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Application of Logit Model in Innovation Adoption: a Study on Biotechnology Academic Researchers in Malaysia

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Abstract: Agro-biotechnology is considered as a strong potential to speed up the movement towards industrialization in Malaysia due to the country's specific needs and social, geographical and industrial context. The level of adoption of agricultural biotechnology in Malaysia should be accelerated to change this potential to actual improve. Academic centers play a great role in Malaysian context because they are the main providers for biotechnology. The aim of this paper is to determine and optimize the technology adoption scenario in Malaysia from the viewpoint of academic researchers. Based on the previous studies the general predictors of the level of adoption are determined as six factors including level of knowledge, amount of funds, level of acceptance and receptiveness, level of cooperation, level of transfer of technology and personal characteristics. According to academic researchers, among the variables mentioned above, level of knowledge, acceptance and transfer of technology influence the level of adoption of biotechnology innovation in Malaysian agro-biotechnology companies. Therefore, to accelerate the adoption of new biotechnology innovations it is suggested that policy makers place greater emphasis on providing facilities to increase the level of knowledge, acceptance and technology transfer as a strategy to accelerate the rate of biotechnology adoption in Malaysia.

Key words: Innovation · Adoption · Logit model · Biotechnology companies · Academic researchers

INTRODUCTION

The need for a linkage between innovators and industry was emphasized [1] who argued that it is necessary to evaluate the market needs and the value of a new technology. For this to happen, there is a need for closer linkage between the researchers/innovators and the users of the innovations. Academic research centers as the producers of the innovations are directly involved in the process of adoption of innovations.

Considering the importance of this issue, the present paper investigated the adoption of biotechnology innovations in Malaysian biotechnology companies from the perspective of the university biotech academics in order to give an insight to the adoption process from the academics' point of view. The two way connection between academic centers and adopters was emphasized by Hoban [2] who suggesting that extension must focus on transfer of the type of biotechnology that is adaptable and profitable for agriculture. Providing this linkage can integrate biotechnology into total agricultural systems, provide the industry with accurate, unbiased information on biotechnology innovations and convert basic scientific research into useful technologies by collaborating closely with university scientists and industry experts.

In Malaysia, this linkage can be developed by an extension system under the supervision of Ministry of Science, Technology and Innovation (MOSTI) [3], to complete the relationship cycle between MOSTI, universities, extension agents and biotechnology companies. Biotechnology companies must be aware of university and research innovations, to be able to utilize them.

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MATERIALS AND METHODS

The target population was limited to 98 academic biotechnology researchers in Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM) and Universiti Putra Malaysia (UPM) due to the limited number of the target population the sample and the population were considered to be the same as mentioned by Creswell [4]. The data collection was done by means of a self-administered questionnaire, which was devised by the researcher. The questions and their content were developed based on the literature review and the local and social situation to ensure validity. The adopted questions were modified to match the research context. The validity of the questionnaire was ascertained by a panel of experts and through a pilot test. A pilot test was carried out to determine the validity and reliability of the questionnaire. The pilot test was conducted in Universiti Sains Malaysia (USM), a member of BioValley Malaysia.

The reliability was measured by using the Cronbach's alpha internal consistency [5]. The calculated reliability coefficients for university biotechnology researchers' questionnaire were .771, .776, .800, .833, .762 and .816 for the different sections of the questionnaire namely: level of knowledge, amount of found, level of acceptance, level of cooperation, level of transfer of technology and rate of adoption, respectively. The reliability coefficient for this questionnaire as a whole was equal to .880.

The validated and reliable questionnaire was distributed to the 98 biotechnology experts working as academics in biotechnology fields in UPM, UKM and UM. The response rate was 89.79% (N=88). The obtained data was used to conduct the logistic regression.

The data used in this study came from academic biotechnology researchers in Malaysia (totally 98 Biotechnology researchers). The survey was done in Malaysian public universities namely UM, UKM and UPM. The survey collected a wide range of detailed information on various aspects of level of knowledge, amount of fund, level of acceptance and receptiveness, level of cooperation, level of transfer of technology and personal characteristics from the perspective of university biotechnology experts.

The participants from the universities were 61.4% females and 38.6% males. The data on the average innovations produced was slightly higher for the female population, equaling .68. While for the males, it was .62 during the period of 2005-2008. However, this difference is not significant and therefore we cannot consider gender as a differentiating factor in this context.

Age and academic experience were the two factors that affect the rate of innovations produced by academics. Classifying the data based on the age of the participants revealed that the most innovative academic members are in the age group ranging from 35 to 45 years there is however a substantial decrease in the age range of 46 to 50 years. The number of innovations increases slightly thereafter. The same pattern applies for working experience, where those with less than 10 years of experience were more innovative while a significant decrease was noted among those in the range of 11 to 15 years. An increase was subsequently seen in those with more than 16 years work experience. This pattern can be attributed to the academic system of promotions and salary increments. The new academic staffs are more eager and enthusiastic. They are energetic and driven by future prospects in their work environment. Later on however as they settle down, the number of innovation appear to decide, perhaps due to complacency. Given new perspectives for change and growth in subsequent years, the academic members get renewed vigor and work harder. This could explain the trend as seen above. The final part of the data on demography dealt with job designations of the university respondents. The participants were categorized into four groups: professors, associate professors, senior lecturers and lecturers. It was observed that the lecturers had the highest productivity rate while professors, the lowest. However, the differences were very minimal (professor=. 60, associate professor= .70, senior lecturer=. 71, lecturer=. 75). Since there were no significant differences among the groups, with respect to academic designations, this cannot be considered as a differentiating factor.

The present study tends to analyse a problem with five independent variables with the level of adoption of biotechnology innovations as the dependent variable. The logistic regression has been recognized as a new approach to obtain more precise estimates on the level of adoption in social sciences [6]. The logistic regression is characterized with representing one or more independent variables that determine a dependent variable or outcome. This outcome is measured or recoded via a binary variable; the independent variable(s) on the other hand can be classified as Continuous, Mixed of Continuous and Categorical.

The goal of logistic regression is to find the best fitting model to describe the relationship between the dichotomous characteristic of interest (dependent variable = response or outcome variable) and a set of independent (predictor or explanatory) variables. Logistic regression generates the coefficients (and its standard errors and

significance levels) of a formula to predict a *Logit transformation* of the probability of presence of interest:

$$logit(p_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_n X_{ni} \quad (1)$$

Where p_i is the probability of presence of the characteristic of interest. The logit transformation is defined as the logged odds:

$$odds = \frac{p_i}{1 - p_i} \quad (2)$$

and therefore the Logits (natural logs of the odds), of the unknown binomial probabilities are modelled as a linear function of the X_i:

$$\log it(p_i) = Ln\left(\frac{p_i}{1 - p_i}\right) = \beta_0 + \sum_{j=1}^{n} \beta_j X_{ji}. \quad (3)$$

The Logit model assumes that underlying stimulus index $logit(p_i)$ is a random variable, which predicts the probability of biotechnology innovation adoption:

$$Chance\ of\ adoption = p_i = \left(\frac{1}{1 + e^{-Logit(p_i)}}\right) = \frac{e^{Logit(p_i)}}{1 + e^{Logit(p_i)}} \quad (4)$$

The above formulas have been used to calculate the probability of adoption of biotechnology innovations that is to predict the possibility and chances for the innovations to be adopted.

RESULTS

MATLAB and SPSS software were used to derive estimates for rate of biotechnology innovation adoption.

Table 1: Omnibus Tests of Model Coefficients

		Chi-square	Df	Sig.
Step 1	Step	45.326	5	.000
	Block	45.326	5	.000
	Model	45.326	5	.000

Table 1 shows the chi-square goodness-of-fit test tests the null hypothesis and determines that the step is justified. Here the step is defined from the constant-only model to the all-independents model. When as here the step was to add a variable or variables, the inclusion is justified if the significance of the step is less than .05. Had the step been to drop variables from the equation, then the exclusion would have been justified if the significance of the change was large (ex., over .10). Therefore, the likelihood ratio chi-square of 45.326 with a *p*-value of .000 shows that outcome model as a whole fits significantly.

Table 2 illustrates the Cox-Snell R^2 and Nagelkerke R^2 are attempting to provide a logistic coefficient of determination R^2 if explained the amount of variation explained by the covariates. The Nagelkerke measure adapts the Cox-Snell measure so that it varies from 0 to 1. Since R^2 and $\overline{R}_2$ exceeds 0.3, it is evident that the model performance is good for prediction.

Table 3 presents the most important and applicable results for this study. The Wald statistic shown in the table and the corresponding significance level together, test the significance of each of the covariate and dummy independents in the model. The ratio of the logistic coefficient B to its standard error S.E., squared, equals the Wald statistic. If the Wald statistic is significant (Sig. less than .05) then the model has a significant parameter.

Table 2: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	76.259[a]	.403	.538

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001

Table 3: Analysis of Maximum Likelihood Estimates

		B	S.E.	Wald	Df	Sig.	Exp (B)
Step 1[a]	Level of knowledge (Avr.B)	-3.571	.985	13.145	1	.000	.028
	Amount of Fund (Avr.C)	.519	.397	1.712	1	.191	1.681
	Level of Acceptance (Avr.D)	2.141	.685	9.776	1	.002	8.509
	Level of Cooperation (Avr.E)	.781	.603	1.677	1	.195	2.184
	Level of Transfer of Technology (Avr.F)	1.778	.721	6.076	1	.014	5.920
	Constant	-7.543	3.239	5.422	1	.020	.001

a. Variable(s) entered on step 1: Avr.B, Avr.C, Avr.D, Avr.E, Avr.F

The Logistic regression analysis showed that all coefficients of simultaneously are statistically different from zero and the test of significance helped in explaining the decisions on the adoption of biotechnology innovations. The parameter estimates for the model were evaluated at 5% level of significance. Logit model estimates for the survey location (Table 3) showed that the effect of the three independent variables, namely level of knowledge, level of acceptance and level of transfer of technology were statistically significant at 5% level.

DISCUSSION

These results are consistent with a number of theoretical and empirical studies revealing that knowledge of an innovation is the first step in the decision-making process [7, 8]. As suggested by Chong *et al*. [9], knowledge is an independent variable that determines the level of adoption of an innovation. Some researchers like Harryson *et al*. [10] believe that knowledge gained from university research benefits companies and accelerates the level of adoption. Empirical results of most of the studies support this finding.

The findings of this study are in line with the justifications given above as they show the negative signs and significance of level of knowledge variable. University researchers are of the view that level of knowledge is an important factor in determining the adoption level of innovation by biotechnology companies. Knowledge about an innovation is an indicator of the level of adoption. As the awareness of knowledge increases it is more likely that their will be a corresponding increase in the level of adoption. Level of knowledge about biotechnology innovations on the other hand contributes to low adoption rate.

The findings indicate that another source affecting the process of adoption of biotechnology innovation is acceptance. The acceptance variable has a positive impact on the decision to adopt biotechnology innovation. This is in line with empirical studies that have noted the importance of trust as one of the indicators affecting adoption based on technology acceptance models [11, 12]. The literature further indicates that the adoption of new technology is a function of profitability, riskiness, initial capital requirement, complexity and availability [7, 13, 14]. The positive sign and significance of the acceptance variables in this study imply that acceptance is a second major factor according to magnitude of coefficient that will promote adoption of innovation by biotechnology companies. The significant result for transfer of technology in the present research shows that this is the third important factor encouraging companies to adopt biotechnology innovations. Empirical results of most studies support this finding. This is presented as an important element by Cottrill *et al.* [15] whereas they confirm that technology transfer and diffusion of innovations provide the link between technology development and utilization, hence transferring work of technology developers into the hands of end users. The potential of new technologies cannot be fully realized without the successful movement of technology out of a development lab and into a user's environment. The national policy includes development innovation in academic biotechnology research, biotechnology industry and transfer of technology (ToT). The dissemination model of technology transfer takes the view that transfer is best accomplished when experts transfer specialized knowledge to a willing receptor [7]. As expected, findings of present research support that transfer of technology is a significant predictor.

Based on MOSTI the support given to the technology companies is in the form of loans, grants and funds. Therefore, it is important for biotechnology companies to be familiar with types of assistance and the nature of their utilization (MOSTI, 2009). The findings illustrate that provision of funds does not have a significant impact on the decisions to adopt biotechnology innovation by companies. However, these findings are contrary to empirical results of previous studies, which found finance as an essential factor affecting adoption decisions [7, 16]. This could be due to the fact that grants are given to researchers for innovation purposes but it is not incumbent upon them to produce suitable and profitable innovations according to company needs. Researchers may devote their efforts to produce new biotechnology products without considering the price information or the needs and demands of the biotechnology companies.

The effect of cooperation has been studied in earlier researches, such as Veugelers and Cassimanb, [17], Schartinger *et al.* [18], Schibany *et al.* [19], Rosenberg and Nelson, [20] and Mansfield, [21]. These researchers argue that gaining basic science, applied science, experimental development, measurement and testing, consulting services, funds and grants, are important reasons for cooperation between companies and universities. However, the findings of the current study do not support that of the earlier mentioned studies.

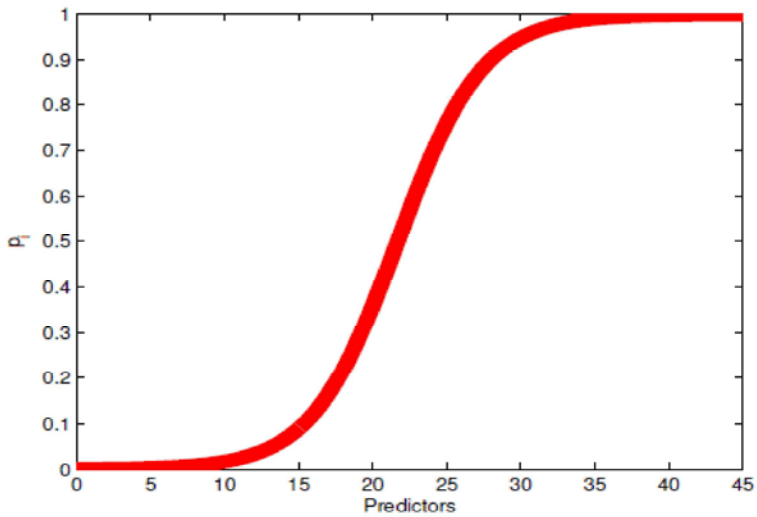

Fig. 1: Chances of Adoption of Biotechnology Innovations Based on Academic Researchers' Data

The results show that the cooperation variable is not a statistically significant factor. This implies that academic centers generally do not believe in the effect of the rate of extension services' in enhancing the level of adoption.

The estimated model is used to predict probability of adoption of biotechnology innovations created by Malaysian Universities for biotechnology companies, from the perspective of university biotechnology experts:

$$Logit(p_i) = Ln\left(\frac{p_i}{1-p_i}\right) = -7.543 + (-3.571)AvrB + 2.141AvrD + 1.778AvrF \quad (5)$$

The probability that a company will adopt a biotechnology innovation, for any units are allocated to this study's predictors, is given by:

$$Chance\ of\ adoption = p_i = \left(\frac{1}{1+e^{-Logit(p_i)}}\right) \quad (6)$$

According to university researchers, the empirical model is used to draw economic justifications for strategies to improve biotechnology innovation in Malaysia. A probability of adoption Figure 1 is drawn to show clearly the percentage change in chances of biotechnology adoption by companies when any unit is allocated to predictors.

In conclusion, the results indicated that the level of knowledge, acceptance and transfer of technology have direct effect on the level of adoption of biotechnology innovations by Malaysian agro-biotechnology companies. Industry and university link can help to boost agricultural biotechnology activities by providing cooperation channels for the biotechnology companies.

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