MEASURING ADOPTION LAGS: FARMER Vs. FARM CONCEPT

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Abstract

Conventional definitions of the time to adoption of an innovation
do not consider whether a potential adopter already had
decision-making responsibilities at the time the innovation
became available. Data from a pest management survey conducted
in India are used to provide empirical support for an alternative
definition that takes into account when farmers assumed
decision-making responsibilities.

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Introduction

Some agricultural technology innovations are opportunities for farmers to improve their livelihood. Most of these opportunities are likely to be realized eventually, but none is ever realized immediately. There is always a lag between the time a technical innovation becomes available and the time it is adopted by any one farmer. Transfer and extension activities should accelerate technology diffusion, avoid erosion of the potential returns to research, and avert undesired distribution effects of differential adoption. These activities are likely to be the more effective the better they can be aimed at particular groups of potential adopters and the better past adoption behavior of the members of these groups can be explained.

A recent review of the literature on adoption of agricultural innovations by Feder et al. (1985) indicates that most of the research on adoption behavior concentrated on the explanans, the factors that contribute to an explanation of adoption. The explanandum, the level of adoption or the time to adoption, in contrast, appears to have been treated as a primitive variable by most authors, not worthy of much attention.

In this paper we concentrate on the time to adoption as the explanandum in empirical adoption research. We compare two measures of the adoption lag. One measure uses the farm as the unit of observation. The farmer, or decision maker, is the unit of observation for the second measure. We suggest that the measure based on farmers is consistent with intentional explanations of adoption whereas the alternative measure is not. We then derive the implications of the two measures for the measurement and interpretation of diffusion and report an empirical comparison of the two measures of the adoption lag.

Adoption lag in causal and Intentional explanations

Economists generally use either causal or intentional explanations for explaining technical change (Elster 1983). This distinction is also applicable to explanations of adoption lags, i.e. the delay in technological change.

A causal explanation of the adoption lag is obtained by finding a regular conjunction between the adoption lag and other observable events that are contiguous to the delay in adoption in space and time, and that precede or are contemporaneous with the adoption event. Causal explanations do not necessarily relate to individual decision-makers, their acts and goals, and they do not refer to expectations held by decision-makers. Hence, in causal explanations the domain of the explanandum 'adoption lag' is not constrained to identifiable decision-makers but may also include other entities, such as farms, villages, or sections of the

agricultural sector, which cannot be said to decide or to act. Causal explanations may therefore be used to explain the adoption lag of farms, as well as the adoption of lag of farmers.

In contrast, intentional explanations characteristically are presented in terms of decision-makers' goals and expectations. For example, an intentional explanation of adoption lag would have to refer to the contribution to goal achievement a potential adopter expects from adoption of a technology. The domain of the explanandum of intentional explanations is limited to individual decision-makers or groups of individuals because goals and expectations can only be ascribed to man. Intentional explanations cannot be used to explain adoption lags of farms or other non-human entities.

Policies for shortening adoption lags may attempt to affect farmers' adoption decisions. Such policies may be justified by intentional, farmer-based, explanations, but not by causal explanations that explain adoption lags of farms, rather than farmers.

Operational Definitions of Farmer's and Farm's Adoption Lags

The adoption lag has been definied as the time from availability of an innovation to its adoption (Lindner et al. 1979). In applied research, adoption is usually defined in terms of the incidence of use for indivisible technologies, and in terms of intensity of use for divisible ones. Here, we regard an innovation as adopted when it is first used on the farm of its adopter, irrespective of the intensity of use.

An innovation may be objectively available in the sense that it could be readily adopted by some potential adopters, but subjectively unavailable to potential adopters unaware of its existence or denied access to it. This situation often arises in developing countries at the periphary of innovative activity. Although a subjective definition of availability is theoretically appealing it is often impractical because awareness cannot be directly observed. As a compromise, the beginning of the adoption lag may be defined in terms of some event indicative both, the innovation's availability to the group of potential adopters and farmers' awareness of this innovation. The first use of the innovation on any one farm from a group of farms is such an event. We can then define the adoption lag of a particular **farm** as the period from the time when the innovation was first used on any one farm of a group of farms and the time when the innovation was first used on that particular farm.

This definition refers only to farms but not to farmers and could be suitable for causal explanations of the adoption lag. Simply substituting 'farmer' for 'farm' would not yield a definition suitable for intentional explanations. Because some individuals may not have been farmers with decision-making responsibilities when the innovation was adopted by the first farmer, simple substitution would then lead to an upwardly biased measure of the adoption lags for these farmers. This bias would be equal to the time from the innovation's first adoption in the group to the time when the particular individual became head of a

farm. Hence, we define the adoption lag for a particular __farmer__
as the period from the time the innovation was available, or the
time the individual assumed headship of a farm, whatever event
occurred last, and the time that farmer used the innovation for
the first time.

More formally, the farm-based adoption lag is defined as:

$$l(i) = a(i)-T \qquad (1)$$

where, $i = 1...M$ is an index for farms, $a(i)$ is the time when the
innovation was adopted on farm i, and T is the time of first
adoption in the group, i.e. $T = \min [a(i)]$.

The farmer-based adoption lag L is defined as:

$$L(j) = A(j) - \max [T; f(j)] \qquad (2)$$

where $j = 1...N$ is an index for farmers, and $f(j)$ is the time
when the j-th farmer assumed responsibility as head of his farm.
$A(j)$ the time when the j-th farmer adopted the innovation, and T
$= \min [A(j)]$.

Note that only one observation per farm is required to
measure $l(i)$, but that two observations per farmer are necessary
for measuring $L(j)$. Furthermore, all adoption lags $l(i)$ have T
as a common origin, whereas the $L(j)$ may not have a common origin
on a calendar time scale.

Adoption Lags and Diffusion

A diffusion curve is a graphical representation of cumulative aggregate adoption plotted against a time scale with arbitrary origin. The diffusion process in a population of M farms is described by the sequence [D (t)] where

$$D(t) = 1/M \sum_{i=1}^{M} d(i,t). \qquad (3)$$

Setting the origin of t at T we obtain

$$d(i,t) = \begin{cases} 0 & \text{if } t-T \leq a(i)-T \\ 1 & \text{if } t-T > a(i)-T \end{cases} \qquad (4)$$

Because $l(i) = a(i) - T$, [D(t)] reflects the distribution of the farm-based adoption lag in the population of farms.

To obtain a similar correspondence between diffusion and the farmer-based adoption lag, we choose the origin for t as max [T, f(j)] and obtain

$$f(j,t) = \begin{cases} 0 & \text{if } t-\max[T,f(j)] \leq A(j)-\max[T,f(j)] \\ 1 & \text{if } t-\max[T,f(j)] > A(j)-\max[T,f(j)] \end{cases} \qquad (5)$$

and

$$\Delta(t) = 1/N \sum_{i=1}^{N} f(j,t)$$

[$\Delta(t)$] then describes the diffusion process in the group of farmers because $L(j) = A(j) - \max [T,f(j)]$.

With a direct correspondence between farms and farmers (i=j), so that $a(i) = A(j)$, the graph of $\Delta(t)$ will never lie to the right of the graph of D(t) because $t-T = l(i) \geq L(i) = t - \max [T,f(j)]$. In other words, D(t) will always lie to the right of $\Delta(t)$ whenever one farmer become farm head after the innovation was first adopted in the group of farms. It can be shown that the deviation of $\Delta(t)$ from D(t) depends on the number

of farmers for whom f(j)>T and on the distribution of the f(j) of these farmers. This distribution is determined by the age structure of farmers, mortality factors, and the laws and customs ruling intergenerational transfer of management responsibility.

An Example: Adoption Lags of High-Volume sprayers

From a sample survey (Mueller et al. 1986) in a village in India we obtained data on adoption of high-volume (HV) spraying from a bullock cart to control the podborer Heliothis armigera in pigeonpea and when they became the heads of their farm households. The sample consisted of 67 farmers. The diffusion process for HV-spraying can be regarded as completed because controlled-droplet applicators (CDA) are quickly replacing dusting and HV-spraying. In the years 1983 and 1984 only two farmers adopted HV-spraying, but 38 farmers used CDAs for the first time.

Adoption of HV-spraying began in 1968. Thirty-three farmers had already been managers of their farms in 1968 and 34 became managers afterwards. The average adoption lag of HV sprayers is 10.8 years when farms are the unit of observation, and 7.7 years for farmers. As can be expected for a population where most adopters became managers after the introduction of the innovation, the alternative diffusion curves differ considerably. The diffusion curve representing adoption of spraying by the farms approximates the usual sigmoid shape whereas the diffusion curve reflecting farmers' adoption lags is considerably steeper and its shape is straighter (Fig. 1).
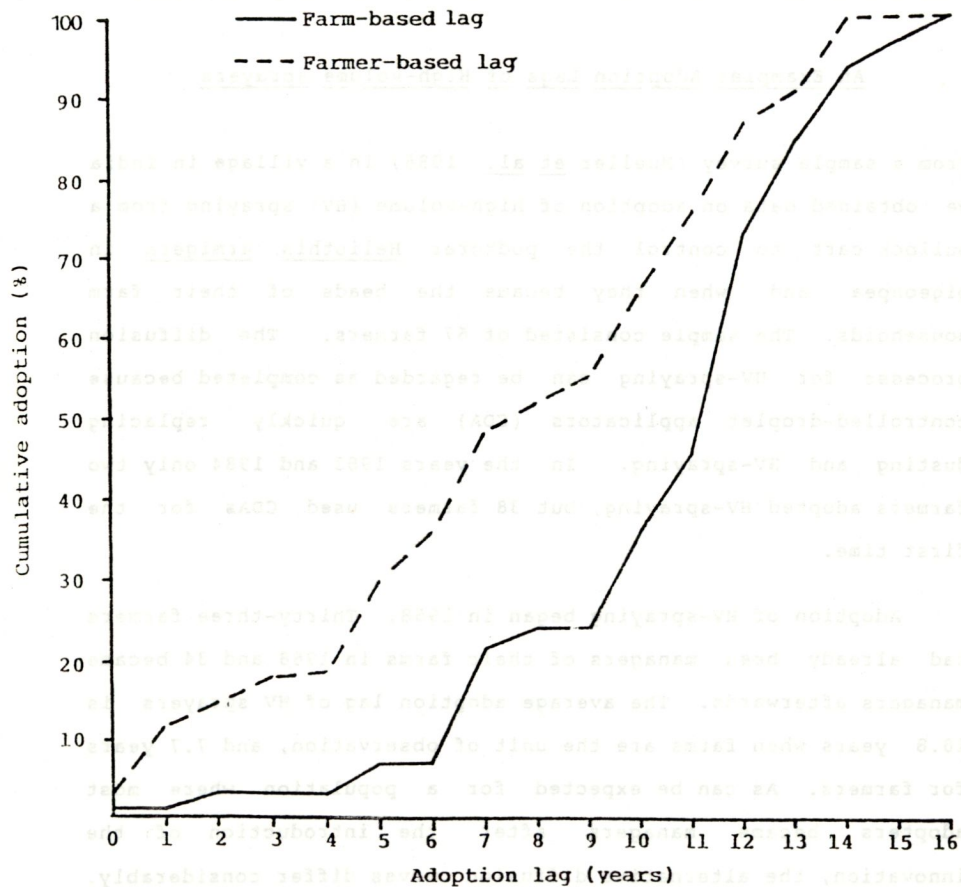
Figure 1.   Diffusion of HY-Spraying.

Based on experience from adoption studies reported in the literature and acquaintance with the social and economic environment in the study village we selected a number of easily observable variables that could explain the time to adoption of HV-sprayers. These variables, their means, and coefficients of variation (CV) are listed in Table 1.

We specified three models containing these variables. In the first model the adoption lag of farmers is the dependent variable. In the second and third models farmers' adoption lag is explained. The latter models vary in only one respect. In the third model we included farmers' years of experience as farm head of his farm at the time of adoption as an independent variable. For all farmers who became head after the introduction of the HV-spraying, this variable is identical to the farmer-based adoption lag.

Results in Table 1 indicate that the two models for explaining farms' adoption lags accounted equally for total variation in the regressand and inclusion of information when farmers became heads did not improve the statistical estimates. When the time when farmers became heads is used to measure farmers' adoption lags less variation remains unexplained and farmers' age at the time of adoption turns out to be a statistically significant variable delaying adoption of HV-sprayers. Thus, measuring adoption lags of farmers rather than farms would allow policy makers to concentrate on younger

Table 1. Regression results (n=67).

Variable	Mean	CV%	Adoption lag					
			Farmer-based		Farmer-based			
					Model 1		Model 2	
			b	SE	b	SE	b	SE
Percentage of pigeonpea area	52	41	-0.004	0.002	0.0031	0.018	0.029	0.018
Age at time of adoption (Y)	42	32	0.17**	0.030	-0.001	0.025	0.039	0.040
Experience at time of adoption (Y)	14	82	-	-	-	-	0.060	0.046
Perceived pest losses (%)	20	29	0.12	0.079	0.095	0.065	0.010	0.065
Schooling dummy (1)	0.48	-	-2.4*	0.85	-2.18**	0.70	-2.0**	0.71
Dusting experience dummy	0.87	-	3.2*	1.3	3.2**	1.1	3.2**	1.1
Dusting by hand dummy	0.69	-	1.8*	0.89	-2.1**	0.74	-2.1**	0.73
Bullock and cart dummy	0.81	-	-0.17	1.2	0.62	0.99	0.66	0.99
Intercept	-	-	-1.5	3.3	6.6	2.7	5.6	2.8
R^2			0.45		0.33		0.34	
F			8.60**		5.67*		5.22	

* Significant at 5% level

** Significant at 1% level.

1) 0=4 years or less, 1=more than 4 years.

farmers if the objective is to accelerate early adoption and on older farmers if the objective is to shift late adoption forward in time.

Summary and Conclusions

In this note we have suggested alternative definitions and measures for the time to adoption of an innovation. In contrast to its alternative, the farmer-based definition accounts for the time when potential adopters can actually make adoption decisions. This measure of the time to adoption is conceptually more appealing than its farm-based alternative when the purpose of measurement is intentional explanation of adoption behaviour for guiding adoption policies. For a small sample of adopters of high-volume spraying measuring the adoption lag of farmers allowed a more precise identification of variables affecting the duration of the adoption lag than its measurement for farms.

The advantages of the proposed measure come only at a cost. First, it requires at least double the number of observations needed for measuring adoption by farms. Second, the farmer-based measurements do not have a common origin in calendar time. This measure is therefore unsuitable for describing diffusion processes historically. Nevertheless, the measure of farmers' adoption lag is consistent with theoretical concepts of adoption decision-making and may allow more comprehensive identification of factors affecting adoption.

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