Redesigned ITESCM Model: An Academic SCM for the Universities

Dr. Md. Mamun Habib[#], Bishwajit Banik Pathik[*]

[#]*Dept. of Operations Management, American International University-Bangladesh (AIUB)*
83/B, Road 4, Kemal Ataturk Avenue, Banani, Dhaka, Bangladesh
[1]mamunhabib@gmail.com

[*]*Dept. of Electrical and Electronic Engineering, American International University-Bangladesh (AIUB)*
83/B, Road 4, Kemal Ataturk Avenue, Banani, Dhaka, Bangladesh
[2]bishwajit.b.pathik@gmail.com

***Abstract*— This exploratory research addresses the academic supply chain which consists of educational supply chain and educational management as the major constituents of the ITESCM (Integrated Tertiary Educational Supply Chain Management) model for the universities. The study revealed four main activities; includes education development, education assessment, research development, and research assessment; in the educational management. Four aspects of each main activity, namely Programs Establishment, University Culture, Faculty Capabilities, and Facilities were investigated at three decision levels. The original ITESCM model was developed based on the secondary data, i.e. analysis of the literature, and primary data, i.e. interviews with stakeholders of tertiary academic institutions. Model structures were defined and confirmed by 493 respondents, representing University administrators of leading tertiary educational institutions around the world, faculty and staffs, employers, and graduates. The resulting model was subsequently evaluated for accuracy and validity by multiple linear regression (MLR) analysis and the structural equation modeling (SEM) technique. The redesigned model is the revised form of original ITESCM, that would be easily understandable and research equations are more user friendly for practical field applications. The research model and equations provide a novel approach for prospective investors or current administrators of the tertiary academic institutions to review and appraise their performance toward fulfillment of ultimate goals, i.e. producing high-competent graduates and significant research outcomes for the betterment of the consumer, i.e. the society.**

***Keywords*—** *Academic Supply Chain Management, redesigned ITESCM, educational management, graduates, research outcomes, educational supply chain*

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1. Introduction

Supply chain management (SCM) helps the business organization to compete in the dynamic global market. The goal of SCM is to integrate activities across and within organizations for providing the customer value. This should also be applicable to the academia, which represents a type of non-profit organizations. It is a surprising fact that researchers develop supply chain models mostly for improving business operations. Few, particularly academics, do not realize that the research on academic SCM may also be conducted for their own educational institutions [20], [28], [31], [32].

Supply chain management is needed for various reasons: improving operations, better outsourcing, increasing profits, enhancing customer satisfaction, generating quality outcomes, tackling competitive pressures, increasing globalization, increasing importance of E-commerce, and growing complexity of supply chains [54].

Based on findings from literature review, the researcher found a large number of papers and articles in supply chain management. Most of them investigated supply chain management in the manufacturing sector [2], [13], [36], [37], [39], [43], [44], [47]-[51], [55]. Only a few addressed issues regarding SCM for the service industry [35], [42], [52]-[54], [57]. Very few focused on educational supply chain management. Just two papers [11], [41] were found to be relevant to the educational supply chain management. Consequently, ITESCM (Integrated Tertiary Educational Supply Chain Management) model was the first empirical study on educational supply chain management for the universities [9], [14], [21].

One of the main goals of an educational supply chain is to improve the well-being of the end customer or the society.

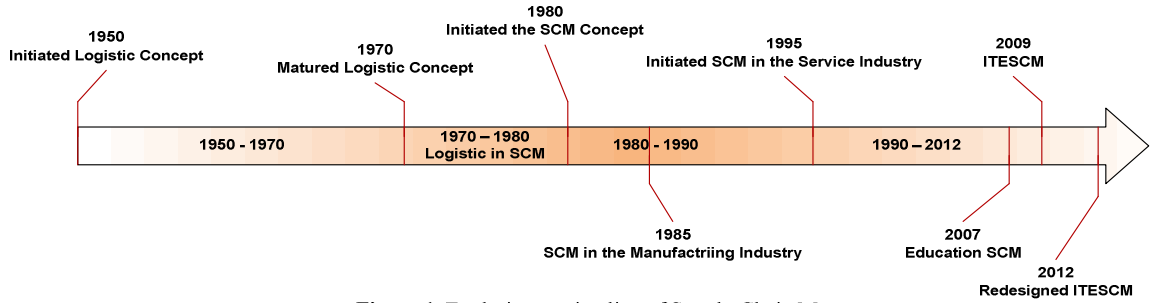

Figure 1. Evolutionary timeline of Supply Chain Management

To achieve this goal, educational institutions need to have a certain degree of knowledge about the partners in their supply chains including suppliers, customers, and the society. The performance of the supply chain management depends on the seamless coordination of all supply chain stakeholders to ensure attainment of desirable outcomes.

The ITESCM Model represents supply chain management for the academia [20], [28], [29]. This model depicts the integrated form of educational supply chain and educational management for the Universities. Educational supply chain also consists of education supply chain and research supply chain. This paper revised ITESCM model, which also represents academic supply chain for the universities.

2. Literature Review

2.1 SCM in Higher Education

SCM in the manufacturing industry is a very common scenario. However, SCM in the service industry especially in higher educational institutions is receiving more attention [11] and [41], [24]. In the service industry, service providers have an incentive of receiving better quality inputs from customer-suppliers, and customer-suppliers have an incentive of getting better quality outputs from the service provider [53].

An example of customer-supplier collaborating takes place in higher education. Students provide their bodies, minds and prior knowledge as inputs to the education process. There can be great advantage if the quality of the prior knowledge sufficiently prepares the students for the university's value-adding process. Universities can collaborate with students by programs establishments that prepare students for matriculation. Further, universities might collaborate with the suppliers of the student-suppliers, namely colleges, high schools, or preparatory schools. Universities can even collaborate with their customers, namely the employers and graduate schools. Such collaboration might include exchanging information about curriculum, programs and about knowledge and skills, which are desirable in students [53].

In the educational supply chain, direct and indirect student services are available to process the raw material, i.e. students. Student sourcing and selection, design and development, academic and non-academic trainings, practical trainings, result testing and grading, and finally their further development are direct student services. The indirect student services include campus advancement and maintenance, IT infrastructure, accommodation, clearances, bookstore, libraries, security, refreshments and sports facilities, etc. [41].

The objective of the educational supply chain is to develop the quality graduates or products with limited resources for the society, which is the final customer or consumer. Collaboration between academic and non-academic student services should be highly developed that students can learn effectively to fit for the society. A few important non-academic courses, such as leadership, ethics, planning, and communication skills, must be mandated to study as part of academic course. It could help the student to perform better in student practical trainings, i.e. group reports, and group final year projects, in order to provide well-formed graduates for the society.

Every student should be designed and developed critically. An advisor should be assigned to supervise the student development process throughout the supply chain. However, the student is different and the university cannot set up one supply chain process for all the students. In educational supply chain, customized supply chain processes for each student is recommended to make sure the student quality [41].

Research is expensive and long-term, requiring customized and responsive supply chain to satisfy the customers. Integration across divisions, even universities and profitable organizations are recommended. For examples, if there is an applied research to develop a specific IT system for an organization, the supply chain should be used to identify all relevant IT professionals to develop

such a system. If there is a basic research to develop a few social observations through research surveys, the supply chain should be managed to communicate the professionals and facilities in the university to prevent duplicated research scope and to streamline the survey time and cost.

According to the concept of three decision levels in SCM, this concept would be adopted in higher education [34]. In educational management, three decision levels, as illustrated in Figure 1 are involved in the process of the university:

Phase 1: Strategic Level
Phase 2: Planning Level
Phase 3: Operating Level

A. Strategic Level: Strategic level decisions are the highest level. Strategic level decision concerns general direction, long-term goals, philosophies and values. These decisions are the least structured and most imaginative; they are the most risky and of the most uncertain result, partly because they attain so far into the future and partly because they are of such significance.

B. Planning Level: Planning level decisions support strategic decisions. They tend to be medium range, medium importance, with moderate outcomes.

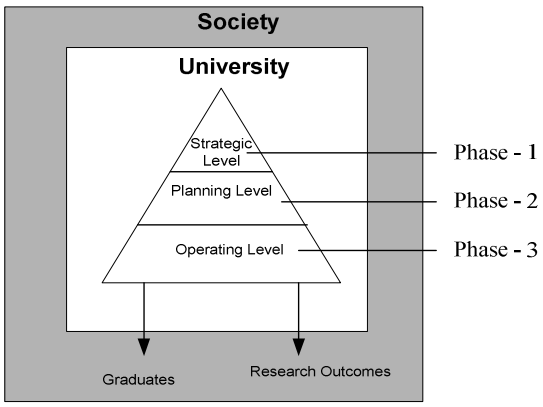

Figure 1. Three-decision Levels in the Universities

C. Operating Level: Operating level decisions are every day decisions, used to support planning level decisions. They are often made with little thought and are structured. Their impact is immediate, short term, short range, and usually low cost. The outcomes of a bad operating level decision will be minimal, although a series of bad or sloppy operating level decisions can cause harm. These decisions can be pre-programmed, pre-defined, or set out clearly in policy manuals.

2.2 Different Factors in the Universities

According to the concept of three decision levels, including strategic, planning and operating, in SCM, this concept would be adopted for the higher educational institutions [54]. To accomplish proper teaching and research works in the universities; different factors have to need analyzed. Four factors, namely faculty capabilities, facilities, programs establishment, university culture [23]; [17], [18], [45], [46] will be illustrated in this section.

Programs Establishments (PE): Programs establishment would be occurred for the education and research in terms of development and assessment in the universities. Universities design different programs, to enhance the diversification in education development and establish various programs to assess the development. Universities also intend different programs to increase the diversification in research development and research assessment. Universities have to attempt product differentiation, i.e. programs establishment. Hands-on experience, industrial placements, social demand, provision of IT facilities, and innovative academic methods all demonstrate attempts to differentiate programs establishment [29].

University Culture (UC): The concept of organizational culture would be applicable for the universities by the name of University Culture. However, the type of the university culture will fully depends on the university management or administrator. In fact, university culture is the personality of the university [24].

Faculty Capabilities (FC): Faculty members establish good communication, provide rich environment for classroom observation, model best practices, create opportunities for reflection, and support students' participation in curriculum planning, teaching and research. Traditionally, university faculty members are evaluated according to the three major criteria: teaching, research, and services [25].

Facilities (FA): Universities offer a wide range of modern facilities to their students. These include state of the art lecture halls, libraries, laboratories and IT services to ensure that students are provided with an environment in which they can learn, both successfully and comfortably. Lecture rooms are principally conducted using state-of-the-art distance learning technology, online education, e-learning via Internet. Online databases, e-journal, digital library, etc. represents modern research facilities in the universities [27].

3. Research Methodology

Model development and analysis was based on both primary and secondary data. Once the existing

body of literature has been thoroughly investigated, a conceptual framework, i.e. original ITESCM model is proposed. Based on the survey research techniques, the resulting model was evaluated for accuracy and validity by the Structural Equation Modeling (SEM) technique through AMOS (Analysis of Moment Structures).

Table 1. Information Regarding Respondents

Respondents	Questionnaire Procedure	No. of Respondents	Total No. of Respondents
University Administrators	Email	48	72
	Self-Administered	24	
Faculty Members	Email	41	64
	Self-Administered	23	
University Staff	Email	9	38
	Self-Administered	29	
Employers	Email	0	153
	Self-Administered	153	
Graduates	Email	8	166
	Self-Administered	158	
			493

The questionnaire was developed and analyzed to determine reliability and validity of the tools. In the scale reliability test, the Cronbach's alpha value is 0.961, which means the scale is excellent reliable [20] and could be used to test the content validity. Validity of the variables was confirmed by experts, as well as academicians. A non-probability sampling technique based on the judgment (purposive) sampling was applied. This judgment sampling depends on the personal judgments from all stakeholders of the Universities. The respondents were asked to indicate the level of significance using five-point Likert scale (1 = strongly disagree, 5 = strongly agree) [9]. For the survey research questionnaire interval scale, statistical parametric scale, were used.

The questionnaires were pre-tested to check the content validity and revised where necessary to ensure the content validity. In pretest, all the respondents were academicians of different world-ranking Universities. As our target groups were University administrators, faculty and staffs from different top ranked universities, employers and graduates, data were gathered through emails, and self-administered.

In large-scale research, the questionnaire was sent to 2356 respondents through emails those are top management in 1-2000 ranking universities around the world. 242 questionnaires were distributed by self-administered to University administrators, faculty members, staff, graduates and employers. Lastly, 823 research questionnaires by self-administered to graduates of different Universities were randomly distributed. Finally, 493 questionnaires were collected from all stakeholders, including experts, faculty, staff, graduates and employers, out of 3421 respondents. Among them, 174 respondents were experts in University administration, faculty, staff, 166 respondents were graduates, and 153 respondents were employers.

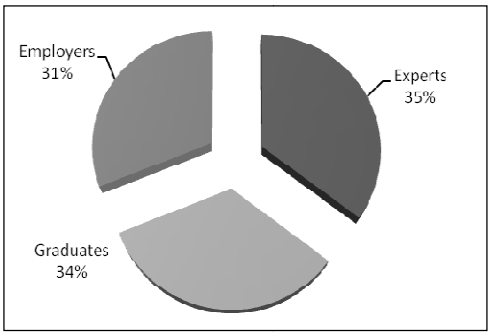

Figure 2. Types of Large Scale Respondents

In large scale, the researcher collected 493 respondents from all stakeholders, including experts in university administration, faculty, staffs, employers, graduates, etc. Most of the respondents (35%) were experts.

4. ITESCM Model Development

An integrated supply chain involves co-ordination and information sharing up and down the process. It is very difficult to determine the supplier and customer of the intangible product in the service industry.

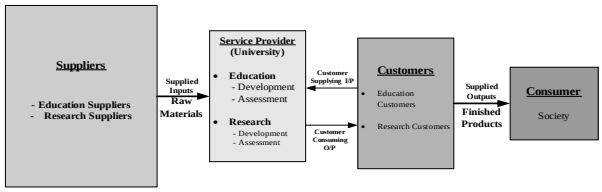

Figure 3. Simplified Form of Supply Chain Management for the Universities

Suppliers, the service provider, customers, and the consumer have been identified in the simplified form of supply chain management which is illustrated in Fig. 3. This study also identifies supplied inputs, customer-consuming output (O/P), customer-supplying input (I/O) and finally supplied outputs. In this supply chain, raw materials are students as well as internal and external projects. Finished products are graduates and research outcomes [28], [32].

Customers can closely monitor the value added by service providers. When customers supply major inputs, they know exactly what condition those inputs are. Then, when they subsequently receive the output from the service provider, they can easily assess the amount of value added by the

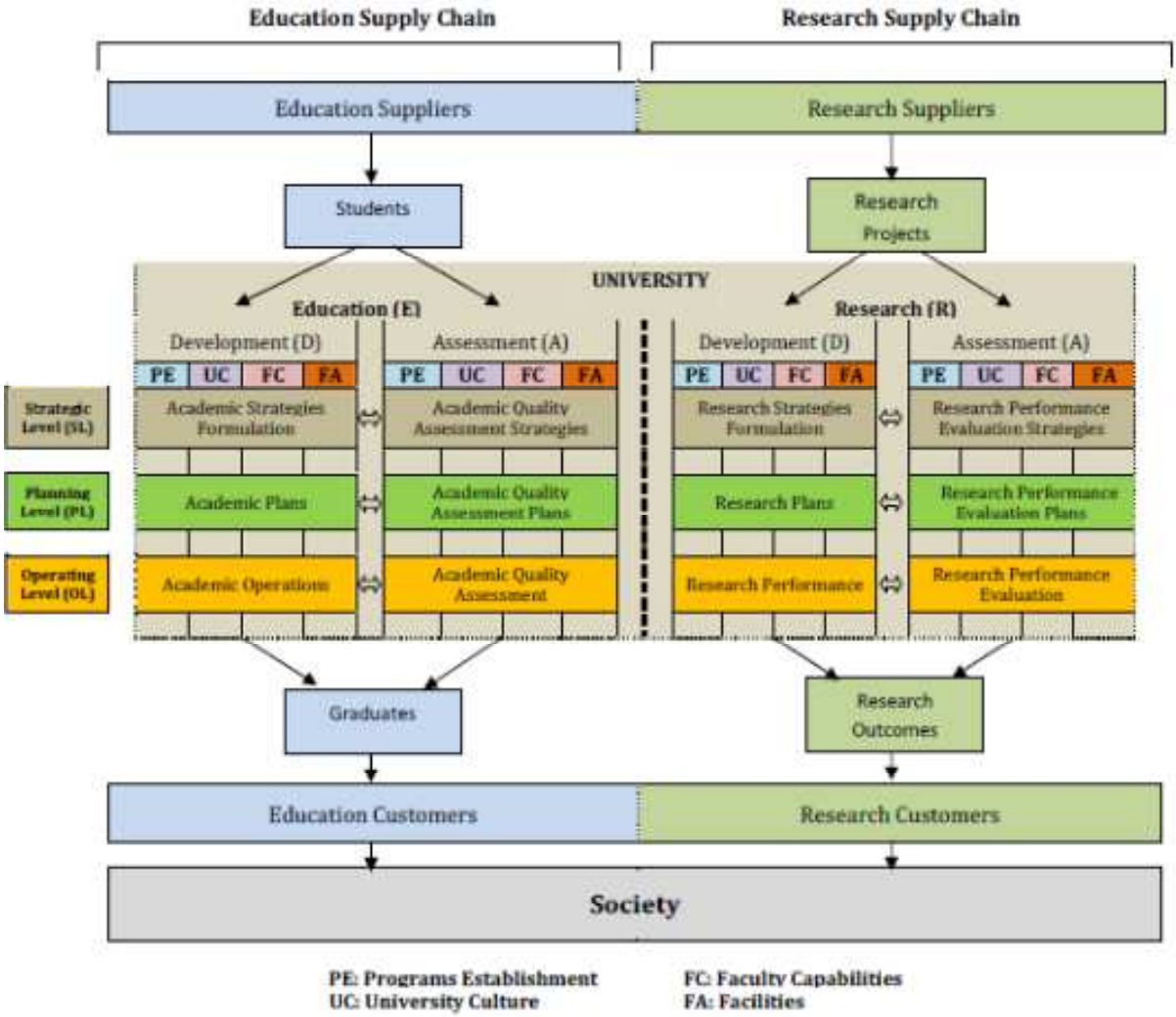

Figure 5. Redesigned ITESCM Model

service provider. Fig. 4 illustrates an education supply chain and a research supply chain, which together form the integrated supply chain for the universities [20], [25], [27].

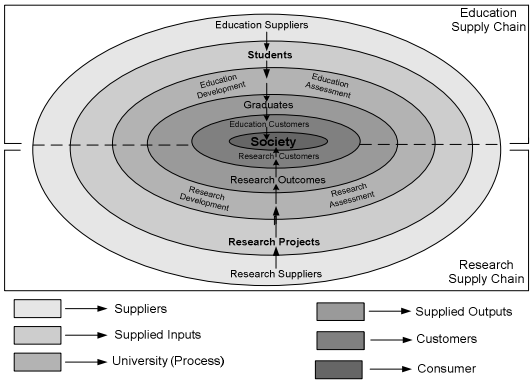

Figure 4. An Integrated Supply Chain for the Universities

4.1 Redesigned ITESCM Model

In this paper, authors intend to redesign ITESCM model that is the revised form of original ITESCM. That model, illustrated in Fig. 5, would be easily understandable and research equations are more user friendly for practical field applications for tertiary educational institutions.

The researchers pointed out twelve hypotheses, among of them seven hypotheses for educational management and remaining five hypotheses for educational supply chain, to verify the educational supply chain management model for tertiary academic institutions. Hypothesis H_1 stands for education development, hypothesis H_2 for education assessment. Hypotheses H_3 and H_4 represent research development and research assessment respectively.

Hypothesis H_5 stands for graduates and hypothesis H_6 for research outcomes. Hypotheses H_7, H_8 represents supplied inputs and hypotheses H_9, H_{10}, H_{11} and H_{12} for supplied outputs. In revised ITESCM model, the authors represent eight models in this section. From the research model, the following hypotheses are established.

H_1 Four factors affect education development in the universities to produce graduates at three

decision level

H_2 Four factors affect education assessment in the universities to produce graduates at three decision level

H_3 Four factors affect research development in the universities to produce research outcomes at three decision level

H_4 Four factors affect research assessment in the universities to produce research outcomes at three decision level

H_5 There is a relationship between education development and education assessment with graduates

H_6 There is a relationship between research development and research assessment with research outcomes

H_7 There is a relationship between Students with education development and education assessment in the universities

H_8 There is a relationship between research projects with research development and research assessment in the universities

H_9 There is a relationship between graduates and education customers

H_{10} There is a relationship between research outcomes and research customers

H_{11} There is a relationship between education customers and the society

H_{12} There is a relationship between research customers and the society

5. Redesigned ITESCM Model Evaluation

5.1 Model A - Education Development

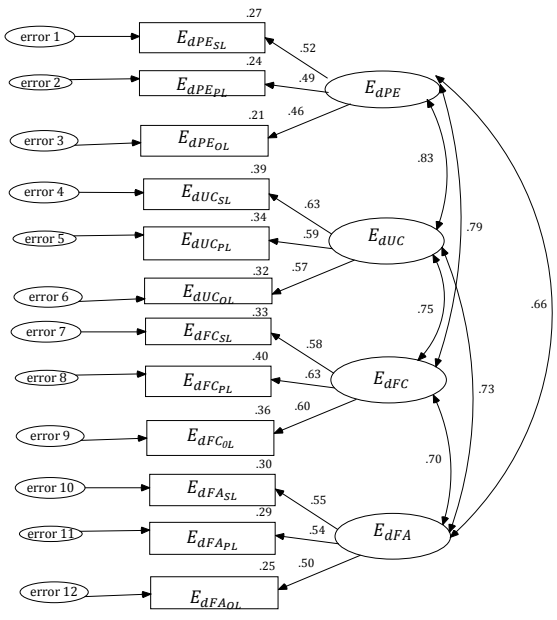

Figure 6. AMOS Graphics Output of Model A (Standardized Estimates)

To verify hypothesis H_1, the researchers used Model A that presents Education Development (E_d). E_d consists of E_{dPE}, E_{dUC}, E_{dFC}, E_{dFA} those representing Programs Establishments, University Culture, Faculty Capabilities, Facilities, respectively. Each factor is available at three decision levels, strategic, planning and operating levels in Fig. 6. Multiple Linear Regression (MLR) equations were developed through AMOS.

Multiple Linear Regression (MLR) Equations

$$E_{dPE} = 0.52E_{dPE_{SL}} + 0.49E_{dPE_{PL}} + 0.46E_{dPE_{OL}} \quad (1)$$

$$E_{dUC} = 0.63E_{dUC_{SL}} + 0.59E_{dUC_{PL}} + 0.57E_{dUC_{OL}} \quad (2)$$

$$E_{dFC} = 0.58E_{dFC_{SL}} + 0.63E_{dFC_{PL}} + 0.60E_{dFC_{OL}} \quad (3)$$

$$E_{dFA} = 0.55E_{dFA_{SL}} + 0.54E_{dFA_{PL}} + 0.50E_{dFA_{OL}} \quad (4)$$

Eq. (1) states that programs establishment of the education development at strategic level decisions are more predominant than planning and operating level. Eq. (2) represents that strategic level decisions are more important than planning and operating level in university culture of the education development. Eq. (3) depicts that planning level decisions are more significant than strategic and operating levels in faculty capabilities of the education development. Eq. (4) highlights that strategic level decisions are more considerable than planning and operating levels in facilities of the education development.

Model Fix Index: Chi-square = 3.567, Degrees of freedom = 48, Probability level = .000, RMSEA = 0.072, NFI = 0.845, CFI = 0.882

Eq. (1), (2), (3), (4), graphics output, Model fit index, and above all statistical discussion on AMOS 6 states that programs establishment, university culture, faculty capabilities, facilities affect significantly the education development to produce graduates, i.e. hypothesis 1 fails to reject.

5.2 Model B - Education Assessment

To verify hypothesis H_2, the researchers used Model B that presents Education Assessment (E_a). E_a consists of E_{aPE}, E_{aUC}, E_{aFC}, E_{aFA} those representing Programs Establishments, University Culture, Faculty Capabilities, Facilities, respectively. Each factor is available at three decision levels, strategic, planning and operating

levels in Fig. 6. Multiple Linear Regression (MLR) equations were developed through AMOS.

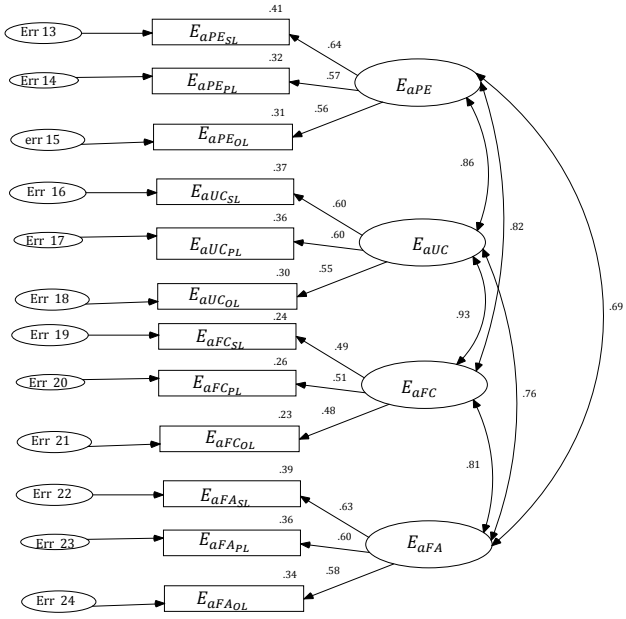

Figure 7. AMOS Graphics Output of Model B (Standardized Estimates)

MLR Equations

$$E_{aPE} = 0.64E_{aPE_{SL}} + 0.57E_{aPE_{PL}} + 0.56E_{aPE_{OL}} \quad (5)$$

$$E_{aUC} = 0.60E_{aUC_{SL}} + 0.60E_{aUC_{PL}} + 0.55E_{aUC_{OL}} \quad (6)$$

$$E_{aFC} = 0.49E_{aFC_{SL}} + 0.51E_{aFC_{PL}} + 0.484E_{aFC_{OL}} \quad (7)$$

$$E_{aFA} = 0.63E_{aFA_{SL}} + 0.60E_{aFA_{PL}} + 0.58E_{aFA_{OL}} \quad (8)$$

Eq. (5) states that strategic level decisions are more predominant than planning and operating level decisions in programs establishment of education assessment. Eq. (6) represents that strategic and planning level decisions are highly contributed to university culture in education assessment. Eq. (7) depicts that planning level decisions are more significant than strategic and operating level decisions in faculty capabilities of education assessment. Eq. (8) highlights that strategic level decisions are more considerable than planning and operating level decisions in facilities of education assessment.

Model Fit Index: Chi-square =2.630, Degrees of freedom = 48, Probability level = .000, RMSEA = 0.058, NFI = 0.897, CFI = 0.932.

Eq. (5), (6), (7), (8), graphics output, Model fit index, and above all statistical discussion on AMOS states that programs establishment, university culture, faculty capabilities, facilities significantly affect the education assessment to produce graduates, i.e. hypothesis H_2 fails to reject.

5.3 Model C – Graduates

The researchers identified graduates as final outcomes of the education part in the university. Education part is divided into two segments including education development and education assessment. Model C contains Education Development (E_d) and Education Assessment (E_a). There are four subgroups, including programs establishment (E_{dPE}), university culture (E_{dUC}), faculty capabilities (E_{dFC}), and facilities (E_{dFA}), respectively in Education Development. Similarly, four subgroups are available for Education Assessment.

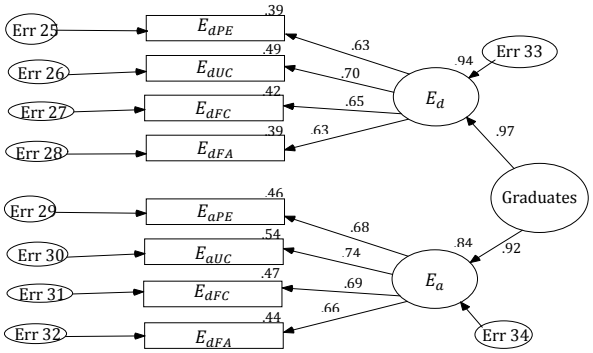

Figure 8. AMOS Graphics Output of Model C (Standardized Estimates)

MLR Equations

$$E_d = 0.63E_{dPE} + 0.70E_{dUC} + 0.65E_{dFC} + 0.65E_{dFA} \quad (9)$$

$$E_a = 0.68E_{aPE} + 0.74E_{aUC} + 0.69E_{aFC} + 0.66E_{aFA} \quad (10)$$

$$Graduates = 0.97E_d + 0.92E_a \quad (11)$$

From the research findings, Eq. (9) states that university culture (E_{dUC}) is the most significant factor in education development. On the other hand, Eq. (10) represents that university culture is highly contributed to education assessment. Finally, Eq. (11) depicts that education development is highly contributed to produce quality graduates in the universities.

$$Graduates = 0.97E_d + 0.92E_a$$

$$= 0.97\ [0.63E_{dPE} + 0.70E_{dUC} + 0.65E_{dFC} + 0.65E_{dFA}] + 0.92\ [0.68E_{aPE} + 0.74E_{aUC} + 0.69E_{aFC} + 0.66E_{aFA}]$$

$= 0.61E_{dPE} + 0.68E_{dUC} + 0.63E_{dFC} + 0.61E_{dFA} + 0.63E_{aPE} + 0.68E_{aUC} + 0.63E_{aFC} + 0.61E_{aFA}$

The above equation shows the significant relationship among all factors namely programs establishment, university culture, faculty capabilities, and facilities in education development as well as education assessment to produce the graduates. University culture at education development and education assessment is highly contributed to produce the graduates in the universities.

$$Graduates = 0.61[\,0.52E_{dPE_{SL}} + 0.49E_{dPE_{PL}} + 0.46E_{dPE_{OL}}] + 0.68\,[\,0.52E_{dUC_{SL}} + 0.49E_{dUC_{PL}} + 0.46E_{dUC_{OL}}] + 0.63\,[\,0.58E_{dFC_{SL}} + 0.63E_{dFC_{PL}} + 0.60E_{dFC_{OL}}] + 0.61\,[0.55E_{dFA_{SL}} + 0.54E_{dFA_{PL}} + 0.50E_{dFA_{OL}}] + 0.63\,[0.64E_{aPE_{SL}} + 0.57E_{aPE_{PL}} + 0.56E_{aPE_{OL}}] + 0.68\,[0.60E_{aUC_{SL}} + 0.60E_{aUC_{PL}} + 0.55E_{aUC_{OL}}] + 0.63\,[0.49E_{aFC_{SL}} + 0.51E_{aFC_{PL}} + 0.48E_{aFC_{OL}}] + 0.61\,[0.63E_{aFA_{SL}} + 0.60E_{aFA_{PL}} + 0.58E_{aFA_{OL}}]$$

$$= 0.32E_{dPE_{SL}} + 0.30E_{dPE_{PL}} + 0.28E_{dPE_{OL}} + 0.35E_{dUC_{SL}} + 0.33E_{dUC_{PL}} + 0.32E_{dUC_{OL}} + 0.37E_{dFC_{SL}} + 0.40E_{dFC_{PL}} + 0.38E_{dFC_{OL}} + 0.34E_{dFA_{SL}} + 0.33E_{dFA_{PL}} + 0.31E_{dFA_{OL}} + 0.40E_{aPE_{SL}} + 0.36E_{aPE_{PL}} + 0.35E_{aPE_{OL}} + 0.41E_{aUC_{SL}} + 0.41E_{aUC_{PL}} + 0.36E_{aUC_{OL}} + 0.31E_{aFC_{SL}} + 0.32E_{aFC_{PL}} + 0.30E_{aFC_{OL}} + 0.38E_{aFA_{SL}} + 0.37E_{aFA_{PL}} + 0.35E_{aFA_{OL}} \quad (12)$$

From the in-depth analysis of Eq. (12), strategic and planning level decisions of university culture and strategic level decisions of programs establishment are highly contributed in education assessment to produce the graduates. On the other hand, planning level decisions of faculty capabilities is highly contributed in education development to produce the graduates in the universities.

Model Fit Index: Chi-square = 8.936 (Ratio of relative chi-square close to 5 indicates reasonable fit) [7], Degrees of freedom = 19, Probability level = .000, RMSEA = 0.127, NFI = 0.880, CFI = 0.891 (NFI and CFI values close to 1 indicate a very good fit) [17].

The Eq. (11), (12), graphics output, Model fit index, and above all statistical discussion on AMOS magnifies that hypothesis H_5 fails to reject and states that there are significant relationship between education development and graduates as well as education assessment and graduates.

5.4 Model D - Research Development

To verify hypothesis H_3, the researchers used Model D that presents Research Development (R_d). R_d consists of R_{dPE}, R_{dUC}, R_{dFC}, R_{dFA} those representing Programs Establishments, University Culture, Faculty Capabilities, Facilities, respectively. Each factor is available at three decision levels, strategic, planning and operating levels in Fig. 6. Multiple Linear Regression (MLR) equations were developed through AMOS.

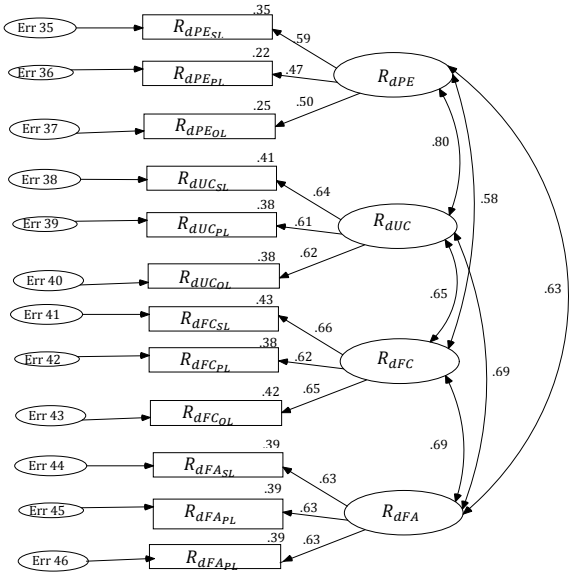

Figure 9. AMOS Graphics Output of Model D (Standardized Estimates)

MLR Equations

$$R_{dPE} = 0.59R_{dPE_{SL}} + 0.47R_{dPE_{PL}} + 0.50R_{dPE_{OL}} \quad (13)$$

$$R_{dUC} = 0.64R_{dUC_{SL}} + 0.61R_{dUC_{PL}} + 0.62R_{dUC_{OL}} \quad (14)$$

$$R_{dFC} = 0.66R_{dFC_{SL}} + 0.62R_{dFC_{PL}} + 0.65R_{dFC_{OL}} \quad (15)$$

$$R_{dFA} = 0.63R_{dFA_{SL}} + 0.63R_{dFA_{PL}} + 0.63R_{dFA_{OL}} \quad (16)$$

Eq. (13) states that strategic level decisions are more predominant than planning and operating level in programs establishment of research development. Eq. (14) represents that strategic level decisions are highly contributed to university culture in research development. Eq. (15) depicts that planning level decisions are most significant factor in faculty capabilities of research development. Eq. (16) highlights that strategic, planning and operating level decisions have equal contribution to facilities in research development.

Model Fit Index: Chi-square =2.802, Degrees of freedom = 48, Probability level = .000, RMSEA = 0.061, NFI = 0.896, CFI = 0.930

Eq. (13), (14), (15), (16), graphics output, Model fit index and above all statistical discussion on AMOS states that programs establishment, university culture, faculty capabilities, facilities significantly affect the research development to produce research outcomes, i.e. hypothesis H_3 fails to reject.

5.5 Model E - Research Assessment

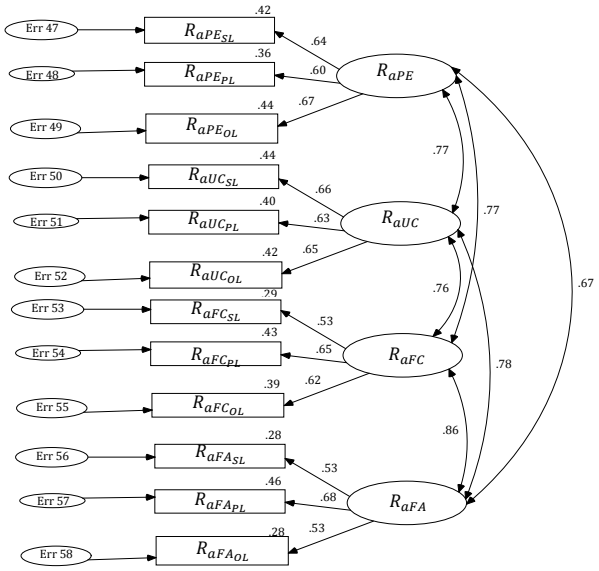

Figure 10 AMOS Graphics Output of Model E (Standardized Estimates)

To verify hypothesis H_4, the researcher used Model E that presents Research Assessment (R_a). R_a consists of R_{aPE}, R_{aUC}, R_{aFC}, R_{aFA} those representing Programs Establishments, University Culture, Faculty Capabilities, Facilities, respectively. Each factor is available at three decision levels, strategic, planning and operating levels in Fig. 6. Multiple Linear Regression (MLR) equations were developed through AMOS.

MLR Equations

$$R_{aPE} = 0.64R_{aPE_{SL}} + 0.60R_{aPE_{PL}} + 0.67RE_{aPE_{OL}} \quad (17)$$

$$R_{aUC} = 0.66R_{aUC_{SL}} + 0.63R_{aUC_{PL}} + 0.65R_{aUC_{OL}} \quad (18)$$

$$R_{aFC} = 0.53R_{aFC_{SL}} + 0.65R_{aFC_{PL}} + 0.62R_{aFC_{OL}} \quad (19)$$

$$R_{aFA} = 0.53R_{aFA_{SL}} + 0.68R_{aFA_{PL}} + 0.53R_{aFA_{OL}} \quad (20)$$

Eq. (17) states that operating level decisions are more predominant than strategic and planning level decisions in programs establishment of research assessment. Eq. (18) represents that strategic level decisions are highly contributed to university culture in research assessment. Eq. (19) depicts that planning level decisions are more significant than strategic and operating level decisions in faculty capabilities of research assessment. Eq. (20) highlights that planning level decisions are highly contributed to facilities in research assessment.

Model Fit Index: Chi-square = 3.138, Degrees of freedom = 48, Probability level = .000, RMSEA = 0.066, NFI = 0.901, CFI = 0.929

Eq. (17), (18), (19), (20), graphics output, Model fit index and above all statistical discussion on AMOS states that programs establishment, university culture, faculty capabilities, facilities significantly affect the research assessment to produce research outcomes, i.e. hypothesis H_4 fails to reject.

5.6 Model F - Research Outcomes

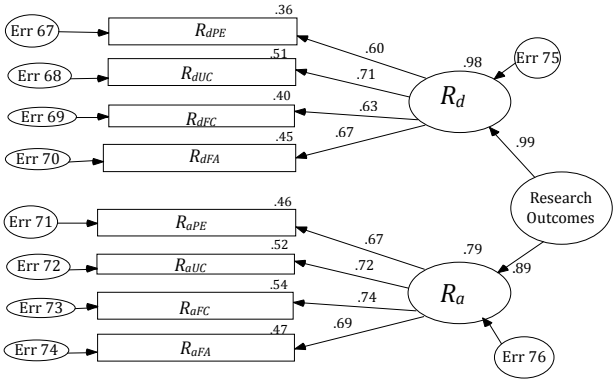

Figure 11. AMOS Graphics Output of Model F (Standardized Estimates)

The authors identified research outcomes as final product of the research wing in the university. Research part is divided into two segments including Research Development and Research Assessment. Model F contains Research Development (R_d) and Research Assessment (R_a). There are four subgroups, including programs establishment (R_{dPE}), university culture (R_{dUC}), faculty capabilities (R_{dFC}), and facilities (R_{dFA}), respectively in Research Development. Similarly, four subgroups are available for Research Assessment.

MLR Equations

$$R_d = 0.60R_{dPE} + 0.71R_{dUC} + 0.63R_{dFC} + 0.67R_{dFA} \quad (21)$$

$$R_a = 0.67R_{aPE} + 0.72R_{aUC} + 0.64R_{aFC} + 0.69R_{aFA} \quad (22)$$

$$Research\ Outcomes = 0.99R_d + 0.89R_a \quad (23)$$

From the research findings, Eq. (21) states that university culture is the most significant factor in research development. On the other hand, Eq. (22) represents that faculty capabilities are highly contributed to research assessment. Finally, Eq. (23) depicts that research development is highly contributed to produce research outcomes in the universities.

$$Research\ Outcomes = 0.99R_d + 0.89R_a$$

$$= 0.99\ [0.60R_{dPE} + 0.71R_{dUC} + 0.63R_{dFC} + 0.67R_{dFA}] + 0.89\ [0.67R_{aPE} + 0.72R_{aUC} + 0.64R_{aFC} + 0.69R_{aFA}]$$

$$= 0.59R_{dPE} + 0.70R_{dUC} + 0.62R_{dFC} + 0.66R_{dFA} + 0.60R_{aPE} + 0.64R_{aUC} + 0.66R_{aFC} + 0.61R_{aFA} \quad (24)$$

From the research results of Eq. (24), they show the significant relation among four aspects, namely programs establishment, university culture, faculty capabilities, and facilities in research development as well as research assessment to produce the research outcomes in the universities. University culture and facilities in research development as well as faculty capabilities in research assessment are highly contributed to produce the research outcomes in the universities.

$$Research\ Outcomes = 0.59[\ 0.59R_{dPE_{SL}} + 0.47R_{dPE_{PL}} + 0.50R_{dPE_{OL}}] + 0.70\ [\ 0.64R_{dUC_{SL}} + 0.61R_{dUC_{PL}} + 0.62R_{dUC_{OL}}] + 0.62\ [\ 0.66R_{dFC_{SL}} + 0.62R_{dFC_{PL}} + 0.65R_{dFC_{OL}}] + 0.66\ [0.63R_{dFA_{SL}} + 0.63R_{dFA_{PL}} + 0.63R_{dFA_{OL}}] + 0.60\ [0.64R_{aPE_{SL}} + 0.60R_{aPE_{PL}} + 0.67R_{aPE_{OL}}] + 0.64\ [0.66R_{aUC_{SL}} + 0.63R_{aUC_{PL}} + 0.65R_{aUC_{OL}}] + 0.66\ [0.53R_{aFC_{SL}} + 0.65R_{aFC_{PL}} + 0.62R_{aFC_{OL}}] + 0.61\ [0.53R_{aFA_{SL}} + 0.68R_{aFA_{PL}} + 0.53R_{aFA_{OL}}]$$

$$= 0.35R_{dPE_{SL}} + 0.27R_{dPE_{PL}} + 0.29R_{dPE_{OL}} + 0.45R_{dUC_{SL}} + 0.43R_{dUC_{PL}} + 0.43R_{dUC_{OL}} + 0.41R_{dFC_{SL}} + 0.38R_{dFC_{PL}} + 0.40R_{dFC_{OL}} + 0.42R_{dFA_{SL}} + 0.42R_{dFA_{PL}} + 0.42R_{dFA_{OL}} + 0.38R_{aPE_{SL}} + 0.36R_{aPE_{PL}} + 0.40RE_{aPE_{OL}} + 0.42R_{aUC_{SL}} + 0.40R_{aUC_{PL}} + 0.42R_{aUC_{OL}} + 0.35R_{aFC_{SL}} + 0.43R_{aFC_{PL}} + 0.41R_{aFC_{OL}} + 0.32R_{aFA_{SL}} + 0.41R_{aFA_{PL}} + 0.32R_{aFA_{OL}} \quad (24)$$

From the in-depth analysis of Eq. (24), strategic, planning and operating level decisions in university culture are highly contributed to research development to produce the research outcomes. On the other hand, planning level decisions in faculty capabilities is highly contributed to research assessment to produce the research outcomes in the universities.

Model Fit Index: Chi-square = 9.991 (Ratio of relative chi-square close to 5 indicates reasonable fit) [7], Degrees of freedom = 19, Probability level = .000, RMSEA = 0.135, NFI = 0.872, CFI = 0.883

The Equations (23), (24), graphics output, Model fit index and above all statistical discussion on AMOS rectifies that hypothesis H_7 fails to reject and states that there are significant relationship between research development and research outcomes as well as research assessment and research outcomes.

5.7 Model G - Supplied Inputs

Model G will test hypotheses H_7 and H_8, those represents the supplied inputs of the educational supply chain. In this model, there are two main inputs for the universities are students and research projects that have been evolved from education suppliers and research suppliers respectively. Model G is presenting the inter relationships among different variables to justify the hypotheses H_7 and H_8 by SEM through AMOS.

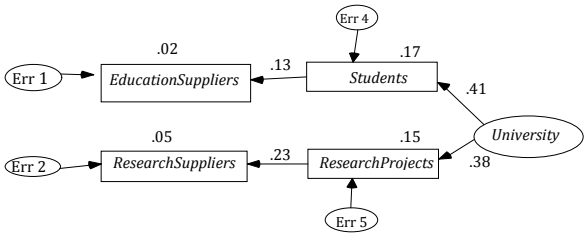

Figure 12. AMOS Graphics Output of Model G (Standardized Estimates)

MLR Equations

$$University = 0.41Students + 0.38ResearchProjects$$

$$= 0.41\ [0.13EducationSuppliers] + 0.38\ [0.23ResearchSuppliers]$$

$$= 0.05EducationSuppliers + 0.09ResearchSuppliers \quad (25)$$

From the research findings, university consists of students as well as research projects. The factor that highly contributed to the university is students. This equation also depicts the relation of education suppliers and research suppliers with the university. Research suppliers are highly contributed to the university.

Model Fit Index: Chi-square = 5.962, Degrees of freedom = 3, Probability level = 0.000, RMSEA = 0.100, NFI = 0.720, CFI = 0.743

Eq. (25), graphics output, Model fit index and above all statistical discussion on AMOS states that there are significant relationships between education suppliers and students, and research suppliers and research projects in the universities. Therefore, research hypotheses H_7 and H_8 fail to reject.

5.8 Model H - Supplied Outputs

Model H will test hypotheses H_9, H_{10}, H_{11} and H_{12} in the supplied outputs of the educational supply chain.

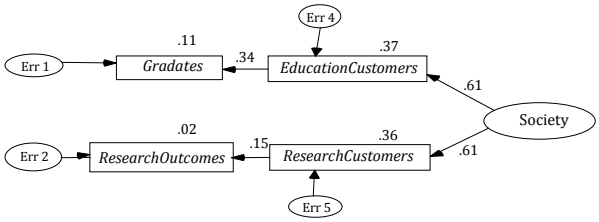

Figure 13. AMOS Graphics Output of Model H (Standardized Estimates)

The main outputs of the universities, including graduates and research outcomes will be delivered to the education customers and research customers respectively. Finally, all outcomes will be generated for the society. Model H is representing the inter relationships among different variables to justify the hypotheses H_9, H_{10}, H_{11} and H_{12} by SEM through AMOS.

MLR Equations

$$Society = 0.61 EducationCustomers + 0.61 ResearchCustomers$$

$$= 0.61\ [0.34 Graduates] + 0.61\ [0.15 ResearchOutcomes]$$

$$= 0.21 Graduates + 0.09 ResearchOutcomes \quad (26)$$

From the research findings, the society consists of graduates and research outcomes. The author defined the society as the function of graduates and research outcomes.

$$Society = f(Graduates, ResearchOutcomes)$$

The Eq. (26) represents that graduates are highly contributed to the society. This equation also depicts that education customers and research customers have equal contribution to the society.

$$Society = 0.21\ [0.97E_d + 0.92E_a] + 0.09\ [0.99R_d + 0.89R_a]$$

$$= 0.20E_d + 0.19E_a + 0.09\ R_d + 0.08R_a$$

The above equation represents the relationship between the society and education development, education assessment, research development, research assessment. Education development and then education assessment are highly contributed to the society.

$$Society = 0.20\ [0.63E_{dPE} + 0.70E_{dUC} + 0.65E_{dFC} + 0.65E_{dFA}] + 0.19\ [0.68E_{aPE} + 0.74E_{aUC} + 0.69E_{aFC} + 0.66E_{aFA}] + 0.09\ [0.60R_{dPE} + 0.71R_{dUC} + 0.63R_{dFC} + 0.67R_{dFA}] + 0.08[0.67R_{aPE} + 0.72R_{aUC} + 0.64R_{aFC} + 0.69R_{aFA}]$$

$$Society = 0.126E_{dPE} + 0.14E_{dUC} + 0.13E_{dFC} + 0.126E_{dFA} + 0.129E_{aPE} + 0.141E_{aUC} + 0.131E_{aFC} + 0.125E_{aFA} + 0.054R_{dPE} + 0.064R_{dUC} + 0.057R_{dFC} + 0.06R_{dFA} + 0.054R_{aPE} + 0.058R_{aUC} + 0.059R_{aFC} + 0.055R_{aFA}$$

$$Society = 0.126\ [0.52E_{dPE_{SL}} + 0.49E_{dPE_{PL}} + 0.46E_{dPE_{OL}}] + 0.14\ [0.63E_{dUC_{SL}} + 0.59E_{dUC_{PL}} + 0.57E_{dUC_{OL}}] + 0.13\ [0.58E_{dFC_{SL}} + 0.63E_{dFC_{PL}} + 0.60E_{dFC_{OL}}] + 0.126\ [0.55E_{dFA_{SL}} + 0.54E_{dFA_{PL}} + 0.50E_{dFA_{OL}}] + 0.129\ [0.64E_{aPE_{SL}} + 0.57E_{aPE_{PL}} + 0.56E_{aPE_{OL}}] + 0.140\ [0.60E_{aUC_{SL}} + 0.60E_{aUC_{PL}} + 0.55E_{aUC_{OL}}] + 0.131\ [0.49E_{aFC_{SL}} + 0.51E_{aFC_{PL}} + 0.48E_{aFC_{OL}}] + 0.125\ [0.63E_{aFA_{SL}} + 0.60E_{aFA_{PL}} + 0.58E_{aFA_{OL}}] + 0.054[0.59R_{dPE_{SL}} + 0.47R_{dPE_{PL}} + 0.50R_{dPE_{OL}}] + 0.064\ [0.64R_{dUC_{SL}} + 0.61R_{dUC_{PL}} + 0.62R_{dUC_{OL}}] + 0.057\ [0.66R_{dFC_{SL}} + 0.62R_{dFC_{PL}} + 0.65R_{dFC_{OL}}] + 0.06\ [0.63R_{dFA_{SL}} + 0.63R_{dFA_{PL}} + 0.63R_{dFA_{OL}}] + 0.054\ [0.64R_{aPE_{SL}} + 0.60R_{aPE_{PL}} + 0.67R_{aPE_{OL}}] + 0.058\ [0.66R_{aUC_{SL}} + 0.63R_{aUC_{PL}} + 0.65R_{aUC_{OL}}] + 0.059\ [0.53R_{aFC_{SL}} + 0.65R_{aFC_{PL}} + 0.62R_{aFC_{OL}}] + 0.055[0.53R_{aFA_{SL}} + 0.68R_{aFA_{PL}} + 0.53R_{aFA_{OL}}]$$

$$Society = 0.067E_{dPE_{SL}} + 0.063E_{dPE_{PL}} + 0.059E_{dPE_{OL}} + 0.074E_{dUC_{SL}} + 0.069E_{dUC_{PL}} + 0.065E_{dUC_{OL}} + 0.078E_{dFC_{SL}} + 0.084E_{dFC_{PL}} + 0.08E_{dFC_{OL}} + 0.071E_{dFA_{SL}} + 0.069E_{dFA_{PL}} + 0.065E_{dFA_{OL}} + 0.084E_{aPE_{SL}} + 0.076E_{aPE_{PL}} + 0.074E_{aPE_{OL}} + 0.086E_{aUC_{SL}} + 0.086E_{aUC_{PL}} + 0.076E_{aUC_{OL}} + 0.065E_{aFC_{SL}} + 0.067E_{aFC_{PL}} + 0.063E_{aFC_{OL}} + 0.08E_{aFA_{SL}} + 0.078E_{aFA_{PL}} + 0.074E_{aFA_{OL}} + 0.032R_{dPE_{SL}} + 0.024R_{dPE_{PL}} + 0.026R_{dPE_{OL}} + 0.041R_{dUC_{SL}} + 0.039R_{dUC_{PL}} + 0.039R_{dUC_{OL}} + 0.037R_{dFC_{SL}} + 0.034R_{dFC_{PL}} + 0.036R_{dFC_{OL}} + 0.038R_{dFA_{SL}} + 0.038R_{dFA_{PL}} + 0.038R_{dFA_{OL}} + 0.034R_{aPE_{SL}} + 0.032R_{aPE_{PL}} + 0.036R_{aPE_{OL}} + 0.038R_{aUC_{SL}} + 0.036R_{aUC_{PL}} + 0.038R_{aUC_{OL}} + 0.032R_{aFC_{SL}} + 0.039R_{aFC_{PL}} + 0.037R_{aFC_{OL}} + 0.029R_{aFA_{SL}} + 0.037R_{aFA_{PL}} + 0.029R_{aFA_{OL}} \quad (27)$$

In the depth analysis from the above mentioned equation, university culture in education assessment and then university culture in education development are highly contributed to the society.

Model Fit Index: Chi-square = 5.494, Degrees of freedom = 3, Probability level = 0.001, RMSEA = 0.096, NFI = 0.896, CFI = 0.911

Eq. (26), (27), graphics output, Model fit index, and above all statistical discussion on AMOS states that there are significant relationships between graduates and education customers, research outcomes and research customers. There are also significant relationships among education customers, research customers and the society. Therefore, hypotheses H_9, H_{10}, H_{11} and H_{12} fail to reject.

5.9 Overall Model Fit Analysis

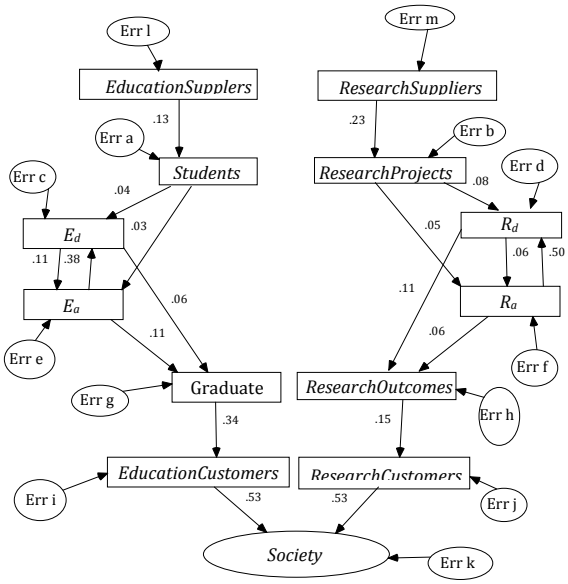

Figure 14. AMOS Graphics Output of Overall Model (Standardized Estimates)

Overall research model represents education supply chain, research supply chain, and educational management in terms of education development, education assessment, research development and research assessment.

AMOS graphics output for overall model is illustrated in Fig 14. There are significant relationships (significant at the 0.05 level – two tailed) between students and education development, students and education assessment, research projects and research development, research projects and research assessment. There are also significant bilateral relationships (significant at the 0.05 level – two tailed) between education development and education assessment, research development and research assessment.

Model Fit Index: CFI = 0.509, GFI = 0.863, CMIN/DF = 8.751

Modification indices should be considered only if it makes theoretical or common sense, chi-square value between 2 and 3, GFI and CFI value between 0.9 and 1 and significant relationship [1]. Overall model would be developed by using the highest Modification Indices (MI) that will make sense.

5.10 Updated Model

By using the Modification Indices (MI), the researchers add the relationships among different variables and eventually develop updated model.

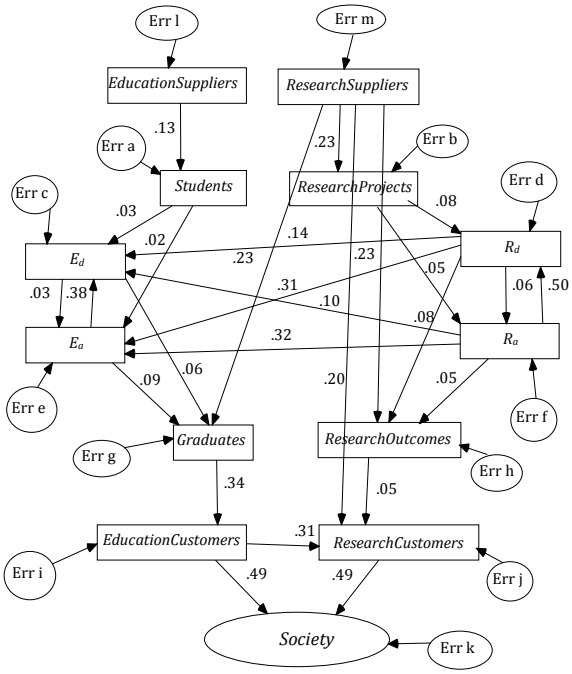

Figure 15 AMOS Graphics Output of Updated Model (Standardized Estimates)

Model Fit Index: CFI = 0.908, GFI = 0.958, CMIN/DF = 2.864

In updated model, the value of GFI and CFI is more than that of overall model. Based on CFI, GFI, CMIN/DF, updated model represents a very good fit.

The current university administrators or prospective investors could apply this updated model as actual implementation to produce quality outcomes, i.e. graduates and research outcomes, for the betterment of the society.

6. Implications of Redesigned ITESCM

Integrated Tertiary Educational Supply Chain Management (ITESCM) model was developed by Habib in 2009 [19]. Due to receiving feedback

from academicians and practitioners, the researchers attempt to revise ITESCM model to comply it in real-life application for different universities in the world. Redesigned model is user friendly and easy to understand for current university administrators and prospective investigators.

If any academician or practitioner chooses Likert Scale 5 (strongly agree) for each function in Eq. (27), in that case, the maximum value of Eq. (27) will equal to **12.96**. On the other hand, if the author selects Likert Scale 1 (strongly disagree) for each function in the equation, in that case, the minimum value of Eq. (27) will equal to **2.592**. Then, the researcher suggests cut off the value for the function of the society at fifty percent is **6.48** to indicate the value can be accepted.

$$\boldsymbol{UniversityOutcomes} = \frac{\boldsymbol{Society} - \mathbf{2.592}}{\mathbf{12.96 - 2.592}} * (\mathbf{100 - 0}) \quad (28)$$

The resulting suitability index, ***UniversityOutcomes*** in Eq. (28) ranges from 0% to 100% with 0% being the least favorable and 100% being the most suitable. The index of at least 50% may serve as a rough acceptance criterion for the well-being society.

7. Conclusion

This study reveals the first large scale empirical study that systematically investigate input, output and process of the tertiary academic institutions through redesigned ITESCM model. This empirical study based on 493 respondents from all stakeholders, including experts and administrators, faculty members and staffs of the university, employers, graduates, etc. The hypotheses testing and SEM technique through AMOS were also applied.

The research proposes the model of integrated educational supply chain management for the universities. This model links educational management with general business management. From a managerial point of view, this research provides a novel approach to developing and assessing supply chain management application in the academia.

There is ample evidence that higher education is one of the most important institutions in any society. Higher education provides benefits to both the society as a whole and individuals within the society. Individual benefits include wealth and a better life for those who are educated; social benefits are usually in terms of economic growth and prosperity of the society. Therefore, this academic supply chain management model provides fruitful outcomes in terms of value-added graduates and significant research outcomes for the well being of the end customer, i.e. the society.

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