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TECHNOLOGY INNOVATION MANAGEMENT MODEL IN FARMING ENTERPRISES OF BABAHOYO, ECUADOR

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ABSTRACT
Agriculture is an important productive sector in the Ecuadorian context. In Babahoyo, Los Rios Province, the farming enterprises sustain economic stability for many years, despite the lack of interest in generating technological innovation. This is why this article presents a model for decision-making that allows the Technology and Innovation Management in the farming enterprises of Babahoyo with mechanisms adapted to the companies in question by focusing their interest in a productive revolution of knowledge and talent through technology and innovation processes.

The application of the model was carried out in a representative sample of the Ecuadorian agricultural sector, through the measurement of an innovation index and later contrast by one-way ANOVA which allowed validating the results of the investigation.

INTRODUCTION
The growing interest in Technology and Innovation Management (TIM) is gaining ground among members of the scientific community of researchers, academics, and professionals, giving rise to a new priority field in the area of administration and management strategy. Likewise, companies with the purpose of increasing competitiveness are aware of the fundamental role played by technology and innovation in improving processes.

In the Ecuadorian context, the agricultural sector is a productive industry that contributes to the national accounts through the trade balance, with 46% and 54% of traditional and non-traditional non-oil exports (BCE, 2013). In Babahoyo, Los Rios Province, the agricultural sector maintains for many years economic stability, despite the conformism and the low power and interest to generate technological innovation (TI), which today keeps the locality with an incipient economic and sustainable development.

The problematic situation that originated the research summarized in this paper is that although Ecuador is an economically agricultural country and rich in natural diversities, it has technological insufficiencies in production, being dependent on the importation of the manufactured products.

TECHNOLOGY AND INNOVATION MANAGEMENT (TIM) OVERVIEW
The development of a science and innovation culture is a competitive imperative. This identifies that the real engines of competitiveness and economic success remain to be science, innovation, technology, education and entrepreneurship. An essential part of developing the science and technology base for sustained competitive advantage is to build the organization’s capacity to manage innovation successfully.

Technology & Innovation Management provides executives with the understanding of how technology works in the innovation process and enables them to make sound business decisions. Successful innovation is inherently multi-functional and matches a profound understanding of user needs and wants to a distinctive technical competence. (Futech Consultancy, 2017)

Table 1. Authors and concepts for TIM

Authors	Concepts
(Nosnik, 2005)	A process aimed at organizing and directing the available human, technical and economic resources, with the aim of increasing the creation of new knowledge, generating ideas to obtain new products, processes or services; improving existing ones and transfer those same ideas to the manufacturing and marketing phases.
(Pérez, 2012)	Set of operations of a managerial nature that establish the technological and resource requirements that ensure the full compliance with the goals proposed by the organization, it also guides the process with the innovative talent that makes possible the creation of new or improved products and services.
(Hernández, 2011)	Need to manage technology and innovation to achieve a balanced development of multidisciplinary satisfaction, with the aim of generating a positive change to a product or service.
(Nagles, 2007)	Process of inclusion of technology and innovation that transforms the nature of a product or service through an added value

TIM MODEL FOR FARMING ENTERPRISES

Innovation in agriculture has played a decisive role in economic and social development throughout modern history since it enabled the emancipation of labor for industrial development in the second half of the nineteenth century, as well as the consolidation of the markets for new products from emerging sectors.

Subsequently, technological innovation has been one of the determining factors in the balance between the supply and demand as well as in central elements in dismantling traditional production models. For its insertion, a systematic accumulation of experimental data, scientific projects, and application of knowledge from several disciplines with the availability of human, physical and institutional resources that together build a strategy of productive diversification.

The requirement for national availability, due to a lack of financing and a lack of global interest in undertaking globalized trends is not very feasible. The processes aimed at improving the efficiency and relevance of agricultural enterprises are sequentially restructured by the lack of scientific paradigms in matters of R&D.

Based on the agricultural production requirement of the rice enterprises in Babahoyo, a TIM (Technology and Innovation Management) Model is proposed and structured with adapted mechanisms to reach Babahoyo farming. (OECD, 1997)

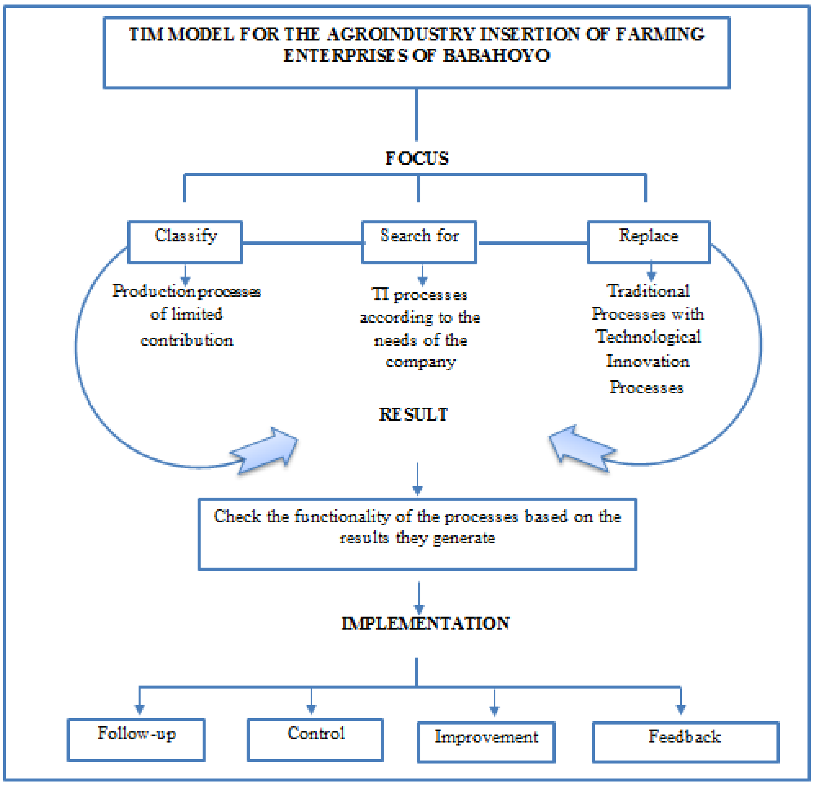

Fig.1 TIM Model for the agroindustrial insertion of farming enterprises of Babahoyo

MATERIALS AND METHODS

The study was conducted in the farming enterprises of Babahoyo, Los Rios province. Out of seven farmers of fifteen (47% of total population) were randomly selected to form the experimental group. On the other hand, the remaining enterprises were deemed as the control group.

Data were collected through a survey and direct interviews to farmers during August, 05, 2016 to September, 20 2016. The Contribution of farming enterprises towards the Innovation Index (II) was the dependent variable and the selected Technology Innovation Management Model (TIMM) constituted the independent variable of the study.

Innovation Index (II)

The II must be understood as a number that summarizes the information of frequency and technological degree of each innovation; it can be seen that this figure gives more wealth than a simple count of innovations, than a weighted average of innovations per producer or a discretionary classification of innovations. The II takes into account two fundamental points. The first is that innovations are not the same, basically because each one of them is in a different region of the technological spectrum present in the chain to which the company belongs and because the effort for its incorporation is not the same, which depends on the capabilities of the entrepreneur. The second point, states that the frequency of each innovation within the economic sector analyzed is not the same either. Some innovations are very common, while others are only implemented by a few companies. (Red RAET de Universidades, 2013)

The basic idea behind the II is to reward those innovations that push the entrepreneurs towards the technological frontier of the analyzed chain (major innovations) and that at the same time are made only by few of them. At the same time, entrepreneurs implementing intermediate technological innovations (intermediate innovations) should be rewarded according to the relative frequency of innovations: a relatively infrequent innovation should

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contribute more to the company's II implementing it, while a fairly frequent innovation in the chain will necessarily contribute less to the II. Finally, the II designed to quantify the innovation in a farming enterprise is defined as:

$$II = \sum_{j=1}^{n} I_j f_j^{kj} \qquad (1)$$

Where j refers to the jth innovation analyzed; n corresponds to the total number of innovations that theoretically exist for the chain; Ij is an indicator equal to 1 if the company in question presents jth innovation and 0 otherwise; fj corresponds to the relative frequency of jth innovation in relation to the total number of producers in the sample and, kj is a power taking the values of - 1, -1/2 and 0 if the jth innovation is higher, intermediate or lower, respectively.

Analysis of variance (ANOVA)
In order to report the statistically significant differences between group means a one-way ANOVA was implemented. Analysis of variance (ANOVA) is a statistical procedure concerned with comparing means of several samples. The purpose is to test for significant differences between class means, and this is done by analysis the variances. (Ostertagová, 2013)

The ANOVA test of the hypothesis is based on a comparison of two independent estimates of the population variance.
When performing an ANOVA procedure, the following assumptions are required:

- The observations are independent from one another.
- The observations in each group come from a normal distribution.
- The population variances in each group are the same (homoscedasticity).

ANOVA is the most commonly quoted advanced research method in the professional business and economic literature. This technique is very useful in revealing important information particularly in interpreting experimental outcomes and in determining the influence of some factors on other processing parameters

The simplest case is one-way ANOVA. A one-way analysis of variance is used when the data are divided into groups according to only one factor.

RESULTS AND DISCUSSION

A list of technological groups was constructed in situ, according to the information gathered in the survey applied to the fifteen farming entrepreneurs of the rice sector Babahoyo Canton, Los Rios province.

Table 2. Description of Technological Groups

TECHNOLOGICAL GROUPS	DESCRIPTION
T1	Physical and chemical soil analysis
T2	Certified seed
T3	Plow and drag with manual machinery
T4	Plow and trawl with high-end machinery
T5	Manual terrestrial irrigation
T6	Air-mechanized irrigation
T7	Phytosanitary control: herbicides, insecticides and fungicides
T8	Fertilizers
T9	Organic fertilizer
T10	Semi-mechanized harvesting
T11	Mechanical harvesting
T12	Process for planning, organization, management and control
T13	Plans for inclusion of agricultural studies of educational institutions

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T14	Electronic billing system
T15	Products with high added value

It is also important to emphasize that the II is calculated for each entrepreneur using two key aspects: the frequency of innovation and the technological degree.

Table 3. Correspondence between technological innovations degree and frequency in the rice sector

	Rice	
Technological groups	N°	Frequency
Lower	7	79%
Intermediate	4	59%
Higher	4	40%
Total Innovations	15	
Total Respondents	15	

The results of the II reveal the corresponding values according to the TIM Model implemented (experimental group) versus the traditional Model (control group) shown in Table 3.1 according to the surveyed respondents.

Table 4. Correspondence between technological innovations degree and frequency in the rice sector

Farming enterprises	**II**	**Management Model**
1	22.19	TIM Model
2	17.49	TIM Model
3	15.71	TIM Model
4	11.72	TIM Model
5	16.59	TIM Model
6	19.71	TIM Model
7	17.72	TIM Model
8	8.57	Traditional Model
9	6.12	Traditional Model
10	6.00	Traditional Model
11	9.45	Traditional Model
12	7.12	Traditional Model
13	8.12	Traditional Model
14	9.57	Traditional Model
15	8.12	Traditional Model
Mean	12.28	

Descriptive Statistics

Variable	Model	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
ii	1	7	0	17.30	1.24	3.27	11.72	15.71	17.49	19.71
	2	8	0	7.884	0.484	1.369	6.000	6.370	8.120	9.230

Variable Model Maximum

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ii	1	22.19
	2	9.570

The descriptive statistics suggest the presumption of differences between the innovation indices according to the models implemented, which will be verified with the development of the one-way ANOVA.

Testing the Assumption of Normality

It has been considered timely to verify the normality that follows the quantitative variable Innovation Index (see Fig. 2), which allows comparing the empirical distribution of the data with the normal distribution. This graph also presents the p-value obtained from the Kolmogorov-Smirnov test to verify the normality assumption, considering 95% confidence.

The hypothesis test considered in the Kolmogorov-Smirnov test is presented below:

H_0: The innovation index follows a normal distribution
Vs
H_1: The innovation index does not follow a normal distribution

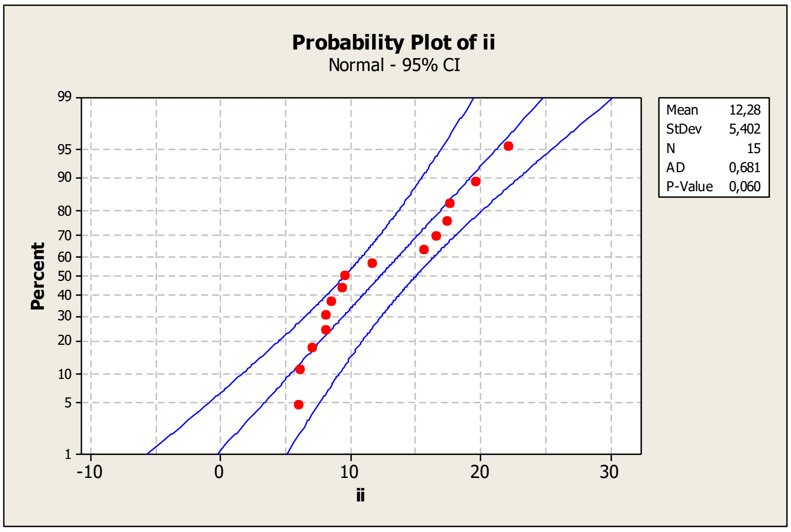

Fig. 2 Kolmogorov–Smirnov test

Based on the p-value=0.06, there is no statistical evidence to reject the null hypothesis, so it is possible to confirm that there is normality in the data set, according to the assumption of Analysis of Variance (ANOVA).

Testing the Assumption of Homogeneity of Variances

Likewise, it has been considered appropriate to verify the homoscedasticity that the variances of the different groups follow, obtaining Graph 4, also called Test for Equal Variance. This graph also presents the p-value obtained from the Levéne test to verify the assumption of homogeneity, considering 95% confidence.
The hypothesis test considered in the Levéne's test is presented below:

H_0: The variances of both groups are not different
Vs
H_1: The variances of both groups are different

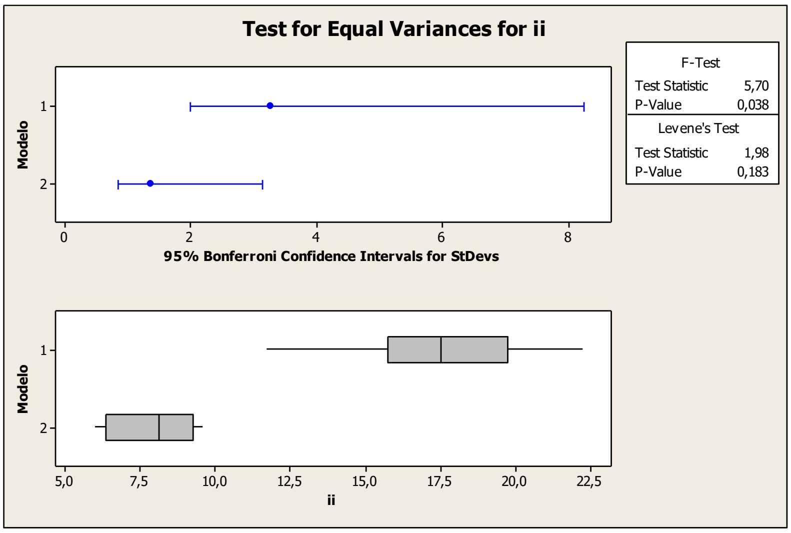

Fig. 3 Levene's test

Based on the p-value=0.183, there is no statistical evidence to reject the null hypothesis, so it is possible to confirm that there is homoscedasticity in the data set, according to the assumption of Analysis of Variance (ANOVA).

Hypothesis Testing Using One-way ANOVA

The hypothesis test considered in the One-way ANOVA is presented below:

H_0: The mean of both groups are not different

Vs

H_1:The mean of both groups are different

Table 3. One-way ANOVA

Source	DF	SS	MS	F	P
Model	1	331.32	331.32	55.78	0.000
Error	13	77.22	5.94		
Total	14	408.54			

From these results, it is observed that the p-value from F statistic is 55.78, which is greater than the 95th percentile value of the Fischer distribution with 1 degree of freedom in the numerator and 13 degrees of freedom in the denominator, which corresponds to 4.67. Likewise and with 95% confidence, the p-value from the test is 0.000, value less than 0.05.

Thus, we can conclude that there is statistical evidence to reject the null hypothesis in favor of the alternative hypothesis. That is, that there are statistically significant differences in the innovation index mean for both groups, which determines that the implementation of the TIM Model does boost technological innovation in entrepreneurs, achieving an improvement in the production processes of the rice sector of Babahoyo.

CONCLUSIONS

The results obtained with the application of this model show that in the context of the agricultural sector of the Babahoyo Canton, the determinants of innovation are expressed differently according to the management model employed. This finding configures the complexity of the innovation processes and the design of the corresponding sectoral policy which leads to confirm the fundamental research hypothesis. That is to say, the application of the Technological Innovation Management (TIM) Model in the agricultural enterprises of the Babahoyo Canton, allows the insertion of these companies in the agroindustrial sector, and transform the business scenario, to become a sector of high value-added products.

The dependent variable was determined by the innovation index, which is relevant to the agricultural sector and sought to measure the innovation of agricultural enterprises.

The innovation index should be understood as a figure that summarizes the information of frequency and technological degree of each innovation. It can be seen that this figure offers more wealth than a simple count of innovations and a weighted average of innovations per producer or a discretionary classification of innovations.

The validation of the proposed TIM model (independent variable) was checked by selecting a representative sample of local entrepreneurs from Babahoyo and a hypothesis testing using one-way ANOVA.

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