that smallholder households are resource constrained in technology adoption did not hold in this study. The source of labour supply dictated choice of variables to be used as proxies for labour availability. The exploration of endogenous relationships in the various factors dictated the use of the single probit model. The spatial factors used were highly significant in adoption, and the predicted probabilities from these factors gave a true spatial prediction. This confirmed reliability of the probit estimates. An understanding of factor interrelationships in adoption gives adoption studies high specificity while making conclusions and recommendations, thus necessitating case studies in adoption.

Keywords: Adoption, factor interrelationship, spatial factors

Introduction

The less developed countries (LDC's) have received increased attention on adoption of agricultural technologies because agriculture is their livelihood, and new technologies bring economic growth, (Feder et al., 1985). A new technology overcomes the law of diminishing marginal returns for existing resources, by shifting the production function upwards, thus increasing marginal productivity. More resources can then be employed to increase production, and still achieve positive marginal returns. Constraints to adoption reduce marginal productivity, thus necessitating studies to identify these constraints. The lower than expected adoption rates for new technologies in the LDC's is proof that there are constraints to adoption, while spatial and temporal factors contribute to the observed differences in adoption rates, (Feder et al., 1985). Studies have been done to explain these patterns of adoption, from which knowledge to explain adoption of any technology is derived. Site-specific studies on adoption are necessary, (Feder et al., 1985; Nkonya et al.,1998; Jabbar et al., 2003; Lapar and Pandey ; Kaliba et al., 1997), because some innovations differ across socio-economic groups and over time. Factors influencing adoption operate in a complex and interactive way (Lapar and Pandey, 1999), and the explanations therefore can only be technology, site, and temporal-specific, hence this study that is specific for western Kenya.

Inspite of the high potential for dairy, and the evident benefits from it, Western Kenya is one of the country's poorest areas with low milk production levels, (Waithaka et al., 2002), hence the need to analyse factors contributing to low production. In view of the incentives from market liberalisation, the low milk production levels reflected major impediments to dairy. The area's high population growth and unemployment rates also justify the study, because dairy leads to increased resource productivity, thereby increasing food production and employment.

Theoretical Framework

Adoption of most agricultural technologies occurs at the smallholder farm-level, and households are the decision-makers. The traditional consumer theory explains how a rational consumer chooses what to consume subject to certain constraints (Sadoulet and de Janvry, 1995), thus providing theoretical underpinnings during analysis. Given two discrete choices, 'i' and 'j', the probability of choosing 'i' over 'j' occurs when the utility of 'i' is greater than that of 'j', that is; $U_{in} \geq U_{jn.}$ Therefore the probability of an individual 'n' choosing 'i' is Pr (i) = Pr $\{U_{in} \geq U_{jn}\}$,

while that of choosing 'j' is Pr (j) = 1 – Pr (i). The utility function, although unobserved, is a function of observed characteristics (Adesina and Zinnah, 1993);

$U_{in} = V_{in} + e_{in,}$

$U_{jn} = V_{jn} + e_{jn}$, where e's are the random components. The V's are the deterministic components, and can be written as;

$\beta_1 X_1, + \beta_2 X_{2...} + \beta_n X_n,$ where the estimated parameters (β's) are marginal utilities and the X's are the observed characteristics. Replacing U with V and e in the above equation gives;

$Pr(i) = Pr\{ U_{in} \geq U_{jn} \}$, and rearranging the components gives;

$Pr(i) = Pr\{e_{jn} - e_{in} \leq V_{in} - V_{jn}\}$.

Thus the differences in the error terms ($e_{jn} - e_{in}$), are the same differences in the observed characteristics. The concept of random utility, which states that the observed inconsistencies in choice behaviour are a result of the analyst's deficiencies (Ben-Akiva and Lerman, 1985), necessitates the utilities to be treated as random variables. The model specification is done by considering differences in the error term, and the assumption that these differences are a large number of unobserved, but independent components gives the probit model, which was used in the study.

Methods used

A survey by the smallholder dairy development (SDP) team characterized households in seven districts in western Kenya: in the year 2000 (Waithaka et al., 2002). Population density, market access, and PPE were spatial factors chosen for stratification of the sampling frame, because they are key in determining milk production and marketing (Staal et al., 1997). Multi-stage and random sampling was done to arrive at 1575 households across seven districts in Western Kenya: Bungoma, Kakamega, Vihiga, Kisii, Rachuonyo, Nyamira, and Nandi. Each household surveyed was geo-referenced with the Global Positioning System (GPS). This data set was used in the study, and the STATA statistical program was used for analysis. Principal components analysis was used to minimise multi-collinearity amongst variables. Three dichotomous choice probit models were estimated; with IDB, Napier production and the use of anti-helminthics as dependent variables. The illustration for each model can be written as; $Y_i = \beta' X_i + \varepsilon_i$, where the X's are the independent variables in Table 1, the β's are the coefficients, and ε_i is the error term.

The nature of adoption, and whether the independent variables were exogenous or endogenous in the model determined the modifications made to the binary Probit single equation models. Endogenous relationships in single equation models generate biased and inconsistent parameter estimates because the error term is correlated with the independent variables. The Heckman sample selection method was therefore used to detect these relationships (Greene, 2000). The error term was non-significant in the study, indicating no interdependence between income and each of the technologies. Income was therefore included in each of the three equations, as an exogenous variable without violating recursivity. Non-significance of ρ during pair -wise analysis of the three equations representing the technologies meant that estimates from the single - equation models were still efficient.

Results

Table 2 shows marginal effects from the single probit estimates. The Huber-White method, (Gujarati, 1995), was used to correct for heteroscedasticity, a common problem in cross-sectional data. The Wald statistic, which measures the model goodness-of-fit, was significant, meaning that the parameter estimates explain the dependent variable. The predictive accuracy for the models was at least 70% for adopters, who were predicted more accurately than non-adopters. As expected, a household with high income was associated with at least a 9% probability of adopting each of the three technologies. However households with non-farm income did not invest in dairy, thus depicting a lack of interdependence between dairy and the non-farm sector.

This result also shows the unlikelihood of credit as a constraint to dairy, because credit can only be a constraint when all the liquidity available has been used up and additional capital is needed to invest. Except for Napier production, gender had a non-significant association with dairy adoption, meaning that both male and female household heads had an equal chance of adopting dairy. Although male household heads increased the probability of Napier production by 20%, educated males showed a negative association with Napier production, meaning they would rather engage in other activities, probably off-farm. A one-acre decrease in land size was associated

Table 2. Marginal effects (%) from Single Probit estimates

Independent Variable	Improved dairy	Napier	Antihelminthics
inc (Monthly Income category of the household) 1=≥ Ksh 5,000, 0=<Ksh 5,000	13 (0.11) ***	0.9 (0.13) ***	16 (0.11) ***
gender (gender of the household head) 1=male, 0=Female	-0.4(0.19)	20(0.23) ***	1(0.19)
Present land size (land size in acres)	-0.2(0.01) ***	-1(0.01) ***	1(0.01)
Fodder10ago (Did you grow fodder 10 years ago?) 1=Yes, 0=No		8 (0.14)***	
Dairy10 (Did you have dairy breeds 10 years ago?)1=yes, 0=no	42(0.12) ***		17 (0.11) ***
TNUrdtype3km (The distance by earth road from the household to the nearest tarmac road)	-1(0.02)	-1(0.02)*	-0.3(0.02)
exttopicsolstck (received extension services on dairy production?) 1=yes, 0=no	16 (0.19) **	21(0.21)	21(0.19) ***
exttopicsolstck●education	-0.5(0.02)	10(0.02) ***	-1(0.02)
Ownermanager (owner of the farm as well as manager?) 1=yes, 0=no	-0.2(0.10)	-4(0.13)	0.2(0.1)
Education (education level of the household head)	1(0.03)	1(0.03)*	1(0.03)
gender●education	1(0.03)	-1(0.03)*	-0.2(0.03)
Kisii (ethnic group of the household head) 1=Kisii, 0=Luhya	16 (0.12) ***	21 (0.17) ***	19(0.12)
Popn (Population density in persons/km^{2}at 5 km radius)	1.2(0.0001)	2(0.0002) ***	
PPE	5.4(0.34) ***	9(0.55) ***	1.9(0.33)
dependency (ratio of pre-school and school-going household members to adults in the household)	-3(0.04) **	-1(0.05)	-1(0.04)
OfffarmYrank (Off-farm income as main source of income)1=Yes,0 =No	-8(0.10)**	-3(0.12)	-6(0.09)ns
Hhage (age of the household head in years)	0.1(0.004)	0.2(0.01)	0.2(0.004)
Constant	-1.63 (0.47)***	-3.7 (0.62) ***	0.60(0.47)
observations	921	921	921
Wald chi-square (17)	217	215	152
Percent of correct prediction			
Adopters	79.45	87.91	73.72
Non-adopters	69.40	77.00	62.77
Overall	74.92	85.56	70.47

with 0.2 % and 1% increase in the probability of IDB adoption and Napier production, respectively. This leads to the view that technologies that increase returns to land, labour or capital are adopted only when factor proportions are constrained. Specifically, efforts to increase returns to land, the constrained factor relative to the other resources, were made through adoption of dairy. This also depicted the households' failure to capture the economies of scale in dairy production, which arises from the fact that more land may mean more crop residue and even more natural pasture, factors that lower costs/unit of production. The finding is contrary to other studies (Nicholson et al., 1998; Staal et al., 2002), which found a positive correlation between land size and adoption of dairy and Napier. Past experience with dairy technologies was associated with a probability increase of 42% in IDB adoption, 17% in the use of anti-helminthics, and 8% in Napier production. Households with past experience in dairy are able to better control the risks in dairy by diagnosing and controlling diseases, and by giving the right kind of feeds. Extension services, were associated with a probability increase of 16% and 21% in IDB adoption and anti-helminthics use, respectively. Extension messages should enable even the less educated to understand and use the information. That specific knowledge on dairy, and not general farming knowledge on farming is quite critical in adoption is evident from the significance of extension and past experience with the technologies. Educated household heads would be associated with a 1% increase in Napier production. A PPE increase by an index of 0.1 gave an increase in the probability of adoption of IDB's and Napier production by 5.4%, and 9%, respectively. A high PPE lowers the cost of dairy farming because it encourages fodder production, and provides water for cattle. As expected, agriculture in the LDC's is highly vulnerable to the whims of the

natural environment. An additional kilometre to the nearest tarmac had no influence on adoption of the IDB's and anti-helminthics. However it increased the probability of Napier production by 1%, and this could be because food crops tend to be grown near homesteads, while cash crops and Napier are grown further away. A high population density was not accompanied by an increase in the probability of adopting IDB, but increased the probability of Napier production by only 2%. The finding was contrary to the Boserupian theory, which asserts that population pressure is an incentive to develop new technologies. This finding shows the low market orientation in this area. A higher dependency ratio is associated with a decrease in the probability of adoption of IDB by 3%. Hiring labour can mitigate the labour constraint, but the low incomes in most households will hamper the effort to hire labour. The study area had only 7% of the households with children providing labour for livestock activities. Labour supply was therefore mainly from the adults, contrary to a study in Tanzania by Kaliba et al., (1997), which found a positive correlation between cattle stall-feeding and availability of male children in the household. Ethnicity was significant in the adoption of the IDB's and Napier production, whereby the Kisii were associated with at least a 16% increase in the probability of adopting each of the two technologies. This was analogous to the finding by Nicholson et al., (1998), that different ethnic groups with different cultures had different perceptions on technologies, where appropriateness of the technology is determined by how the technology conforms to their cultures. Non-significance of the ethnic factor to adoption of anti-helminthics means that this is a technology that has been equally accepted across all households in the area. Management and age were also non-significant in adoption, thus increasing the diversity of potential adopters of IDB. Spatial factors are the primary determinants of dairy adoption, and Figures 1 and 2 show spatial predictions of probabilities of IDB adoption and Napier production respectively. Figure 1 shows the predicted probabilities of dairy adoption based on PPE alone, because PPE was the only significant spatial factor in the probit estimates. As expected the districts with the highest predicted probabilities of dairy adoption were Kisii, Nyamira, Vihiga, and parts of Nandi, with the highest predicted probability of 0.75. Population density, PPE and distance from the household to the nearest main road were significant spatial factors in Napier production, therefore included in prediction of the probabilities. Figure 2 shows that Napier had a higher predicted probability of adoption than dairy, with Kisii, Nyamira, and Vihiga having the highest (1). Napier was more likely to be grown where PPE was high because of the favourable agro-climatic conditions, where population density was high because of high land pressure, and in areas closer to main roads. No spatial factor was significant in the Probit estimation for adoption of anti-helminthics, hence no map to show spatial prediction of probabilities.

Conclusions

The study showed a unique adoption process by showing that—

- availability of some productive assets (land, non-farm income) had a negative association with adoption
- the high milk deficits in the face of increasing population growth provided ready milk markets but there was low response to this marketing opportunity

The facts above also reveal the opportunities available for dairy development. Increased opportunities also arise from the fact that adoption is possible regardless of age and whether the owner of the household is the manager of the farm or not. Although education is important in understanding extension messages, specialised information is more critical to adoption than formal education. The results show high association of dairy technologies with spatial factors, and these patterns are comparable to the actual spatial adoption pattern in the study area. The maps can be used for simulation studies to show how the adoption patterns change with change in spatial factors, and this would interest different stakeholders.

Recommendations

- Interventions to promote dairy should exploit the opportunities available and address the circumstances under which adoption decisions are made. The Government should give information at this initial stage of dairy development because information is still a public good, therefore unattractive to the private sector.
- The government's extension services should target dairy development. High on the agenda of extension programs should be the crop-livestock interaction projects. Households should take advantage of the low opportunity cost of labour to increase the competitiveness of dairy among other

farming enterprises. Thus the productivity potential of existing resources should be exhausted before moving to additional resources.

- Women should be supported through women groups. Areas of intervention include sponsoring dairy projects that recognise women's constraints and those projects that enable women have control of the resources and benefits.
- A look at the broader perspective of rural development is necessary. The Government should also develop the rural non-agricultural sector in order to increase people's income and diversify out of agriculture. This is because demand for livestock products is income elastic.
- All the interventions suggested would give a higher incremental impact in this area than in areas that had already explored the existent opportunities in dairy.

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