AGREKON

Vol 40 Number/Nommer 3
September 2001

Published by the
Agricultural Economics
Association of South Africa

Gepubliseer deur die
Landbou-ekonomievereniging
van Suid-Afrika

DETERMINING ASSOCIATION AMONG PRODUCTION ENHANCING FACTORS: CASE OF MANKWENG DISTRICT IN THE NORTHERN PROVINCE

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Several models are selected using model selection loglinear analysis on data collected from farmers in the Mankweng District in Northern Province. The objective is to determine patterns of associations among production increasing factors, namely, use of recommended technologies, participation in a cooperative or project, accessibility of inputs in time, security of land ownership, as well as ability to run own finance. The results reveal that participation in a project and the use of technology are always associated. Only land tenure model resulted in a significant saturated model, where a three way association with both technology and project participation had significant effects. Access to input on time was only associated with technology use, but not with participation in a project. The ability to run own finances was associated with project participation, but not with technology use. The dynamic relationships among these factors are important when introducing technologies and support services for the future.

1. INTRODUCTION

Maize is a major staple food for the majority of rural households in South Africa. Due to limited purchasing power, most of the households are encouraged to increase production of own maize. Empirical evidence has shown that production tends to increase when production-enhancing technologies are provided with other support services (Kirsten *et al*, 1993; Mathabatha, 1996). The objective of the study is to determine patterns of association or interdependence among factors that enhance production.

The question regarding accelerating the usage of production enhancing factors still bother many researchers. According to Heisey *et al* (1998), farmers will make use of technology only if they expect to benefit from the new technology. This evaluation boils down to benefits (yield advantage and cost

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savings) and costs of accessing and utilising the technology and support factors. These factors have been explored in numerous studies which tend to put emphasis on the institutional factors. For example, several studies found that lack of information and appropriate extension support, and unavailability of inpust on time limit the use of improved varieties (Bisanda and Mwangi, 1996; Nguluu *et al*, 1996; Mose *et al*, 1996). Other institutional factors included membership to cooperative (Morokolo *et al*, 1998) as well as availability of credit and local input suppliers (Hassan *et al*, 1998).

The basic theoretical exposition for enhancing production when farmers utilise technologies and support services involves a shift in the production function. Rauniyar (1990) showed that such a shift leads to an increase in the marginal productivity of other inputs. Such shifts are brought about by access and utilisation of some factors, which can either be utilised as a package (Van Rooyen, 1995) or in a stepwise form (Rauniyar and Goode, 1992). Basically, there is interaction among farm level factors (Heisy *et al*, 1998) which necessitates a formal test of the patterns of association.

This paper employs a loglinear method to evaluate the dynamic interaction among technology and some institutional factors. The data for this study was obtained from a 1996 survey of about 200 farmers in the Mankweng district of the Northern Province. Several variables were constructed in order to analyse the dynamics of the use of production enhancing technologies. Model selection loglinear analysis was employed to evaluate associations among technology use, participation in the project, receiving inputs in time, land tenure security, and whether the farmer can run finances.

2. LOGLINEAR MODEL FOR PRODUCTION ENHANCING FACTORS

The chi-square analysis is generally used to test independence between the two categorical factors. The null hypothesis is rejected when there is association. However, the test does not give any information about the source of interaction or association between factors. Also, the analysis is not applicable when there are more than 2x2 contingency tables. The loglinear model does not suffer from these limitations. Thus, loglinear models can be used for the advanced analysis of categorical data (Ngqaleni and Makhura, 1995).

In the loglinear model, independent variables (factors) are used for classification and the frequencies in the cross tabulation cell are a dependent variable (Knoke & Burke, 1980; Mucavele, 1998). Therefore, for a cross tabulation with i rows and j columns, the multiplicative model is used to express frequencies in each cell f_{ij} as function of the controlling factors as follows:

$$f_{ij} = \eta \tau_i^T \tau_j^P \tau_{ij}^{TP}$$

This formulation represents the relationship in a two-way contingency table, which can be generalised to a multi-dimensional table. The model can be transformed into a linear equation by taking natural logarithms as follows:

$$\begin{aligned} Ln(f_{ij}) &= Ln(\eta \tau_i^T \tau_j^P \tau_{ij}^{TP}) \\ &= \mu + \lambda_i^T + \lambda_j^P + \lambda_{ij}^{TP} \end{aligned}$$

where μ or log (μ) is the mean effect, λ_i^T or log (τ_i^T) and λ_j^P or log (τ_j^P) represent the main effects of technology (T) and project participation (P) respectively, called main effects. The λ_{ij}^{TP} or log (τ_{ij}^{TP}) represents interaction (first order) effects indicating the existence of association between T and P. The constraint imposed is that the sum of the effects over the row (i), column (j), and across (ij) is zero. As such, because of the linearity between main effects, there are 1+(I-1) +(J-1)+(I-1)(J-1)=IJ unknown parameters (μ and λ's). The model is referred to as saturated hierarchical log-linear model. The model is selected by testing the null hypothesis that the interaction effects are zero (Maddala, 1992). Since we apply hierarchical modelling, the lower order effects and main effects are always included in a selected model.

Following Morokolo *et* al (1998) and the preliminary analysis, several variables were constructed. The following are the variables and the respective categories:

Technology use (T): measures the level of technology use in terms of using both certified seed and fertiliser. The variable has two categories: (1) did not use certified seed and fertiliser, and (2) used certified seed and fertiliser.

Project participation (P): measures farmers' participation in the project (or co-operative). There are two categories: (1) not participate in the project, and (2) participates in the project.

Receive inputs on time (R): determines whether farmers receive inputs on time. The variable has two categories: (1) did not receive inputs on time, and (2) receive inputs on time.

Security of land ownership (L): Reflects the feeling of security of land ownership; (1) feel insecure about land ownership, and (2) feeling secure.

Run own finance (F): determine whether the farmer can run own finance; (1) cannot run own finance, and (2) can run own finance.

3. SURVEY RESULTS

3.1 Effect on productivity

The survey results (in Table 1) show that the mean production of maize is 3.36 bags[4] per hectare. This production is relatively low, as farmers in the area do not apply all the production enhancing factors. Those who do, tend to realise higher production per hectare as compared to those who don't. Table 1 indicates the results of One-way Analysis of Variance (ANOVA) in comparing means among different groups applicable to different factors.

Table 1: Oneway analysis of variance in maize productivity (80 kg bags/ha)

Production per ha	N	Mean (bags)	Std Deviation	F-Statistics (DF) Sign
All farmers	151	3.362	5.02	-
Technology Use:				
No	45	.69	2.28	20.55 (1;149)***
Yes	106	4.50	5.42	
Project:				
Non participant	71	2.64	6.17	2.23 (1;126)#
Participant	57	3.93	2.36	
Receive inputs in time:				
No	28	1.99	4.74	12.38 (1;143)*
Yes	64	4.86	5.43	
Security of land				
No	96	2.50	2.13	8.06 (1;149)***
Yes	55	4.86	7.64	
Run own finance:				
No	101	2.76	5.00	3.58 (1;142)**
Yes	43	4.38	3.94	

**** 1% level of significant at, ** 5% level of significance, * 10% level of significance, and # 15% level of significance.*

4 *A bag is equivalent to 80kg. About 12,5 bags make a ton. Bags were used as unit of measurement since it was commonly understood by respondents.*

Those who used certified seed and fertilisers produced five times more per hectare as compared to those who did not. On the other hand, those participating in a project tend to produce more maize per hectare as compared to those who don't. However, the less significant difference could be attributed to the spillover of the project effect. Further, feeling secure about land ownership makes a significant difference in production per hectare. This feeling gives farmers confidence to access technologies that lead to increased productivity. Finally, the ability to run own finance could be associated with arrangements of pooling funds to purchase inputs.

3.2 Results of loglinear analysis

Three models involving a three-way interaction were fitted using the above variables. These were more parsimonious and the size of usable (valid) cases was relatively small to get useful information from higher order interactions. Table 2 presents frequencies generated by the loglinear models.

Table 2: Observed frequencies* generated by the loglinear models

		Model I Extension Distance		**Model II** Receive Input in Time		**Model III** Tenure Security		**Model IV** Run Own Finance	
Technology	Project	Close	Further	No	Yes	No	Yes	No	Yes
No	No	32	48	68	3	65	17	73	8
	Yes	1	1	4	0	1	3	3	1
Yes	No	8	21	7	7	6	24	24	5
	Yes	7	42	6	47	46	8	21	29

**For saturated model 0.5 is added to all observed cells when computing the models.*

Model I fitted technology (T), project participation (P) and receiving inputs in time (R). The question is whether receiving inputs on time can enhance application or utilisation of technologies. The results of loglinear models are presented in Table 3.

Two first order effects were significant. The model can be expressed as follows:

$$Ln(f_{ijk}) = \eta + \lambda_i^T + \lambda_j^P + \lambda_k^R + \lambda_{ij}^{TP} + \lambda_{jk}^{TR}$$

The first order effects imply that receiving inputs on time encourages farmers to use production enhancing technologies. This is expected since when inputs

Table 3: Results of the loglinear model

Model I Technology*Project*Receive-Input-time		**Model II** Technology*Project*Tenure Security		**Model III** Technology*project*Run-Finance)	
Factor	**Coefficient**	**Factor**	**Coefficient**	**Factor**	**Coefficient**
Main Effects		Main Effects		Main Effects	
Technology	-.58*** (-2.722)	Technology	-.29** (-2.014)	Technology	. 41*** (2.650)
Project	.51** (2.424)	Project	.56*** (3.841)	Project	40 *** (2.743)
Receive Input on time	.26 (1.204)	Own land		Run own finance	. 52*** (3.552)
1st Order Effect		1st Order Effect		1st Order Effect	
Technology*Project	.65*** (3.085)	Technology*Project	.79*** (4.456)	Technology *project	79*** (5.374)
Technology*Receive Input in time	1.04*** (4.898)	Technology*Ownland		Technology *Run own finance	.23 (1.55)
				Project *Run own finance	.39*** (2.65)
2nd Order Effect		2nd Order Effect		2nd Order effect	
		Technology*Project* Ownland	649 *** (4.456)		

*** significant at 1%, ** significant at 5%, * significant at 10%

are received on time farmers will be ready to use them. Participation in the a project also encourages technology use. Those farmers in the project or associated with cooperative are able to benefit from group advantages. Normally, such groups would have a programme of production activities.

In **Model II**, factors T, P and the security of land ownership (L) were fitted. The saturated model fitted well, implying that farmers participating in the project, felt more secure in land ownership and, thus, tended to use production-enhancing technologies. Based on the significance of the coefficient, the model that fits the data can be expressed as:

$$Ln(f_{ijk}) = \eta + \lambda_i^T + \lambda_j^P + \lambda_k^L + \lambda_{ij}^{TP} + \lambda_{jik}^{TPL}$$

The results of the second order effect (T*P*L) indicates that farmers involved in a project are more likely to use technologies when they feel secure about land ownership. The first order and main effects involving land ownership were not significant. This means that land tenure reform cannot be effective in isolation; it should be packaged with other elements.

In **Model III**, the variable, run own finance (F) was included in T and P. The second order effects were not significant. The model is thus:

$$Ln(f_{ijk}) = \eta + \lambda_i^T + \lambda_j^P + \lambda_k^F + \lambda_{ij}^{TP} + \lambda_{jik}^{PF}$$

The first order effect, P*F implied that those farmers in a project learn how to manage their finance. However, the significance of association between technology use and ability to run own finance is not very strong.

4. CONCLUSION

In general, the emerging farmers express willingness to access and utilise production-increasing technologies. Appropriate institutional arrangements are indispensable in encouraging farmers to use such technologies. The results of this study revealed that farmers tend to use technologies extensively when operating in a cooperative or project setting. Typically, a cooperative or project will facilitate availability and access to recommended technologies.

The study further revealed that when farmers receive inputs on time they are likely to use improved technologies. It appears that receiving inputs on time is not exclusively associated with farmers participating in a project. This is probably due to spill-overs from existence of a project such that farmers not

participating in the project take advantage of improved institutional arrangements created by the project environment.

The security of land ownership was associated with both technology use and project participation. However, it is clear that land tenure alone is not enough to make the difference. It requires packaging with other factors. The ability to run own finance is associated with participation in a project. That is so since project or cooperative development involves pooling of funds that train participant in financial management. However, in the study area, the association between ability to run own finances and the use of technology is not strongly significant.

New and existing cooperatives or project approaches could be implemented to improve institutional setting. This will ensure availability of inputs on time since late arrival of inputs is costly to farmers. The package should also include training in financial management as well improvement of land tenure.

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