Evaluation of Product & Process Innovation Performance: An education sector perspective with ERP implementation

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Abstract: The key to an advanced future of developing countries like India passes through technological and commercial innovation. ERP has been coded as one of the most noteworthy high-tech advances to develop during the past decade and various researchers consider development and implementation of ERP systems among the major IT innovations. Evaluation of Product & Process Innovation Performance (PPIP) is a critical issue related to innovation management research (Blindenbach et al. 2010). This study was projected to develop and validate a measurement scale for product & process innovation performance for ERP systems comprising five dimensions: technical performance, financial performance, strategic performance, market performance and customer performance.

Introduction
Rapid technological changes dominate the new global context with shrinking product life cycles, increasing customer demands, increase in productivity and quality requirements and fierce global competition comprising the new globalized environment (Evanschitzky et al., 2012). Technological and commercial innovation is becoming key to the future of developing countries like India in an era of globalization and fiscal and demographic constraints. Most innovation is messy that involves false starts, recycling between stages, jumps out of sequence and dead ends.

According to Garcia-Muina et al. 2009, technological innovation has been regarded as a key element to maintain and improve competitive advantages. In order to achieve product innovation performance, firms require a deep understanding of innovation dynamics, well thought innovation strategy, well-defined process of innovation strategy implementation, and above all profound tools to measure innovation performance (Hannachi, 2015). Evaluation and validation of Product & Process Innovation Performance is a critical issue related to innovation management research (Blindenbach et al. 2010). According to Cedergen et al. 2010, Product Innovation Performance (PIP) measurement is gaining importance due to its effectiveness and efficiency that not only determines an organization’s competitive advantage, but also its very survival. Given the importance of product innovation performance, its measurement is a daunting challenge. In fact, a relevant measurement instrument of Product and Process Innovation Performance is required by both the researchers and managers. (Alegre et al. 2006).

The continuous development and implementation of ERP systems has been considered by many researchers and practitioners among the major IT innovations in last decade. Jalal [2011] describes ERP as one of the most significant technological advances to emerge during the last decade. The systems are being widely
implemented by organizations to enhance productivity through integration and automation and increase overall performance of the business. According to Davenport (2000), ERP (enterprise resource planning systems) comprises of a commercial software package that promises the seamless integration of all the information flowing through the company—financial, accounting, human resources, supply chain and customer information. A large number of multinationals have either adopted ERP systems or are in the process of adopting these systems. The reason behind this growth is the fact that ERP systems hold the promise of improving business performance and decreasing operational costs. A successfully implemented ERP systems provides integrated business processes and linking of different areas of an organization like Human Resource, Manufacturing, Financial systems, suppliers and customers. The aim of this paper is to develop and validate a measurement scale for measuring PPIP for ERP systems.

**Literature review**

The PPIP is a broad concept, hence its measurements are quite heterogeneous. This can be presented from many points of view: commercial, financial, technical, etc. Given that the primary goal of a product or process innovation is profit generation, the most used criteria by firms to assess performance are based on financial and market aspects (Suomala, 2004). It was seen that objectives/effects of product innovation include: improved loyalty of existing customers, improvement of the company image, growth into new markets, etc. (Storey and Easingwood, 2009). These authors argued that these effects are of considerable importance to a firm. Some empirical research found that some criteria such as customer satisfaction, reputation and competitive advantage produced, despite being considered by managers to be the most useful, are rarely mobilized as measures in reality (Driva et al. 2000). Calik and Barudeen (2016) focused on sustainable innovation and proposed a model for measuring sustainable innovation in manufacturing sector. The authors defined their boundaries, they focused on product/process innovation, for economic, environmental and societal aspects.

Blindenbach et al. (2010) defined product innovation performance as the combination of two dimensions: operational & product performance. “Product performance evaluates the commercial outcome of an innovation project whereas operational performance reflects how the innovation project was executed” (Blindenbach et al. 2010, p. 574). The first dimension comprises financial and market aspects like adherence to profit & growth targets, market share targets, competitive advantage, and customer satisfaction. The second dimension includes adherence to schedule and budget targets and quality. Cooper and Kleinschmidt (1995) found that product innovation measures produced three dimensions, the first is financial performance that includes profitability, payback period, sales, and profits. The second is market impact and is measured by domestic market share & foreign market share. The last is termed as ‘opportunity window’ that groups new categories of products and a window on new markets. Hsu and Fang (2009) identified four dimensions of product innovation performance: Customer performance (customer acceptance, customer satisfaction); Market performance (revenue, market forecast accuracy, market share, etc.); Product performance (quality,
competitive advantages, and timely launch) and Financial performance (overall profitability and return on investment). Hannachi, 2015 combined the existing literature on product innovation performance and came forward with a list of twenty-eight items that formed their basis of generating a new scale. The scales presented in the table formed the basis of the qualitative test which aimed to choose the appropriate terminology to adopt and include their corresponding items to their product innovation performance scale.

**Model Development**

The proposed model was developed combining Hannachi, 2015 & Calik and Barudeen, 2016, thus covering both product and process innovation with regards to ERP systems. The model was designed to measure innovation performance of ERP systems in education sector and it comprises of PPIP as a second order variable with 6 dimensions: financial performance, technical performance, market performance, customer performance, strategic performance. The financial performance comprises of the attributes related to profits and return on investment whereas technical performance includes the service quality, information quality, advantage and timelines. In ERP systems implemented in education sector the market performance will measure their objective fulfilment and comparative analysis. The customers in this case are the end users of ERP systems. The term ‘end users’ or the ‘direct users’ refers to someone who actually uses the product. In information systems the end user is the person for whom the product has been actually designed/programmed by the developers. An educational institution is being influenced by different types of users. In this study the end users are taken as the persons who use the ERP systems. These users include the staff and students of the educational institution. This dimension measures their satisfaction level, acceptance and their complaints regarding use of ERP systems. The strategic dimension gives measurement for achievement of strategic goals of the organization. The proposed model is shown in fig 2.
Methodology

The quantitative approach for research was followed. A 13-item scale based questionnaire was designed on five point Likert Scale. Table 2 shows the thirteen items and their corresponding dimensions. The aim of the study was to measure innovation performance of ERP systems in educational institutes. Educational institutes of Punjab, which have implemented and have been using ERP systems was taken as the study sample. Data was collected through survey instrument that comprised of two sections (Appendix A). The first section includes the demographic information about the educational institute and the second includes the 13 item PPIP instrument that was designed on five point Likert scale with 1 representing strongly agree to 5 representing strongly disagree. The respondents were the persons who were involved with management of these institutes and had information regarding all the financial, technical and operational aspects of their educational institute. A total of 12 educational institutes were considered on the basis of their willingness and the anonymity of the respondent was guaranteed.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Performance</td>
<td>Using ERP system has achieved the objectives set in terms of profit</td>
</tr>
<tr>
<td></td>
<td>Using ERP system has achieved objectives in terms of Return on Investment</td>
</tr>
<tr>
<td></td>
<td>Profits attributable to use of ERP systems are higher than earlier management systems</td>
</tr>
<tr>
<td>Technical Performance</td>
<td>ERP system provides better service quality than earlier management systems</td>
</tr>
<tr>
<td></td>
<td>ERP system provide better information quality than earlier management systems</td>
</tr>
<tr>
<td></td>
<td>Using ERP systems adheres to functional timelines</td>
</tr>
<tr>
<td>Market Performance</td>
<td>ERP system help us to achieve objectives in terms of educational processes</td>
</tr>
<tr>
<td></td>
<td>Compared to earlier management systems, ERP system has achieved superior results in terms of educational processes</td>
</tr>
<tr>
<td>Customer Performance</td>
<td>Customers (end users) are satisfied with performance of ERP systems</td>
</tr>
<tr>
<td></td>
<td>Compared to earlier management systems, customers (end users) have less complaints regarding ERP systems</td>
</tr>
<tr>
<td>Strategic Performance</td>
<td>ERP systems have given a competitive advantage to our educational institute</td>
</tr>
<tr>
<td></td>
<td>ERP systems have reached all the set goals</td>
</tr>
<tr>
<td></td>
<td>ERP systems have improved the reputation of educational institute</td>
</tr>
</tbody>
</table>

Table 2: Dimensions of PPIP scale (adopted from Hannachi, 2015)

Data Analysis
Out of the 48 questionnaire (4 for each institute) distributed, 38 were returned and eliminating missing information responses, 33 were taken forward for the analysis. Anderson and Gerbing (1998) two-step approach were followed, where firstly the measurement model is analyzed to test reliability and validity of the instrument and secondly the structural model is analyzed to test the research hypotheses. The data analysis was carried out using structural equation modelling (SEM) technique. According to Ringle et al. (2005), structural equation modelling has been used with numerous statistical models that are used in evaluating validity of substantive theories with empirical data. The proposed theoretical model in this study was tested using SmartPLS (v.3.2.4) software (Ringle et al. 2015).

Among the twelve institutes that were surveyed, about 50% of them have been using ERP systems from the past 1 year and about 41% have used it from the past 1-2 years. Only one institute has been using it for the past 2-3 years. This clearly reflects that ERP systems implementation is new in this sector and is surely
gearing up. 9 out of the 12 institutes are offering post graduate courses while only 2 of them offer doctoral degree. The average numbers of users of ERP systems in each institute is around 3000 which includes the administrative staff, teaching staff and the students. Most of the institutes have opted for customized ERP solutions from local vendors while one of them has inbuilt its system. Student management (that includes timetable, examination, database, results & grading) has been the most commonly implemented module followed by fee and payments.

**Results and Discussion**

Cronbach Alpha was used to test the reliability of the instrument that measures how well a set of items measure a single one-dimensional construct. In most of social sciences research, a reliability coefficient of 0.60 or above is considered to ‘acceptable’. Table 1 shows the reliability results and all constructs exhibit Cronbach’s alpha greater than 0.7. Although Cronbach’s alpha is most frequently used to measure reliability, the better estimate of reliability is given by composite reliability. According to Skerlavaj (2007), no single benchmark is available for minimum acceptable value of composite reliability. Hair (1998) considers, a value of 0.7 acceptable values. According to Fornell and Larcker (1981), if AVE is < 0.5 but composite reliability is >0.6, then the convergent validity of the construct is still adequate. Table 1 shows Composite reliability, average variance extracted (AVE) and factor loadings for all items.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Item</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Cronbach Alpha</th>
<th>AVE</th>
<th>CR</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Performance</td>
<td>FP1</td>
<td>2.76</td>
<td>.867</td>
<td>.792</td>
<td>.879</td>
<td>.709</td>
<td>.913</td>
</tr>
<tr>
<td></td>
<td>FP2</td>
<td>2.67</td>
<td>.645</td>
<td></td>
<td></td>
<td></td>
<td>.736</td>
</tr>
<tr>
<td></td>
<td>FP3</td>
<td>2.85</td>
<td>.795</td>
<td></td>
<td></td>
<td></td>
<td>.866</td>
</tr>
<tr>
<td>Technical Performance</td>
<td>TP1</td>
<td>2.27</td>
<td>.876</td>
<td>.929</td>
<td>.955</td>
<td>.876</td>
<td>.951</td>
</tr>
<tr>
<td></td>
<td>TP2</td>
<td>2.18</td>
<td>.950</td>
<td></td>
<td></td>
<td></td>
<td>.948</td>
</tr>
<tr>
<td></td>
<td>TP3</td>
<td>2.64</td>
<td>.929</td>
<td></td>
<td></td>
<td></td>
<td>.907</td>
</tr>
<tr>
<td>Market Performance</td>
<td>MP1</td>
<td>2.09</td>
<td>.947</td>
<td>.925</td>
<td>.963</td>
<td>.930</td>
<td>.958</td>
</tr>
<tr>
<td></td>
<td>MP2</td>
<td>2.24</td>
<td>.969</td>
<td></td>
<td></td>
<td></td>
<td>.970</td>
</tr>
<tr>
<td>Customer Performance</td>
<td>CP1</td>
<td>2.76</td>
<td>1.00</td>
<td>.930</td>
<td>.966</td>
<td>.934</td>
<td>.964</td>
</tr>
<tr>
<td></td>
<td>CP2</td>
<td>2.79</td>
<td>1.05</td>
<td></td>
<td></td>
<td></td>
<td>.969</td>
</tr>
<tr>
<td>Strategic Performance</td>
<td>SP1</td>
<td>2.21</td>
<td>.927</td>
<td>.900</td>
<td>.937</td>
<td>.833</td>
<td>.905</td>
</tr>
<tr>
<td></td>
<td>SP2</td>
<td>2.58</td>
<td>.792</td>
<td></td>
<td></td>
<td></td>
<td>.889</td>
</tr>
<tr>
<td></td>
<td>SP3</td>
<td>2.09</td>
<td>.914</td>
<td></td>
<td></td>
<td></td>
<td>.944</td>
</tr>
</tbody>
</table>
As can be seen, all the items have significant values for Cronbach alpha, composite reliability, average variance extracted and factor loadings. Campbell and Fiske (1959) introduced the concept of discriminant validity to test that the constructs that should not be related are not related. Discriminant validity was examined comparing the square roots of AVE with the factor correlation coefficients based on the criteria by Fornell and Larcker (1981). The results of discriminant validity shown in Table 2 highlight that the two factors are statistically different. The results of the model reflect that the model has good reliability (construct reliability and indicator reliability) and validity (convergence validity and discriminant validity).

<table>
<thead>
<tr>
<th>Dimension Relationship</th>
<th>Path Coefficient</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPIP- FP</td>
<td>.520</td>
<td>.270</td>
</tr>
</tbody>
</table>

Table 2: Discriminant validity
Table 3: Discriminant Validity and Cross Loadings

<table>
<thead>
<tr>
<th></th>
<th>PPIP-TP</th>
<th>PPIP-MP</th>
<th>PPIP-CP</th>
<th>PPIP-SP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.621</td>
<td>.571</td>
<td>.536</td>
<td>.696</td>
</tr>
<tr>
<td></td>
<td>.385</td>
<td>.326</td>
<td>.288</td>
<td>.485</td>
</tr>
</tbody>
</table>

**Discussion and Conclusion**

The PPIP scale has shown a high reliability index and the scale has been validated that can be measured by five first order constructs and one second order construct. In other words, PPIP is a second-order construct that strongly determines its five dimensions (financial performance, technical performance, market performance, strategic performance and customer performance). Validation of the PPIP scale as a multidimensional concept is in line with the work of Alegre et al. (2006) and Hannachi (2015) who tested the scale with biotechnology firms in France. Also the scale mobilizes the three dimensions that were proposed by Griffin and Page (1996) and includes the fourth dimension of Market performance that was proposed by Hsu and Fang (2009). A fifth dimension of ‘strategic performance’ proposed by Hannachi (2015) was also considered. Thus, the results are in consistence with previous literature on innovation management: they show that financial performance, technical performance, market performance, customer performance and strategic performance can be considered as complementary dimensions of innovation performance. The emergence of strategic performance as strongest indicator for measuring innovation performance of ERP systems indicates the important role of strategic decisions in implementing ERP systems.

The stability and validity of the scale should be checked with other industries and other countries. This scale could be used for further research on innovation performance measurement. The work also provides managerial contributions and since the aim of the scientific validation of a measurement instrument or a model is its future use with a confidence that it is based on a well-established theory, the managers could use this scale in setting innovation products performance targets. This scale could be also adopted as a post implementation evaluation instrument to assess PPIP for ERP systems. Such evaluation will pinpoint the necessary changes by determining strengths and weaknesses of ERP innovation. The results have to be viewed in the light of limitations of research. Since the study took place considering the ERP in education sector only, hence further research is required to achieve generalization of results.

**References:**


### APPENDIX A

**QUESTIONNAIRE**

Dear Participant,

You are invited to participate in the research survey regarding the ERP system implemented in your institute. The research aims to measure the innovation performance of ERP systems. This survey is purely for research purpose and your identity would be kept anonymous. Please spare a few minutes of your valuable time to answer this simple questionnaire. The complete questionnaire has been divided into two parts. The first part comprises details of the educational institute followed by the second part which includes your opinions regarding the ERP system implemented at your campus.
Part I:

- Name:  

- Designation:  

- Name of Institute:  

- Number of years of using ERP systems  
  - Less than 1  
  - 1-2 years  
  - 3-5 years  
  - More than 5  

- Highest Level of courses taught at institute  
  - High School  
  - Bachelor’s Degree  
  - Master’s Degree  
  - Doctoral Degree  
  - If Others (please specify) -  

- Approximate number of users of ERP system within the organization:  

- Name of ERP service provider:  

- Modules being used within the organization: (you can select multiple options)  
  - Finance  
  - Purchase/Inventory  
  - Admissions  
  - Marketing  
  - Faculty and staff management  
  - Exams and Grading  
  - Student management  
  - Fee and scholarship  
  - Transport/vehicle management  
  - Payroll management  
  - Timetable/attendance management  
  - Event management  
  - E-learning system  
  - Library management  
  - Hostel management
Part II:

The following questions are based upon five point Likert scale. Kindly select only one option that you consider appropriate.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Using ERP system has achieved the objectives set in terms of profit</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2</td>
<td>Using ERP system has achieved objectives in terms of Return on Investment</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3</td>
<td>Profits attributable to use of ERP systems are higher than earlier management systems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4</td>
<td>ERP system provides better service quality than earlier management systems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5</td>
<td>ERP system provide better information quality than earlier management systems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>6</td>
<td>Using ERP systems adheres to functional timelines</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>7</td>
<td>ERP system help us to achieve objectives in terms of educational processes</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>8</td>
<td>Compared to earlier management systems, ERP system has achieved superior results in terms of educational processes</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>9</td>
<td>Customers (end users) are satisfied with performance of ERP systems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>10</td>
<td>Compared to earlier management systems, customers (end users) have less complaints regarding ERP systems</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>11</td>
<td>ERP systems have given a competitive advantage to our educational institute</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>12</td>
<td>ERP systems have reached all the set goals</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>13</td>
<td>ERP systems have improved the reputation of</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
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<tr>
<td>educational institute</td>
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<tr>
<td>14 ERP systems are high innovation in terms of product and process performance</td>
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Thank you for your valuable response