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Biotechnology Innovation Adoption: A Comparison Between University and Company Perspectives

[1]Hadi Farid, [1]Abu Daud Silong, [1]Ismi Arif Ismail, [1]Azimi Hamzah and [2]Saroje Kumar Sarkar

[1]Department of Professional Development and Continuing Education, Faculty of Educational Studies, Universiti Putra Malaysia 43400, UPM Serdang, Selangor, Malaysia
[2]Department of Statistics, University of Rajshahi, Rajshahi-6205, Bangladesh

Abstract: Researchers are producers of biotechnology innovations and agricultural biotechnology companies are potential users of them. Providing a linkage between these parties can be beneficial for both. Especially in Malaysia where the level of agriculture biotechnology adoption is low compared to other countries, providing the knowledge to build this linkage seems a necessity. This study tended to find the predictors of level of biotechnology innovations adoption in biotechnology companies from the perspective of both university biotechnology experts and biotechnology companies professionals. The significant influence found were factors of knowledge, cooperation and acceptance indicates the effectiveness of these factors to encourage innovation adoption. Fund and transfer of technology were found to be in effect causes of biotechnology innovation adoption. Comparing the data exhibits that the most powerful predictor to increase the level of adoption is the amount of fund allocated to adopting companies by the government.

Key words: Academic researchers · Adoption · Biotechnology companies · Innovation · Policy makers

INTRODUCTION

Adoption of an innovation is not a solid set procedure and it can be very time taking since the time extent of adoption of a technology follows different settings among characteristics of the technology itself, clienteles and geographical areas [1]. In view of these facts, obtaining a thorough knowledge about the process of adoption of a new technology and its diffusion is essential for modeling appropriate extension programs and agriculture related research [2, 3]. Developing and reinforcing the linkage between the academic researchers, as potential producers of innovations and the agricultural biotechnology companies as potential users of these innovations, can be advantageous for both. In order for the highest benefits to be achieved by both sides it is necessary to supply the academics and the companies with relevant knowledge about the adoption of agricultural biotechnology innovations, the issues affecting the adoption process, the participants' perspective about the other participants' needs and local circumstances with regard to adoption [4, 5]. Providing this understanding necessitates more research on the circumstances of the involved parties, their awareness about each other and their direct and indirect interactions. The main objective of the present research was to provide the information related to the issues mentioned above about the agricultural biotechnology companies and the universities in Malaysia. Reviewing the adoption procedures from the standpoints of both academics and companies can help to eliminate these existing problems.

The importance of innovation adoption necessitates a thorough understanding of the factors affecting the adoption process of new products and services [3]. This concept has recently been challenged [6-8]. Studies' demonstrating in Malaysia, the level of adoption of agriculture biotechnology is low in comparison with other Asian countries and in the world. Also, Malaysia has not achieved the target of the Ninth Malaysian plan to surge the number of biotechnology-related companies to 400 by 2010. A list provided by Ministry of Science, Technology & Innovation (MOSTI) of Malaysia shows that only 28.5% of the 2010 target has been attained [9]. Consequently seeking an understanding on the nature of technology adoption in Malaysia was crucial to find the variables by which the level of adoption is affected.

Correspoding Author: Hadi Farid, Department of Professional Development and Continuing Education, Faculty of Educational Studies, Universiti Putra Malaysia 43400, UPM Serdang, Selangor, Malaysia. Mob: +6 012 252 1957.

This study was designed to recognize factors that improve or hinder innovation in the Malaysian biotechnology context. The research tended to help to fill the gap by investigating to what extent the government-supported biotechnology companies are receptive to the transferred biotechnology innovations introduced by Malaysian universities. The predominant question underling this study is:

What are the predictors of level of adoption of biotechnology innovations in biotechnology companies from the perspective of the university biotechnology experts and biotechnology companies?

MATERIALS AND METHODS

The foremost aim of this study was to define the predictors of the level of adoption of academic biotechnology innovations by agro-biotechnology companies. The academic centers which are active in the field of agricultural biotechnology are Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM), Universiti Putra Malaysia (UPM) and Universiti Sains Malaysia (USM). These universities are the main participants in the bio-valley project [10]. Since Universiti Sains Malaysia (USM) mostly focuses on pharmaceuticals biotechnology and the scope of this study is agricultural biotechnology, USM was excluded from this study. Based on the information obtained from the universities' official websites at the time of data collection 98 biotechnology researchers work in UM, UKM and UPM [9]. The number of agricultural biotechnology companies supported by MOSTI in Malaysia was 51 at that time according to a list provided by MOSTI. This limited number provided the possibility to investigate the whole target population as stated in Creswell [11] and Thompson [12] as a sampling possibility, the sample and the target populations are considered to be the same in this study.

This study was carried out quantitatively via a survey and a questionnaire was used to collect the data. The questionnaire was developed by the researcher and its validity was established by using a panel of experts and a pilot test. Cronbach's alpha internal consistency was used to measure the reliability of the questionnaire [13, 14]. In order to conduct the pilot test to determine the reliability, 24 academic staff of the School of Biological Sciences in USM University and 10 Malaysian biotechnology companies were asked to complete the questionnaire. These participants were omitted from the target population of the research since their biotechnology activities were mostly pharmacological and not agricultural but still they work in the same setting. The questionnaire had two versions adopted for the academic members and the company managers. The Cronbach alpha was conducted separately for each item of the questionnaire. All the coefficients were found more than 0.70 and indicate the responses corresponding to the items under different constructs were consistent.

The reliability coefficient for the academic members and the questionnaire given to managing director and R&D managers in the biotechnology companies as a whole was equal to 0.880 and 0.902 respectively. The validated and reliable questionnaire were distributed to 98 biotechnology experts who are working as academics in biotechnology fields in UM, UKM and UPM universities and 51 agricultural biotechnology companies. The university response rate was 89.79% (N=88) and the participants feedback rate for biotechnology company managers was 90.19% (N=46). This data was used to conduct Multiple Linear Regression.

The participants from the three universities were 61.4% females and 38.6% males whose age ranged from 35 years to 58 years. The mean for age factor is 45 years. All of the academic staff members were Ph.D. degree holders (N=88). The results obtained from descriptive analysis are shown 43.2% of the participants were professors, 28.4% associate professors, 23.9% senior lecturers and remaining 4.5% were lecturers. Gather data shows mean for academic experience was 12 years. The data collected from the academics indications that during the period 2005 to 2008, the number of innovations was low. In agreement with the ratings of less than two innovations measured as being low, data also shows that none of the academic researchers had more than two adoptions in innovation per year.

The participants from the biotechnology companies' comprised of 28.3% females and 71.7% males, 46 of whom responded to the questionnaire. The participants aged between 31 years to 58 years. 30-35 years = 19.6%, 36-40 years = 26.1%, 41-45 years = 23.9%, 46-50 years = 21.7%, 51-55 years = 2.2% and more than 55 years = 6.5%. The mean for the age factor was 42 years. 37.0% of the participants were managing directors and 63.0% were R&D managers. Most of the company respondents in this group held bachelor's degree (n=4.3%) while 65.2% had a master's degree and 30.4% were PhD holders. The participants' experiences ranged from 3 to 16 years.

Prior study by Farid [15] noted that 46 companies participated in this research among which 69.5% dealt with GM agricultural biotechnology activities, 19.6% were Non-GM agricultural biotechnology companies and 10.9% were manufacturing companies.

Multiple linear regression was conducted to examine the relationship among the level of adoption of biotechnology innovations, as the dependent variable and the factors of knowledge, funds, acceptance, cooperation and transfer of technology as the independent variables. The regression was selected to support the modeling of the relationship between the research variables [16].

RESULTS

The multiple linear regression was used to analyze and compare the data collected from all respondents.

Table 1 illustrates the independent variables and the dependent variable for Academic researchers and Biotechnology companies professionals.

First part of Table 2 specifies that R = .681, this demonstrate a fair positive correlation. The rate of biotechnology adoption of independent variable for 46% is indicated by the value $R^2 = .464$. On the other hand for biotechnology companies presented in Second part of Table 2, R = .890 that explains strong positive correlation. The importance of R square is obvious when coefficient of determination is provided, whilst the amount of calculation of outcome variability is done by the predictors. The value $R^2 = .793$ means that the independent variables account for 79% of the rate of biotechnology adoption.

First part of Table 3 demonstrates that the F-statistics $F(n_1,n_2) = 14.201$ and the corresponding $p - value = .000 < .001$ were highly significant for academic researchers. Then again the F-statistics $F(n_1,n_2) = 30.628$ and the corresponding $p - value = .000 < .001$ were highly significant for biotechnology companies as shown in second part of Table 3. This illustrated that zero is not the result for slop estimation of linear regression model line, it can be confirmed that in this study the supposed five-predictor in multiple linear regression are adjusted with the data.

The Estimates of coefficients part of the output in Table 4 for academic researchers provide values that are needed to write the regression equation. In this model the most significant contribution is done by the predictor only if the $t - test$ is significantly different from zero ($p < .05$). For this model, level of knowledge (Avr.B) $t(82) = -3.856$, $p < .05$, amount of fund (Avr.C) $t(82) = 3.394$, $p < .05$, level of acceptance (Avr.D) $t(82) = 3.309$, $p < .05$ and level of cooperation (Avr.E) $t(82) = 4.453$, $p < .05$ are strong significant predictors of level of adoption of biotechnology innovations as $p < .05$, but level of transfer of technology (Avr.F) is not a significant predictor of outcome. The largest beta coefficient obtained (in absolute value), was .409 for level of cooperation (Avr.E) with the highest $t - statistic$ of 4.453. In this model when all other predictor variables are controlled and explained by the variance the strongest contribution is

Table 1: Stepwise Method for Variable Selection (Variables Entered/Removed[b])

Academic Researchers & Biotechnology Companies:			
Model	Variables Entered	Variables Removed	Method
1	Level of Transfer of Technology (Avr. F), Level of Cooperation (Avr. E), Amount of Fund (Avr. C), Level of knowledge (Avr. B), Level of Acceptance (Avr. D[a])	.	Enter

a. All requested variables entered.
b. Dependent Variable: Level of Adoption (Avr.G)
Source: [16]

Table 2: Model Summary and Related Statistics

Academic Researchers:				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.681[a]	.464	.431	.57855

a. Predictors: (Constant), Avr.F, Avr.E, Avr.C, Avr.B, Avr.D

Biotechnology Companies:				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.890[a]	.793	.767	.347

a. Predictors: (Constant), Avr.F, Avr.B, Avr.D, Avr.C, Avr.E

Table 3: ANOVA[b] for Academic Researchers

Academic Researchers:

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	23.767	5	4.753	14.201	.000[a]
	Residual	27.447	82	.335		
	Total	51.215	87			

a. Predictors: (Constant), Avr.F, Avr.E, Avr.C, Avr.B, Avr.D

b. Dependent Variable: Avr.G

Biotechnology Companies:

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	18.445	5	3.689	30.628	.000[a]
	Residual	4.818	40	.120		
	Total	23.263	45			

a. Predictors: (Constant), Avr.F, Avr.B, Avr.D, Avr.C, Avr.E

b. Dependent Variable: Avr.G

Table 4 Estimates of Coefficients for the Model Coefficients[a]

Academic Researchers:

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	.042	.690		.061	.952
	Level of Knowledge (Avr. B)	-.641	.166	-.396	-3.856	.000
	Amount of Fund (Avr. C)	.314	.093	.305	3.394	.001
	Level of Acceptance (Avr. D)	.327	.099	.350	3.309	.001
	Level of Cooperation (Avr. E)	.610	.137	.409	4.453	.000
	Level of Transfer of Technology (Avr. F)	.275	.142	.212	1.938	.056

a. Dependent Variable: Level of Adoption (Avr.G)

Biotechnology Companies:

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	T	Sig.
1	(Constant)	-.608	.985		-.618	.540
	Level of knowledge (Avr. B)	-.065	.169	-.029	-.384	.703
	Amount of Fund (Avr. C)	1.074	.132	.853	8.158	.000
	Level of Acceptance (Avr. D)	.028	.092	.025	.307	.760
	Level of Cooperation (Avr. E)	-.123	.296	-.048	-.415	.681
	Level of Transfer of Technology (Avr. F)	.240	.118	.168	2.035	.049

a. Dependent Variable: Level of Adoption (Avr.G)

Table 5 Predictors of Level of Adoption as Perceived for Academic Researchers and Biotechnology Companies

Test	Results
Academic Researchers:	- Level of Cooperation (Avr.E) - Level of Acceptance (Avr.D) - Level of knowledge (Avr.B) - Amount of Fund (Avr.C)
Biotechnology Companies:	- Level of Transfer of Technology (Avr.F) - Amount of Fund (Avr.C)

made by this variable and attempted to express the depended variable (level of adoption). It suggests that one standard deviation increase in level of cooperation (Avr.E) is followed by .409 standard deviation increase in level of adoption. The Beta value for level of acceptance (Avr.D) was next highest at .350; go after with amount of fund (Avr.C) in the third place (.305). The smallest Beta value is dedicated to the level of knowledge (Avr.B) with result of (-.396), it can be judged that the least contribution is made (Table 5).

As can be seen from the Table 4, the estimated model is as follows:

$$\hat{y} = .042 + (-.641)AvrB + .314AvrC + .327AvrD + .610AvrE + e$$

On the other hand, the coefficients part of the output for biotechnology companies also gives the values that are needed in order to write the regression equation as shown in the second part of Table 4. Amount of fund, (Avr.C) $t(40) = 8.158$, $p = .000 < .05$ and level of transfer of technology (Avr.F) $t(40) = 2.035$, $p = .049 < 05$ are significant predictors of level of adoption, but level of knowledge (Avr.B), level of acceptance (Avr.D) and level of cooperation (Avr.E) are not significant predictors. The biggest beta coefficient obtained for biotechnology companies was .853 for amount of fund (Avr.C) with the highest $t - statistic$ of 8.158. The results, as shown indicate that one standard deviation increase in amount of fund (Avr.C) is followed by .853 standard deviation increase in level of adoption of biotechnology innovations. The Beta value for level of transfer of technology (Avr.F) was smaller than the value for amount of fund (Avr.C) (Beta Value=.168) and indicates that it made the least contribution (Table 5).

The results obtained from the preliminary analysis of coefficients table and the estimated model is as follow:

$$\hat{y} = -.608 + 1.074AvrC + .240AvrF + e$$

DISCUSSION

The multiple linear regression was conducted to model the connections and relationships among the variables in order to discover the factors encouraging adoption of biotechnology innovations. Nezu *et al*. [17] believes that intensity of adoption is related to knowledge about a new technology and cooperation programs among big companies. Also, Cosnard [18] and Ellefson *et al*. [19] claimed that it is an option to transfer of experiences from research centers to companies by encouraging companies to employ more researchers. The noteworthy influence of knowledge, cooperation, acceptance and fund was high to indicate them as effective factors inspiring adoption of biotechnology innovations by companies (for more detail about Academic Researchers data, see: [16]). Experimental results of other studies support this finding. The outcomes also show that transfer of technology does not have a substantial influence on the adoption decision in the Malaysian setting, which is not in line with earlier empirical studies. The following graph demonstrates the value of the dependent variable, based on the units allocated to the independent variable.

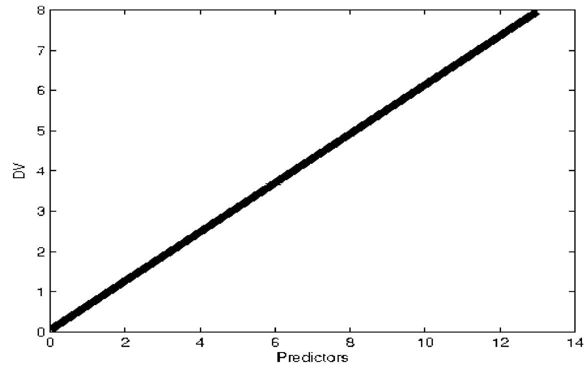

Fig. 1: Multiple Linear Regression Based on Academic Researchers' Data Source: [16]

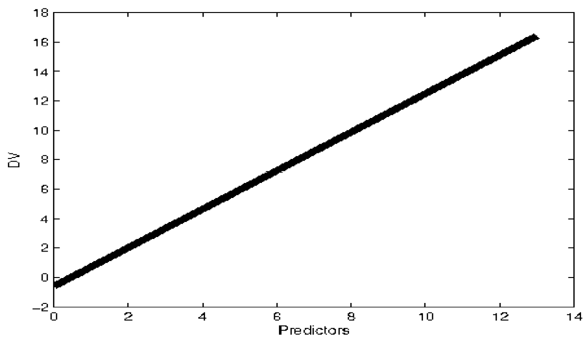

Fig. 2: Multiple Linear Regression Based on Biotechnology Companies' Data

This research also discovered that operative causes of adoption of biotechnology innovation, based on companies' data, are fund and transfer of technology and these variables affect the decision to adopt biotechnology innovations. Moreover, it was found that knowledge, acceptance and cooperation do not have a statistically significant impact in this case. Figure 1 and 2 illustrates the value of adoption for each value allocated to the effective dependent variables.

CONCLUSION

The significant influence of knowledge, cooperation, acceptance and fund based on the interpretation of Multiple Linear Regression results indicates that these are effective factors to encourage innovation adoption by biotechnology companies. The results also showed that transfer of technology does not have any significant impact on the adoption decision, which is not compatible with earlier experimental studies. The Fund and transfer of technology were found to be in effect causes of biotechnology innovation adoption, based on companies' data. Previous empirical studies, as discussed in the last section consider this variable to have no significant effect on the level of adoption. Furthermore, the findings suggest that the effect of knowledge, acceptance and cooperation is not statistically significant in this case.

On the other hand comparing the data obtained from the statistical procedures used in this study as summarized in Table 5 shows that the most powerful predictor of the increase of the level of adoption for both biotechnology companies and academic researchers is the amount of fund allocated to adopting companies by the government.

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