Diffusion of Crossbred Cow Technology in Sri Lanka using Duration Analysis

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Abstract
Livestock plays an important role in the Sri Lankan economy and the smallholders contribute significantly to dairy production. This study was carried out to analyze the time-to- adoption of crossbred cow technology by smallholder dairy farmers. Hazard or duration analysis was used to examine the impact of time-varying and time-invariant variables on the speed of adoption of crossbreeds by smallholders. A Cox Proportional Hazard model was estimated using a sample of 401 farmers spanning 8 districts in the country. The empirical results highlight the importance of farming system, extension services, education level of farmers, their society memberships and geographical zones on accelerated adoption. However, higher transaction costs, experience, less accessibility to credit, less contacts with extension services and higher costs of production delay the time to adoption.

Key words: Cox model, Crossbred cow adoption, Duration analysis

Introduction
Milk production in Sri Lanka has a significant potential in growing, because the local demand is higher than the production. Consumption of dairy products has increased since the 1977s with the open economics policies (Ranaweera, 2009). The policy on dairy development is aimed at producing 50% of country's requirement of milk by the year 2015. To achieve this target, milk production needs to be increased in significant proportions. One way of achieving this is by popularizing the crossbred cow technology. Apart from increasing national production, crossbreeding will increase farmer incomes making it a poverty alleviation strategy.

A crossbreed is an animal with purebred parents of two different breeds, varieties, or populations while crossbreeding is the process of breeding the animal with the purpose to create off spring that share the traits of both parents or producing an animal with hybrid vigour. Traits such as reproduction, growth, maternal ability, and end product influence the productivity and profitability of the dairy production.

Cross breeding programs are implemented in farms across the country to suit each agro ecological zone. Despite the effort, the performance of sector is far below the expected targets. Adoption of technology is a process based on sequence of individual decisions, after which innovation is either accepted or rejected, which can be defined as the process by which the use of an innovation is spread throughout a productive system (Karshenas and Stoneman, 1995). Quicker adoption of crossbreds by the smallholder farmers will make it easier to achievement of the national goal of 50% self sufficiency. Therefore, this research looks at some factors that make a farmers' time to adoption shorter, making the diffusion of this important technology faster.

Materials and Methods
Duration Analysis is a statistical method that has been used to analyze adoption processes of agricultural technologies (Alcon *et al.*, 2011). It attempts to relate a set of covariates to time-to-event data. Length of a spell is started with the entry and end after a new state is achieved. Here we estimate the effect of covariates that shorten/extend this time to adoption.

In here, $f(t)$ is continuous probability density of a random variable T. The corresponding cumulative distribution is taken as,

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$F(t) = \int_0^t f(s)\,ds = Pr(T \leq t)$ (1)

The survival function which is denoted in (2) gives the probability that the event has not occurred at time'*t*'. In relation to the present study, the survival function gives the probability of a farmer not adopting a crossbred at the end of the study period.

$S(t) = Pr(T>t) = 1 - F(t)$ (2)

Where, S (t) gives the probability that a spell is of length at least'*t*', that is, the probability that the random variable *T* exceeds *t*.

$$h(t) = \lim_{\Delta t \to 0} \frac{Pr(t \leq t+\Delta t / T \geq t}{\Delta t)} \quad (3)$$

The distribution of *T* is characterized differently in the Hazard function, which is sometimes called the instantaneous occurrences of the event. The Hazard function can be given by:

$$= \lim_{t\Delta \to 0} \frac{F(t+\Delta) - F(t)}{\Delta S(t)} = \frac{F(t) - F(t)}{S(t)}$$

Where, S(t) is the Survival function and F(t) is the continuous probability density function.

The most commonly used parametric model in duration analysis is the Proportional Hazard model and it takes the following form:

$$h(t, X, \theta, \beta) = h0(t, \theta)\, g(X, \beta) \quad (5)$$

Where, $h_0(t, \theta)$ is the baseline hazard, $g(X\beta)$ is the scaling factor, and θ, β are parameters to be estimated (An and Butler, 2012). Data used here has been collected in 2009 for a previous study (Edirisinghe, 2010). Data were collected from 401 smallholder dairy farmers from 8 districts in Sri Lanka during January-April 2009. Stata 11 statistical software is used to estimate the Cox Proportional Hazard model.

Results and Discussion

Most of the respondents were in the intermediate (40%) and dry zone (38%). Majority of respondents were male (76%) with the average age of 46 years. From total respondents, considerable number of farmers had secondary education (75.8%) while average experience of farmers was 14 years. Out of total respondents 63% unemployed and 27% employed. Comparatively most of farmers engaged in cattle farming as a part time operation (71%) while 29% as full time (29%).

Majority of farmers carries out a semi intensive (54%) farming system while 44% of the farmers' rear animals in extensive systems with the average herd size are nine animals. Farmers took an average of 13 minutes to access the market. Out of total farmers 86.3% agreed with the statement that cross bred cows are suitable to their area. Majority of farmers has a membership with the farmer group (76%). About 42% of the farmers use the farmer groups as an information source. Close to 79% of farmers visited the veterinary service at least a nine time a year while 63% have attended training programs on dairy farming.

Out of the total sample, 85.3% adopted the technology and 14.7% have not. The duration is the length of time to adopt the innovation. There is no clearly defined date for the adoption of the innovation. Earliest year is 1965 and therefore, the maximum duration is 45 years.

Table 1. General duration models

Variables	*Cox model*
Wet	1.38(0.013)**
Intermediate	1.43(0.000)**
Elevation	1.00(0.307)
Age	1.01(0.100)
Employment	1.03(0.149)
Education	1.03(0.083)*
Experience	0.92(0.000)**
Working time	1.01(0.875)
Time to market	0.99(0.579)
Management system	1.16(0.047)**
Herd size	1.01(0.089)*
Cost	0.99(0.049)
Income	1.00(0.433)
Perception	0.76(0.013)**
Society membership	1.58(0.000)**
Information	0.85(0.033)**
Credit	0.96(0.546)
Training	1.00(1.000)
Extension	1.01(0.015)**
Log likelihood	-1467.66
LR chi2(20)	135.78 (0.00)**

Note: All coefficients are reported as Hazard ratios. Significant levels at 0.05(**) and 0.1(*) are reported in parentheses.

Average duration is nine years.

In Table 1 results of Cox model is reported. Cox model is the more general model of all duration models. A hazard ratio greater than one denote that the variable has positive impact on the likelihood of the adoption and vice versa.

In terms of location, wet and intermediate zone (1.38 and 1.43) has higher rate of adoption with compared to dry zone. That is, farmers in wet and intermediate zones have high probability of adopting crossbred technology sooner than dry zone farmers. Management system (1.16) has a positive hazard rate show that the intensive farming system has a higher probability of adoption than the other farming system. Farmer, who is a member of a dairy society (1.58), adopt sooner than farmers who are not members of dairy societies.

Also an extension services and education positively impact on the adoption of cross bred technology significantly. Farmers with higher education showed a higher adoption rate. It may be because, farmers can be aware of crossbred technologies and their benefits through extension services and also, they possess a good knowledge when they are educated. Therefore, higher human capital increases the speed of adoption. Perhaps, farmers may not willing to participate, or may reluctant to practise the strategies introduced even though they participated for the training programmes. Hence, there is no impact from training programmes on the adoption of crossbred technology, whereas the result isn't significant. Further, farmers tend to continue dairy farming with the increase of herd size by improving the productivity. Therefore, there is a possibility to adopt crossbreds. On the other hand, farmers' income might not solely depend on dairy farming, but on many other ways. Thus, results showed that income has no impact on adoption even though it is insignificant. However, farmers' wealth as measured by the herd size has a significant impact on the duration taken to adopt.

Since experience, cost of production, and perception on cross bred cows hazard ratios, it can be concluded that farmers believe conventional farming can sustain productivity than adopting cross bred cows.

Information taken from the milk society shows a contradictory lower hazard ratio. Time taken to market and credit are found to have a negative impact on adoption but failed to show significance.

The results revealed that the adoption of farmers speeds up with their education, farming system they adopt, herd size, society membership, extension services and the area of the farms are situated while experience, costs of production, information and perception delays adoption. It is therefore, prudent to improve extension services, knowledge of farmers, and strengthen the institutional innovations such as dairy societies. Further, reductions in transaction costs of selling and finding ways to reduce costs of production are important. Moreover, extension services can look at reducing negative perceptions of farmers to speed up adoption rates.

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