Enhancing Supply Chain Management for the Universities: ITESCM Model Perspective

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Abstract—This exploratory research addresses the application guidelines of ITESCM (Integrated Tertiary Educational Supply Chain Management) model for better Supply Chain Management in Universities. This study encompasses education supply chain, research supply chain and educational management as major constituents of ITESCM. Four main activities, includes education development, education assessment, research development, and research assessment in four aspects, namely Programs Establishment, University Culture, Faculty Capabilities, and Facilities were investigated at three decision levels. The ITESCM model was formulated 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 world-ranking universities, faculty and staffs, employers, and graduates. The resulting structure was subsequently evaluated for accuracy and validity by multiple linear regression (MLR) analysis and the structural equation modeling (SEM) technique. This empirical study represents two contributions in terms of human resource contribution and research contribution to the end customer, i.e. the society. Model evaluation by actual implementation is suggested for prospective investors or current university administrators.

Keywords—ITESCM, supply chain management (SCM), educational management, graduates, research outcomes, education supply chain, research supply chain.

1. Introduction

Supply chain management (SCM) contributes the business organization to compete in the dynamic global market. Amidst fierce competition in all industries, SCM has gradually been embraced as a proven managerial approach to achieving sustainable profits and growth. This is accomplished primarily by focusing on the whole SCM process to deliver the right products or services, in the right quantity, to the right place, at the right time and with the maximum benefits. Numerous literatures suggest a need to examine the phenomena of SCM more closely to define clearly the term and concept, to identify those aspects that contribute to effective SCM, and to suggest how the adoption of an SCM approach can affect corporate strategies, plans, operations and performance.

The goal of SCM is to integrate activities across and within organizations for providing the customer value. This would also be applicable to the academia, which represents a type of non-profit organizations. One of the main goals of an educational supply chain is to the betterment of the end customer or the society. 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 (Integrated Tertiary Educational Supply Chain Management) 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 mainly focuses on application guidelines of ITESCM model for the universities those intend to enhance their supply chains.
2. Literature Review

The researchers investigate numerous literatures on SCM to shed lights on educational supply chain components and how they may be operated and integrated to achieve the goals. Though the researchers found a large number of papers and articles in SCM, however, most of them investigated supply chain management in the manufacturing sector [2], [13], [36], [37], [39], [43], [44], [49]-[53], [57]. Only a few addressed issues regarding SCM for the service industry [35], [42], [54]-[56], [59]. 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].

2.1 Three Decision Levels of SCM

According to the concept of three decision levels in SCM, this concept would be adopted in ITESCM model [34]. In educational management, three decision levels are involved in the process of the university:

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

i. Strategic Level (SL): 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.

ii. Planning Level (PL): Planning level decisions support strategic decisions. They tend to be medium range, medium importance, with moderate outcomes.

iii. Operating Level (OL): 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 Aspects in the Universities

To accomplish proper teaching and research works in the universities; different aspects have to need analyzed. Four aspects, namely faculty capabilities, facilities, programs establishment, university culture [23], [17], [18], [45], [46] would be demonstrated 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].

Researchers identified four main activities for the universities namely Education Development, Education Assessment, Research Development and Research Assessment in order to produce quality graduates and research outcomes.

Table 1. Examples of Education Development (E_d) for the Universities [16], [20]

<table>
<thead>
<tr>
<th>Decision Level</th>
<th>Programs Establishment (PE)</th>
<th>University Culture (UC)</th>
<th>Faculty Capabilities (FC)</th>
<th>Facilities (FA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic (SL)</td>
<td>School of Engineering, School of Business, School of Arts</td>
<td>Academic good governance by University council</td>
<td>Professors, associate professors</td>
<td>University’s academic and supportive facilities</td>
</tr>
<tr>
<td>Planning (PL)</td>
<td>Department of Electrical Engineering, Department of Finance, Department of Linguistics</td>
<td>Academic good plans by deans/program directors</td>
<td>Professors, associate professors, assistant professors, senior lecturers</td>
<td>School’s academic and supportive facilities</td>
</tr>
<tr>
<td>Operating (OL)</td>
<td>Majors in power systems, instrumentation and control, robotics</td>
<td>Academic good operations by faculty members</td>
<td>Assistant professors, lecturers</td>
<td>Department’s academic and supportive facilities</td>
</tr>
</tbody>
</table>

Table 2. Examples of Education Assessment (E_a) for the Universities [16], [20]

<table>
<thead>
<tr>
<th>Decision Level</th>
<th>Programs Establishment (PE)</th>
<th>University Culture (UC)</th>
<th>Faculty Capabilities (FC)</th>
<th>Facilities (FA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic (SL)</td>
<td>University’s academic assurance program</td>
<td>Management by objectives (MBO), University’s academic excellence</td>
<td>University’s academic faculty performance evaluation</td>
<td>University’s academic and supportive facilities quality assessment</td>
</tr>
<tr>
<td>Planning (PL)</td>
<td>School’s academic assurance program</td>
<td>School’s academic excellence</td>
<td>School’s academic faculty performance evaluation</td>
<td>School’s academic and supportive facilities quality assessment</td>
</tr>
<tr>
<td>Operating (OL)</td>
<td>Department’s academic assurance program</td>
<td>Department’s academic excellence</td>
<td>Department’s academic faculty performance evaluation</td>
<td>Department’s academic and supportive facilities quality assessment</td>
</tr>
</tbody>
</table>

Table 3. Examples of Research Development (R_d) for the Universities [16], [20]

<table>
<thead>
<tr>
<th>Decision Level</th>
<th>Programs Establishment (PE)</th>
<th>University Culture (UC)</th>
<th>Faculty Capabilities (FC)</th>
<th>Facilities (FA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic (SL)</td>
<td>Engineering research programs, business research programs, social research programs</td>
<td>University’s research orientation</td>
<td>Professors, associate professors</td>
<td>University’s research and supportive facilities</td>
</tr>
<tr>
<td>Planning (PL)</td>
<td>Electrical engineering, mechanical engineering, finance, operations research projects</td>
<td>School’s contract research programs and joint research programs</td>
<td>Professors, associate professors, assistant professors, researchers</td>
<td>School’s research and supportive facilities</td>
</tr>
<tr>
<td>Operating (OL)</td>
<td>Research topics - supply chain management, artificial intelligence</td>
<td>Innovative academic research projects enrollments by departments</td>
<td>Assist. professors, lecturers, researchers</td>
<td>Department’s research and supportive facilities</td>
</tr>
</tbody>
</table>
### Table 4. Examples of Research Assessment (R_A) for the Universities [16], [20]

<table>
<thead>
<tr>
<th>Decision Level</th>
<th>Programs Establishment (PE)</th>
<th>University Culture (UC)</th>
<th>Faculty Capabilities (FC)</th>
<th>Facilities (FA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic (SL)</td>
<td>University’s research quality assurance program</td>
<td>University’s research findings quality assessment, research excellence</td>
<td>University’s research faculty performance evaluation</td>
<td>University’s research and supportive facilities quality assessment</td>
</tr>
<tr>
<td>Planning (PL)</td>
<td>School’s research quality assurance program</td>
<td>School’s research environment assessment</td>
<td>School’s research faculty performance evaluation</td>
<td>School’s research and supportive facilities quality assessment</td>
</tr>
<tr>
<td>Operating (OL)</td>
<td>Department’s research quality assurance program</td>
<td>Department’s research excellence</td>
<td>Department’s research faculty performance evaluation</td>
<td>Department’s research and supportive facilities quality assessment</td>
</tr>
</tbody>
</table>

### 2.3 Education & Research Activities in the Universities

#### 2.3.1 Education Development (E_D) and Education Assessment (E_A)

Education development could be performed in terms of four aspects, namely programs establishment, university culture, faculty capabilities and facilities through launching the new programs based on the local and global demands, values of the university, faculty enrichment by teaching, research and community service, state of the art teaching facilities.

![Figure 2. Education & Research Activities in Universities](image)

- **University**
  - Education
  - Research
- **Assessment**
  - Academic Development
  - Research Development
- **Suppliers**
  - Education Suppliers
  - Research Suppliers
- **Graduates**
- **Research Outcomes**

The overall goal of assessment is to improve student learning in terms of education. Assessment provides students, parents or guardians, and teachers with valid information concerning student progress and their attainment of the expected curriculum.

Assessment measure whether or not learning and/or learning objectives are being met. Assessment requires the gathering of evidence of student performance over a period to measure learning and understanding. Effective faculty members will use assessment techniques regularly and on a daily basis to improve student learning and to guide instruction.

#### 2.3.2 Research Development (R_D) and Research Assessment (R_A)

Research development would be occurred through launching innovative internal and external research projects, promoting research environment by the university key personnel, recruiting research expertized faculty members, modern research facilities.

Assessment for research would be a review of conference and journal entries, written work, presentation, research papers, essays, story writing, tests, exams etc. and will display a sense of more permanent learning and clearer picture of a student's ability.

For assessing university education and research quality, different performance indicators may be developed to give information about the performance of an educational institution in different aspects of input, process, and outcome. Fig. 2 represents education and research development and assessment activities in the universities.

### 2.4 Modules of ITESCM Model [20]

In ITESCM model, students as well as internal and external projects are identified as raw materials. In contrast, graduates and research outcomes are recognized as finished products [10]. An integrated supply chain for the universities is illustrated in Fig. 3.

#### 2.4.1 Suppliers

In the conceptual model, the researcher identified two major parts in the suppliers, namely education suppliers and research suppliers for the universities [3], [22].

![Figure 3. Suppliers of the Universities](image)
**Education Suppliers:** Suppliers of the student (High school/college), suppliers of the faculty (other universities), self-funding students, source of fund family (parents, siblings), relatives, etc. government and private organizations (scholarship), suppliers of assets or equipment (furniture, computer, networking equipment, etc.), suppliers of educational materials (stationery, instruction materials, etc.).

**Research Suppliers:** Suppliers of internal research projects (university self-funding), suppliers of external research projects (external research funds, Ministry of education, private organizations, etc.).

**Figure 4.** An Integrated Supply Chain for the Universities

2.4.2 Service Provider

A university is regarded as a service provider in this paper. The researcher identified two major wings including development and assessment for both education and research in the university. Fig. 4 represents educational supply chain for the universities in four aspects, including programs establishment, university culture, faculty capabilities, and facilities, are considered for development and assessment in both education and research segment. The final outcomes of the university, i.e. graduates and research outcomes are delivered to the society [21].

2.4.3 Customers

In the conceptual model, the researcher identified two major parts in the customers namely education customers and research customers for the universities [11], [23].

**Education Customers:** Graduates, family (parents, siblings, relatives, etc.), employers of government and private organizations

**Research Customers:** Funding organizations of research projects, research outcomes (researchers, research publications, findings etc.), Others (research professional organizations - IEEE, INFORMS, ACM, Society of manufacturing engineers etc. and Trade associations -American trade association, Grocery manufacturers association, etc.).

**Figure 5.** Customers of the Universities

2.4.4 Consumer

The researcher identifies the society as the end customer or the consumer in this educational supply chain. As universities are the part of the society, the final outcomes of this supply chain, including graduates with desirable quality and quality research outcomes are delivered to the society [1], [8], [9], [18].

Fig. 6 illustrates an education supply chain and a research supply chain, which together form the tertiary educational supply chain for the universities to produce quality outcomes. The three decision levels including strategic, planning and operating level in the university have been explored in this research model. These three decision phases build up an integrated form of educational supply chain for the universities.

2.4.5 Final Outcomes

(i) Graduates with Desirable Quality

Graduates with desirable quality is one of the final outcomes in the educational supply chain management. Benchmarking and value enhancement determinants are identified and incorporated in the process of the university to produce graduates with desirable quality.

(a) Graduates benchmarking includes knowledge (tacit or explicit), skills, competencies, capabilities, ethics, career development programs, etc.

(b) Graduates value enhancement includes source of fund (self-funding, scholarship, etc.), wisdom, faculty capabilities, facilities, Information & Communication Technology (ICT), research involvements, etc.
(ii) Quality Research Outcomes

The authors defined another final outcome of the educational supply chain management is quality research outcomes. The university develops strategic plans for multidisciplinary research to maintain an emphasis on research as an important component of the academic mission of the university. Research outcomes may include problem solution, pure theory, internal and external projects applications, thesis findings, research publications, or research findings, etc.

2.5 Multiple Linear Regression (MLR) Equations of ITESCM [16], [48]

The ITESCM consists of 8 separate models, namely Education Development, Education Assessment, Graduates, Research Development, Research Assessment, Research Outcomes, Supplied Inputs, and Supplied Outputs. The following Multiple Linear Regression (MLR) equations have been come up from there through AMOS (Analysis of Moment Structure).

2.5.1 Model A - Education Development ($E_d$)

\[
E_d = 0.52E_{UP} + 0.49E_{UP} + 0.48E_{UP}
\]

\[
E_d = 0.63E_{UP} + 0.59E_{UP} + 0.57E_{UP}
\]

\[
E_d = 0.59E_{UP} + 0.63E_{UP} + 0.60E_{UP}
\]

\[
E_d = 0.65E_{UP} + 0.51E_{UP} + 0.50E_{UP}
\]

Where,

$E_{UP}$: Programs Establishment in Educational Development

$E_{UP}$: Strategic Level decisions at Programs Establishment in Educational Development

$E_{UP}$: Planning Level decisions at Programs Establishment in Educational Development

$E_{UP}$: Operating Level decisions at Programs Establishment in Educational Development

Figure 6. The Redesigned ITESCM Model [48]
2.5.2 Model B - Education Assessment ($E_A$)

$$E_{AUC} = 0.64E_{APE} + 0.57E_{UFC} + 0.56E_{FAE}$$  \hspace{1cm} (5)

$$E_{AUC} = 0.60E_{UFC} + 0.60E_{UFC} + 0.55E_{FCU}$$  \hspace{1cm} (6)

$$E_{FAE} = 0.49E_{FAC} + 0.51E_{FAC} + 0.48E_{FAE}$$  \hspace{1cm} (7)

$$E_{FAE} = 0.62E_{FAE} + 0.50E_{FAE} + 0.50E_{FAE}$$  \hspace{1cm} (8)

Where,

- $E_{APC}$: Programs Establishment in Educational Assessment
- $E_{APE}$: Strategic Level decisions at Programs Establishment in Educational Assessment
- $E_{UFC}$: Planning Level decisions at Programs Establishment in Educational Assessment
- $E_{FAE}$: Operating Level decisions at Programs Establishment in Educational Assessment
- $E_{UC}$: University Culture in Educational Assessment
- $E_{UCP}$: Strategic Level decisions at University Culture in Educational Assessment
- $E_{UFC}$: Planning Level decisions at University Culture in Educational Assessment
- $E_{FAE}$: Operating Level decisions at University Culture in Educational Assessment
- $E_{FG}$: Faculty Capabilities in Educational Assessment
- $E_{FGC}$: Strategic Level decisions at Faculty Capabilities in Educational Assessment
- $E_{FGC}$: Planning Level decisions at Faculty Capabilities in Educational Assessment
- $E_{FGC}$: Operating Level decisions at Faculty Capabilities in Educational Assessment
- $E_{FAC}$: Facilities in Educational Assessment
- $E_{FAC}$: Strategic Level decisions at Facilities in Educational Assessment
- $E_{FAE}$: Planning Level decisions at Facilities in Educational Assessment
- $E_{FAE}$: Operating Level decisions at Facilities in Educational Assessment

Table 5 Summary of Education Development ($E_d$)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Aspects</th>
<th>Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Development ($E_d$)</td>
<td>University Culture (UC)</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Faculty Capabilities (FC)</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Facilities (FA)</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Programs Establishment (PE)</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Table 6 Summary of Education Assessment ($E_A$)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Aspects</th>
<th>Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Assessment ($E_A$)</td>
<td>University Culture (UC)</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>Faculty Capabilities (FC)</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>Programs Establishment (PE)</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>Facilities (FA)</td>
<td>0.66</td>
</tr>
</tbody>
</table>

2.5.4 Model D - Research Development ($R_d$)

$$R_{APC} = 0.59R_{APC} + 0.47R_{APC} + 0.50R_{APC}$$  \hspace{1cm} (13)

$$R_{APC} = 0.64R_{APC} + 0.51R_{APC} + 0.62R_{APC}$$  \hspace{1cm} (14)

$$R_{APC} = 0.66R_{APC} + 0.52R_{APC} + 0.65R_{APC}$$  \hspace{1cm} (15)

$$R_{APC} = 0.59R_{APC} + 0.60R_{APC} + 0.50R_{APC}$$  \hspace{1cm} (16)

Where,

- $R_{APC}$: Programs Establishment in Research Development
- $R_{APC}$: Strategic Level decisions at Programs Establishment in Research Development
- $R_{APC}$: Planning Level decisions at Programs Establishment in Research Development
- $R_{APC}$: Operating Level decisions at Programs Establishment in Research Development
- $R_{APC}$: University Culture in Research Development
- $R_{APC}$: Strategic Level decisions at University Culture in Research Development
- $R_{APC}$: Planning Level decisions at University Culture in Research Development
- $R_{APC}$: Operating Level decisions at University Culture in Research Development

Graduates $= 0.97E_d + 0.92E_A$  \hspace{1cm} (11)
2.5.6 Model F - Research Outcomes

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

\[ R_r = 0.67R_{dPE} + 0.72R_{dUC} + 0.64R_{dFC} + 0.69R_{dFA} \]  
(22)

Research Outcomes = 0.99R_d + 0.89R_r  
(23)

Table 7 Summary of Research Development (R_d)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Aspects</th>
<th>Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development (R_d)</td>
<td>University Culture (UC)</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>Facilities (FA)</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Faculty Capabilities (FC)</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Programs Establishment (PE)</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Table 8 Summary of Research Assessment (R_r)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Aspects</th>
<th>Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment (R_r)</td>
<td>Faculty Capabilities (FC)</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>University Culture (UC)</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Facilities (FA)</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>Programs Establishment (PE)</td>
<td>0.67</td>
</tr>
</tbody>
</table>

2.5.7 Model G - Supplied Inputs

\[ F_{University} = 0.41\, \text{Students} + 0.38\, \text{Research\,Projects} \]  
= 0.41 [0.13 EducationSuppliers] + 0.38 [0.23 ResearchSuppliers] + 0.05EducationSuppliers + 0.09ResearchSuppliers  
(25)

2.5.8 Model H - Supplied Outputs

\[ F_{Society} = 0.61\, \text{Education\,Customers} + 0.61\, \text{Research\,Customers} \]  
= 0.61 [0.34Graduates] + 0.61 [0.15ResearchOutcomes]  
(26)

2.5.9 Overall Model

The equation of overall model (27) of ITESCM has been evolved after combining all equations (1 to 26) of eight separate models.

\[ F_{Society} = 0.61\, \text{Education\,Customers} + 0.61\, \text{Research\,Customers} \]  
= 0.61 [0.34Graduates] + 0.61 [0.15ResearchOutcomes]
Figure 7. AMOS Graphics Output of Overall Model (Standardized Estimates)

\[ \text{Graduates} = 0.21 \text{Graduates} + 0.09 \text{ResearchOutcomes} \]

\[ = 0.21[0.97E_d + 0.92E_d] + 0.09[0.99R_d + 0.89R_d] \]

\[ = 0.20E_d + 0.19E_d + 0.09R_d + 0.08R_d \]

\[ F_{\text{Society}} = [0.126E_{dPE} + 0.14E_{dUC} + 0.13E_{dBC} + 0.126E_{dFA} + 0.129E_{dPE} + 0.141E_{dUC} + 0.131E_{dPC} + 0.125E_{dFA}] + \]

\[ [0.054R_{dPE} + 0.064R_{dUC} + 0.057R_{dBC} + 0.06R_{dFA}] \]

\[ + [0.054R_{dPE} + 0.058R_{dUC} + 0.059R_{dPC} + 0.055R_{dFA}] \]

\[ = 0.032R_{dPE} + 0.038R_{dPC} + 0.032R_{dPC} + 0.038R_{dFA} \]

Modification Indices (MI) should be considered only if it makes theoretical or common sense, chi-square value between 2 and 3, GFI (Goodness Fit Index) and CFI (Comparative Fit Index) value between 0.9 and 1 and significant relationships [1]. Therefore, we can improve the overall model by using the highest Modification Indices (MI) that would make sense.

**Table 9** Highest Modification Indices in Overall Model

<table>
<thead>
<tr>
<th>Suggested Relationships of ITESCM</th>
<th>Modification Indices (MI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Assessment &amp; Research Assessment</td>
<td>102.394</td>
</tr>
<tr>
<td>Education Assessment &amp; Research Development</td>
<td>98.128</td>
</tr>
<tr>
<td>Research Customers &amp; Education Customers</td>
<td>59.42</td>
</tr>
<tr>
<td>Education Customers &amp; Research Customers</td>
<td>51.395</td>
</tr>
<tr>
<td>Research Customers &amp; Research Suppliers</td>
<td>32.4</td>
</tr>
<tr>
<td>Graduates &amp; Research Suppliers</td>
<td>25.54</td>
</tr>
<tr>
<td>Research Outcomes &amp; Research Suppliers</td>
<td>23.939</td>
</tr>
<tr>
<td>Education Development &amp; Research Development</td>
<td>23.783</td>
</tr>
<tr>
<td>Education Development &amp; Research Assessment</td>
<td>20.051</td>
</tr>
</tbody>
</table>

MLR equations of eight separate models of ITESCM were mathematically formulated and eventually synthesized into an overall model. Fig. 5 illustrates overall model of ITESCM. By using Modification Indices (MI) of AMOS, different relationships were added that was formed into updated overall model. [20]

Fig. 8 denotes overall updated model after modification through highest modification indices as of Table 8.

3. **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. In full launch survey, total 493
respondents were participated through email and self-administered process. Among of them, 174 respondents were experts (35%) in university administration, faculty, staff, 166 respondents were graduates (34%), and 153 respondents were employers (31%). Totally 493 respondents from all stakeholders, including experts, faculty, staffs, graduates and employers, out of 3421 respondents are usable (14.41%).

Based on the survey research techniques, the resulting model was evaluated for accuracy and validity by the Structural Equation Modeling (SEM) technique through AMOS. The findings of the ITESCM model have been formulated through the application guidelines for real life application that would be fruitful for the prospective investors and current university administrators.

4. Application Guidelines from Research Findings [20], [30]
In this research, the ultimate goals of the study are the quality graduates and quality research outcomes. SEM technique was applied to define aspects that affect the integrated educational supply chain management model. This research is focused on the universities and all stakeholders, including experts in university administration, faculty members, staff, employers and graduates, accomplished the survey. As per Equation (28), regression coefficients and ITESCM aspects were descended in the Table 10.

### Table 10. Ranked Order of Significant Aspects in ITESCM [20]

<table>
<thead>
<tr>
<th>ITESCM Aspect</th>
<th>Regression Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>University Culture in Educational Assessment (E_{uc})</td>
<td>0.141</td>
</tr>
<tr>
<td>University Culture in Educational Development (E_{ud})</td>
<td>0.13</td>
</tr>
<tr>
<td>FacultyCapabilities in Educational Assessment (E_{fa})</td>
<td>0.125</td>
</tr>
<tr>
<td>Programs Establishment in Educational Assessment (E_{pe})</td>
<td>0.064</td>
</tr>
<tr>
<td>Programs Establishment in Educational Development (E_{pd})</td>
<td>0.059</td>
</tr>
<tr>
<td>Facilities in Educational Development (E_{fd})</td>
<td>0.057</td>
</tr>
<tr>
<td>Facilities in Research Development (R_{rd})</td>
<td>0.055</td>
</tr>
<tr>
<td>Programs Establishment in Research Assessment (R_{pra})</td>
<td>0.054</td>
</tr>
</tbody>
</table>

The recommendations of this study are as follows:

- To foster good governance in the tertiary educational institutions, selection of key executives is very important. In order to develop the university as center of excellence in the society, key executives must possess some characteristics like visionary, ethical, high potentiality, high capability, etc. In fact, university culture is the prime mover for other aspects, including programs establishments, faculty capabilities, and facilities in the universities.
- From research findings, university culture enhances education development and assessment in the universities to produce quality graduates.
Therefore, university management or university council would be revised to review their performance for further improvements. In that case, good governance would be highly recommended for the universities.

- From research findings, University culture in education development and assessment is highly contributed to the society. In other words, graduates are highly contributed to the society. By the good governance, university culture could produce quality graduates through proper academic development and academic quality assessment for the well-being society.

- Faculty members’ recruitment is the key factor in the universities to produce quality graduates. The office of human resource management could select the faculty members not only based on the academic performance, but also provide attention towards other capabilities like potentiality, ethical, motivation, controlling, knowledgeable, research involvements, etc.

- Different programs establishment in the universities depends on the demand of the society. In that case, universities must have provision for regular monitoring the feasibility of different new programs based on the respective country and global perspectives. Diversification in programs establishment would be fruitful for the students to build up their careers in different fields, which they like.

- From the research findings, university culture and facilities are highly contributed to the research development, and faculty capabilities enhance research assessment in the universities to produce quality research outcomes. Therefore, university management must provide all facilities, including online databases, digital libraries, journals, etc. for the research projects and engage those faculty members who have expertise in research.

- University must ensure modern teaching facilities for the students. Libraries, classroom facilities, laboratory facilities, online facilities, international publications, etc. are mandatory for any university, however, admission center for the new students, recreation center, refreshments, residence hall, etc. are also recommended for the universities.

- As ethics is the identified as benchmarking for the graduates in this study, therefore, university must have Ethics Center. This center will circulate ethics seminar, ethics courses, etc. to the students as the mandatory to complete the graduation.

- To produce quality graduates, education assessment would evaluate the students through proper academic development. Quality assurance center would assess the quality of the graduates in terms of different performance indicators through quality assessment strategies and plans.

- As research involvements are one of value enhancements for the graduates, however, research suppliers have to be related with the graduates to ensure the type of the research projects that able to enhance the quality of the graduates. Different research projects of internal and external research suppliers would enlighten the quality of the graduates.

- Universities, specially teaching based universities, would provide high priority to the research projects. Universities could arrange different international conferences in the universities through various professional organizations, which would enhance the students to involve in the research.

- From the findings, students and research suppliers are highly contributed to the universities. Therefore, universities should have prerequisite, like entrance exam or admission test, to justify the quality of intake students. Universities must have good communication with internal and external research suppliers to receive research projects in order to produce quality research outcomes. Different professional organizations, one of the external research suppliers, would be fruitful as research suppliers for the universities.

- In research supply chain, the relationships between research suppliers and research outcomes will enhance research projects in the university. In order to produce quality research outcomes, research suppliers monitor research development and consequently research outcomes. Therefore, universities must set up research center to coordinate the different entities in the research supply chain. Universities research center would follow up the research developments to make sure the quality research outcomes for the research customers.

- To produce quality research outcomes, research assessment would evaluate the research projects through proper research development. Therefore, universities should have strategies and plans to assess the performance of the internal and external research projects through research center.

- As research development, education development, research assessment and education assessment could influence each other, therefore, these activities would be monitored concurrently in the universities to produce the quality outcomes.

- The mutual relationships would be developed between research development and education development, research assessment and education assessment, research assessment and education development, research development and education assessment. These components could influence each other to produce quality graduates and research outcomes by the universities.
• The relationship between education customers and research customers would be possible since they have significant influence on each other. In fact, these relationships among the variables would develop the link between education supply chain and research supply chain in the universities. As university’s performance depends on the quality graduates and quality research outcomes, therefore, the mutual interaction between different components of education supply chain and research supply chain would be highly appreciated.

• University should arrange the survey in order to justify the stakeholders’ satisfaction in the education supply chain. Universities could invite employers, one of the education customers, to convey their requirements to the prospective graduates. Different career development programs, one of the components in graduates benchmarking, including seminars, workshops, industrial tour job fair, etc. would be fruitful in that case.

5. Implications of ITESCM Model

Integrated Tertiary Educational Supply Chain Management (ITESCM) model was developed by Habib in 2009 [8], [9]. 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 the researcher chooses the highest value (5, strongly agree of 5 point Likert Scale) for each function in equation (27), in that case, the maximum value of \( F_{\text{Society}} \) will equal to 7.545. On the other hand, if the author selects the lowest value (1, strongly disagree of Likert Scale) for each function in the equation, in that case, the minimum value of \( F_{\text{Society}} \) will equal to 1.509. [45], [46]

According to the ITESCM model university administrator could find out their university outcomes by the following equation. From equation (27), the value of \( F_{\text{Society}} \) would come up [45], [46].

\[
F_{\text{University Outcomes}}(\%) = \frac{F_{\text{Society}} - 1.509}{7.545 - 1.509} \times (100 - 0)
\]

(28)

The resulting suitability index, in equation (28) ranges from 0% to 100% with 100% being the most suitable (excellent) and 0% being the least favorable (worst). The researchers defined \( F_{\text{University Outcomes}} \) in terms of different scale like excellent, very good, good, moderate, bad, very bad, worst through percentages that was defined in Table 11. The index of at least 50% may serve as a rough acceptance criterion for the well-being society. [9], [46].

Table 11. Suitability index of \( F_{\text{University Outcomes}} \)

<table>
<thead>
<tr>
<th>Range of ( F_{\text{Society}} )</th>
<th>( F_{\text{University Outcomes}} ) (%)</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{\text{Society}} = 7.545 )</td>
<td>100</td>
<td>Excellent</td>
</tr>
<tr>
<td>( 6.3378 &lt; F_{\text{Society}} &lt; 7.545 )</td>
<td>Above 80 to below 100</td>
<td>Very Good</td>
</tr>
<tr>
<td>( 5.1306 &lt; F_{\text{Society}} \leq 6.3378 )</td>
<td>Above 60 to 80</td>
<td>Good</td>
</tr>
<tr>
<td>( 3.9234 &lt; F_{\text{Society}} \leq 5.1306 )</td>
<td>Above 40 to 60</td>
<td>Moderate</td>
</tr>
<tr>
<td>( 2.716 &lt; F_{\text{Society}} \leq 3.9234 )</td>
<td>Above 20 to 40</td>
<td>Bad</td>
</tr>
<tr>
<td>( 1.509 &lt; F_{\text{Society}} \leq 2.716 )</td>
<td>Below 20</td>
<td>Very Bad</td>
</tr>
<tr>
<td>( F_{\text{Society}} = 1.509 )</td>
<td>0</td>
<td>Worst</td>
</tr>
</tbody>
</table>

6. Conclusion

It is an amazing fact that researchers develop supply chain management models mostly for improving business operations in profitable organizations. Few, particularly academic researchers, do not realize that the research on academic SCM may also be conducted for their own educational institutions [20], [28]. ITESCM, Integrated Tertiary Education Supply Chain Management, 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.

The applicability of the model can be confirmed empirically. However, model evaluation by actual implementation is suggested for prospective investors or current university administrators. University outcomes would be derived by the University management through equation (28) and expressed in terms of different scale for further improvement. The current decision makers may apply the research equations of Integrated Tertiary Educational Supply Chain Management (ITESCM)
model for their universities to enhance their supply chain operations.

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References


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