ANALYZING THE EFFECT OF PRODUCTION RISK AND TIME PREFERENCE ON THE USE AND CHOICE OF IMPROVED LIVESTOCK FEEDING PRACTICE IN ETHIOPIA

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Abstract: A number of improved feeding practices such as stall feeding, rotational grazing, and tethering can help increase livestock productivity in Ethiopia. The main aim of this paper is to determine what factors affect the adoption of on such improved feeding practice; i.e. Stall Feeding (SF) and the choice of animal or season for its application. A bivariate probit model was estimated using observations from 367 rural farmers in Northern Ethiopia. Production risk and the frequency of shock are found to be key determinants. As expected, the results from bivariate model revealed that the expected yield positively influenced SF adoption decision and its full-year application while yield variability and risk of yield failure had a negative effect on SF adoption decision and its full-year application. Likewise, previous animal shocks positively contribute to SF adoption. The major contribution of this paper is its explicit treatment of production risk, shock and time preference in the decision to adopt and apply SF. Expected benefits that the farmer can derive from low production risk due to SF adoption should be included in the promotion agenda of SF practice. The implication is that intervention that reduces the variance of return and exposure to downside risk are some desirable in the adoption and choice decision.

Keywords: *stall-feeding adoption, production risk, shock, discount rate control function, bivariate model*

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INTRODUCTION

In sub-Saharan Africa (SSA), livestock production plays multiple fundamental roles for rural households when crop farming becomes variable due climate change (Cecchi et al 2010). These roles can be illustrated by a few statistical numbers. Agriculture accounts for about 43% of the gross domestic product and over 60% of exports (Odame et al 2013) in SSA. In Ethiopia, livestock is central to the livelihood of the rural poor by contributing about 12–16% of the total GDP, and 40% of total agricultural GDP excluding the values of draught power, transport and manure (Halderman 2004).

Livestock production accounts for nearly 80% of farmer income in the country and ownership of livestock denotes social status during the cultural marriage (Ilyin 2011). In addition, it provides 14 million tons of manure annually mainly for fuel and organic fertilizer uses. The value of animal draught power input into arable production is about 26.4% of the value of annual crop production (FAO 2005).

Livestock production in Ethiopia is, however, low in productivity in terms of milk and meat production per animal (MoA 2012; World Bank 2007). This is due to among others: i) fluctuating weather conditions which result in fodder and

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grass, either not available in sufficient quantities or are of poor nutritional quality when they are available; ii) poor availability of feed and fodder that affect livestock productivity; iii) animal diseases infection that is responsible for low livestock production in the region (Amudavi et al., 2009); and iv) low technology practices and poor marketing (Gebremedhin 2009; Benin et al 2006).

Livestock losses resulting from climate change seriously affect livestock production and disrupt every aspect of the livelihoods of households (Kabubo- Mariara 2009). Over 12 million people have suffered from the adverse effects of climate change on earnings from livestock production in the SSA region (Armstrong et al 2013). Most countries in East Africa including Ethiopia are not adequately prepared for the aftereffects of disasters which occur frequently causing livestock loss. Severe droughts (1984, 2000, 2003 and 2011) in Ethiopia resulted in heavy livestock losses and production failure (Benin et al 2006). This is further aggravated by the land degradation resulting from overgrazing, reducing the contribution from livestock and pose a threat to food security in the region (Ilyin 2011).

In response to this, a risk-reducing practices such as rotational grazing, zero grazing (ZG), tethering, stall-feeding (SF)¹⁾ along with the improved cows have been proposed in the region as a potential options to alleviate the animal feed shortage, reduce land degradation and improve livestock production by minimizing production risks caused by theft, flood, disease and cattle fighting due to free grazing (FAO 2007; De Cao et al 2013; Bishu 2014; Lenaerts 2013).

Among these technologies, SF, where animals are kept indoors and fed in a cut and carry system is suggested as an alternative climate-smart strategy. This is because SF protects livestock from diseases and deaths by avoiding free livestock contact, cattle fighting, flood, theft, predation and exposure to a high temperature in free grazing system (USAID 2013). SF is an ideal way to maintain breed cows, address land degradation of

grazing land and improve fodder and milk productivity (Ilyin 2011; Bishu 2014). An earlier study in Uganda confirmed that SF is economically viable and ecologically sustainable (Garcia et al 2008). Although the introduction of SF is believed to be a risk-reducing and feed saving technology, the adoption rate has remained slow and low in the region (Lenaerts 2013; FAO 2007).

Of particular interest has been the role of risk attitudes in technology adoption. As a result, much empirical evidence suggests that risk-averse individuals are less likely to adopt new technology, despite risk-reducing nature of the technology (Liu and Huang 2013). A farmer may choose to adopt feed-saving technology to hedge against weather risk (De Pinto et al 2013). The adoption of new technologies always involves a degree of risk and uncertainty concerning the effect of this input on the distribution of farmers' profits. Uncertainty associated with the adoption of new technology includes the perceived riskiness of future farm yield after adoption and production uncertainty related to farming itself (Koundouri et al 2006). A proper analysis of farmers' production decisions is supposed to account for production risk and farmer's risk attitude (Czekaj & Henningsen 2013). Production risk affects new technology adoption and that farmers choose to adopt the new technology in order to hedge this production risk (Koundouri et al 2006). A risk-averse farmer may hedge against weather risk or reduce weather-related risk by adopting risk-reducing technologies (Antle 1987; De Pinto et al 2013; Kahan 2013).

A recent study by Holden and Westberg (2016) and Bezabih and Sarr (2012) pointed out that shock plays a vital role in the technology adoption but got less attention. Despite their relevance, production risk and shock are, rarely, used in agricultural adoption studies, particularly in the case of cattle farming and East Africa (Just et al 2010; Holden & Quiggin 2017).

To the best of the author's knowledge, it is not known a priory whether production risk itself or the uncertainty associated with the new technology may lead to sub-optimally slow diffusion of SF practice in the region. This paper therefore seeks to examine whether livestock farmers in North Ethiopia are facing production risks and have a coping strategy that they opted for in order to curb the negative effects of these risks. Thus, the main objective of this paper is not to analyze production

¹⁾ Stall Feeding (SF) adoption in this paper is defined as the practice of feeding some or all animals in an open homestead land. Full Stall Feeding (FSF) adoption is the practice of stall feeding some or all animals in in a full-year round and Seasonal Stall Feeding (SSF) is for at least one season of the year.

per se but the effect of production risk and shock exposure on SF and animal/seasonal choice: This is done adapting moment-based approach (Antle 1987) for estimating production risk. A bivariate model was used for the joint decision of SF adoption and animal/season selection using a dataset of 518 farmers sampled during 2014/2015 farming season in Tigrai.

The analysis is organized around four questions. First, does production risk induce or reduce stall feeding adoption and its full year application? Second, how does previous frequency of animal shock impacts stall feeding adoption and its full year application? Third, which animal is the choice of smallholder farmers for stall feeding? Using the theoretical framework suggested by Antle (1987) and Koundouri et al (2006), the author shows production risk to be the main determinants of SF adoption using estimated moments of the value of milk production.

First, farmers are expected to be motivated to adopt SF whenever it promises them higher return (i.e. the first moment-predicted mean is positively related to adoption). Second, output variability (as measured by the second moment) discourage farmers from applying SF. Third, higher probability of output failure (downside risk), as measured by skewness of yield, increases the farmers' chance of adoption or decreases adoption when farmers view SF as risk-reducing or as risk-increasing. Fourth, animal shocks are expected to positively affect SF adoption and animal selection.

Little, if any, has been published on the explicit treatment of production risk, shock and discount rate on technology adoption. Thus, by explicitly considering production risk, shock and discount rate in the decision to adopt and apply SF, this paper adds to a very scarce literature in Ethiopia and all of sub-Saharan Africa. Measuring exogenous risk (production risk) from the milk production function further distinguishes this paper from previous studies, which explicitly focus on crop production.

RESEARCH METHODS

Study area and Dataset

The study is conducted in the Tigrai region in the northern part of Ethiopia by randomly selecting 632 farm households. A mixed crop and

livestock farming is the dominant livelihood system for smallholder farmers (Tesfay 2010). Having a favorable environment for dairy production, the country is endowed with an estimated 12 million cows (Tegegne et al 2013; CSA 2016), which further indicates that 2.8 billion liters of milk were produced in 2012/2013, out of which 42.3% was used for household consumption.

This study used a cross-sectional data from Tigrai Rural Household Survey dataset collected in 2015 run by NMBU-MU². Initially, to reflect systematic variation in agro-climatic conditions, agricultural potential, population density and market access conditions, four communities were selected from each of the four zones and three communities that represent irrigation projects. Likewise, one with low population density and one with high population density were strategically selected from each zone among communities to reflect far distance market (Hagos 2003). The study was conducted in five zones covering 11 districts and 21 Tabias so as to yield 632 sample size. The dataset includes a panel of five rounds conducted in 1997/98, 2000/01, 2002/03, 2005/06 and 2014/2015 where the author is involved only in collecting the data for the last round. A cross-sectional data set for the year 2014/2015 was extracted from the survey since some variables used in this paper were only added in the last wave. The estimation of production risk parameters further reduced the sample size to 367 farmers, including those who only harvested milk during the study year. The descriptive statistics of importance to the study are presented in Table1 and are discussed below.

Theoretical Framework

In the agricultural farming activity, uncertainty and risk are inherent features of agricultural production (Kumbhakar et al 2006). Production uncertainty (production risk) makes farmers' revenue uncertain where this is related to the uncertainty of the outcome due to weather conditions, and animal diseases, natural disasters, and even climatic changes in the long run. A theoretical framework

² Norwegian University of Life science –Mekelle University. This dataset has been initially used by Gehbru (2010) and Hagos (2003) for their PhD study.

that accounts for this production risk is specified following the model introduced by Antle (1987) and developed by Koundouri et al (2006).

Estimating Production Risk

Since the milk yield function is not necessarily affected by the adoption decision, moments of yield can be assumed exogenous to the adoption decision (see e.g. Antle and Goodger 1984; Koundouri et al 2006; Kassie et al 2009; Kim and Chavas 2003; Juma et al 2009 and Ogada et al 2014). The estimation procedure follows two steps: First, the first three sample moments (namely, mean, variance, and skewness) of each household were computed from the milk production function, then the estimated moments were included in the adoption decision discrete model. Adapting a sequential estimation procedure of Kim and Chavas (2003), milk yield was regressed on input variables to obtain estimates of mean. The general functional form of the model is:

$$\pi_i = f_1(X_i, \beta_1) + u_{i1} \quad (1)$$

Where i indicates individual farmers, π is milk yield per cow, X is the vector of variable inputs (labor, cow, feed and capital value), and u_{i1} is the usual error term with mean zero. The Ordinary Least Squares (OLS) results in consistent and efficient estimates of parameters β_1 under the exogeneity assumption of the explanatory variables, (X) (Koundouri et al 2006). The j^{th} central moment of the value of milk about its mean is, therefore, computed as:

$$\mu_j(X) = E[(\pi(X) - \mu_1)^j], \text{ for } j = 1, \dots, m, \quad (2)$$

Where μ_1 represents the mean milk yield or the first moment of yield. As a result, the estimated errors from the mean effect regression computed as $(e = \pi - f_1(X_i, \beta_{i1}))$ are estimates of the first central moment of the yield distribution. Then, the estimated errors e are then squared and regressed in turn on the same set of explanatory variables so as to compute the second central moment of the milk yield following the model:

$$e_i^2 = f_2(X_i, \beta_2) + u_{i2} \quad (3)$$

The use of OLS on (3) gives consistent estimates of β_2 and the predicted values are consistent estimates of the second central moment of the yield distribution (the variance) adapting

previous similar approaches (Antle 1987; Kim and Chavas 2003; Koundouri et al 2006). Following the same procedure, the third central moment was estimated, by using the estimated errors (e) raised to the power of three, as the dependent variables in the same estimated models. Even if the distribution functions are well approximated by their first two moments, adding the third moment, which measures the probability of yield failure, might be vital for farmer's selection of production inputs (Antle and Goodger 1984).

Bivariate Model

The analysis has two major steps. The first one is an estimation of production risk parameters using the three moments of milk yield distribution - the mean, variance, and skewness by selecting similar input variables used by Antle and Goodger (1984) and Just and Pope (1978). In the second stage, production risk parameter estimates were used to estimate the bivariate model for SF adoption decision and animal or seasonal selection. The decision to adopt SF practice and the decision to select which animal to feed under SF or which season to apply SF by farmers was considered to be a two-stage process. The first stage is whether farmers adopt SF or not while the second stage involved whether farmers choose feeding cows rather than another animal for SF, and practice SF in full-year rather than a single season after being users of SF. The second stage (outcome) stage is considered a sub-sample of the first stage (selection) stage. It is likely that the outcome stage sub-sample will be non-random and different from those farmers who did not adopt SF. A sample selection bias is then created (Heckman 1979).

The first step is to create a model of farmers who are users of SF, and then given that model, the outcomes (choice) is modeled (Deressa et al 2009). The author incorporates the simultaneous decisions into the expected utility framework following Walton et al. (2008).

Let U_1^* be the farmer's expected utility from SF Adoption:

$$U_1^* = E[U_A] - E[U_N] \quad (4)$$

Where U_A and U_N are the utilities from SF adoption and non-adoption. The latent variable, U_1^* is unobservable to researchers but assumed to be a function of exogenous variables so that

$$U_1^* = X'\beta + \varepsilon_1 \quad (5)$$

While X is a vector of exogenous variables, β is a vector of unknown parameters to be estimated assuming the error term ε_1 to have a normal distribution with zero mean. The decision of whether or not to adopt is observed by a discrete variable, Y_1

$$Y_1 = \begin{cases} 1 & \text{if } U_1^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

In the same fashion, let U_2^* represent the farmer's utility from feeding cow under SF or choosing the year round for SF practice:

$$U_2^* = (U_A|U_1^* > 0) - E[U_N|U_1^* > 0] \quad (7)$$

The first term on the right-hand side of equation (7) represents the actual realization of utility from adoption while the second term is the ex-ante expectation of utility from adoption. U_2^* is also unobservable variable, but assumed to be a function of observable variables such that

$$U_2^* = Z'\gamma + \varepsilon_2 \quad (8)$$

Where Z is the vector of exogenous variables, γ is a vector of unknown parameters to be estimated, and ε_2 is the error term, also assumed to be normally distributed with zero means. The decision of whether to feed a cow or another animal under SF or to practice SF in full year or in a single season is also observed by a discrete variable, which we denote as Y_2

$$Y_2 = \begin{cases} 1 & \text{if } U_2^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (9)$$

Substituting equation (4) into equation (5) and equation (8) into equation (9), the probability that the farmer chooses a cow to stall feed or chooses a year to practice SF is given by

$$\begin{aligned} Pr[Y_1 = 1, Y_2 = 1] &= Pr[U_1^* > 0, U_2^* > 0] \\ &= Pr[\varepsilon_1 > -X'\beta, \varepsilon_2 > -Z'\gamma] \\ &= Pr[\varepsilon_1 < X'\beta, \varepsilon_2 < Z'\gamma] \\ &= \Phi_2(X'\beta, Z'\gamma, \rho) \end{aligned} \quad (10)$$

Where Φ_2 is the bivariate standard normal distribution and ρ is the correlation coefficient between the error terms ε_1 and ε_2 . When $\rho = 0$ equation (10) falls to a product of two univariate

standard normal distributions of ε_1 and ε_2 or the two decisions farmers face are independent of each other. Since the probability of not choosing a cow or not practicing SF in a year-round is the difference of the probability of SF adoption and the probability of choosing a cow or practicing SF in a year-round, it can be obtained by subtracting the right hand side of equation (10) from the univariate probability distribution of SF adoption, defined as $(X'\beta)$.

$$Pr[Y_1 = 1, Y_2 = 0] = \Phi(X'\beta)\Phi_2(X'\beta, Z'\gamma, \rho) \quad (11)$$

The probability of non-adoption can be then obtained by using equations (10) and (11) in order to fully explain the possible three states of this decision, cow/year selection, other animal/season selection and non-adoption of SF.

$$Pr[Y_1 = 0] = 1 - \Phi_2(X'\beta, Z'\gamma, \rho) - [\Phi(X'\beta) - \Phi_2(X'\beta, Z'\gamma, \rho)]$$

$$Pr[Y_1 = 0] = 1 - \Phi(X'\beta) \quad (12)$$

Having defined the three states, the objective of the econometric analysis is to maximize the likelihood function of each state which is given as follows:

$$\begin{aligned} L = \prod_{Y_1=1, Y_2=1} \Phi_2(X'\beta, Z'\gamma, \rho) \prod_{Y_1=1, Y_2=0} \Phi(X'\beta) \\ - \Phi_2(X'\beta, Z'\gamma, \rho) \prod_{Y_1=0} 1 \\ - \Phi(X'\beta) \end{aligned} \quad (13)$$

Then the log-likelihood function is given as:

$$\begin{aligned} \ln L = \sum_{Y_1=1, Y_2=1} \Phi_2(X'\beta, Z'\gamma, \rho) \\ + \sum_{Y_1=1, Y_2=0} \Phi(X'\beta) \\ - \Phi_2(X'\beta, Z'\gamma, \rho) \\ + \sum_{Y_1=0} 1 - \Phi(X'\beta) \end{aligned} \quad (14)$$

I obtain maximum likelihood estimates by simultaneously equating the first derivatives of equation (14). Hence, our empirical model consists of two equations, one for adoption decision equivalent to equation (5) and the other for animal/season choice decision equivalent to equation (8) including the two vectors of exogenous variables, X , and Z , specified in equations (5) and (8), respectively.

DISCUSSION

Descriptive statistics

Referring to Table1, the observable dependent variables, Y_1 in equations (3) takes a value of 1 if the farmer adopts SF practice, and 0 otherwise. The results indicated that 62% of a total of 367 livestock farmers were adopters of SF and 38% were non-adopters during the study period. The other dependent variable, Y_2 in equations (6) takes a value of 1 if the farmers choose to stall feed cows instead of other animals or to practice SF in a year-

round than single season, and 0 otherwise. Among 228 livestock farmers who were users of SF, 51% choose to feed cow under SF and, 63 % of them apply SF over a full year. Adopters of SF are seemingly worse off than non-adopters in terms of animal shock experience. Adopters on average experience more than twice as many as animal shock as compared to non- adopters in the past four years. On the production risks, the average first moment, second and third moments are not statistically different between the two groups, but non-adopting farmers have slightly lower values compared with the value of adopters.

Table1. Description and Summary Statistics for SF Adoption Decision

Variable Description		Non-adopters mean	Adopters mean	T=test P-value (5%)
Network(1= if household got assistance from relatives & friends)		0.237	0.855	0.0000
Gender(1= Male)		0.770	0.728	0.3759
Education(1= Literate)		0.252	0.688	0.0000
Credit (1= Access to credit)		0.194	0.263	0.1328
Animal shock(1=animal shock from 2012 to 2014)		0.158	0.232	0.0878
Improved(1=breed cows)		0.0144	0.061	0.0324
Information (1=own Radio, TV and Mobile)		0.374	0.800	0.0000
Location (1= if household lives above 2000m.a.s.l		0.554	0.666	0.0306
Distance to nearest road (walking minute)		50.00	41.06	0.0363
Household age (years)		57.19	55.83	0.4196
Total livestock (TLU)		5.082	4.810	0.4302
Total cows (number)		1.835	1.768	0.6716
Total labor time spent for cattle feeding(hour)		43.72	334.0	0.0000
distance to free grazing (walking minute)		51.80	59.06	0.1355
Feed transporting time (walking minute)		729.3	2,016	0.3165
Total plots (number)		3.432	3.772	0.1133
Farm size owned(hectare)		1.125	1.269	0.1420
Total own produce feed value		5415.2	6367.8	0.0706
Village Experience of SF(year)		2.662	4.013	0.0000
Total daily milk harvest(Litre/per cow /day)		1.156	1.321	0.2720
Value of farm tools(cart, water tanker, cattle & fodder shed) (ETB)		789.4	847.9	0.7469
First moment(expected mean)		0.230	0.168	0.2632
Second moment (variance of yield)		0.438	0.441	0.7069
Third moment (Skewness of yield)		-0.0102	-0.046	0.1575
Total family size(number)		5.813	6.364	0.0255
Sample		139	228	
Dependent variables in the first & second equations				
SF adoption	1 if household adopt SF	0.380	0.620	
Animal	1 if household feed only cows under SF		0.513	
choice	2 if household feeds only an ox under S		0.487	
Seasonal	1 if household practices SF the whole year		0.632	
choice	0 if household practices SF in a single season		0.368	

Source: Author compilation, 2016

Access to credit by farmers facilitates labor hiring and thus promotes technology adoption. The findings indicated that adopters had the highest proportion of farmers that used credit (26%) followed by non-users (19%). Adopters of SF are seemingly worse off than non-adopters in animal shock experience. Adopters of SF seem to have higher mean value (23%) in terms of animal shock exposure. Moreover, adopters have a significantly higher network (86%) as measured by gifts/assistance from relative or friends as well as higher access to fodder shed (42%).

The average farm size is 1.269 ha for users with a mean of 3.77 number of plots as compared to 1.125 ha for non-users. The result also indicated that the mean family size of adopting farmers is 6.3, with an average age of 55.8 years. On average, farmers who adopt SF spend 41.06 and 2016 minutes to travel to the nearest road service and animal straw site. SF users owned a herd size of 4.8TLU units with a mean of 1.76 milking cows while those non-users of SF owned about 5.8 TLU units with a mean of 1.8 milking cows.

Farmers using SF also spend 59 minutes than non-users with only spend 51 minutes per day to

reach free grazing land. In relation to the village exposure to SF, on average SF users had 4 years' village exposure than non-users with 2.66 years, suggesting that farmers whose villages are exposed to SF had the necessary exposure to process information on this practice. Among male farmers, 77% are non-adopters and 72% are adopters. SF users had a significantly higher literacy level (69%) than that of non-users (25%). SF users own breed cows, on average 4 times higher than that of non-users. Moreover, 20% of the farmers reported to having access to information via radio, TV or mobile, of which 80% of them were found to be SF users. The proportion of SF adoption was highest for households living in the highland (67%) followed by 55% for non-users. Most of the highlands are attributed to low land holdings due to population pressure which forces farmers to invest in output -increasing or feed -saving practices.

Bivariate Model

Estimation of the production function was useful only for generating production risks and its estimate results are presented in Table 2.

Table 2 Estimated Cobb-Douglas of Milk Production Function, 2015

Input Variables	(OLS) ln milkyield
Ln cow (number of milking cows)	0.188*** (0.0652)
ln TLT (total labor time spent on cattle)	0.0292 (0.0399)
ln fvalue (total farm tool value)	0.114*** (0.0241)
ln pfvalue (total own produce feed value)	0.286*** (0.0342)
Constant	-3.074*** (0.354)
Observations	367
R-squared	0.363

NB: Asterisks (***, **, *) imply that the estimated parameters are significantly different from zero at 1, 5, and 10% significance level, respectively. Figures in parentheses are standard errors.

Econometric results from the Univariate and Bivariate models were presented in Table 3. The results indicated that the model had good overall predictive power, as indicated by the overall 99% prediction for the selection model and 38% for the outcome model in the case of animal selection, and

15% in the case of seasonal selection. The Wald Chi-square test of independent equations examines the null hypothesis that the error terms in the two equations are uncorrelated. The correlation coefficient estimate of $\rho = 0$ and the p-value = 0.000 suggests that the two error terms are

positively and statistically significant which justifies the use of bivariate probit model with sample selection, instead of two separate probit in the case of a seasonal choice model estimate. Exogenous variables included either in the adoption equation (5) or choice equation (8) had a significant predicting power of SF adoption and choice.

With respect to the farmers' production risk, the analysis revealed the following: As expected, production risks seem to have a central role in the decision to adopt SF and to choose which season to practice or animal to feed. The expected milk yield (first moment) had a positive significant effect on the adoption decision and season selection, indicating that the higher the expected return, the greater the probability of adopting SF in full-year than a single season. On the other hand, milk variability (second moment) and skewness of milk (third moment) showed to have a significant negative influence on the adoption and season selection probability. This implies that the higher the variance of return and probability of milk failure (downside risk) were, the lower the probability of adopting SF in full-year term. Findings here are consistent with previous studies (Koundouri et al 2006; Kassie et al 2009; Sauer et al 2009; Juma et al 2009; Tang et al 2013; Ogada et al 2014).

The study conducted in Greece by Koundouri et al. (2006) indicated that production risk significantly affects irrigation technology adoption and farmers adopt the new technology in order to hedge against production risk. Kassie et al (2009) revealed that variance and crop failure had a negative significant impact on fertilizer adoption in Ethiopia however, expected return positively affected fertilizer adoption and conservation adoption. Sauer and Zilberman (2009) indicated that the expected profit had a positive significant effect on the automatic milking adoption while profit variability and skewness of profit showed to have a significant negative influence on the adoption. In addition to the variance of return, downside risk (crop failure) may affect technology adoption (Di Falco and Chavas 2009).

Similarly, Juma et al (2009) showed that yield variability and the risk of crop failure affect farm technology adoption in Kenya and higher expected yield was associated with high probability of fertilizer and improved maize adoption in Kenya (Ogada et al 2014).

In addition to production risk, individual shock exposure was also accounted for and captured by the frequency of animal shock exposure using survey measures. Animal shock is positively associated with adoption. This confirms the findings by Bezabih and Sarr (2012) who found that covariate shocks from rainfall variability were positively related to farmers' decision to diversify crops in Ethiopia. However, it contradicts with the results of Holden et al (2016) in which the probability of using technology was negatively affected by rainfall variability and rainfall shock in the case of fertilizer in Tigray region.

Besides, Holden (2015) found that exposure to past drought shocks motivated poor farmers to adopt a drought tolerant maize but to dis-adopt local maize using mixed experiment and survey data in Malawi. Ayenew et al (2015), also found that farmers with a higher level of relative risk premium were more likely to opt for crop diversification in Ethiopia. Gillespie et al (2004) found that more risk-averse producers were more likely to adopt artificial insemination and breeding technologies. With regard to time preference, Access to information positively and significantly affected adoption and cow selection confirming the result of Gunte (2015). Similarly, Deressa et al (2009) discovered that information on climate change increased adoption of adaptation strategy. The proxy for social network showed to be positive and significant with respect to the SF adoption decision and season selection in line with the finding in Barret et al (2001). There are empirical findings on the role of informal credit for the purchase of fertilizer (McIntosha et al 2013). Gender had significant but a negative effect on adoption and full year SF application, in contrary to a study by Beshir (2014) in which male farmers were more responsive to forage adoption.

The level of education significantly and positively affected adoption and cow selection. Previous research (Feder et al., 1985; Gebremedhin & Swinton 2003) indicated that farmers that have more years of schooling are more likely to realize the benefit of new technology and adopt it than their illiterate counterparts. As expected, age has a negative and significant effect on both adoption and selection models for the simple reason that younger people are more energetic for the farming activity.

Table 3. Univariate and Bivariate Estimation of Sf Adoption and Animal or Seasonal Choice

Variables	(Univariate)	(bivariate: Animal Choice)		(bivariate: Seasonal Choice)	
	Adoption	Adoption	cow	Adoption	year
Expected mean (First Moment)	0.107*** (0.0397)	0.108*** (0.0396)	0.0477 (0.0891)	0.106*** (0.0374)	0.135** (0.0657)
Variance of yield (Second moment)	-0.434** (0.200)	-0.438** (0.199)	-0.0890 (0.371)	-0.388** (0.190)	-0.230 (0.275)
Skewness of yield (Third moment)	-0.157* (0.0904)	-0.155* (0.0903)	0.0707 (0.218)	-0.154* (0.0815)	-0.464*** (0.168)
Family size(number)	-0.0018 (0.0055)	-0.0016 (0.0054)	-0.0157 (0.0117)	-0.0020 (0.0052)	0.0147* (0.0083)
Network(1/0)	0.0676*** (0.0261)	0.0677*** (0.0258)	0.0211 (0.0700)	0.0721*** (0.0249)	0.296*** (0.0526)
Animal shock of 2012-14 (Yes=1)	0.0548*** (0.0185)	0.0553*** (0.0183)	-0.0308 (0.0334)	0.0533*** (0.0178)	-0.00981 (0.0230)
Information(TV, radio & mobile =1)	0.0736*** (0.0251)	0.0739*** (0.0250)	0.0827 (0.0643)	0.0672*** (0.0233)	-0.0151 (0.0447)
Improved (Bred cow=1)	-0.0527 (0.162)	-0.0530 (0.149)	0.123 (0.120)	-0.0442 (0.150)	0.173* (0.0955)
Village Exposure of SF (years)	0.0225*** (0.00736)	0.0221*** (0.0073)	0.0188*** (0.0072)	0.0257*** (0.0078)	0.0013 (0.0043)
Labor(hour)	0.0003*** (7.86e-05)	0.0003*** (7.77e-05)	0.0001 (0.0001)	0.0003*** (7.42e-05)	0.0004*** (8.44e-05)
Age of household head (years)	-0.0018** (0.0008)	-0.0018** (0.0008)	-0.0042*** (0.0016)	-0.0018** (0.0008)	0.0011 (0.0011)
Gender of head (Male=1)	-0.0558** (0.0275)	-0.0530* (0.0281)	-0.0815 (0.0558)	-0.0526* (0.0269)	-0.0676* (0.0366)
Education of head (literate=1)	0.0412* (0.0241)	0.0423* (0.0240)	0.104** (0.0520)	0.0441** (0.0225)	-0.0273 (0.0366)
Herd size(TLU)	-0.0098** (0.0047)	-0.0101** (0.0047)	-0.0265** (0.0105)	-0.0099** (0.0049)	0.0018 (0.0067)
Feed transporting time (minutes))	9.59e-06** (4.30e-06)	9.70e-06** (4.29e-06)	-1.45e-05 (2.93e-05)	9.36e-06** (4.14e-06)	-0.0001** (5.21e-05)
Distance to free grazing (minutes)	0.0013*** (0.0002)	0.0013*** (0.0002)	-5.86e-05 (0.0004)	0.0012*** (0.0002)	0.0016*** (0.0001)
Distance to road(minute)	-0.0007** (0.0004)	-0.0007** (0.0004)	0.0006 (0.0006)	-0.0007** (0.0004)	-0.0017*** (0.0005)
Farm size owned (hectare)	0.0413* (0.0228)	0.0400* (0.0228)	-0.00244 (0.0205)	0.0385 (0.0234)	-0.0076 (0.0161)
Location (highland=1)	-0.0212 (0.0542)	-0.0227 (0.0532)	0.0755 (0.0947)	-0.0823** (0.0397)	0.0084 (0.0622)
Predicted prob	0.991	0.991	0.377	.996	0.149
Wald Statistics , $H_0 : \rho(Rho)=0$		Pr-value (5%)= 0.6501		Pr-value (5%)= 0.003	
Observations	367	367	288	367	288

NB: Asterisks (***, **, *) imply significantly different from zero at 1, 5, 10%, respectively.

Results of this study support the principal hypotheses that adoption of SF and chance of choosing cow for SF is high in villages where SF is practiced, confirming the result of Sauer et al (2009) in Europe and Beshir (2014) in Ethiopia. Labor positively influenced adoption and season selection. Similar signs are found for similar technologies (Beshir 2014; Gebremedhin & Swinton 2003; Turinawe 2012). Family size has a positive and significant relationship with the decision to adopt SF in full year, implying that people with higher family size show a greater interest in practicing SF the whole year.

The ownership of improved cows, inline to Beshir (2014), promoted the chance of applying SF under full-year term. Herd size was negative and significant determinants of adoption and selection. This is consistent with the findings of Kassie et al. (2009). Distance to nearest road was negatively correlated with joint adoption of SF and year selection, reinforcing the finding of Beshir (2014). Farmers with long distance to grazing lands site and crop residue site had a higher probability of adopting SF in full-year than their counterparts with a short distance. A 1% increase in the availability of land in hectare increased SF adoption by 4%. This result coincides with the finding of Beshir (2014).

CONCLUSION

Livestock farmers in developing countries experience risk and uncertainties. In Ethiopia, rural farmers are exposed to a variety of risks, including harvest failure, flood, frost, sickness, loss of stock, predation, input, and output price variability, the death and illness of livestock (Dercon, 2002). A number of feed management practices such as stall feeding (SF), rotational grazing, and tethering that could help mitigate the negative effects of these risks have been adopted.

This paper seeks to answer the following research questions of i) Do farmers have coping strategy that they opted for in order to curb the negative effects of production risks and shocks exposure? ii) May farmers view SF as risk-increasing or risk-reducing practice? iii) Are poor rural farmers impatient and less likely to adopt beneficial technology? iv) Are farmers in favor of full year adoption of SF over a seasonal use and feeding cows under SF system over oxen?

In view of these research questions, the main objective of the paper was then to estimate the

motivation for SF adoption and application using production risk and shock exposure as key determinants of the joint decision. The study was based on a cross-sectional household survey data collected from a sample of 518 farmers during the 2015 farming season in Northern Ethiopia. A bivariate probit approach was used to determine factors that affect SF adoption decision and choice of animal or season.

As expected, The empirical analysis revealed that production risk is a key determinant of SF adoption and full year application. The first moment has a highly significant positive effect on the adoption decision and full year SF application, implying that local farmers are driven by output maximization. Thus, they would be encouraged to use yield enhancing practices whenever it promises them higher returns. The second moment showed to have a significant negative influence on the adoption probability, and a higher probability of milk failure (downside risk) reduces the chance of SF adoption and full year application. This indicates that SF is only attractive and applicable to the local farmer when yields can be guaranteed. Thus, farmers seem to view SF as risk-increasing practice when the probability of milk production failure is high.

Results also show farmers shock exposure is to be important for the decision to adopt SF. In line with a priori expectations, shock exposure significantly increased the probability of adopting SF. Other factors having a significant positive effect on SF adoption and its application were: a social network, information access, family size and labor, distance to grazing land and crop residue, as well as the household's literacy and exposure to SF. Adoption of SF and feeding cow were supported by the younger, female households. Perhaps younger people are physically stronger to manage their livestock at home, and female farmers favored SF for feeding a cow than ox for the purpose of milk products.

How then can the results from this study be used to promoting the adoption of the new practices? The second and the third moments had a negative effect on SF adoption, indicating that farmers might view SF as risk-increasing practice. Policy-makers should then consider the importance of farmer's risk perception when promoting new technology adoption. Expected benefits that the farmer can derive from low production risk due to SF adoption should be included in the practice promotion agenda. Farmers' education and access to information appeared to play a significant role in adoption.

Information diffusion using demonstration center appear to be justifiable to stimulate and nurture the adoption process. A better coordination by extension agents seems to be needed to facilitate the intensification of SF and the dissemination of consistent information regarding its benefit. The implication is that intervention that reduces the variance of return and exposure to downside risk are some desirable in the adoption and choice decision.

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