INAUGURAL LECTURE series

Professor Dr.
Bahaman Abu Samah

UNIVERSITI PUTRA MALAYSIA
BERILMU BERBAKTI

Enhancing Extension Education Research using Structural Equation Modeling

Enriching Evidence-Based Extension Work Practices

Enhancing Extension Education Research using Structural Equation Modeling

Enriching Evidence-Based Extension Work Practices

PROFESSOR DR. BAHAMAN ABU SAMAH

Enhancing
Extension Education Research
using Structural Equation Modeling

Enriching Evidence-Based Extension Work Practices

Professor Dr. Bahaman Abu Samah
Diploma in Agric. (UPM), BSc (Crop Science) Louisiana State University,
M. Sc (Extension Education) Louisiana State University, Ph.D (Extension Education)
Iowa State University

18 November 2016

Auditorium Pendidikan
Fakulti Pengajian Pendidikan
Universiti Putra Malaysia

Universiti Putra Malaysia Press
Serdang • 2016
http://www.penerbit.upm.edu.my

First Print 2016

UPM Press is a member of the Malaysian Book Publishers Association (MABOPA)
Membership No.: 9802

ISBN 978-967-344-648-3

Typesetting : Sahariah Abdol Rahim @ Ibrahim
Cover Design : Md Fairus Ahmad

Design, layout and printed by
Penerbit Universiti Putra Malaysia
43400 UPM Serdang
Selangor Darul Ehsan
Tel: 03-8946 8855 / 8854
Fax: 03-8941 6172
http://www.penerbit.upm.edu.my

Contents

ABSTRACT

Amidst the increasing global demand for food, health, social, economic and political security, the need for new knowledge and technologies initiated by higher learning as well as other research and development institutions is undeniably significant. The transfer of such knowledge and technologies takes place systematically through the support of impactful, effective and efficient extension work practices. The continuous challenge that awaits extension professionals is to ensure that the knowledge and technology transfer process is not only demand-driven, but most importantly, research-driven and evidence-based. Research-driven and evidence-based extension work practices can scientifically complement the demands of the community and industry. Poor research and extension work practice linkages will leave the community and industry unfamiliar with new knowledge and technologies. This calls for an enhancement of extension education research to enrich evidence-based extension work practices. This gap needs to be addressed by utilizing appropriate research and statistical applications that can help extension professionals to explain technical findings in a simple and straightforward manner to their clients. Through evidence-based extension work practices, extension work professionals can connect clients with research-based information, which will eventually improve their overall well-being.

Current and future trends in extension work practices call for more participatory knowledge and technology transfer approaches as compared to the old 'top down' model. Extension professionals should thus equip themselves with knowledge on adult education and extension education research, as well as substantial technical knowledge in planning, implementation and evaluation of extension programs.

Given the need for a combination of research-driven, participatory and demand-driven extension work practices, this

inaugural lecture will focus on how extension education research and organizational extension work practices can be enhanced through the utilization of appropriate statistical applications, specifically Structural Equation Modeling (SEM). Based on my personal and professional knowledge and experience, the first part of this lecture will be an elaboration on how extension education stakeholders can take advantage of the powerful statistical analyses provided by Structural Equation Modeling (SEM) in their research and development projects. Secondly, I will highlight the importance of equipping extension professionals with adequate knowledge and skill in the application and interpretation of SEM outputs. Finally, I will address how the incorporation of SEM analysis can lead to better development and enrichment of evidence-based extension work practices.

Malaysia and the world are faced with the task of providing more evidence-based extension education work practices. This is where research and extension linkages need to utilize cutting edge analysis tools that can provide more objective and tangible evidence to inform extension professionals on the impact of their work with the community and industry. The use of empirical evidence in evaluating the impact of extension education programs must be embraced by stakeholders at all levels. Future extension education work and research will go beyond reporting feedback from clients and partners and calculating income generated from extension collaboration. By making use of tangible evidence to inform clients, which includes policy makers, researchers and extension practitioners at all levels (Ministries, Higher Learning Institutions, Research and Extension agencies and other relevant bodies) can provide more rigorous input to improve and advance the overall research-extension-utilization ecosystem. Hence, in this inaugural lecture, I will humbly share how Structure Equation Modeling (SEM) can enhance extension education research and ultimately enrich evidence-based extension work practices.

INTRODUCTION

The increasing global demand for food, health, social, economic and political security has called for new knowledge and technologies initiated by higher learning as well as other research and development institutions to be significantly extended to the wider community and industry (Bahaman et al., 2012). This transfer of knowledge and technologies systematically takes place through the support of impactful, effective and efficient extension work practices. The continuous challenge for extension professionals is to ensure that the knowledge and technology transfer process is not only demand-driven, but most importantly research-driven and evidence-based. Clients in recent years have voiced their penchant for participatory and demand-driven extension methodologies (Baig & Aldosari, 2013). Research-driven and evidence-based extension work practices can scientifically complement the demands of community and industry. Poor research and extension work practice linkages will leave community and industry unfamiliar with new knowledge and technologies. This calls for an enhancement of extension education research to enrich evidence-based extension work practices. Extension professionals should cogently explain to the public and other stakeholders how their work practices impact their economic, environmental and social well-beings (Gagnon, Garst & Franz, 2015).

This gap needs to be addressed by utilizing appropriate research and statistical applications that can help extension professionals to explain technical findings in a simple and straightforward manner to their clients. Through evidence-based extension work practices, extension work professionals can connect clients with research-based information, which will eventually improve their overall well-being (Bahaman et al., 2011a). Evidence based practices extension are exceptional as it emphasizes on the use of statistical analyses to transfer science to practice in its research and extension linkages (Dunifon et al., 2004).

EXTENSION EDUCATION: THE TRADITION AND THE UPM STORY

The term extension education was first introduced in 1873 by Cambridge University to refer to systematic educational initiatives undertaken by the University to disseminate relevant knowledge and information to common people outside of university premise (Addison, 1972). This idea of educational initiative through extension education was later spread to other universities in England and other parts of the world including the United States.

The enactment of Smith-Lever Act in 1914 marked the beginning of agricultural extension in the United States. This Act led to the establishment of a national Cooperative Extension Service (CES) that provides rural American with relevant agricultural knowledge through land-grant colleges and universities. Initially agricultural extension dealt primarily on agricultural advancement. Nonetheless, the initiatives were later extended to include home economics, youth development, community and rural development and leadership development. At the time of the establishment of CES, more than 50 percent of the US population resided in rural areas and about 30 percent of labor force were involved in agricultural related jobs or income generating activities. On the contrary only 17 percent of the population is currently living in rural areas. (https://nifa.usda.gov/cooperative-extension-history).

Extension function was introduced in Malaya in 1905 with the establishment of Department of Agriculture (DOA), Ministry of Agriculture with the mandate to oversee all development related to agricultural sector (Azimi, 2007). However, eventually extension services in Malaysia are undertaken by various agencies under at least six different ministries that cater for specific commodities or service sectors (Rahim, 1992).

As for the higher learning institution, the founding custodian of extension education originate in the establishment of Centre for Extension and Continuing Education (CECE) in Universiti Pertanian Malaysia in 1976 which strategically went through tremendous development serving the nation, the Asian region and worked closely with partners across the globe. The UPM extension story is worth sharing because it provides the original idea of what it is like in nowadays university-community-industry engagement. In 1996, with the rapid change of focus at the macro national context from an agro-based to a knowledge based economy, CECE was then transferred to Faculty of Educational Studies, UPM as Department of Extension Education and continue providing extension education advise and services to the community within and outside UPM (Universiti Putra Malaysia). Interestingly, in 2001, with the concern on the importance of food security and how it relates to the well-being of the global citizen, Malaysia realized that despite the need to compete and strive towards becoming a developed nation embracing ICT and knowledge based economy, agriculture should never be sidelined and in fact, a sector that should be sustained so as to enhance the food security and well-being of Malaysia. Agriculture was again seen as the important source to national sovereignity and extension education as one of the pillars in supporting agricultural productivity and the overall national well-being went through a rejuvenation exercise. UPM eventually established a Centre for Extension, Entrepreneurship and Professional Advancement or APEEC, which is now the University Community Transformation Centre or UCTC.

By being the guardian of extension and community engagement for UPM, UCTC has grown to become an institution to be reckoned with. Extension services in UPM have branched out beyond agricultural extension, covering a wider focus on the social and economic well-being of the community in Malaysia and across the globe. However, the overarching question that continuously stimulate my lifelong commitment to my profession as a reflective extension education scholar, researcher and practitioner is to what extent is our present extension education research and development activities are in tandem with the current and how do we prepare for the future trends in extension work practices? In the following sections, I will elaborate how extension work practices in UPM and Malaysia can be enhanced to fulfill the needs of various stakeholders in and outside Malaysia.

EXTENSION: LINKING PRACTICES AND EDUCATION

Various definitions of extension have been put forward by various authors. According to Kelsey and Hearne (1966), "extension work is an out of school system of education in which adults and young people learn by doing. It is a partnership between the government, the land-grant institutions, and the people, which provides services and education designed to meet the needs of the people".

Another definition was accorded by Leagans (1961), extension education is an applied science consisting of content derived from research, accumulated field experiences and relevant principles drawn from the behavioral science synthesized with useful technology into a body of philosophy, principles, content and methods focused on the problems of out of school education for adults and youth.

Another definition was proposed by Maimunah (1989) which states that extension is a two-way communication process that connects knowledge center with an intermediary (extension worker) and the final recipients (community). The goal of extension is to bring about change among extension workers and finally the community through the process of non-formal education so that they can improve their living standard towards prosperity.

It is interesting to note that extension is an out of school activity that provides non-formal education for community to help them improve their living standards. Research is an important component to ensure success of extension program. Extension research should be based on issues and problems faced by community in order to come up with relevant solutions or technological innovation through research should be channeled to these groups to further improve their current practice thus resulting increase productivity (Bahaman et al., 2009). In a research project on 'Youth and Telecentres in Community Building in Rural Peninsular Malaysia', (Bahaman et al., 2013), utilizing SEM analysis, my team and I found how youths' utilization of telecentres can contribute to and influence community building. Characteristics related to the quality of information acquired and utilized by these youth form the more powerful predictor to effective community building. The SEM analysis provided a more 'precise' and 'accurate' research findings that enrich my evidence-based extension work practices. I would like to argue that in most extension education research and work practices, researchers and practitioners are faced with the challenging task of explaining the complex and latent construct encapsulating their work to the wider community and industry in a more rigorous manner. Based on my career experiences I profoundly believe that some of our present extension education research particularly in UPM, lack this rigor and can be further improved by reporting findings and recommend strategies that are more precise and inclusive to enrich and sustain our extension work practices.

Research and Extension Linkages

Research is an essential component of extension education to ensure relevant and beneficial programs to its stakeholders. In the United State, the notion of incorporating extension and research can be traced back to the enactments of the Morrill (1862) and Smith-Lever (1914) Acts. Particularly the Smith-Lever Act led to the partnership between the United State Department of Agriculture (USDA) and Land-Grant universities resulting in the establishment of Cooperative Extension Service (CES). This CES enabled extension clients comprised farmers and home economics to benefit in terms of better understanding and skills from research findings generated by USDA and Land-Grant universities.

Extension can be envisaged as research-extension linkages through which knowledge, information and innovation from research entities are channeled to community by extension agents (Rahim, 1992). Issues and problem faced by extension clientele should be used as basis for research which in turn help to generate solutions which will be channeled back to the people. In order to make sure that extension provides relevant and beneficial programs to its stakeholders, continuous research employing appropriate theories and methodologies must be continually enhanced (Braverman & Engle, 2009)

Research is important in extension as it 1) Generates new knowledge and technologies, 2) helps to better understand issues/problems, 3) is crucial to assessing community and program needs, 4) is a tool for program development and policies, 5) is the basis for decision making, 6) enhances knowledge to address extension problems, 7) ensures success of extension programs, and 8) helps to evaluate effectiveness of extension programs.

The Need for Research-Driven, Participatory and Demand-Driven Extension Model

Current and future trends in extension work practices have called for more participatory knowledge and technology transfer approach as compared to old 'top down' model. Extension professionals are expected to provide more effective, accountable and evidence-based extension education program (Fetsch, MacPhee & Boyer, 2012). Extension professionals should equip themselves with knowledge in adult education and extension education research, as well as substantial technical knowledge in planning, implementation and evaluation of extension programs.

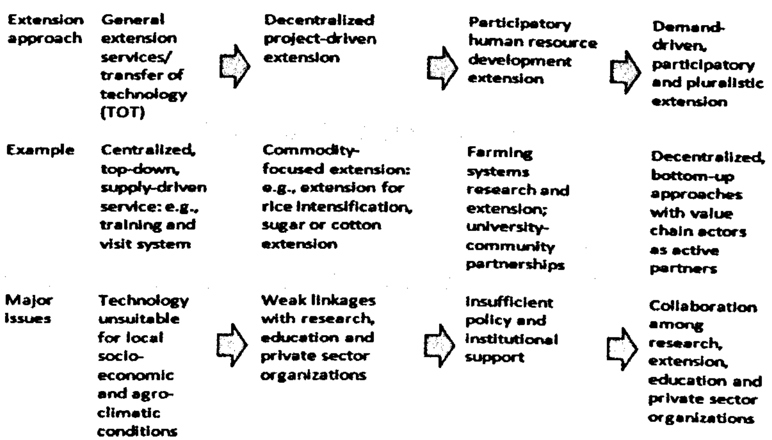


Figure 1 Evolution of Extension Practices (Suvedi & Kaplowitz, 2016)

With the need for a combination of research-driven, participatory and demand-driven extension work practices, this inaugural lecture will focus on how to enhance extension education research and organizational extension work practices through utilizing appropriate statistical applications, specifically Structural

Equation Modeling (SEM). Using my personal and professional knowledge and experience, this lecture will also discuss how extension education stakeholders should take advantage of the powerful statistical analyses provided by Structural Equation Modeling (SEM) in their research and development projects. Besides that, I will then highlight the importance equipping extension professionals with adequate knowledge and skill in the application and interpretation of SEM output. Finally, I will address how the incorporation of SEM analysis can be linked to better development and enrichment of evidence-based extension work practices.

STATISTICAL ANALYSES IN EXTENSION EDUCATION

Data analysis is an integral component in any social science research activities including extension research. Research in this discipline involves complex interrelationships between constructs which comprise independent, dependent as well as intervening constructs. The intervening constructs include, among others, mediators and moderators. In this light, lecturers, researchers or graduate students must have mastery of two important elements, namely, 1) knowledge and understanding on statistics, and 2) skill in using statistical software, in order to equip them for data analyses. One must be familiar with various statistical procedures, from basic statistics to multivariate statistics. Understanding of commonly used statistics, such as t-test, ANOVA, correlation and regression analyses, must be internalized by every researcher. In addition, to ensure the appropriate application of each statistic, a researcher needs to understand seven basic information which include: 1) purpose of the statistics; 2) requirements to use the statistics; 3) assumptions required to apply the statistics; 4) how to run the analysis in the statistical package; 5) what and how to present the results of analysis; 6) understand the decision criteria; and 7) make the right interpretation.

As for statistical packages, there are a number of them that are commonly used which include, among others, SPSS, SAS, Minitab, R and Stata. These statistical packages are employed for general purpose statistical analyses. However, there is another category of statistical packages that are used for structural equation modeling. The use of structural equation modeling is not a substitute for the other existing statistical analysis. Nevertheless, its usage is considered a complement to the others.

However for multi-dimensional constructs (i.e., it consists of multiple underlying concepts), the use of SEM is an advantage. The distinction between constructs and concepts is clearer in multi-dimensional constructs, where the higher order abstraction is called a construct and the lower order abstractions are called concepts. The nature of social research often involves social theories to explain the phenomena we observe in the social world. This seems a fairly straightforward exercise, but we need to remember that social phenomena are not stand-alone events but are entwined with a series of constructs that need to be viewed within more comprehensive interrelationships.

STRUCTURAL EQUATION MODELING (SEM)

Structural equation modeling (SEM) which has its roots in path analysis was pioneered by Sewall Wright, a geneticist, in 1921 (Hox & Bechger, 1998). It has been widely employed in various fields of studies, especially in social sciences (Cheng, 2001). SEM is a multivariate statistical technique that incorporates factor analysis, path analysis and multiple regression (Hox & Bechger, 1998, Ho, 2006). The use of SEM has gained rapid momentum since the 1970s, which is attributed to the availability of user-friendly software such as AMOS (MacCallum and Austin, 2000). Additionally, its popularity is attributed to its explanatory ability and statistical efficiency for model testing with a single comprehensive procedure (Cheng, 2001; Hair, 2006). SEM is a group of statistical models that seek to explain a series of simultaneous dependence relationships between the independent variables and dependent variables (Hair et.al ., 2010; Ho, 2006). SEM provides a quantitative test of a theoretical model hypothesized by the researchers, including how sets of variables define constructs and how these constructs are related to each other (Schumacker and Lomax, 2010).

In order to provide a much clearer idea about the applications of SEM, relevant results from a study (Mohammad Badsar and Bahaman Abu Samah, 2011) entitled "Factors influencing sustainability of information and communication technology telecenter projects in rural Peninsular Malaysia" will be presented here.

ADVANTAGES OF USING SEM IN EXTENSION EDUCATION RESEARCH

The following are some of the advantages or benefits of using SEM over other existing statistical procedures that can be applied in extension education research:

1. **Model interdependencies between several outcome (DVs) and their causal factors (IVs)**

   One common limitation of using the multivariate techniques is that they can examine just a single relationship at a time, even though the techniques such as multivariate analysis of variance allow for multiple dependent variables, but represent only a single relationship between the dependent and independent variables (Hair et.al 2006, p.705). Structural equation modeling on the other hand allows the researcher to test a series of dependence relationships simultaneously. The SEM technique is especially useful in testing theories that include multiple equations comprising dependence relationships (Hair et.al 2010, p.630) which can be applied to further enhance extension education research.

2. **SEM enables simultaneous tests of overall model fit as well as individual parameter estimate tests**
   Without information about the model's goodness-of-fit, it is difficult to assess the adequacy of the theory underlying the hypothesized model (Ho, 2006). SEM is capable of estimating the model fit and multiple and interrelated dependence relationships at the same time.

3. **SEM allows us to use latent (unobserved) variables in dependence relationships**
   As indicated by Schumacker and Lomax (2010) researchers are becoming more aware of the need to use multiple observed variables as a measure of a latent variable. The latent variable provides a better measure of an abstract or complex construct compared to using a single item variable. The SEM analysis has the ability to incorporate latent (or unobserved) variables in the analysis. A latent variable is a hypothesized or unobserved construct which cannot be measured directly (Ho, 2006).

4 **SEM involves greater recognition of validity**
   One of the biggest advantages of SEM is its ability to assess the construct validity of the proposed measurement theory. Construct validity is the extent to which a set of measured items

actually reflect the theoretical latent constructs those items are designed to measure (Hair et al., P, 708). Construct validity as indicated by Hair et al., (2010) is made up of four components: convergent validity, discriminant validity, nomological validity and face validity.

5. **SEM software programs such as AMOS have become increasingly user friendly**

   Today, most SEM software programs (such as AMOS, Lisrel, Mplus and EQS) are Windows-based and use pull-down menus and a wide selection of drawing tools, which are much easier to use compared with software that need inputs (Schumacher & Lomax, 2010).

6. **SEM improves statistical estimation by incorporating measurement errors**

   Generally the univariate and multivariate statistical techniques assume that there is no error associated with the measurement of the variables (Ho, 2006). However, as indicated by Hair et al., (2010), from both practical and theoretical perspectives, researchers cannot measure a concept perfectly and thus some degree of measurement error is always present. For example, when asking about household income, we know some people will not provide their actual income. Therefore, the answers provided have some form of measurement errors and that affects the estimate of the true structural coefficient (Hair et al., 2010). Consequently, SEM incorporates measurement errors in its analysis.

In order to show how SEM improves statistical estimation the results of two separate analyses are presented, that employ multiple linear regression (Figure 2) and structural equation modeling

(Figure 3). These analyses involve four independent variables (leadership competency, telecenter characteristics, understanding community and individual factors) and one dependent variable (telecenter sustainability). As depicted by the two results, the coefficient of determination for multiple linear regression is (R^2 = .517) while for SEM it is (R^2 = .641). In other words, the four independent variables in multiple linear regression explain 51.7 percent of the variance in telecenter sustainability. On the other hand in SEM, the set of variables explain 64.1 percent of the variance in the dependent variable, which is a substantial increase (12.4 percent) in statistical estimation. This increase is attributed to the use of measurement errors in SEM.

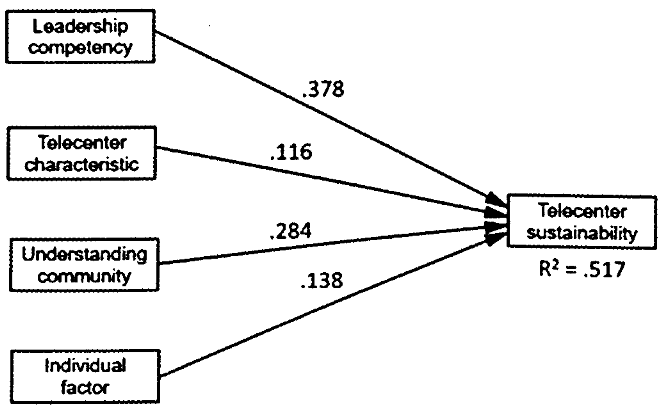


Figure 2 Results of Multiple Linear Regression

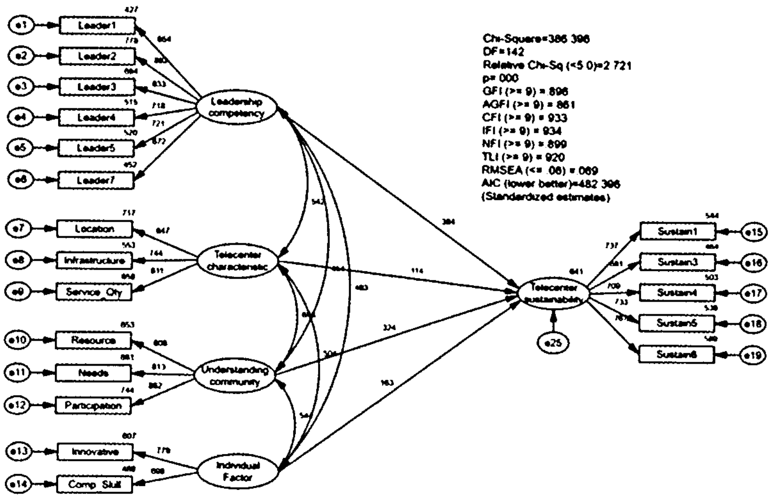


Figure 3 Results of SEM Analysis

SEM TERMINOLOGIES

SEM applies several terms for the variables used in its analysis. These terms include latent variable, manifest variable, exogenous variable and endogenous variable.

1. A latent variable is an unobserved concept that is not directly measured. The latent variable is represented by a number of observed variables (items/indicators). Therefore, the latent construct is measured indirectly through multiple observed variables or indicators (Hair et al., 2010). According to Westland (2010), many social variables are conceptual in nature, which cannot be measured directly. The main advantages of using the latent construct, as indicated by Hair et al. (2006), are "the improvements in statistical estimates (by incorporating the measurement error and capacity to assess validity as well as reliability), that better represent the theoretical concept

(collective set of items will represent the concept better than any single item), and directly account for measurement error" (p, 712). Figure 4 shows a latent variable (leadership) which comprises seven items/indicators. Each indicator comes with a measurement error. The latent variable is depicted as an ellipse (oval) object.

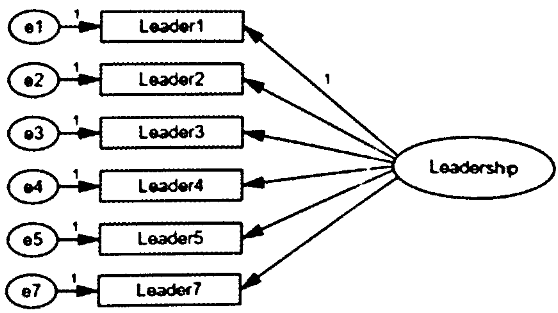


Figure 4 A sample of latent construct

2. A manifest or observed variable is a variable that is observed and measured directly by the researcher (e.g. income and age). Similarly indicators to a latent variable, as in Figure 5, are considered as manifest variables. Manifest variable is represented by a rectangle as displayed in the Figure 5.

Figure 5 A sample of a manifest construct

3. An exogenous variable is a variable that is not influenced by other variables in the model (Carvalho, J.D, Chima, F.O, 2014). Exogenous variables are equivalent to independent variables (Hair et al., 2010). These variables are displayed on the left side of a research conceptual framework.

4. An endogenous variable is a variable whose variation is explained by exogenous variables and other endogenous variables (including mediator variables) in the causal model/ path diagram. The endogenous variables are equivalent to dependent variables (Hair et al., 2010). These variables are displayed on the right side of a research conceptual framework.

REQUIREMENTS IN SEM

Before taking a decision to use SEM, the researcher should check two major requirements for SEM analysis, namely, the number of indicators and the sample size required.

1. Number of Indicators

The number of indicators or items is one of the contentious issues in structural equation modeling. From one angle, internal consistency reliability is greater if there are more items (Kline, 2011, p.70). From another angle, more items (measured variables or indicators) are not necessarily better. Even though more items produce higher reliability estimates and generalizability, more items also require larger sample sizes and can thus make it difficult to produce truly unidimensional factors. As the researcher increases the number of scale items (indicators) representing a single construct (factor), they may include a subset of items that inadvertently focuses on some specific aspect of a problem and may create a sub-factor (Hair et al., 2010, p.698).

Practically speaking, a model needs "...a minimum of three items per factor, preferably four, not only to provide minimum coverage of the construct's theoretical domain, but also to provide adequate identification for the construct". Identification refers to "whether enough information exists to identify a solution to a set of structural equations" (Hair et al., 2010, p.698).

Models and even constructs can be characterized by their degree of identification, which is defined by the degree of freedom of a model after all the parameters to be estimated have been specified. The degree of freedom in SEM differs from the degree of freedom in (for example) regression analysis in that it is not influenced by the sample size. In regression analysis, the degree of freedom is the sample size minus the number of estimated coefficients, while the degree of freedom in SEM "represent[s] the amount of mathematical information available to estimate model parameters" (Hair et al., 2006, p.745). The degree of freedom for a SEM model is determined by the following formula:

$$df = \frac{1}{2}[(p)(p+1)] - k$$

(Hair et al., 2006, p.746)

Where
p = number of observed variables
k =number of estimated (free) parameters.

An easy and practical way to calculate and check the degree of model identification is to subtract the parameters to be estimated from the unique term (which refers to the number of variances and covariances to be estimated). Thus, the number of indicators used in the model or construct could be used to establish the degree of identification in three levels.

The first level is when a construct is defined using two items or indicators. This produces a negative degree of freedom and consequently the level of model identification would be under-identified. It is important to note that an under-identified model cannot be computed. The second level is when a construct is defined using three items or indicators where as a result, its degree of freedom is zero and it is thus referred to as saturated. In this situation, the level of identification is called just-identified. In a just-identified model, the number of unique variances/covariances is equal to the number of estimated parameters. While a just-identified model can be computed and factor loading for items can be estimated, the model fit cannot be computed.

The third level is when a construct is defined using four or more indicators in which the model would have more unique covariances and variances terms than parameters to be estimated. Therefore the model has a positive degree of freedom, for which a fit value can be computed. The third level of identification which is termed as over identified is in which all required estimations, including factor loadings and model fit indices, have been computed.

2. **Sample Size**

Sample size is another requirement of SEM that needs careful consideration. It is generally understood among statisticians that SEM requires large sample sizes. However, it is difficult to give a simple answer to the question of how large a sample needs to be (Kline, 2005, 2010). According to Ho (2006), there is no agreement on the meaning of "sufficiently large" (p.290).

Kline (2005, 2010), as one of the pioneers in SEM, has offered very rough guidelines for determining a sufficiently large sample size. He asserts that a sample with fewer than 100 cases would be untenable except in the evaluation of a very simple bare-bones model. Further, a sample with fewer than 100 cases in descriptive research is not sufficiently large and is considered a "small" sample size. A "medium" sample size could range from 100 to 200 cases but, most importantly, this is not absolute and confirmation of the sample size's adequacy is dependent on the complexity of the model. If the number of cases exceeds 200, this is considered a "large" sample size. Overall, Kline's (2005, 2010) guidelines for sample size in estimation methods are: small, $n < 100$; medium, n between 100 and 200; and large, $n > 200$.

Hair et al. (2010) are also among the pioneers of SEM, and believe that the adequacy of the sample size in SEM is dependent on the model's complexity and the basic measurement model's characteristics, including the number of constructs and the indicators of each construct. They further suggest that sample size should be increased when the data deviates from multivariate normality or when the amount of missing data exceeds 10 per cent. An important point to consider is that the type of estimation technique is also influential in determining the size of the sample. For example, using sample-intensive estimation techniques (e.g. ADF) requires a larger sample size while using group analysis necessitates meeting the requirements of the adequacy of the sample size in each group (Hair et al., 2010, p.662). The general rule of Hair et al. (2010) in determining sample size by pre-consideration of the abovementioned characteristics is as follows: 100 cases is the minimum requirement of a model with five or fewer constructs (each construct with more than three items), in which the standardized factor loading of items should exceed the value of .6. A total of 150 cases is the minimum requirement of a model with seven constructs or fewer (each construct with more than two items), in which the standardized factor loading of items should stand at the modest communalities means of .5. A total of 300 cases is the minimum requirement of a model with seven or fewer constructs (fewer than three constructs with two items), in which the standardized factor loading of items is below .45. A total of 500 cases is the minimum requirement of a model with a large number of constructs, in which some have items with standardized factor loading values below .45 and some have fewer than three measured items.

To finalize the discussion on how large a sample needs to be in SEM, the researcher needs to consider the following criteria when deciding on the sample size: number of constructs, number of items of each construct, the level of communalities (standardized factor loading), the model complexity, the amount of missing data, the level of normal distribution and the type of estimation technique. After careful consideration of the factors influencing sample size, the researcher could use a recommended sample size range. Schumacker & Lomax (2010) recall the rule of thumb of statistics' texts as ten cases per variable or 20 cases per variable, while Bentler & Chou (1987) suggest a ratio of five to ten cases per observed variable. Five cases per observed variable would be sufficient for a model with normal distribution (in which each latent variable needs to have multiple indicators) and ten cases per observed variable would be sufficient for a model with other types of distribution. Lastly, the most appropriate minimum ratio is ten respondents per parameter, with an increase in the sample size as the model complexity increases.

The last but also the most important point, from our point of view, is that after considering the aforementioned criteria and using any of the aforementioned rules in determining the sample size, it is better to double-check the adequacy of the sample size. The importance of this is related to the generalizability of the findings, as the number of cases can affect the results of statistical tests by either making them insensitive, for small sample sizes, or overly sensitive, for very large sample sizes. According to Byrne (2010), a small sample size tends to over-reject true population models. According to Hair et al. (2006), at a certain alpha level, a larger sample size increases the power of statistical tests where smaller effects would be found to be statistically significant while for extremely big sample sizes, approximately any effect is significant.

Thus, double-checking the sample size after using the recommended rules in SEM involves considering the practical significance against the statistical significance.

This double-checking, as per our recommendation, can be done using any of the appropriate methods/formulas or software (online Daniel Soper calculator): the former determines the sample size based on the population size, while the latter determines the sample size based on the effect size, desired statistical power, number of latent variables, number of observed variables and probability level (The Daniel Soper calculator (Figure 6) can be accessed from the website - *http://www.danielsoper.com/statcalc3/calc.aspx?id=89)*. Making a decision about which method is more appropriate for double-checking also depends on some other factors that have been mentioned in the sample size sections of most multivariate, statistics and research methodology books. The sample number calculated based on the recommended rules of SEM pioneers and that calculated using other rules (considering the population or test type) need to be compared. While big gaps between the results of these two calculations need cautious consideration, if the gap is small then the researcher can use the highest number for the number of survey items distributed and the lowest for the adequate number of collected survey items.

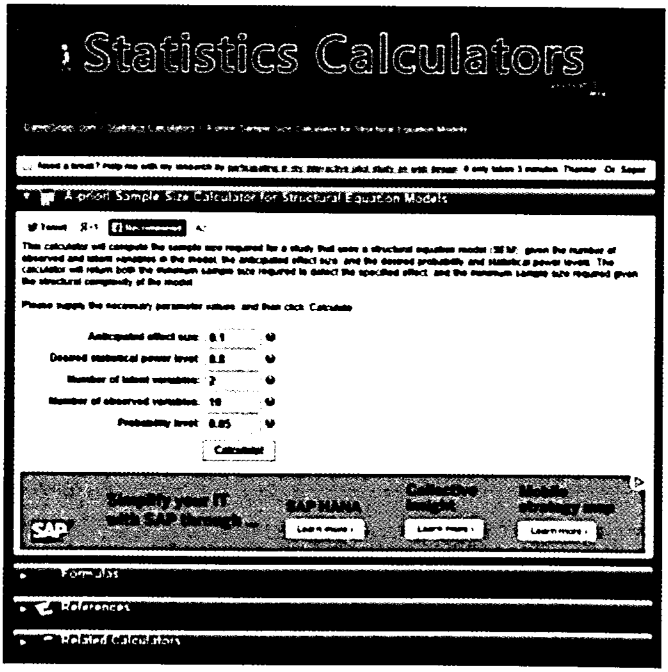


Figure 6 A-Priori Sample Size Calculator for SEM

ASSUMPTIONS IN SEM

Normality

One of the main assumptions in using ML estimation is normal distribution of the data. Non-normal data affects the variance/ covariance among the variables and can occur due to the limited sample size or the limited scaling of the variables, such as that due to the use of ordinal scales rather than interval scales (Schumacker & Lomax, 2010). According to Kline (2011), evidence has suggested that if the skew and kurtosis values are within reasonable ranges, this satisfies the multivariate normality assumption. The skew implies that "the shape of a unimodal distribution is asymmetrical about its mean" (p.60), in which positive skew means most of the scores are below the mean and negative skew indicates that most of the scores are above the mean. The kurtosis value is about the tail and peak of the unimodal asymmetrical distribution shape, in which positive kurtosis (called leptokurtic) indicates a heavier tail and a higher peak, while negative kurtosis (called platykurtic) indicates just the opposite (Kline, 2011).

Different rules of thumb are applicable to different resources to identify the normality issue. According to Schumacker & Lomax (2004) categorical data and ordinal data with values less than 15 are assumed to be normal if the skewness and kurtosis values are within the range of ±1.0. However, according to other references, values of ±1.5 or even ±2.0 are acceptable. Nevertheless, Byrne (2010) recommends the cut-off point of less than ±7 as an acceptable kurtosis value.

Outlier

An outlier is a score that is different from the rest (Kline, 2011) or that refers to a data value that is extreme or atypical (Schumacker & Lomax, 2010). Outliers may affect the mean, standard deviation and correlation coefficient values. The different sources of outliers include: data entry errors, observation errors, measurement errors (either based on the instruction or layout) or respondents' extreme points of view and self-reported extreme values (Schumacker & Lomax, 2010). To find outliers, Hair et al. (2006) discuss the Mahalanobis distance (d-squared) measure, which is "the distance in standard deviation units between a set of scores for one case and the sample mean (centroid)" (p.65). Byrne (2010) also places emphasis on looking at the d-squared value to find the outlier cases and declares that a d-squared value that stands distinctively apart from all other d-squared values shows the possibility of outliers.

Multicollinearity

Multicollinearity refers to high correlation among variables. Multicollinearity occurs when two or more variables measure the same aspect instead of different constructs. One of the reasons for the occurrence of multicollinearity is due to the researcher inadvertently using composite variables and their constitute variables together (Kline, 2011). The criterion for determining multicollinearity, according to Hair et al. (2010), is a correlation greater than .9 and according to Kline (2011), a correlation greater than .85. The multicollinearity assessment in AMOS software is based on the results of the correlation matrix in the measurement model.

To overcome the issue of multicollinearity, the first method is to combine the highly correlated constructs, if this is theoretically accepted and applicable in the field (Byrne, 2010). The second method is to remove one of the highly correlated constructs (Kline, 2011).

WHAT IS AMOS?

AMOS, which stands for Analysis of MOment Structures, is one of the popular software for SEM. Other software that are used for SEM include LISREL, EQS, CALIS, MPlus and MxGraph. AMOS, a covariance based SEM software, utilizes a simple and user-friendly interface to build models that more realistically reflect complex relationships between constructs within a research conceptual framework.

AMOS is an easy-to-use program where the user can specify, view and modify their model graphically by using simple drawing tools on the screen (Arbuckle, 2011). Further, by using AMOS, users can simply evaluate their model fit, make modifications and print out the results of their final model. There are different versions of the AMOS software and recent versions (20, 21, and 22) released have extensive documentation and user guides, including online help systems and advanced reference materials (Arbuckle, 2011). The present version (22) is much more practical and even more user friendly for users who are beginners in using AMOS and are not very familiar with intermediate statistics.

GOODNESS-OF-FIT INDICES

Several measures called goodness-of-fit indices are available to assess the overall fit of the hypothesized model. The overall model fit refers to a test of whether the model proposed by the researcher is close enough to observe the covariance input matrix (Kline, 2011). In other words, goodness-of-fit indices are the extent to which the actual data that has been gathered (or the observed covariance input matrix) corresponds or departs from the proposed model (Ho, 2006). Goodness-of-fit measures can be classified into three categories (Ho, 2006): absolute fit measures, incremental fit measures and parsimonious fit measures. These are discussed in the following sections, along with the corresponding measures for each category.

Although there are many different indices, it is not possible and not necessary for all of the indices to meet the fit criteria. The endeavors of different scholars have shown the importance of using different indices to support the model fit. For example, Jaccard & Wan (1996, cited in Garson, 2009) recommend the use of at least three fit tests. Kline (1998, cited in Garson, 2009) recommends using at least four tests, such as chi-square, GFI, NFI or CFI; NNFI; and SRMR tests. Hair et al. (2006) also state that reporting χ^2 and degree of freedom values along with CFI and RMSEA values will often provide sufficient unique information for evaluation. We rely on the most comprehensive point of view that is applicable across a wide range of situations which is the view suggested by Hair et al. (2010). Hair et al. (2010) indicate that if three to four fit indices meet the criteria it provides adequate evidence of model fit. The aforementioned three to four indices should include one incremental index and one absolute index, in addition to the χ^2 value and the associated degrees of freedom. In the case of comparing two models, the agreement of at least one of the parsimonious fit indices is also required.

CONSTRUCT VALIDITY

As mentioned earlier, one of the main advantages of using SEM is its ability to assess the construct validity of a proposed model rather than only to test the reliability. Construct validity is the extent to which a set of measured items actually reflect the theoretical latent construct. Therefore, construct validity deals with the accuracy of a construct's measurement (Hair et al., 2010). The assessment of construct validity is made up of four important components: content and face validity, convergent validity, discriminant validity and nomological validity.

1. Content and face validity

   Content validity refers to the consistency of a scale and the theoretical definition of the concept and how the concept works. The face validity measure is also important as it is related to judgements on whether the instrument looks good and appropriate. Usually, a panel of experts who know the theoretical foundation of the concept judges the face and content validity of a scale (Muijs, 2004). The content and face validity must be established prior to any theoretical testing when using

CFA. Without an understanding of every item's content or meaning, it is impossible to specify a valid construct correctly.

2. Convergent validity

Convergent validity refers to the converging or sharing of a proportion of variance among the indicators of a specific construct. The ways to estimate the relative amount of convergent validity among item measures (according to Hair et al., 2006) are factor loading, variance extracted and construct reliability, which can be outlined as follows:

Factor loading is the value that appears on each arrow of the model and it reflects the correlation between the original variable and the factor, showing the nature of that particular variable in the factor. To support the convergent validity of a construct, all factor loading values should first be statistically significant. Secondly, a good rule of thumb is that standardized factor loading estimates should be .5 or higher (ideally .7 or higher) to support the convergent validity.

Average variance extracted (AVE) is the average of the squared factor loading. An AVE value of .5 or higher is a good rule of thumb suggesting adequate convergent validity. An AVE value of less than .5 indicates that, on average, the amount of variance explained by the latent factor is less than the error remaining in the items. The AVE value is calculated using the following formula (Hair et al., 2010, p.709):

$$AVE = \frac{\Sigma\lambda^2}{n}$$

Construct reliability indicates the internal consistency of a construct and its assessment follows the same rule as Cronbach's alpha calculation. Thus, the value of the construct reliability should be .7 or higher, to indicate adequate convergent validity of the construct. Construct reliability can be calculated using the following formula (Hair et al., 2010, p.710):

$$CR = \frac{(\Sigma\lambda)^2}{(\Sigma\lambda)^2 + (\Sigma\delta)}$$

3. Discriminant validity
   Discriminant validity is the extent to which a construct is truly distinct from the other constructs. The average variance extracted (AVE) for two factors should be greater than the squared correlation between the two factors, to provide evidence of discriminant validity.

4. Nomological validity
   Nomological validity is concerned with the relationship of any construct with other constructs according to the hypothesized relationship derived from theory. Nomological validity is tested by examining whether the correlations among the constructs in a measurement theory make sense. The matrix of correlations can be useful in such an assessment and correlation of less than .2 is questionable.

BUILDING A THEORY BASED MODEL

SEM is strongly theory based: theory plays an important role in establishing the hypothesized relationships of the proposed model (Hair et al., 2010; Ho, 2006). Further, in SEM, any modification to the proposed model needs to be justified by relevant theories. Thus, when making any modifications or contributing to a theoretically proposed model, the researcher needs to hypothesize the modifications using relevant theory or logical grounds, not empirical grounds (Kline, 2005). Overall, SEM is dissimilar to other multivariate analysis methods due to its strength as a theory-based approach and it leading researchers to conduct theory-based research. The use of a theory-based approach in SEM, along with theory-based specifications, identification and modifications of the proposed model, and interpretations also based on theory (Ho, 2006, p.283) is more likely to contribute to the world of knowledge

THE PRACTICAL STAGE OF SEM ANALYSIS

Generally, SEM analyses comprise three stages, namely 1) confirmatory factor analysis for individual constructs (CFA);, 2) a measurement model; and 3) a Structural model. The first two stages are more for data preparation while the last stage is used to respond to research objectives and hypotheses.

1. CFA for Individual Constructs

The first stage of conducting SEM is to run factor analysis for individual constructs. Factor analysis aims to simplify a large number of intercorrelated items into a few representative constructs. There are two approaches to conducting factor analysis: exploratory factor analysis(EFA) and confirmatory factor analysis(CFA). However, a combination of both is also acceptable. Exploratory factor analysis determines the number of factors that could best describe the data based on the statistical results. In fact, a researcher who has no strong literature to support the number of factors that really exist or does not know which variables or items belong to which factors will need to conduct EFA. EFA is used when a researcher needs to develop a scale instead of using prior research scales.

Since researchers generally use standard scales or prior research scales with some modifications for their research situations and as

SEM involves strictly theory-based analysis, CFA is recommended. It is worth noting that EFA follows the same procedure as CFA except that EFA has a prior stage. To conduct EFA, a researcher should first explore the indicators of each factor and the number of factors that exist in the data set. Practically speaking, in this situation the research should use a general approach to factor analysis (using SPSS). The explored number of factors and the indicators of the factors can then be confirmed using SEM, with the same procedure for CFA.

In CFA, the researcher theoretically has literature support to determine the number of factors that exist for a set of variables and the number of items that belong to a factor. Further, CFA confirms or rejects the theoretical specification of the factors and shows how the theoretical factors match the actual data (Hair et al., 2010).

There are debates on the importance of individual CFA over the measurement model. Some scholars believe that since in SEM analysis we are interested in testing the intercorrelation of factors, we should not drop the items or indicators of any construct in isolation from other factors. Although this reason behind the debate is true and important, individual CFA is still the best way to find the bad items in a less complex model and it is easier to manage compared with the measurement model. Further, when we get perfect fit for each individual construct, it is then easier to achieve good model fit in the overall measurement model. Thus, we recommend first conducting individual CFA to identify the weak items/indicators and trying to find the best indicators of each individual construct. Items should only be dropped after running the measurement model to know how the deletion of each item could influence other factors or indicators.

To conduct individual CFA after drawing the hypothesized model extracted from theory or explored in EFA, the researcher needs to: a) test for model fit; b) check for convergent validity; and c) determine construct reliability.

a. Test for model fit

   Two criteria must be fulfilled in order to establish model fit – 1) have at least three or four of the fit indices from the absolute and incremental fit measures; and 2) meet the requirements for standardized factor loadings. The fit indices should include relative chi-square, RMSEA and any one or two of the other fit indices. As for the standardized factor loading, all the loadings must be positive, more than .50 and none more than 1.0.

b. Convergent validity

   AVE can be used as a measure of convergent validity. AVE is calculated by dividing the total squared factor loading by the number of items/indicators. An AVE equivalent to or more than .50 meets convergent validity for a construct.

c. Construct reliability

   In SEM, the above mentioned formula can be used to calculate construct reliability. This construct validity is comparable to the Cronbach alpha in SPSS. By convention, the cut-off value for construct reliability is more than or equal to .70.

Types of CFA for Individual Constructs

Individual CFA can be categorized as first-order CFA and second-order CFA. First-order CFA can be simple individual construct CFA (Figure 7), in which the variable measured is based on a series of indicators or an individual construct with dimensions, where each dimension is measured by a series of items (Figure 8). In second-order CFA, a variable is measured based on a series of dimensions under a bigger construct (Figure 8). The decision of which type of

CFA to select depends on the essence of the variable, the method of variable measurement and the researcher's hypothesized path.

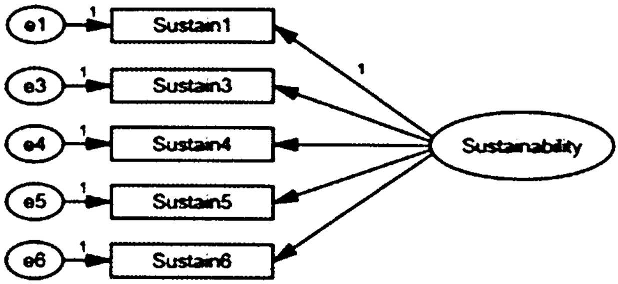


Figure 7 Simple Individual Construct CFA

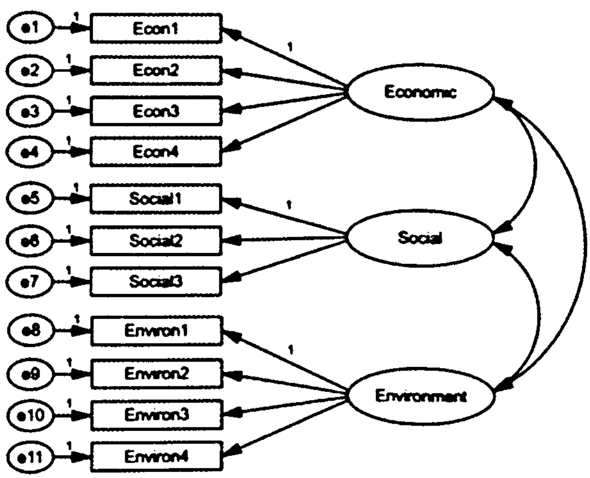


Figure 8 Individual Construct with Three Dimensions Based on First-Order CFA

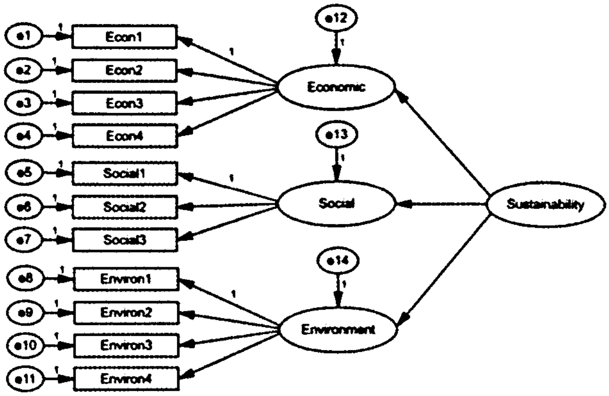


Figure 9 Individual Construct with Three Dimensions Based on Second-Order CFA

The following figure displays the results of the confirmatory factor analysis for telecenter sustainability. Based on the fit indices and factor loadings for each indicator, as in Figure 10, this variable meets the model fit. In addition, based on the results in Table 1, this variable also meets convergent validity (AVE=.528) and construct reliability (CR=.848).

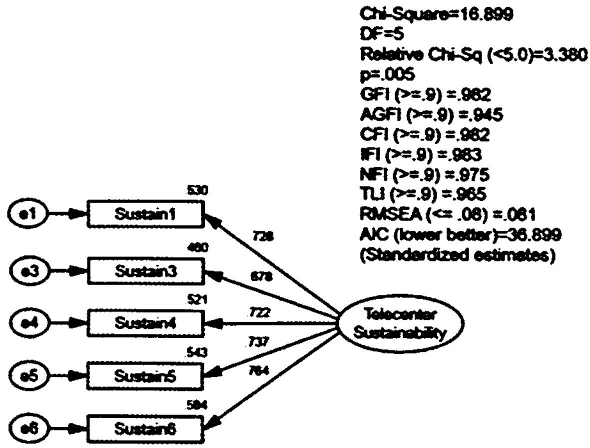


Figure 10 Results of CFA for Telecenter Sustainability

Table 1 Factor Loading, Average Variance Extracted and Construct Reliability for Telecenter Sustainability

Items/Indicators	Factor loading	AVE	CR
Sustain 1	.728	.528	.848
Sustain 3	.678		
Sustain 4	.722		
Sustain 5	.737		
Sustain 6	.764		

2. Measurement model

The measurement model is the second stage in SEM analysis. At this stage, all the individual constructs are entered into the model with no demarcation between exogenous and endogenous variables. According to Hair et. al. (2006), each latent construct to be included in the model is identified and the measured indicator variables (items) are assigned to latent constructs in the measurement model.

The following tasks are to be tested in the measurement model:

a Test for model fit

The same criteria as in CFA is applied to test for the model fit of a measurement model. Generally, if the individual construct meets the model fit, the tendency for the measurement model to meet the model fit will be high.

b. Convergent validity

If you skip CFA for the individual construct, then you can test for convergent validity in this measurement model. The same criteria applies to test for convergent validity of the individual construct in the measurement model.

c Test for discriminant validity

Discriminant validity refers to the extent to which a construct is truly distinct from other constructs. This validity involves the relationship between a particular latent construct and other constructs of a similar nature (Brown, 2006). Discriminant validity is measured to check that a construct is really different from other constructs. For any two constructs, the discriminant validity is met if the correlation coefficient (r) is less than .90 (Fornell and Larcker, 1981; Hair et al, 2010) or their individual AVE is greater than their corresponding r^2 (Bryne, 2010).

d Test for normality

Structural equation modeling is a parametric statistic. Hence the distribution of scores for all the constructs must meet the assumption of normality. Skewness and kurtosis can be used to test for this assumption. This assumption is met if skewness is between -2 to +2 and kurtosis is between -7 to +7.

e. Test for multicollinearity

Multicollinearity refers to high correlations between exogenous/ independent variables. Multicollinearity occurs when correlations between two exogenous variables is .90 or more (Hair et. al. (2010)

f Test for outliers

An outlier is a value that is substantively too small or too big as compared to other scores. Mahalanobis D squared can be used for this purpose. Cases with high Mahalanobis D squared, are potentially outliers. The second criteria is to calculate Mahalanobis D squared by degree of freedom. Degree of freedom refers to the total number of indicators. For a sample size of more than 200, if the quotient is bigger than 4, the corresponding cases are potentially outliers.

In this study, a total of six constructs (four exogenous and two endogenous) were involved. In the measurement model, all variables were entered with no differentiation made between the two categories of variables (Figure 11). With reference to fit indices and factor loadings for each indicator, the measurement model meets the model fit.

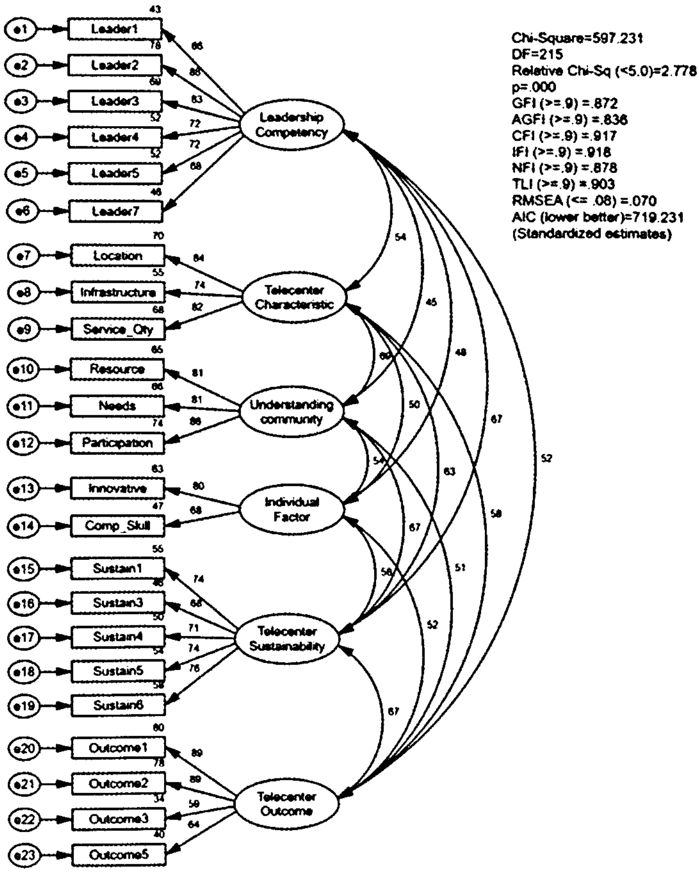


Figure 11 Measurement Model

Results for the measurement model are presented in Table 2. Based on the construct reliability (CR) values, all the six variables are reliable (CR > .7) and all the variables meet convergent validity (AVE > .5). The results of this table can be used to test for discriminant validity. Any two variables meet discriminant validity when the AVEs for the two variables are higher than their corresponding *r* squared.

Table 2 Construct Reliability, Average Variance Extracted (on the Diagonal) and Squared Correlation Coefficients (on the Off-diagonal) for Study Instruments

Construct	CR	TS	TO	LC	TC	UC	IC
Telecenter sustainability (TS)	.848	.528					
Telecenter outcome (TO)	.840	.449	.577				
Leadership competency (LC)	.882	.453	.274	.559			
Telecenter chaaracterisstic (TC)	.845	.394	.340	.293	.645		
Understanding commmunity (UC)	.867	.444	.255	.297	.472	.686	
Individual factor (IC)	.708	.336	.272	.229	.249	.296	.550

3. Structural model

While the overall measurement model is specified and validated with CFA, in the last stage of structural equation modeling, the structural model is represented by specifying the set of relationships between the constructs. The representation of the theory with a set of structural equations is usually depicted with a visual path diagram. The structural equation model is an inclusive model that specifies the pattern of relationships among exogenous and endogenous variables, either observed or latent (Hair et al., 2010; Ho, 2006). In other words, the structural model specifies the way that each variable affects the others. The focus here is not on testing the construct validity of the latent variables, as in the measurement model, but to examine the relationships between latent or manifest constructs. The structural model is used to test the level of model fit and the direct, indirect and total effects of the exogenous variables on the endogenous variable.

Figure 12 displays the results of the structural model which comprises four exogenous variables (leadership competency, telecenter characteristics, understanding community and individual factors), one mediation variable (telecenter outcome) and one endogenous variable (telecenter sustainability).

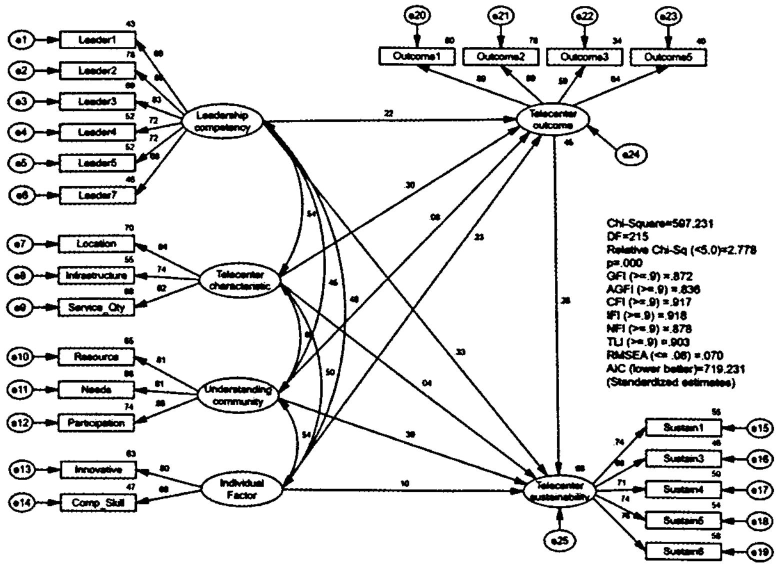


Figure 12 Structural Model

As mentioned earlier, the structural model depicts the relationship between the exogenous and endogenous variables. Using this structural model, the following analyses can be carried out, namely, 1) determine direct, indirect and total effects; 2) analyses related to multiple linear regression; 3) test for mediation effect; and 4) test for moderation effect.

DIRECT, INDIRECT AND TOTAL EFFECTS

If there is a mediating variable in a structural model, then it is possible to calculate direct, indirect and total effects. The advantage of using this information is that it gives a better picture of the contributions of each predictor variable towards the prediction of the endogenous variables. In addition, it is possible to compare the contribution of the direct and indirect effects of the exogenous to endogenous variables. In the following structural model (Figure 13), regression weights for each path are labelled as a, b, c, d, e, f, g, h and i.

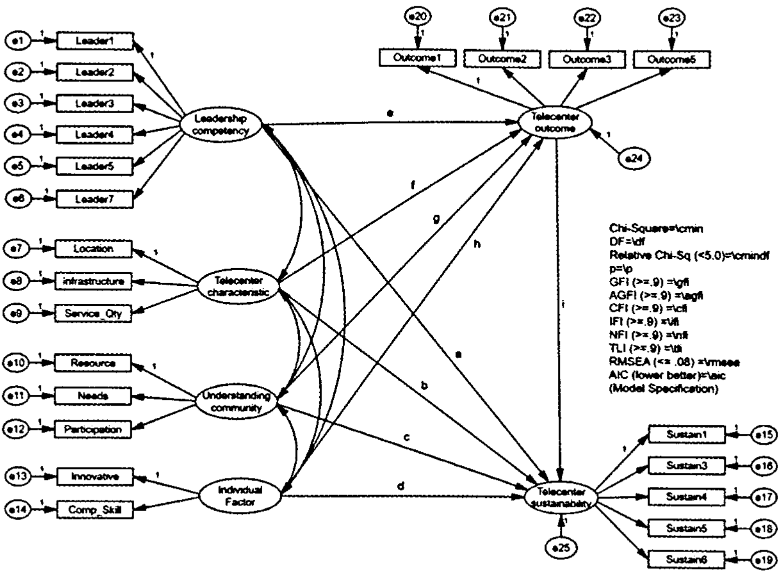


Figure 13 Structural model with labelled regression weights

Based on the above labels, the direct, indirect and total effects of the four exogenous variables on the endogenous variable (telecenter sustainability) can be calculated using the formulae presented in Table 3.

Table 3 Formulae for Calculating Direct, Indirect and Total Effects

Path	Direct	Indirect	Total
Leadership competency → Sustainability	a	ei	a + ei
Telecenter characteristics → Telecenter sustainability	b	fi	b + fi
Understanding community → Telecenter sustainability	c	gi	c + gi
Individual factors → Telecenter sustainability	d	hi	d + hi

ANALYSES RELATED TO MULTIPLE

Linear Regression

The results from the structural model can be used to respond to analyses in multiple linear regression. The analyses include: 1) test for regression model; 2) test for slope; and 3) model summaries. Testing for the regression model is embedded in the test for model fit. The test for model fit comprises fit indices and factor loadings and the requirements for model fit are similar to that for CFA and the measurement model.

The second analysis involves testing of slope which is to test the contribution of the individual predictors to the dependent variable. Instead of the t-value, as in multiple linear regression, SEM provides an alternative statistic, the critical ratio (CR) to test the significance of the contribution of the individual predictors. While these two statistics are comparable the test of the significance is based on the given p-value.

The final analysis is to derive and interpret the model summaries which include the multiple correlation coefficient (R) and coefficient of determination (R^2). The R, which ranges between 0 to 1, indicates the strength of the relationship between the set of predictors and the dependent variables while the R^2, which also ranges between 0 to 1, depicts the amount of variance in the dependent variable that is explained by the set of predictors.

Results from the structural model are summarized in Table 4. Leadership competency, understanding community and telecenter outcome contribute significantly toward telecenter sustainability. The highest contribution is attributed by leadership competency (Beta=.326), followed by understanding community (Beta=.300) and telecenter outcome (Beta=.275). In contrast, both telecenter characteristics and individual factors do not contribute significantly towards telecenter sustainability.

Based on the multiple correlation coefficient, the relationship between all the five factors and telecenter sustainability is considered to be high (R=.826). In addition, this set of factors contribute a total of 68.3 percent of the variance in telecenter sustainability (R^2=.683)

Table 4 Results of SEM on Effect of Predictors on Telecenter Sustainability

Construct	*B*	*SE*	*Beta*	*CR*	*p*
Leadership competency	.362	.067	.326	5.440	.000
Telecenter characteristics	.037	.076	.035	.483	.629
Understanding community	.305	.071	.300	4.276	.000
Individual factors	.119	.079	.100	1.518	.129
Telecenter outcome	.237	.052	.275	4.566	.000

R = .826

R^2 = .683

MEDIATION EFFECT

There has been a growing trend in recent years whereby researchers are not interested in just studying the relationships between the predictor and criterion variables, but also in incorporating the effects of mediating variables. Investigation of these mediating variables can further facilitate explanation of the complex inter-relationships between the variables in a given model.

With the advancements in computing, testing of the mediation effect, which used to be complicated, incorporating a series of multiple linear regression analyses, can now be done easily and efficiently through the use of structural equation modeling. According to Baron and Kenny (1986), a variable may function as a mediator when it accounts for the relationship between the predictor and the criterion. The mediator explains how external physical events take on an internal psychological significance and how or why such an effect occurs. A mediator is the medium through which the predictor influences the criterion. The mediator is part of the causal process whereby the mediator is depicted in a path diagram together with the predictor and criterion variables.

Rather than hypothesizing a direct causal relationship between the predictor and criterion, a mediation model hypothesizes that the predictor causes the mediator, which in turn causes the criterion variable. The mediator serves to clarify the nature of the relationship between the predictor and criterion variables (MacKinnon 2008). A mediation effect occurs when a third construct intervenes between two other related constructs. The mediator explains the relationship between the other two constructs (Hair et al. 2010).

A variable may be considered a mediator to the extent that it carries the influence of predictor to the criterion variables. The general test for mediation is to examine the relationship between, 1) predictor and the criterion variables; 2) predictor and the mediator variables; and 3) mediator and the criterion variables. All of these correlations should be significant. The relation between predictor and criterion should be reduced (to zero in the case of total mediation) after controlling the relationship between the mediator and criterion variables.

Types of Mediation Models

Figure 14 depicts the direct relationship between a predictor (X) and a criterion variable (Y). The symbol c refers to the path coefficient between X and Y. It represents the total effect between X and Y.

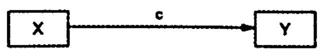


Figure 14 Direct relationship between predictor and criterion

As mentioned earlier, a mediator is a variable that intervenes in the relationship between the predictor and criterion variables. Generally, there are three different types of mediation models, namely, the single mediation model, single-step multiple mediation model, and multiple-step multiple mediation model. This categorization is based on the number of mediator variables and the nature of the relationship between the predictor, mediator and criterion variables.

1. Simple Mediation Model

The Simple Mediation Model consists of a predictor, a mediator and a criterion variable, as in Figure 15. In this model, the direct, indirect and total effects are as follows:

Direct effect = c'

Indirect effect = ab

Total effect = c' + ab

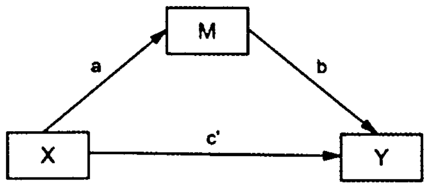


Figure 15 Simple mediation model

2. Single-Step Multiple Mediation Model

This model comprises more than one mediator variable. As depicted in Figure 16, two mediator variables (M1 and M2) coexist in the model together with a predictor and criterion variable. The predictor is related to the individual mediator variables separately from the criterion variable. Calculations for direct, indirect and total effects are given below:

Direct effect = c'

Indirect effect = a1b1 + a2b2

Total effect = c' + a1b1 + a2b2

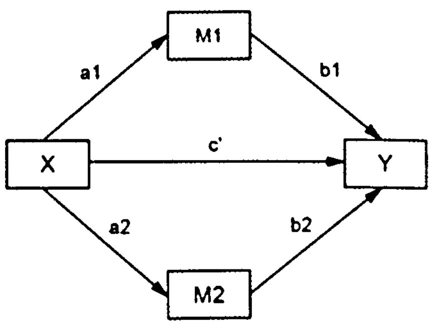


Figure 16 Single-step multiple mediation model

3. Multiple-Step Multiple Mediation Model

As in the above mediation model, the Multiple-Step Multiple

Mediation Model also consists of more than one mediator variable. However, instead of having separate links between the mediator variables and the criterion variable, the predictor variable is related to the first mediator (M1) through the second mediator (M2) and to the criterion variable, as presented in Figure 17.

The direct, indirect and total effects are given as follows:

Direct effect = c'

Indirect effect = a1b1 + a2b2 + a1a3b2

Total effect = c' + a1b1 + a2b2 + a1a3b2

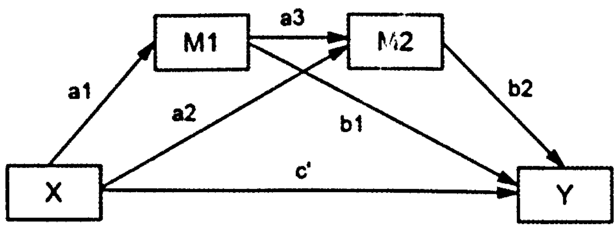


Figure 17 Multiple-step multiple mediation model

Importance of the Mediation Test

The basic importance of the mediation test is to answer the questions of the "how" and "why" of the inter-relationship between the constructs. MacKinnon et al. (2007), in their article on mediation analysis, have outlined three reasons for mediation in psychology: 1) it is the root of the stimulus organism response model; 2) the mediation variables form the basis of many psychological theories; and 3) it relates to methodological considerations.

Approaches to the Mediation Test

MacKinnon (2000) has outlined three major methods to test for the mediation effect, namely, the causal steps approach, coefficient difference, and product of coefficients. Interestingly, all these three methods utilize the results of the three regression analyses below. The first equation is derived from simple linear regression between the predictor (X) and criterion (Y). The second equation is the result of simple linear regression between the predictor (X) and criterion (M) while the third equation results from a multiple linear regression between the predictors (X and M) and the criterion (Y). Note that b_0 and e_i for all the three equations represent intercept (constant) and residual, respectively.

$$\hat{Y} = b_0 + cX + e_i \quad \text{... Equation 1}$$
$$M = b_0 + aX + e_i \quad \text{... Equation 2}$$
$$\hat{Y} = b_0 + c'X + bM + e_i \quad \text{... Equation 3}$$

1. Causal Steps Approach

The causal steps approach was popularized by Baron and Kenny (1986) and is the most commonly used method to test for the mediation effect. This approach entails four steps to establish the mediation effect, namely:

a) The predictor (X) significantly affects the criterion (Y), as in Equation 1.

b) The predictor (X) significantly affects the mediator (M), as in Equation 2.

c) The mediator (M) significantly affects the criterion (Y) in the presence of predictor (X), as in Equation 3.

d) The regression coefficient (c'), as in Equation 3, is significantly reduced as compared to c, as in Equation 1.

2. Coefficient Difference Method

MacKinnon and Dwyer (1993) postulate that the value of the mediated or indirect effect can be calculated as ab or c – c'. The c and c' are derived from Equations 1 and 3, respectively. The difference in the coefficients (c – c') reflects the reduction in the effect of the predictor (X) on the criterion (Y) when the mediator is entered into the regression model. In order to test for the mediation effect, the difference in the coefficients is divided by the standard error of the difference. The resulting value is compared against the standard normal distribution for decision and conclusion.

3. Product of Coefficients Method

The mediated or indirect effect, according to Alwin and Hauser (1975), is computed by multiplying coefficient a from Equation 1 and coefficient b from Equation 3. The product ab is then divided by its standard error to yield a value that can be compared against a standard normal distribution for decision and conclusion.

Multi-Model Analysis

As mentioned earlier, Multi-Model Analysis employs the causal steps approach, as proposed by Baron and Kenny (1986). The analysis involves three different models, namely, the full mediation model, indirect model and direct model. The Multi-Model Analysis for the mediation test involves two major stages. The first stage is to establish the presence of a mediation effect in the overall structural model. Once the presence of a mediation effect is established, the second stage is to test the mediation effect of the mediator on the specific paths in the structure.

1. Establishing the presence of a mediation effect

The two different structural models are compared – full mediation model and indirect model. If the full mediation model is found to be better than the indirect model, then it can be established that some form of mediation effect is present in the structural model. From the results of SEM analyses, the values of chi-square, Parsimony Normed Fit Index (PNFI) and Akaike Information Correction (AIC) are compared using the following criteria:

a. Chi-Square. The smaller the $\chi 2$ value, the better the model.
b. Parsimony Normed Fit Index (PNFI). A larger PNFI value indicates a better model.
c. Akaike Information Correction (AIC). A smaller AIC value specifies a better model.

2. Test mediation effect for individual path/s

At this stage, the full mediation model is compared with the direct model. Based on the comparison, four plausible outcomes of the mediation test can be established, which are:

a. Full mediation. The mediator fully mediates the relationship between the exogenous and endogenous variables.
b. Partial mediation. The mediator only partially mediates the relationship between the exogenous and endogenous variables.
c. No mediation. The mediator does not mediate the relationship between the exogenous and endogenous variables.
d. Indirect effect. There is only an indirect relationship between the exogenous and endogenous variables through the mediator.

The decision criteria for the mediation test using multi-model analysis are presented in the following table.

Table 5 Decision criteria for the mediation test

Decision	Direct Model	Mediation Model			
	X → Y	X → Y		X → M	M → Y
	P	Beta	*p*	*p*	*p*
No mediation				NS	NS
Indirect effect	NS		NS	S	S
Partial mediation	S	↓	S	S	S
Full mediation	S	↓	NS	S	S

Note: S significant
NS non-significant
↓ reduce/decrease

The results from the mediation test using the multi-model analysis (MMA) are presented in Table 6. Based on the results and the above decision criteria it can be concluded that: 1) telecenter outcome partially mediates the relationship between leadership competency and telecenter sustainability; 2) There exists an indirect effect between telecenter characteristics and telecenter sustainability through the telecenter outcome; 3) the telecenter outcome does not mediate the relationship between understanding community and telecenter sustainability; and 4) telecenter outcome fully mediates the relationship between individual factors and telecenter sustainability

Table 6 Results of Mediation Effects of Telecenter Outcome on Relationship between Leadership Competency and Telecenter Sustainability (MMA)

Factor/Model/ Hypothesized Paths	**Beta**	***p***
Leadership Competency		
Direct Model		
Leadership competency → Telecenter sustainability	.384	.000
Mediation Model		
Leadership competency → Telecenter sustainability	.326	.000
Leadership competency → Telecenter outcome	.326	.000
Telecenter outcome → Telecenter sustainability	.060	.004
Telecenter Characteristics		
Direct Model		
Telecenter characteristics → Telecenter sustainability	.114	.121
Mediation Model		
Telecenter characteristics → Telecenter sustainability	.035	.629
Telecenter characteristics → Telecenter outcome	.082	.001
Telecenter outcome → Telecenter sustainability	.060	.004
Understanding Community		
Direct Model		
Understanding community → Telecenter sustainability	.324	.000
Mediation Model		
Understanding community → Telecenter sustainability	.300	.000
Understanding community → Telecenter outcome	.022	.306
Telecenter outcome → Telecenter sustainability	.060	.004
Individual Factors		
Direct Model		
Individual factors → Telecenter sustainability	.163	.016
Mediation Model		
Individual factors → Telecenter sustainability	.100	.129
Individual factors → Telecenter outcome	.062	.020
Telecenter outcome → Telecenter sustainability	.060	.004

Bootstrap Method

In almost all studies, data collection incurs a substantial amount of money and manpower. Researchers normally utilize the sample data to get the best possible estimates of statistics such as the sample means and standard deviation. These estimates can be more accurately generated if a series of samples are used to measure the said estimate. Unfortunately, due to financial, time, as well as, manpower constraints, such endeavors cannot be undertaken.

Bootstrapping can be employed as an alternative method to overcome the above constraints and at the same time still accomplish the task of approximating the estimates. Bootstrapping was introduced by Bradley Efron (1979) as a procedure to estimate the sampling distribution of a parameter estimate. Since its inception, the bootstrap method has gained extensive acceptance among statisticians and has been incorporated into popular statistical analysis software such as SPSS and AMOS. According to Arbuckle (2007), the bootstrap method can generate an approximate standard error for practically any estimate used in AMOS.

Bootstrapping is a resampling technique that involves resampling (with replacement) from one set of sample data. The process of resampling is conducted many times. Generally the minimum number of resampling is 1,000 times although Hayes recommends at least 5,000 times. In the case of a simple mediation model with one predictor, criterion and mediator variables, the bootstrapping procedure will yield numerous values of a, b and ab, which represent path coefficient X → M, path coefficient M → Y and indirect effect (X → M → Y), respectively. A summary of values computed from each of the bootstrap samples will constitute the bootstrap distribution of the indirect effect.

Bootstrapping, which is an option in AMOS, can be applied to test for the mediation effect. Hayes (2009), in his article entitled "Beyond Baron and Kenny: Statistical Mediation Analysis in the New Millennium," has reviewed Baron and Kenny's causal steps approach, the Sobel test and bootstrapping as three different approaches for testing the mediation effect. Simulation studies have shown that bootstrapping accords the highest power. Bootstrapping tests the significance of the indirect effect between X → M → Y. As iterated by Hayes (2009), the bootstrapping indirect effect has been gaining attention as a test of the mediation effect.

The bootstrapping method for testing the mediation effect involves a two-step reporting procedure. The initial step is to report the results of the bootstrap analysis to enable the direct model to be used to test the significance of the direct effect between the predictor (X) and criterion (Y). In order to establish the mediation effect, the direct effect must be significant. A non-significant direct effect eliminates the possibility of any mediation and instead, it can just be an indirect effect.

The second step constitutes the bootstrap analysis for the mediation model (including the mediator variable). The report results of the analysis include relevant coefficients and significant values. Based on the values of the above statistics, four plausible outcomes of the mediation test can be established through the bootstrap method, which are: i) full mediation effect; ii) partial mediation effect; iii) no mediation effect; and iv) indirect effect. The following table displays the decision criteria:

Table 7 Decision criteria for mediation test using the Bootstrap method

Decision	Direct Model	Mediation Model			
	X → Y	X → Y		SIE	95% CI
	P	Beta	*p*	*p*	0
No mediation				NS	Inside
Indirect effect	NS		NS	S	Outside
Partial mediation	S	↓	S	S	Outside
Full mediation	S	↓	NS	S	Inside

Note: S significant
NS non-significant
↓ reduce/decrease

Analysis using the bootstrap method yields the following two results, namely, results of the direct model (Figure 18); and results for the mediation model (Figure 19). In the direct model, all indirect paths are set as constraints in which all the paths are set as zero (as if there is no mediator in the model). The mediation model, on the other hand, includes the mediator, which leads to a combination of direct and indirect effects.

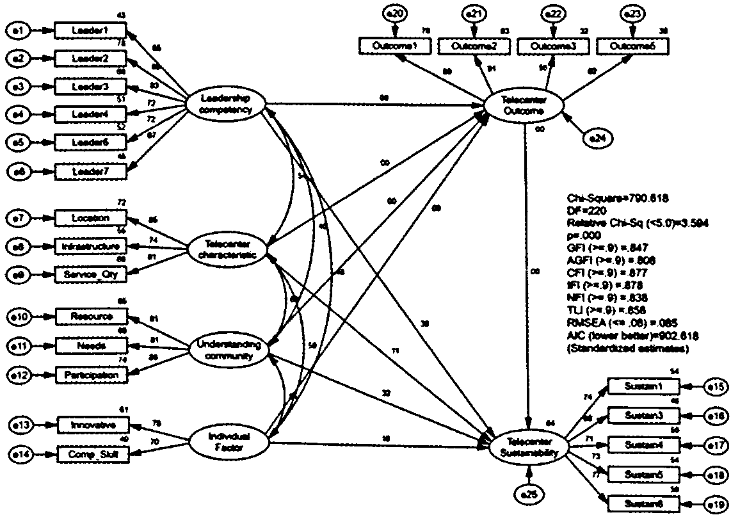


Figure 18 Results of the direct model

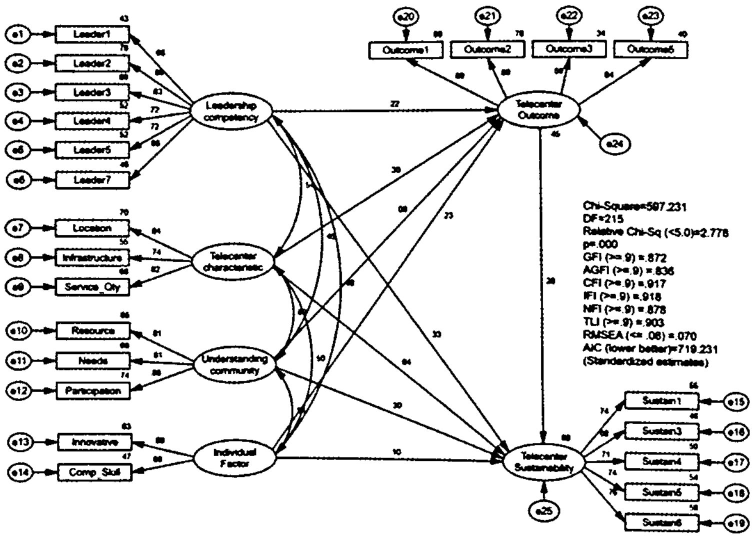


Figure 19 Results of the mediation model

Summary of the results from the direct and mediation models are presented in Table 8. Based on the above decision criteria, 1) telecenter outcome partially mediates the relationship between leadership competency and telecenter sustainability; 2) there is an indirect effect of telecenter outcome on the relationship between telecenter characteristics and telecenter sustainability; 3) there no mediation effect of telecenter outcome on the relationship between understanding community and telecenter sustainability; and 4) telecenter outcome fully mediates the relationship between individual factors and telecenter sustainability.

Table 8 Bootstrap Results of Mediation Effect of Telecenter Outcome on Relationship between Factors and Telecenter Sustainability

Factor/Model/ Hypothesized Paths			**95% CI Bootstrap BC**	
	Beta	***p***	**LB**	**UB**
Leadership Competency				
Direct Model				
Leadership competency → Telecenter sustainability	.384	.000		
Mediation Model				
Leadership competency → Telecenter sustainability	.326	.000		
Standardized Indirect Effect (SIE)	.060	.004	.020	.120
Telecenter Characteristics				
Direct Model				
Telecenter characteristics → Telecenter sustainability	.114	.121		
Mediation Model				
Telecenter characteristics → Telecenter sustainability	.035	.629		
Standardized Indirect Effect (SIE)	.082	.001	.033	.159

Understanding Community				
Direct Model				
Understanding community → Telecenter sustainability	.324	.000		
Mediation Model				
Understanding community → Telecenter sustainability	.300	.000		
Standardized Indirect Effect (SIE)	.022	.306	-.021	.078
Individual Factor				
Direct Model				
Individual factors → Telecenter sustainability	.163	.016		
Mediation Model				
Individual factors → Telecenter sustainability	.100	.129		
Standardized Indirect Effect (SIE)	.062	.020	.010	.140

MODERATION EFFECT

A moderator variable M is a variable that alters the strength of the causal relationship between independent and dependent variables. For instance, psychotherapy may reduce depression more for men than for women, and so we would say that gender (M) moderates the causal effect of psychotherapy (X) on depression (Y) (David & Kenny, 1986).

Relevant questions for moderation relate to "when" and "for whom" a variable most strongly predicts or causes an outcome variable (Frazier & Tix 2004). The effect of a moderator is reflected by the change in direction or magnitude of the relationship between predictor and criterion variables (Baron & Kenny 1986; Holmbeck 1997; Rose et al. 2004). The decision to establish any variable as a moderator should be based on the theory used and adequate support from the literature.

The relationship between two variables depends on the value of the moderator. The moderator either strengthens or weakens the relationship between the predictor and outcome. An example is the relationship between motivation and completion of data analysis. For those who have a lot of time, motivation exhibits a strong relationship whereas for those who have little time, motivation does not show a strong relationship to completion of data analysis. Therefore time moderates the relationship between the two variables.

A typical path diagram for a moderation is shown in Figure 20.

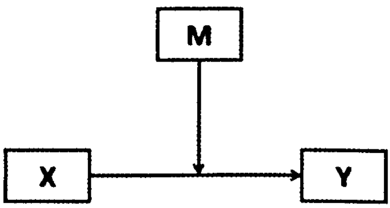


Figure 20 Moderation Effect

Multi-Group Analysis

Test for the moderation effect in structural equation modeling is done through Multi-Group Analysis. The group represents the moderator variable. If a moderator is hypothesized to moderate the relationship between several predictors on a criterion variable, then the test for moderation will consist of two major stages.

1. Establishing the presence of a moderation effect

In order to establish the presence of a moderation effect in the overall structural model, two models need to be compared: Unconstrained (Variant-Group) and Measurement Residuals (Invariant-Group). The presence of moderation is established when the Unconstrained model is better than the Measurement Residuals model.

In order to establish the presence of a moderation effect in the overall structural model, the Unconstrained model is compared with the Measurement Residuals model. If the Unconstrained model is found to be better than the Measurement Residuals model, a moderation effect is present.

The first step is to compare the chi-square values of the two models. The model with the lower chi-square value is deemed to be the better model. The next step is to test for the significance of the chi-square difference for the two models. To do this using the software click on View Text and then on Model Comparison. Then look at the Measurement Residuals.

If the reported sig-$\chi2$ is less than alpha, the difference in $\chi2$ is significant. If the $\chi2$ for the Unconstrained model is smaller than that for the Measurement Residuals model, the difference in $\chi2$ is significant and it can be concluded that a moderation effect is present in the overall structural model.

The second and the final step in the moderation effect test is to assess whether the moderator moderates the relationship for the individual paths. Three different decision criteria can be employed in the tests for the individual paths:

1. The first criterion is proposed by Hair (2010) and is based on the value of the standardized path coefficient (Beta). According to Hair, the path X $\rightarrow$ Y is moderated by the moderator if:

- Beta for Group 1 is significant while for Group 2 it is non-significant, or
- Beta for both groups (Group 1 and 2) are significant. Nevertheless, one is positive while the other is negative.

2. The second criterion comes from Robert Ho (2006). The decision on the moderation effect is based on the value of the critical ratio (CR) for the difference for a specific path between the two groups. At a .05 level of significance, the cut-off point for the CR is 1.96.

- Significant moderation effect if CR ≥ 1.96
- No significant moderation effect if CR < 1.96

3. The third criteria is proposed by Chin (2000) in which a t-statistic is computed based on sample size, unstandardized regression coefficients and standard errors for the two groups of the mediator. The decision will based on comparison of sig-t to the level of significance (α).

- Significant moderation effect if sig-t ≤ α
- No significant moderation effect if sig-t > α

This analysis was done to test the moderation of gender on the relationships between the four independent variables and telecenter sustainability. Data were analyzed using the multi-group analysis which resulted in two structural models that represent the two groups of the moderating variable – male (Figure 21) and female (Figure 22). Results for the structural models are presented in the following figures.

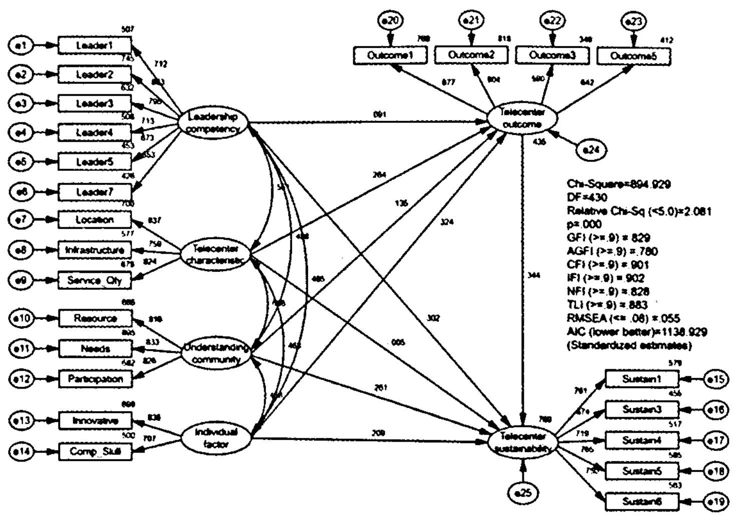


Figure 21 Structural model for Male

In the multi-group analysis, test for moderation effect is by comparing the results of individual paths of the male and female groups using any one of the three criteria – 1) Hair; 2) Robert Ho; or 3) Chin. Decisions can be facilitated using SLT 3 (Statistical Learning Tool for SEM).

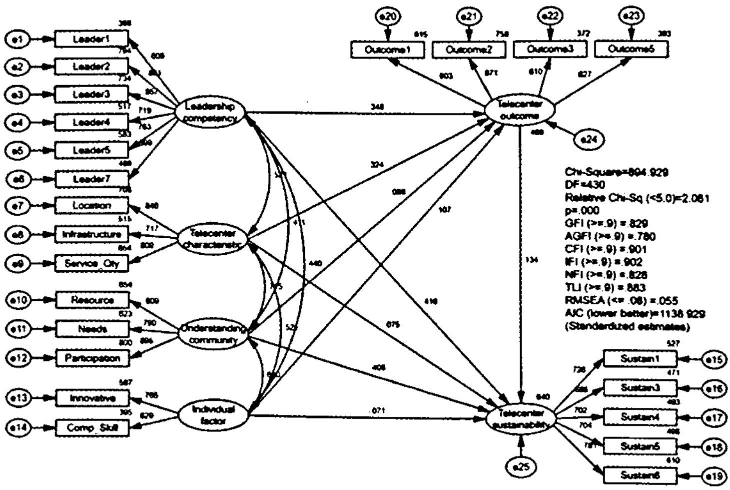


Figure 22 Structural model for Female

The summary of results for the moderation analysis are presented in Table 9. Based on the decision criteria by Hair (2010), only one path is being moderated by gender. Gender moderates the relationship between individual factors and telecenter sustainability in which the beta for male is positive while beta for female is negative. In addition, beta for male is significant while beta for female is non significant.

The results based on Robert Ho's (2016) criteria also reveals identical decisions. Consistently, only the relationship between individual factors and telecenter sustainability is found to be moderated by gender and the critical ratio for the difference (|-2.083|) is bigger than 1.96.

Table 9 Results of Moderation Effect of Gender on Relationship between Predictors and Sustainability (Hair and Robert Ho)

Paths	***b***	***SE***	***Beta***	***p***	***CR for Difference***
Leadership competency					
→ Telecenter Sustainability					1.048
Male	.326	.086	.302	.000	
Female	.469	.106	.418	.000	
Telecenter characteristics					
→ TelecenterSustainability					0.535
Male	-.005	.099	-.005	.959	
Female	.076	.114	.075	.506	
Understanding community					
→ Telecenter sustainability					0.465
Male	.294	.099	.261	.003	
Female	.262	.106	.406	.000	
Individual Factors					
→ Telecenter sustainability					-2.083
Male	.252	.104	.209	.016	
Female	-.083	.122	-.071	.498	

The summary results of the test for moderation effect of gender on the relationship between the four independent variables and telecenter sustainability are displayed in Table 10. Using the criteria by Chin (2000), *t*-statistic is computed and recorded alongside its significant value. Consistent with the other two decision criteria, only one path (relationship between individual factor and telecenter sustainability) is found to be moderated by gender (t=2.071, p<.05).

Table 10 Results of Moderation Effect of Gender on Relationship between Predictors and Sustainability (Chin)

Paths	***n***	***b***	***SE***	***Beta***	***t***	***p***
Leadership competency						
→ Telecenter Sustainability					-1.05	.301
Male	170	.326	.086	.302		
Female	190	.469	.106	.418		
Telecenter characteristics						
→ TelecenterSustainability					-.532	.595
Male	170	-.005	.099	-.005		
Female	190	.076	.114	.075		
Understanding community						
→ Telecenter sustainability					.220	.826
Male	170	.294	.099	.261		
Female	190	.262	.106	.406		
Individual Factors						
→ Telecenter sustainability					2.071	.039
Male	170	.252	.104	.209		
Female	190	-.083	.122	-.071		

CONCLUSION

In this lecture, I have provided an overview of extension and the importance of research in extension. I have *humbly* shared on how Structure Equation Modeling (SEM) can enhance extension education research and ultimately enrich evidence-based extension work practices Statistical analyses represent an integral component in any extension education research. Various appropriate statistical analyses were/are employed to respond to research objectives and hypotheses. In addition to the existing commonly used statistical analyses, extension education researchers can incorporate use of Structural Equation Modeling to further enhance extension research analyses and results. With the various advantages of using this SEM analyses, the least that an extension education researcher can do is to test for construct validity of study instrument which can be easily performed in SEM. Subsequently ensuring the validity of research instrument used.

Comparable to multiple linear regression, SEM generally provides a better statistical estimation as SEM utilizes latent variables that incorporate measurement errors. In addition multiple models can be compared simultaneously as in testing for mediation and moderation effects. Testing of mediation effect using multi-group analysis or bootstrap method can be easily done in SEM. The same is also true for test of moderation effect which can be done effectively in SEM.

To end my lecture, I humbly would like to pose several questions for consideration among extension education researchers and organizations in UPM, Malaysia and the World:

- Have extension education researchers taken advantage of the powerful statistical analyses provided by structural equation modeling in their research projects?
- Do extension education researchers possess the adequate knowledge and skill in using SEM and the ability to make the right interpretations of SEM output?
- How can incorporation of structural equation modeling analyses be linked to better development of extension programs?
- How can we develop expertise among researchers in extension education organizations to promote use of structure equation modeling?

REFERENCES

Addison. H. M (1972). Agricultural Extension: A Reference Manual. Food and Agricultural Organization of the United Nations. Rome

Alwin DF, Hauser RM (1975). The Decomposition of Effects in Path Analysis. *Am. Sociol. Rev. 40*, 37–47.

Arbuckle JL (2007). AMOS 16 User's Guide. Chicago, IL: SPSS Inc.

Azimi Hamzah. (2007). Agricultural Extension Responsiveness in Malaysia. In 50 Years of Malaysian Agriculture (pp. 740-752). Serdang: Universiti Putra Malaysia Press.

Bahaman Abu Samah & Mohamad Badsar (A draft). Practical Guide to Structural Equation Modeling using AMOS

Bahaman Abu Samah, Hayrol Azril Mohammed Shaffril, Md Salleh Hassan, Musa Abu Hassan & Narimah Ismail. (2009). Contribution of Information and Communication Technology in Increasing Agro-based Entrepreneurs Productivity in Malaysia. *Journal of Agriculture & Social Sciences, 5*, 93-97.

Bahaman Abu Samah, Hayrol Azril Mohammed Shaffril, Musa Abu Hassan & Jeffrey Lawrence D'Silva. (2011a). Can Technology Acceptance Model be Applied on the Rural Setting: The Case of Village Development and Security Committee in Malaysia. *Journal of Social Sciences, 7*(92), 113-119.

Bahaman Abu Samah, Hayrol Azril Mohammed Shaffril, Jeffrey Lawrence D'Silva & Jegak Uli. (2011b). The Negative Environmental Changes on the Sea and its Impact on the Aspects of Economic, Social and Health of the Fishermen Living in the East Coast Zone of Peninsular Malaysia. *American Journal of Environmental Sciences, 7*(6), 534-541.

Bahaman Abu Samah, Jeffrey Lawrence D'Silva, Hayrol Azril Mohammed Shaffril, Norsida Man & Azmariana Azman. (2012). Malaysian Contract Farmers' Attitude towards Sustainable Agriculture. *Journal of Basic and Applied Scientific Research, 2*(9), 9205-9210.

Bahaman Abu Samah, Mohamad Badsar, Musa Abu Hassan, Nizam Osman & Hayrol Azril Mohammed Shaffril. (2013). Youth and Telecentres in Community Building in Rural Peninsular Malaysia. *Pertanika Journal of Social Science & Humanities, 21*(S), 67-78.

Baig, M. B., & Aldosari, F. (2013). Agricultural Extension in Asia: Constraints and Options for Improvement. *The Journal of Animal & Plant Sciences, 23*(2), 619-632

Baron RM, Kenny DA (1986). The Moderator-Mediator variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal Personal Social Psychology, 51*, 1173–1182.

Braverman, M. T, & Engle, M. (2009). Theory and rigor in Extension program evaluation planning. *Journal of Extension [On-line], 47*(3) Article 3FEA1

Brown, T.A. (2006). Confirmatory Factor Analysis for Applied Research. New York: The Guilford Press.

Bryne, B.M. (2010). Structural Equation Modeling with AMOS: Basic concepts, application and programing. London: Lawrence Erlbaum Associates.

Carvalho, J.D, Chima, F.O. (2014). Applications of Structural Equation Modeling in Social Sciences Research. *American International Journal of Contemporary Research 4*(1): 6-11.

Cheng, E. W. L (2001). SEM being more effective than multiple regression in parsimonious model testing for management development research. Journal of Management Development, 20(7), 650-667. http://dx.doi.org/10.1108/02621710110400564

Cooperative Extension History. (n.d.). Retrieved August 31, 2016, from https://nifa.usda.gov/cooperative-extension-history

Dunifon, R., Duttweiler, M., Pillemer, K., Tobias, D., & Trochim, W. M. K. (2004). Evidence-Based Extension. Journal of Extension, 42 (2): 1-16.

Efron B (1979). Bootstrap Method: Another Look at the Jackknife. *Annals of Statistics, 7*, 1–26.

Fetsch, R. J., MacPhee, D. & Boyer, L. K (2012). Evidence-Based Programming: What Is a Process an Extension Agent Can Use to Evaluate a Program's Effectiveness. *Journal of Extension, 50*(5), 1-14.

Fornell, C. & D.F. Larcker (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research, 18*(1), 41-54.

Frazier PA & Tix AP (2004). Testing Moderator and Mediator Effects in Counseling Psychology Research. *Journal of Counseling Psychology, 51*(1), 115–134.

Gagnon, R. J, Garst, B. A, & Franz, N. K. (2015). Looking Ahead: Envisioning the Future of the Extension Program Development Model. Education Publications, Paper 10. School of Education, Iowa State University

Hair, J.F., Black W.C., Babin, B.J., Anderson, R.E., Tatham, R.L. & (200). Multivariate Data Analysis, 7th Edition. Upper Saddle River, New Jersey: Pearson Prentice Hall.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black W.C. (2010). Multivariate Data Analysis: A Global Perspective (7th Edition). Upper Saddle River, New Jersey: Pearson Prentice Hall.

Hayes Andrew H. (2009). Beyond Baron and Kenny: Statistical Mediation Analysis in the New Millennium. *Communication Monographs, 76*(4), 408–420.

Holmbeck G.N. (1997). Towards Terminological, Conceptual, and Statistical Clarity in the Study of Mediators and Moderators: Examples from the Child-Clinical and Pediatric Psychology Literatures. *Journal of Consulting and Clinical Psychology, 65*, 599–610

Hox, J.J. & Bechger, T.M. (1998). An Introduction to Structural Equation Modeling. *Family Science Review, 11*, 354-373

Kelsey, L.D. and Hearne C.C. (1966). Co-operative Extension Work. New York: Constock Publishing Associates.

Kline, R. (2005). Principles and Practices of Structural Equation Modeling (2nd.edition). New York: Guilford Press.

Kline, R.B. (2011). Principles and Practice of Structural Equation Modeling. (3rd ed.). New York: The Guilford Press

Leagan, I.P. (1961). Extension Education for Community Development. Directorate of Extension, Ministry of Food and Agriculture Government of India, New Delhi

MacCallum, E.W.L., Austin, J. (2000). Applications of Structural Equation Modeling in Psychological Research. *Annu. Rev. Psychol, 51*, 201-226

MacKinnon D.P., Dwyer J.H. (1993). Estimation of Mediated Effects in Prevention Studies. *Eval. Review, 17,* 144–158.

MacKinnon D.P. (2000). Contrasts in Multiple Mediator Models. In Multivariate Applications in Substance Use Research: New Methods for New Questions, ed. JS Rose, L Chassin, C.C. Presson, SJ Sherman, pp. 141–160. Mahwah, NJ: Erlbaum.

MacKinnon D.P., Fairchild A.J., Fritz M.S. (2007). Mediation Analysis. *Annual Review of Psychology,* 593–614.

Maimunah Ismail (1989). Pengembangan: Implikasi ke atas Pembangunan Masyarakat. Kuala Lumpur: Dewan Bahasa dan Pustaka

Radhakrishna,R, Tobin, D., Foley, C. (2014). Integrating Extension and Research Activities: An Exploratory Study. *Journal of Extension* [On-line], *52*(1) Article 1FEA1

Rahim M. Sail (1992). Extension Programmes and Services in Poverty Redressal: The Case of Kuala Langat District, Selangor. In Issues in Rural Development in Malaysia (pp. 207-227). Kuala Lumpur: Dewan Bahasa dan Pustaka.

Rose BM, Holmbeck GN, Coaklet RM, & Frankss EA (2004). Mediator and Moderator Effects in Developmental and Behavioral Pediatric Research. *Developmental and Behavioral Pediatrics, 25*(1), 58–67.

Schumacker, E.E, Lomax, R.G. (2010). A Beginner's Guide to Structural Equation Modeling: 3rd. Ed. New York: Routledge.

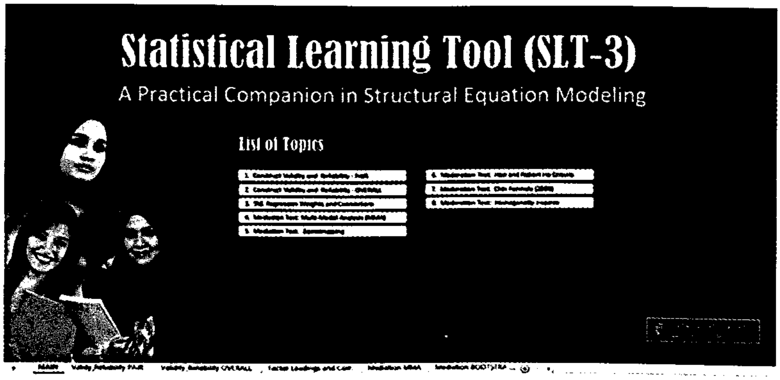
Suvedi, M & Kaplowitz, M. (2016). What Every Extension Worker Should Know. Michigan: MEAS.

Westland, C. J. (2010). Lower bounds on sample size in structural Equation Modeling. Electronic Commerce Research and Applications, 9(6), 476-487. http://dx.doi.org/10.1016/j.elerap.2010.07.003

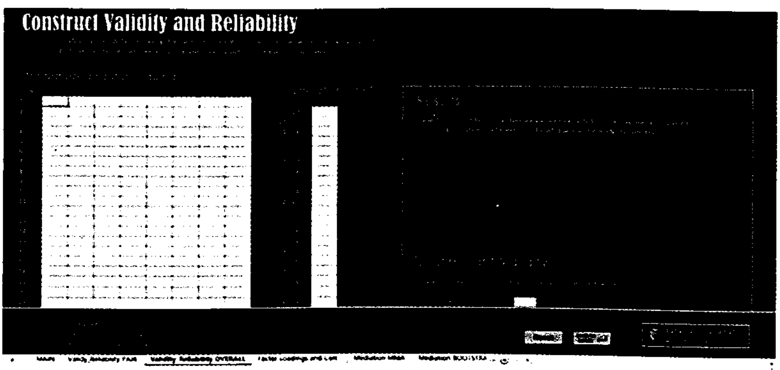
STATISTICAL LEARNING TOOL (SLT 3)
Sample of Screen Captures

The Interface Page

List and Link to Applications

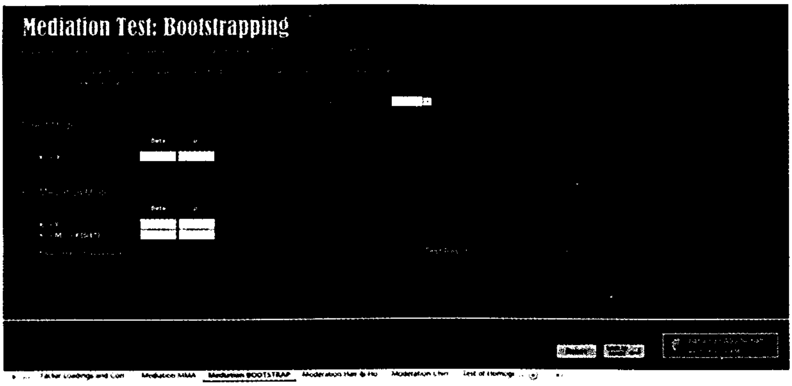


Construct Validity and Reliability



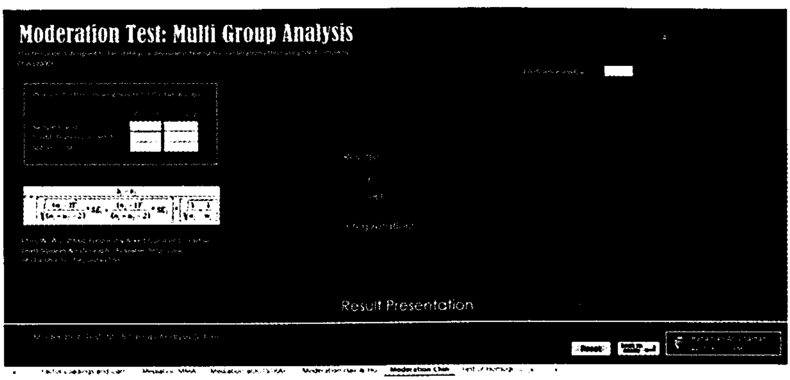
Mediation Test

Using Bootstrap Procedure



Moderation Test

Using Multi-group Analysis



BIOGRAPHY

Bahaman Abu Samah is a Professor of Extension Education at the Department of Professional Development and Continuing Education, Faculty of Educational Studies, Universiti Putra Malaysia (UPM).

He was born on the 3rd of December, 1956, in Batu Gajah, Perak, Malaysia. He is the fourth of seven siblings in his family. He is married to Hajjah Faridah Hj. Mohd Idris and they are blessed with two sons, Haniff and Ahmad Auzuddin, as well as 5 grandchildren, Anas Naufal, Safa Maisarah, Afif Faisal, Aiman Lutfi and Akid Daniel.

Bahaman completed his primary and secondary education at Sekolah Kebangsaan, Sekolah Menengah Rendah and Sekolah Menengah Sultan Yusuff, Batu Gajah, Perak. He obtained his Malaysian Certificate of Education in 1974. He then graduated with a Diploma in Agriculture (Universiti Pertanian Malaysia) in 1978. After having completed his Bachelor of Science in Crop Science in May 1980 and Master of Science in Extension Education in December 1981, both from Louisiana State University, he joined UPM as a lecturer in 1982. Subsequently, while pursuing his Ph.D. study at Iowa State University, he was awarded the Gamma Sigma Delta, the Honour Society of Agriculture and the Honour Society of Phi Kappa Phi in 1991. He completed his Doctor of Philosophy in Extension Education in December 1992.

Bahaman's research, teaching and extension experiences span the fields of extension education, program planning, participation studies, statistics and computer applications in human resource development. To date, as a main supervisor, Bahaman has graduated 12 Doctoral, 57 Master and 25 Bachelor students. Additionally, as an inventor, he has developed several statistical analysis and publication tools to facilitate student learning and understanding of statistics and academic writing.

Further, as a researcher, Bahaman has completed 54 research and consultancy projects funded by local and international agencies in the areas of Extension Education, Youth Development, Community Development, Human Resource Development and ICT applications, 11 of them as the principal researcher. His research projects have won 4 Gold, 3 Silver and 6 Bronze medals at UPM Research Innovation and Invention Exhibitions, from 2005 to 2014. His research findings have had an impact on revitalising extension and communication work practices in Malaysia and abroad. His research has received funding from various agencies which include, among other, the Malaysian Rubber Research and Development Board, Palm Oil Research and Development Board, RISDA, KEMAS, Multimedia Development Corporation (MDEC), Department of National Unity and Integration, Prime Minister's Department, UNESCO, Nippon Foundation and AMIC.

His research projects entitled '*Assessment of farmers' participation in Integrated Agricultural Development Projects in Peninsular Malaysia*' and '*Farmers participation in Group Projects in Selangor*' as well as '*A review of extension activities of rubber smallholders*' transformed the practices of the Ministry and agro-communities in enhancing participation in extension, which is one of the core factors that drives productivity across all agricultural activities.

Bahaman's significant work also focused on enhancing community social well-being. His research projects entitled '*University students' perception on National Unity*' and '*Effectiveness of Volunteering Patrol Scheme and Pattern of Urban and Rural Community Participation*' provided policy strategies on how to transform communities' commitment to enhance their participation and contribution to national unity. His other projects which looked into how community kindergartens contribute to the overall community development ecosystem synergy, involving parents and other stakeholders, enabled government, private and NGO organizations to review their existing practices and launche some 'game-changing' initiatives to enhance healthy participation from communities across sectors and cultures.

In addressing the rapid changes generated by globalisation that also affects the Malaysian lifestyles and well-being, his research projects looking into rural community ICT participation entitled '*Gerakan Desa Wawasan Village Development Committee Members' (VDCM) Commitment, Participation and Competencies*' and '*Gerakan Desa Wawasan Village Development Committee Members' (VDCM) ICT Usage: The Creation of an e-Community*' transformed the way VDCM works and paved the way for the creation of active Malaysian e-communities that embrace ICT in their daily lives.

His work with youth in projects like '*i-Think Pilot Project Achievement Status*' and '*Setting the context for youth entrepreneurship through ICT: Exploring how ICT influence Youth Entrepreneurship in Malaysian Rural Community*', '*Conceptualising the Critical Issues in Development of ICT Projects: towards understanding the role of ICT on Youth's Sustainable Livelihood*' and '*Selangor Youth Policy Development*' provided indicators for policy changes in enhancing youth ICT penetration and their participation as partners in nation building. His recent project also looked into developing an instrument that measures Malaysian urban youth's subjective well-being.

Another community which significantly interests Bahaman is the 'at-risk' community. His research which covers prison-community participation to address recidivism entitled '*Effectiveness of Prison Department's Rehabilitation Program in Addressing Recidivism*' provides a new look into how communities at all levels can collaborate and support to help prisoners and ex-convicts make a successful comeback into the community and lead a more positive life.

To date, Bahaman has authored and co-authored 124 ISI/Thomson/Scopus and peer reviewed journal articles, 8 books and 17 book chapters, 8 teaching and training modules, 84 conference proceeding papers and 17 technical research reports. His co-authored paper entitled '*Working conditions and predictors of quality of working life: A psychological analysis of Malaysian Information System Personnel*', won the best paper award at the Asian Conference of the Academy of HRD in Seoul, Korea in 2004. He has been invited as an expert master trainer and conducted 90 technical trainings for local and international participants, ranging from statistical analyses using SPSS and Structural Equation Modelling using AMOS to extension program planning, extension and development communication, leadership and motivation. He has also been involved in editing journal and proceeding articles as well as textbooks and book chapters during his stint at the Institute for Social Science Studies and Faculty of Educational Studies, UPM. He has also attended and presented papers at national and international conferences, workshops and seminars related to his fields of interest.

His sits in a number of professional committees including the Implementation Committee of Integrated Agricultural Development Project (IADP) and Training Organizing Committee of Integrated Agricultural Development Project (IADP), Penang, as well as the Oil Palm Training Committee of Palm Oil Research Institute Malaysia (PORIM).

Bahaman has held several important posts in UPM such as, the Head of the Continuing Education Unit, Centre for Extension and Continuing Education; Program Head, Institute for Distance Education and Learning; Laboratory Head, Institute for Community and Peace Studies; and Deputy Director and eventually Director of the Institute for Social Science Studies. Currently, he serves as the Head of the Department of Professional Development and Continuing Education, Faculty of Educational Studies.

He was promoted to Associate Professor in 2000, and Professor in 2014. He was awarded Excellent Service Awards by UPM in 2003, 2004, 2005 and 2006. In 2005, he was awarded the Vice Chancellor Fellowship for excellence in teaching.

All in all, Bahaman Abu Samah enjoys his work in UPM, is grateful to Allah SWT for His blessings and divine assistance, and is thankful to be surrounded by inspiring colleagues and mentors, loving family members as well as caring friends. As a passionate extension professional, Bahaman will continue to contribute significantly to UPM, the nation and the world.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and Most Merciful, I am sincerely grateful to Allah the Al-Mighty for His guidance and blessings in shaping my academic career.

I would like to express my profound appreciation and gratitude to Prof. Datin Paduka Dr. Aini Ideris, the Vice Chancellor of Universiti Putra Malaysia, and Prof. Dato' Dr. Mohd Fauzi Haji Ramlan, the former Vice Chancellor, for their continuous support throughout my career development.

I am indebted to the Perak State Government for providing me with the financial support to undertake my diploma studies and the Government of Malaysia for the financial support that enabled me to undertake my bachelor, master's and PhD degrees. Without their support, I would not have been able to complete my studies.

My heartfelt gratitude and appreciation to all former Directors of the then Center for Extension and Continuing Education, Prof. Dr. Aida Suraya Md Yunus, Dean, Faculty of Educational Studies and Prof. Dr. Ab. Rahim Bakar, former Dean, Faculty of Educational Studies, for their constant support and encouragement.

I would like to convey my special appreciation and gratitude to all my co-researchers, both in the Department of Professional Development and Continuing Education and the Institute for Social Science Studies, for their commitment and diligence in collectively acquiring research funds, conducting research projects and disseminating the results of our work. A special thanks to Dr. Hayrol Azril Mohamed Shaffril and Dr. Jeffrey Lawrence D'Silva for their dedication in this regard.

Similar appreciation and gratitude to all my graduate students who have been so committed in undertaking their Master's and Ph.D research, as well as in their contributions to publications. Special appreciation goes to Dr. Mohamad Badsar, for it was through his

Ph.D research that I first explored the power of structural equation modeling. Through a series of subsequent training workshops, we managed to further develop our expertise in using this statistical tool.

I would like to convey my appreciation to all academic and support staff of the Department of Professional Development and Continuing Education, Faculty of Educational Studies and the Institute for Social Science Studies, for their continuous support and for making my academic career a success. Special thanks to Assoc. Prof. Dr. Ismi Arif Ismail, Assoc. Prof. Dr. Abdul Lateef Krauss Abdullah, Prof. Dr. Turiman Suandi, Assoc. Prof. Dr. Azahari Ismail, Dr. Siti Raba'ah Hamzah, Prof. Dr. Maimunah Ismail and Dr. Zoharah Omar.

Last but not least, my sincere gratitude and appreciation to my wife, Hjh. Faridah Hj. Mohd Idris, my beloved mother – Hjh. Aishah Hj. Pandak Simun, my late father – Hj. Abu Samah Kulop Muhammad, my two sons – Haniff and Ahmad Aizuddin, my daughters-in-law – Najihah Hj. Abdul Rahman and Wan Rusila Wan Zulkifeli, my grandchildren – Anas Naufal, Safa Maisarah, Afif Faisal, Aiman Lutfi and Akid Daniel, and all my brothers and sisters, for their endless *do'a*, encouragement, moral support and understanding.

LIST OF INAUGURAL LECTURES

1. Prof. Dr. Sulaiman M. Yassin
The Challenge to Communication Research in Extension
22 July 1989

2. Prof. Ir. Abang Abdullah Abang Ali
Indigenous Materials and Technology for Low Cost Housing
30 August 1990

3. Prof. Dr. Abdul Rahman Abdul Razak
Plant Parasitic Nematodes, Lesser Known Pests of Agricultural Crops
30 January 1993

4. Prof. Dr. Mohamed Suleiman
Numerical Solution of Ordinary Differential Equations: A Historical Perspective
11 December 1993

5. Prof. Dr. Mohd. Ariff Hussein
Changing Roles of Agricultural Economics
5 March 1994

6. Prof. Dr. Mohd. Ismail Ahmad
Marketing Management: Prospects and Challenges for Agriculture
6 April 1994

7. Prof. Dr. Mohamed Mahyuddin Mohd. Dahan
The Changing Demand for Livestock Products
20 April 1994

8. Prof. Dr. Ruth Kiew
Plant Taxonomy, Biodiversity and Conservation
11 May 1994

9. Prof. Ir. Dr. Mohd. Zohadie Bardaie
Engineering Technological Developments Propelling Agriculture into the 21st Century
28 May 1994

10. Prof. Dr. Shamsuddin Jusop
Rock, Mineral and Soil
18 June 1994

11. Prof. Dr. Abdul Salam Abdullah
Natural Toxicants Affecting Animal Health and Production
29 June 1994

12. Prof. Dr. Mohd. Yusof Hussein
Pest Control: A Challenge in Applied Ecology
9 July 1994

13. Prof. Dr. Kapt. Mohd. Ibrahim Haji Mohamed
Managing Challenges in Fisheries Development through Science and Technology
23 July 1994

14. Prof. Dr. Hj. Amat Juhari Moain
Sejarah Keagungan Bahasa Melayu
6 August 1994

15. Prof. Dr. Law Ah Theem
Oil Pollution in the Malaysian Seas
24 September 1994

16. Prof. Dr. Md. Nordin Hj. Lajis
Fine Chemicals from Biological Resources: The Wealth from Nature
21 January 1995

17. Prof. Dr. Sheikh Omar Abdul Rahman
Health, Disease and Death in Creatures Great and Small
25 February 1995

18. Prof. Dr. Mohamed Shariff Mohamed Din
Fish Health: An Odyssey through the Asia - Pacific Region
25 March 1995

19. Prof. Dr. Tengku Azmi Tengku Ibrahim
Chromosome Distribution and Production Performance of Water Buffaloes
6 May 1995

20. Prof. Dr. Abdul Hamid Mahmood
Bahasa Melayu sebagai Bahasa Ilmu-Cabaran dan Harapan
10 June 1995

21. Prof. Dr. Rahim Md. Sail
Extension Education for Industrialising Malaysia: Trends, Priorities and Emerging Issues
22 July 1995

22. Prof. Dr. Nik Muhammad Nik Abd. Majid
The Diminishing Tropical Rain Forest: Causes, Symptoms and Cure
19 August 1995

23. Prof. Dr. Ang Kok Jee
The Evolution of an Environmentally Friendly Hatchery Technology for Udang Galah, the King of Freshwater Prawns and a Glimpse into the Future of Aquaculture in the 21st Century
14 October 1995

24. Prof. Dr. Sharifuddin Haji Abdul Hamid
Management of Highly Weathered Acid Soils for Sustainable Crop Production
28 October 1995

25. Prof. Dr. Yu Swee Yean
Fish Processing and Preservation: Recent Advances and Future Directions
9 December 1995

26. Prof. Dr. Rosli Mohamad
Pesticide Usage: Concern and Options
10 February 1996

27. Prof. Dr. Mohamed Ismail Abdul Karim
Microbial Fermentation and Utilization of Agricultural Bioresources and Wastes in Malaysia
2 March 1996

28. Prof. Dr. Wan Sulaiman Wan Harun
Soil Physics: From Glass Beads to Precision Agriculture
16 March 1996

29. Prof. Dr. Abdul Aziz Abdul Rahman
Sustained Growth and Sustainable Development: Is there a Trade-Off 1 or Malaysia
13 April 1996

30. Prof. Dr. Chew Tek Ann
Sharecropping in Perfectly Competitive Markets: A Contradiction in Terms
27 April 1996

31. Prof. Dr. Mohd. Yusuf Sulaiman
Back to the Future with the Sun
18 May 1996

32. Prof. Dr. Abu Bakar Salleh
Enzyme Technology: The Basis for Biotechnological Development
8 June 1996

33. Prof. Dr. Kamel Ariffin Mohd. Atan
The Fascinating Numbers
29 June 1996

34. Prof. Dr. Ho Yin Wan
Fungi: Friends or Foes
27 July 1996

35. Prof. Dr. Tan Soon Guan
Genetic Diversity of Some Southeast Asian Animals: Of Buffaloes and Goats and Fishes Too
10 August 1996

36. Prof. Dr. Nazaruddin Mohd. Jali
Will Rural Sociology Remain Relevant in the 21st Century?
21 September 1996

37. Prof. Dr. Abdul Rani Bahaman
Leptospirosis-A Model for Epidemiology, Diagnosis and Control of Infectious Diseases
16 November 1996

38. Prof. Dr. Marziah Mahmood
Plant Biotechnology - Strategies for Commercialization
21 December 1996

39. Prof. Dr. Ishak Hj. Omar
Market Relationships in the Malaysian Fish Trade: Theory and Application
22 March 1997

40. Prof. Dr. Suhaila Mohamad
Food and Its Healing Power
12 April 1997

41. Prof. Dr. Malay Raj Mukerjee
A Distributed Collaborative Environment for Distance Learning Applications
17 June 1998

42. Prof. Dr. Wong Kai Choo
Advancing the Fruit Industry in Malaysia: A Need to Shift Research Emphasis
15 May 1999

43. Prof. Dr. Aini Ideris
Avian Respiratory and Immunosuppressive Diseases- A Fatal Attraction
10 July 1999

44. Prof. Dr. Sariah Meon
Biological Control of Plant Pathogens: Harnessing the Richness of Microbial Diversity
14 August 1999

45. Prof. Dr. Azizah Hashim
The Endomycorrhiza: A Futile Investment?
23 October 1999

46. Prof. Dr. Noraini Abdul Samad
Molecular Plant Virology: The Way Forward
2 February 2000

47. Prof. Dr. Muhamad Awang
Do We Have Enough Clean Air to Breathe?
7 April 2000

48. Prof. Dr. Lee Chnoong Kheng
Green Environment, Clean Power
24 June 2000

49. Prof. Dr. Mohd. Ghazali Mohayidin
Managing Change in the Agriculture Sector: The Need for Innovative Educational Initiatives
12 January 2002

50. Prof. Dr. Fatimah Mohd. Arshad
Analisis Pemasaran Pertanian di Malaysia: Keperluan Agenda Pembaharuan
26 January 2002

51. Prof. Dr. Nik Mustapha R. Abdullah
Fisheries Co-Management: An Institutional Innovation Towards Sustainable Fisheries Industry
28 February 2002

52. Prof. Dr. Gulam Rusul Rahmat Ali
Food Safety: Perspectives and Challenges
23 March 2002

53. Prof. Dr. Zaharah A. Rahman
Nutrient Management Strategies for Sustainable Crop Production in Acid Soils: The Role of Research Using Isotopes
13 April 2002

54. Prof. Dr. Maisom Abdullah
Productivity Driven Growth: Problems & Possibilities
27 April 2002

55. Prof. Dr. Wan Omar Abdullah
Immunodiagnosis and Vaccination for Brugian Filariasis: Direct Rewards from Research Investments
6 June 2002

56. Prof. Dr. Syed Tajuddin Syed Hassan
Agro-ento Bioinformation: Towards the Edge of Reality
22 June 2002

57. Prof. Dr. Dahlan Ismail
Sustainability of Tropical Animal-Agricultural Production Systems: Integration of Dynamic Complex Systems
27 June 2002

58. Prof. Dr. Ahmad Zubaidi Baharumshah
The Economics of Exchange Rates in the East Asian Countries
26 October 2002

59. Prof. Dr. Shaik Md. Noor Alam S.M. Hussain
Contractual Justice in Asean: A Comparative View of Coercion
31 October 2002

60. Prof. Dr. Wan Md. Zin Wan Yunus
Chemical Modification of Polymers: Current and Future Routes for Synthesizing New Polymeric Compounds
9 November 2002

61. Prof. Dr. Annuar Md. Nassir
Is the KLSE Efficient? Efficient Market Hypothesis vs Behavioural Finance
23 November 2002

62. Prof. Ir. Dr. Radin Umar Radin Sohadi
Road Safety Interventions in Malaysia: How Effective Are They?
21 February 2003

63. Prof. Dr. Shamsher Mohamad
The New Shares Market: Regulatory Intervention, Forecast Errors and Challenges
26 April 2003

64. Prof. Dr. Han Chun Kwong
Blueprint for Transformation or Business as Usual? A Structurational Perspective of the Knowledge-Based Economy in Malaysia
31 May 2003

65. Prof. Dr. Mawardi Rahmani
Chemical Diversity of Malaysian Flora: Potential Source of Rich Therapeutic Chemicals
26 July 2003

66. Prof. Dr. Fatimah Md. Yusoff
An Ecological Approach: A Viable Option for Aquaculture Industry in Malaysia
9 August 2003

67. Prof. Dr. Mohamed Ali Rajion
The Essential Fatty Acids-Revisited
23 August 2003

68. Prof. Dr. Azhar Md. Zain
Psychotheraphy for Rural Malays - Does it Work?
13 September 2003

69. Prof. Dr. Mohd. Zamri Saad
Respiratory Tract Infection: Establishment and Control
27 September 2003

70. Prof. Dr. Jinap Selamat
Cocoa-Wonders for Chocolate Lovers
14 February 2004

71. Prof. Dr. Abdul Halim Shaari
High Temperature Superconductivity: Puzzle & Promises
13 March 2004

72. Prof. Dr. Yaakob Che Man
Oils and Fats Analysis - Recent Advances and Future Prospects
27 March 2004

73. Prof. Dr. Kaida Khalid
Microwave Aquametry: A Growing Technology
24 April 2004

74. Prof. Dr. Hasanah Mohd. Ghazali
Tapping the Power of Enzymes- Greening the Food Industry
11 May 2004

75. Prof. Dr. Yusof Ibrahim
The Spider Mite Saga: Quest for Biorational Management Strategies
22 May 2004

76. Prof. Datin Dr. Sharifah Md. Nor
The Education of At-Risk Children: The Challenges Ahead
26 June 2004

77. Prof. Dr. Ir. Wan Ishak Wan Ismail
Agricultural Robot: A New Technology Development for Agro-Based Industry
14 August 2004

78. Prof. Dr. Ahmad Said Sajap
Insect Diseases: Resources for Biopesticide Development
28 August 2004

79. Prof. Dr. Aminah Ahmad
The Interface of Work and Family Roles: A Quest for Balanced Lives
11 March 2005

80. Prof. Dr. Abdul Razak Alimon
Challenges in Feeding Livestock: From Wastes to Feed
23 April 2005

81. Prof. Dr. Haji Azimi Hj. Hamzah
Helping Malaysian Youth Move Forward: Unleashing the Prime Enablers
29 April 2005

82. Prof. Dr. Rasedee Abdullah
In Search of An Early Indicator of Kidney Disease
27 May 2005

83. Prof. Dr. Zulkifli Hj. Shamsuddin
Smart Partnership: Plant-Rhizobacteria Associations
17 June 2005

84. Prof. Dr. Mohd Khanif Yusop
From the Soil to the Table
1 July 2005

85. Prof. Dr. Annuar Kassim
Materials Science and Technology: Past, Present and the Future
8 July 2005

86. Prof. Dr. Othman Mohamed
Enhancing Career Development Counselling and the Beauty of Career Games
12 August 2005

87. Prof. Ir. Dr. Mohd Amin Mohd Soom
Engineering Agricultural Water Management Towards Precision Framing
26 August 2005

88. Prof. Dr. Mohd Arif Syed
Bioremediation-A Hope Yet for the Environment?
9 September 2005

89. Prof. Dr. Abdul Hamid Abdul Rashid
The Wonder of Our Neuromotor System and the Technological Challenges They Pose
23 December 2005

90. Prof. Dr. Norhani Abdullah
Rumen Microbes and Some of Their Biotechnological Applications
27 January 2006

91. Prof. Dr. Abdul Aziz Saharee
Haemorrhagic Septicaemia in Cattle and Buffaloes: Are We Ready for Freedom?
24 February 2006

92. Prof. Dr. Kamariah Abu Bakar
Activating Teachers' Knowledge and Lifelong Journey in Their Professional Development
3 March 2006

93. Prof. Dr. Borhanuddin Mohd. Ali
Internet Unwired
24 March 2006

94. Prof. Dr. Sundararajan Thilagar
Development and Innovation in the Fracture Management of Animals
31 March 2006

95. Prof. Dr. Zainal Aznam Md. Jelan
Strategic Feeding for a Sustainable Ruminant Farming
19 May 2006

96. Prof. Dr. Mahiran Basri
Green Organic Chemistry: Enzyme at Work
14 July 2006

97. Prof. Dr. Malik Hj. Abu Hassan
Towards Large Scale Unconstrained Optimization
20 April 2007

98. Prof. Dr. Khalid Abdul Rahim
Trade and Sustainable Development: Lessons from Malaysia's Experience
22 June 2007

99. Prof. Dr. Mad Nasir Shamsudin
Econometric Modelling for Agricultural Policy Analysis and Forecasting: Between Theory and Reality
13 July 2007

100. Prof. Dr. Zainal Abidin Mohamed
Managing Change - The Fads and The Realities: A Look at Process Reengineering, Knowledge Management and Blue Ocean Strategy
9 November 2007

101. Prof. Ir. Dr. Mohamed Daud
Expert Systems for Environmental Impacts and Ecotourism Assessments
23 November 2007

102. Prof. Dr. Saleha Abdul Aziz
Pathogens and Residues; How Safe is Our Meat?
30 November 2007

103. Prof. Dr. Jayum A. Jawan
Hubungan Sesama Manusia
7 December 2007

104. Prof. Dr. Zakariah Abdul Rashid
Planning for Equal Income Distribution in Malaysia: A General Equilibrium Approach
28 December 2007

105. Prof. Datin Paduka Dr. Khatijah Yusoff
Newcastle Disease virus: A Journey from Poultry to Cancer
11 January 2008

106. Prof. Dr. Dzulkefly Kuang Abdullah
Palm Oil: Still the Best Choice
1 February 2008

107. Prof. Dr. Elias Saion
Probing the Microscopic Worlds by Lonizing Radiation
22 February 2008

108. Prof. Dr. Mohd Ali Hassan
Waste-to-Wealth Through Biotechnology: For Profit, People and Planet
28 March 2008

109. Prof. Dr. Mohd Maarof H. A. Moksin
Metrology at Nanoscale: Thermal Wave Probe Made It Simple
11 April 2008

110. Prof. Dr. Dzolkhifli Omar
The Future of Pesticides Technology in Agriculture: Maximum Target Kill with Minimum Collateral Damage
25 April 2008

111. Prof. Dr. Mohd. Yazid Abd. Manap
Probiotics: Your Friendly Gut Bacteria
9 May 2008

112. Prof. Dr. Hamami Sahri
Sustainable Supply of Wood and Fibre: Does Malaysia have Enough?
23 May 2008

113. Prof. Dato' Dr. Makhdzir Mardan
Connecting the Bee Dots
20 June 2008

114. Prof. Dr. Maimunah Ismail
Gender & Career: Realities and Challenges
25 July 2008

115. Prof. Dr. Nor Aripin Shamaan
Biochemistry of Xenobiotics: Towards a Healthy Lifestyle and Safe Environment
1 August 2008

116. Prof. Dr. Mohd Yunus Abdullah
Penjagaan Kesihatan Primer di Malaysia: Cabaran Prospek dan Implikasi dalam Latihan dan Penyelidikan Perubatan serta Sains Kesihatan di Universiti Putra Malaysia
8 August 2008

117. Prof. Dr. Musa Abu Hassan
Memanfaatkan Teknologi Maklumat & Komunikasi ICT untuk Semua
15 August 2008

118. Prof. Dr. Md. Salleh Hj. Hassan
Role of Media in Development: Strategies, Issues & Challenges
22 August 2008

119. Prof. Dr. Jariah Masud
Gender in Everyday Life
10 October 2008

120 Prof. Dr. Mohd Shahwahid Haji Othman
Mainstreaming Environment: Incorporating Economic Valuation and Market-Based Instruments in Decision Making
24 October 2008

121. Prof. Dr. Son Radu
Big Questions Small Worlds: Following Diverse Vistas
31 October 2008

122. Prof. Dr. Russly Abdul Rahman
Responding to Changing Lifestyles: Engineering the Convenience Foods
28 November 2008

123. Prof. Dr. Mustafa Kamal Mohd Shariff
Aesthetics in the Environment an Exploration of Environmental: Perception Through Landscape Preference
9 January 2009

124. Prof. Dr. Abu Daud Silong
Leadership Theories, Research & Practices: Farming Future Leadership Thinking
16 January 2009

125. Prof. Dr. Azni Idris
Waste Management, What is the Choice: Land Disposal or Biofuel?
23 January 2009

126. Prof. Dr. Jamilah Bakar
Freshwater Fish: The Overlooked Alternative
30 January 2009

127. Prof. Dr. Mohd. Zobir Hussein
The Chemistry of Nanomaterial and Nanobiomaterial
6 February 2009

128. Prof. Ir. Dr. Lee Teang Shui
Engineering Agricultural: Water Resources
20 February 2009

129. Prof. Dr. Ghizan Saleh
Crop Breeding: Exploiting Genes for Food and Feed
6 March 2009

130. Prof. Dr. Muzafar Shah Habibullah
Money Demand
27 March 2009

131. Prof. Dr. Karen Anne Crouse
In Search of Small Active Molecules
3 April 2009

132. Prof. Dr. Turiman Suandi
Volunteerism: Expanding the Frontiers of Youth Development
17 April 2009

133. Prof. Dr. Arbakariya Ariff
Industrializing Biotechnology: Roles of Fermentation and Bioprocess Technology
8 May 2009

134. Prof. Ir. Dr. Desa Ahmad
Mechanics of Tillage Implements
12 June 2009

135. Prof. Dr. W. Mahmood Mat Yunus
Photothermal and Photoacoustic: From Basic Research to Industrial Applications
10 July 2009

136. Prof. Dr. Taufiq Yap Yun Hin
Catalysis for a Sustainable World
7 August 2009

137 Prof. Dr. Raja Noor Zaliha Raja Abd. Rahman
Microbial Enzymes: From Earth to Space
9 October 2009

138 Prof. Ir. Dr. Barkawi Sahari
Materials, Energy and CNGDI Vehicle Engineering
6 November 2009

139. Prof. Dr. Zulkifli Idrus
Poultry Welfare in Modern Agriculture: Opportunity or Threat?
13 November 2009

140. Prof. Dr. Mohamed Hanafi Musa
Managing Phosphorus: Under Acid Soils Environment
8 January 2010

141. Prof. Dr. Abdul Manan Mat Jais
Haruan Channa striatus a Drug Discovery in an Agro-Industry Setting
12 March 2010

142. Prof. Dr. Bujang bin Kim Huat
Problematic Soils: In Search for Solution
19 March 2010

143. Prof. Dr. Samsinar Md Sidin
Family Purchase Decision Making: Current Issues & Future Challenges
16 April 2010

144. Prof. Dr. Mohd Adzir Mahdi
Lightspeed: Catch Me If You Can
4 June 2010

145. Prof. Dr. Raha Hj. Abdul Rahim
Designer Genes: Fashioning Mission Purposed Microbes
18 June 2010

146. Prof. Dr. Hj. Hamidon Hj. Basri
A Stroke of Hope, A New Beginning
2 July 2010

147. Prof. Dr. Hj. Kamaruzaman Jusoff
Going Hyperspectral: The "Unseen" Captured?
16 July 2010

148. Prof. Dr. Mohd Sapuan Salit
Concurrent Engineering for Composites
30 July 2010

149. Prof. Dr. Shattri Mansor
Google the Earth: What's Next?
15 October 2010

150. Prof. Dr. Mohd Basyaruddin Abdul Rahman
Haute Couture: Molecules & Biocatalysts
29 October 2010

151. Prof. Dr. Mohd. Hair Bejo
Poultry Vaccines: An Innovation for Food Safety and Security
12 November 2010

152. Prof. Dr. Umi Kalsom Yusuf
Fern of Malaysian Rain Forest
3 December 2010

153. Prof. Dr. Ab. Rahim Bakar
Preparing Malaysian Youths for The World of Work: Roles of Technical and Vocational Education and Training (TVET)
14 January 2011

154. Prof. Dr. Seow Heng Fong
Are there "Magic Bullets" for Cancer Therapy?
11 February 2011

155. Prof. Dr. Mohd Azmi Mohd Lila
Biopharmaceuticals: Protection, Cure and the Real Winner
18 February 2011

156. Prof. Dr. Siti Shapor Siraj
Genetic Manipulation in Farmed Fish: Enhancing Aquaculture Production
25 March 2011

157. Prof. Dr. Ahmad Ismail
Coastal Biodiversity and Pollution: A Continuous Conflict
22 April 2011

158. Prof. Ir. Dr. Norman Mariun
Energy Crisis 2050? Global Scenario and Way Forward for Malaysia
10 June 2011

159. Prof. Dr. Mohd Razi Ismail
Managing Plant Under Stress: A Challenge for Food Security
15 July 2011

160. Prof. Dr. Patimah Ismail
Does Genetic Polymorphisms Affect Health?
23 September 2011

161. Prof. Dr. Sidek Ab. Aziz
Wonders of Glass: Synthesis, Elasticity and Application
7 October 2011

162. Prof. Dr. Azizah Osman
Fruits: Nutritious, Colourful, Yet Fragile Gifts of Nature
14 October 2011

163. Prof. Dr. Mohd. Fauzi Ramlan
Climate Change: Crop Performance and Potential
11 November 2011

164. Prof. Dr. Adem Kiliçman
Mathematical Modeling with Generalized Function
25 November 2011

165. Prof. Dr. Fauziah Othman
My Small World: In Biomedical Research
23 December 2011

166. Prof. Dr. Japar Sidik Bujang
The Marine Angiosperms, Seagrass
23 March 2012

167. Prof. Dr. Zailina Hashim
Air Quality and Children's Environmental Health: Is Our Future Generation at Risk?
30 March 2012

168. Prof. Dr. Zainal Abidin Mohamed
Where is the Beef? Vantage Point form the Livestock Supply Chain
27 April 2012

169. Prof. Dr. Jothi Malar Panandam
Genetic Characterisation of Animal Genetic Resources for Sustaninable Utilisation and Development
30 November 2012

170. Prof. Dr. Fatimah Abu Bakar
The Good The Bad & Ugly of Food Safety: From Molecules to Microbes
7 December 2012

171. Prof. Dr. Abdul Jalil Nordin
My Colourful Sketches from Scratch: Molecular Imaging
5 April 2013

172. Prof. Dr. Norlijah Othman
Lower Respiratory Infections in Children: New Pathogens, Old Pathogens and The Way Forward
19 April 2013

173. Prof. Dr. Jayakaran Mukundan
Steroid-like Prescriptions English Language Teaching Can Ill-afford
26 April 2013

174. Prof. Dr. Azmi Zakaria
Photothermals Affect Our Lives
7 June 2013

175. Prof. Dr. Rahinah Ibrahim
Design Informatics
21 June 2013

176. Prof. Dr. Gwendoline Ee Cheng
Natural Products from Malaysian Rainforests
1 November 2013

177. Prof. Dr. Noor Akma Ibrahim
The Many Facets of Statistical Modeling
22 November 2013

178. Prof. Dr. Paridah Md. Tahir
Bonding with Natural Fibres
6 December 2013

179. Prof. Dr. Abd. Wahid Haron
Livestock Breeding: The Past, The Present and The Future
9 December 2013

180. Prof. Dr. Aziz Arshad
Exploring Biodiversity & Fisheries Biology: A Fundamental Knowledge for Sustainabale Fish Production
24 January 2014

181. Prof. Dr. Mohd Mansor Ismail
Competitiveness of Beekeeping Industry in Malaysia
21 March 2014

182. Prof. Dato' Dr. Tai Shzee Yew
Food and Wealth from the Seas: Health Check for the Marine Fisheries of Malaysia
25 April 2014

183. Prof. Datin Dr. Rosenani Abu Bakar
Waste to Health: Organic Waste Management for Sustainable Soil Management and Crop Production
9 May 2014

184. Prof. Dr. Abdul Rahman Omar
Poultry Viruses: From Threat to Therapy
23 May 2014

185. Prof. Dr. Mohamad Pauzi Zakaria
Tracing the Untraceable: Fingerprinting Pollutants through Environmental Forensics
13 June 2014

186. Prof. Dr. -Ing. Ir. Renuganth Varatharajoo
Space System Trade-offs: Towards Spacecraft Synergisms
15 August 2014

187. Prof. Dr. Latiffah A. Latiff
Tranformasi Kesihatan Wanita ke Arah Kesejahteraan Komuniti
7 November 2014

188. Prof. Dr. Tan Chin Ping
Fat and Oils for a Healthier Future: Makro, Micro and Nanoscales
21 November 2014

189. Prof. Dr. Suraini Abd. Aziz
Lignocellulosic Biofuel: A Way Forward
28 November 2014

190. Prof. Dr. Robiah Yunus
Biobased Lubricants: Harnessing the Richness of Agriculture Resources
30 January 2015

191. Prof. Dr. Khozirah Shaari
Discovering Future Cures from Phytochemistry to Metabolomics
13 February 2015

192. Prof. Dr. Tengku Aizan Tengku Abdul Hamid
Population Ageing in Malaysia: A Mosaic of Issues, Challenges and Prospects
13 March 2015

193. Prof. Datin Dr. Faridah Hanum Ibrahim
Forest Biodiversity: Importance of Species Composition Studies
27 March 2015

194. Prof. Dr. Mohd Salleh Kamarudin
Feeding & Nutritional Requirements of Young Fish
10 April 2015

195. Prof. Dato' Dr. Mohammad Shatar Sabran
Money Boy: Masalah Sosial Era Generasi Y
8 Mei 2015

196. Prof. Dr. Aida Suraya Md. Yunus
Developing Students' Mathematical Thinking: How Far Have We Come?
5 June 2015

197. Prof. Dr. Amin Ismail
Malaysian Cocoa or Chocolates: A Story of Antioxidants and More...
14 August 2015

198. Prof. Dr. Shamsuddin Sulaiman
Casting Technology: Sustainable Metal Forming Process
21 August 2015

199. Prof. Dr. Rozita Rosli
Journey into Genetic: Taking the Twist and Turns of Life
23 October 2015

200. Prof. Dr. Nor Aini Ab Shukor
The Un(Straight) Truth About Trees
6 November 2015

201. Prof. Dato' Dr. Ir Mohd Saleh Jaafar
Advancing Concrete Materials and Systems: The Search Continues
13 November 2015

202. Prof. Dr. Maznah Ismail
Germinated Brown Rice and Bioactive Rich Fractions: On Going Journey form R&D to Commercialisation
29 April 2016

203. Prof. Dr. Habshah Midi
Amazing Journey to Robust Statistics Discovering Outliers for Efficient Prediction
6 May 2016

204. Prof. Dr. Mansor Ahmad @ Ayob
Going Green with Bionanocomposites
27 May 2016

205. Prof. Dr. Fudziah Ismail
Exploring Efficient Numerical Methods for Differental Equations
23 September 2016

206. Prof. Dr. Noordin Mohamed Mustapha
Meandering Through the Superb Scientific World of Pathology: Exploring Intrapolations
30 September 2016

207. Prof. Dr. Mohd. Majid Konting
Teaching for Quality Learning: A Leadership Challenge
21 October 2016

208. Prof. Dr. Ezhar Tamam
Are University Students Getting Enough Interethnic Communication and Diversity Engagement Experiences? Concerns and Considerations
11 November 2016