WWW.JAQM.RO

JOURNAL OF APPLIED QUANTITATIVE METHODS

Quantitative Methods Inquires

Vol. 10
No. 4
Winter
2015

ISSN 1842–4562

JAQM Editorial Board

JAQM Advisory Board

Contents

JOURNAL OF APPLIED QUANTITATIVE METHODS

Quantitative Methods Inquires

MULTI-CRITERIA GROUP DECISION MAKING IN INTUITIONISTIC FUZZY ENVIRONMENT BASED ON GREY RELATIONAL ANALYSIS FOR WEAVER SELECTION IN KHADI INSTITUTION[1]

Partha Pratim DEY

E-mail:

Surapati PRAMANIK
PhD, Department of Mathematics,
Nandalal Ghosh B.T. College, India

E-mail: sura_pati@yahoo.co.in

Bibhas C. GIRI

E-mail:

Abstract

The objective of this paper is to present multi-criteria group decision making in intuitionistic fuzzy environment based on grey relational analysis for weaver selection in Khadi institution. Weaver selection is a group decision making process involving qualitative and quantitative criteria. Intuitionistic trapezoidal fuzzy weighted arithmetic average operator and intuitionistic trapezoidal fuzzy weighted geometric average operator are employed to aggregate individual opinions of Khadi experts into a group opinion. In the selection process, criteria and weights of the criteria are obtained from Khadi domain experts. The importance of the Khadi experts is presented by linguistic variables that can be expressed by intuitionistic trapezoidal fuzzy numbers. Normalized weights of Khadi experts are determined by expected weight value. The rating of an alternative with respect to certain criteria considered by Khadi experts is characterized by linguistic variable that can be represented by intuitionistic trapezoidal fuzzy number. Finally, grey relational analysis is applied for ranking and selection of alternatives to constitute a panel of selected weavers. The effectiveness of the proposed approach is illustrated through a numerical example for weaver selection.

Key words: grey relational analysis, grey relational coefficient, intuitionistic trapezoidal fuzzy number, multi-criteria group decision-making, weaver selection

1. Introduction

Khadi refers a handspun or woven material made up from cotton, silk and woolen yarn, which is a mixture of any two or all such yarns [1]. The Khadi industry occupies a significant role in ensuring employment opportunities and economic growth in India. It is important to note that it generates production at low capital cost, promotes the use of local materials, uses local skills and prevents the migration of labour force to the other districts or States. Khadi products are made by the weavers under institutions registered under Societies/ Charitable Trust/ Co-operatives Act or Khadi institutions under the Khadi Mahajan (Owner of Khadi institution). A Khadi institution needs sufficient number of efficient weavers for continuous production for smooth running of the organization. Selecting suitable weavers is a very challenging task.

Atanassov [2] introduced the concept of intuitionistic fuzzy sets which is a generalization of fuzzy sets [3], proposed by Zadeh in 1965. Deng [4] originally developed grey relational analysis (GRA) method for group decision analysis in 1989. GRA has been widely applied to multi-criteria group decision making (MCGDM) problems, where the data set are discrete in nature and information regarding attribute values is incomplete or sometimes unknown. Zhang and Liu [5] developed a GRA based intuitionistic fuzzy MCGDM method for personnel selection. Pramanik and Mukhopadhyaya [6] presented GRA based intuitionistic fuzzy MCGDM approach for teacher selection in higher education. Recently, Baskaran et al. [7] discussed the application of the grey approach for Indian textile suppliers' sustainability evaluation based on the selected sustainable criteria.

In the present study, we have presented an intuitionistic trapezoidal fuzzy MCGDM model with GRA for weaver selection in Khadi institution.

Rest of the paper is organized as follows. In Section 2, we present preliminaries of intuitionistic trapezoidal fuzzy numbers (ITFNs) and transformation between linguistic variables and ITFNs. Section 3 presents operational definition regarding weaver selection. Section 4 describes GRA. Section 5 is devoted to present intuitionistic trapezoidal fuzzy MCGDM based on GRA. Section 6 provides relevant example for illustrating the proposed approach. Finally, Section 7 concludes the paper.

2. Preliminaries

In the following, we first provide some basic concepts related to ITFNs.

Definition 1 [8-11] Let $\tilde{a}$ be an ITFN, its membership function $t_{\tilde{a}}(x)$ and non-membership function $f_{\tilde{a}}(x)$ can be defined as follows:

$$t_{\tilde{a}}(x)=\begin{cases}\dfrac{x-a}{b-a}t_{\tilde{a}}, & a\le x<b\\ t_{\tilde{a}}, & b\le x\le c\\ \dfrac{x-d}{c-d}t_{\tilde{a}}, & c<x\le d\\ 0, & \text{otherwise}\end{cases} \quad \text{and} \quad f_{\tilde{a}}(x)=\begin{cases}\dfrac{b-x+f_{\tilde{a}}(x-a_1)}{b-a_1}, & a_1\le x<b\\ f_{\tilde{a}}, & b\le x\le c\\ \dfrac{x-c+f_{\tilde{a}}(d_1-x)}{d_1-c}, & c<x\le d_1\\ 0, & \text{otherwise}\end{cases}$$

where $0 \le t_{\tilde{a}}(x) \le 1$; $0 \le f_{\tilde{a}}(x) \le 1$ and $0 \le t_{\tilde{a}}(x) + f_{\tilde{a}}(x) \le 1$; $a, a_1, b, c, d, d_1 \in \Re$. $\tilde{a}$ = {([a, b, c, d]; $t_{\tilde{a}}$), ([a_1, b, c, d_1]; $f_{\tilde{a}}$)} is called ITFN. For convenience, let $\tilde{a}$ = ([a, b, c, d]; $t_{\tilde{a}}, f_{\tilde{a}}$).

Definition 2 [8-11] Let $\tilde{a}_1$ = ([a_1, b_1, c_1, d_1]; $t_{\tilde{a}_1}, f_{\tilde{a}_1}$) and $\tilde{a}_2$ = ([a_2, b_2, c_2, d_2]; $t_{\tilde{a}_2}$, $f_{\tilde{a}_2}$) be two ITFNs and $\alpha \ge 0$, then

(i) $\tilde{a}_1 + \tilde{a}_2 = ([a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2]; t_{\tilde{a}_1} + t_{\tilde{a}_2} - t_{\tilde{a}_1} t_{\tilde{a}_2}, f_{\tilde{a}_1} f_{\tilde{a}_2})$

(ii) $\tilde{a}_1 . \tilde{a}_2 = ([a_1 a_2, b_1 b_2, c_1 c_2, d_1 d_2]; t_{\tilde{a}_1} t_{\tilde{a}_2}, f_{\tilde{a}_1} + f_{\tilde{a}_2} - f_{\tilde{a}_1} f_{\tilde{a}_2})$

(iii) $\alpha \tilde{a}_1 = ([\alpha a_1, \alpha b_1, \alpha c_1, \alpha d_1]; 1 - (1 - t_{\tilde{a}_1})^{\alpha}, f_{\tilde{a}_1}^{\alpha})$

(iv) $\tilde{a}_1^{\alpha} = ([a_1^{\alpha}, b_1^{\alpha}, c_1^{\alpha}, d_1^{\alpha}]; t_{\tilde{a}_1}^{\alpha}, 1 - (1 - f_{\tilde{a}_1})^{\alpha})$

Definition 3 [10] Let $\tilde{a}_1$ = ([a_1, b_1, c_1, d_1]; $t_{\tilde{a}_1}, f_{\tilde{a}_1}$) and $\tilde{a}_2$ = ([a_2, b_2, c_2, d_2]; $t_{\tilde{a}_2}, f_{\tilde{a}_2}$) be two ITFNs, then the normalized Hamming distance between $\tilde{a}_1$ and $\tilde{a}_2$ is defined as follows:

$$H(\tilde{a}_1, \tilde{a}_2) = \frac{1}{8}\left(\left|(1 + t_{\tilde{a}_1} - f_{\tilde{a}_1})a_1 - (1 + t_{\tilde{a}_2} - f_{\tilde{a}_2})a_2\right| + \left|(1 + t_{\tilde{a}_1} - f_{\tilde{a}_1})b_1 - (1 + t_{\tilde{a}_2} - f_{\tilde{a}_2})b_2\right| + \left|(1 + t_{\tilde{a}_1} - f_{\tilde{a}_1})c_1 - (1 + t_{\tilde{a}_2} - f_{\tilde{a}_2})c_2\right| + \left|(1 + t_{\tilde{a}_1} - f_{\tilde{a}_1})d_1 - (1 + t_{\tilde{a}_2} - f_{\tilde{a}_2})d_2\right|\right)$$

Definition 4 [12] Let $\tilde{a}$ = ([a, b, c, d]; $t_{\tilde{a}}, f_{\tilde{a}}$) be an ITFN in the set of real numbers $\Re$. Then its expected value is defined as follows:

$$EV(\tilde{a}) = \frac{1}{4}(a + b + c + d)$$

Definition 5 [13] For a normalized intuitionistic trapezoidal fuzzy decision making matrix $\tilde{A} = (\tilde{a}_{ij})_{m \times n}$ = ([a_{ij}, b_{ij}, c_{ij}, d_{ij}]; t_{ij}, f_{ij}) where $0 \le a_{ij} \le b_{ij} \le c_{ij} \le d_{ij} \le 1$, $0 \le t_{ij} + f_{ij} \le 1$. The intuitionistic trapezoidal fuzzy positive ideal solution (PIS) and intuitionistic trapezoidal fuzzy negative ideal solution (NIS) are formulated as follows:

$\tilde{a}^{+}$ = ([a^{+}, b^{+}, c^{+}, d^{+}]; t^{+}, f^{+}) = ([1, 1, 1, 1]; 1, 0)

$\tilde{a}^{-}$ = ([a^{-}, b^{-}, c^{-}, d^{-}]; t^{-}, f^{-}) = ([0, 0, 0, 0]; 0, 1).

2.1 Transformation between linguistic variables and ITFNs

A linguistic variable is referred as a variable whose values are words or sentences in a natural language. For example, the rating of alternative with respect to certain criteria could be expressed in terms of linguistic variables such as extreme good, very good, good, etc. Linguistic variables can be transformed into ITFNs (see Table1).

Table1. Transformation between the linguistic variables and the ITFNs

Linguistic variables	ITFNs
Extreme good (EG)	([0.80, 0.85, 0.90, 0.95]; 0.95, 0.05)
Very good (VG)	([0.70, 0.75, 0.80, 0.90]; 0.85, 0.10)
Good (G)	([0.60, 0.70, 0.75, 0.80]; 0.80, 0.10)
Medium good (MG)	([0.55, 0.60, 0.65, 0.70]; 0.70, 0.15)
Medium (M)	([0.45, 0.50, 0.55, 0.60]; 0.60, 0.20)
Medium low (ML)	([0.40, 0.45, 0.50, 0.55]; 0.50, 0.25)
Low (L)	([0.30, 0.40, 0.45, 0.50]; 0.45, 0.30)
Very low (VL)	([0.25, 0.30, 0.35, 0.40]; 0.35, 0.40)
Extreme low (EL)	([0.20, 0.25, 0.30, 0.35]; 0.40, 0.50)

3. Operational definition of the terms related to weaver selection problem

(i) **Skill**: Performing the weaving without damaging the Khadi outcome.

(ii) **Previous experience**: Weaving experience expressed in years.

(iii) **Honesty:** Honesty refers truthfulness along with the absence of lying, cheating, or theft of weaving raw materials.

(iv) **Physical fitness:** Physical fitness refers the ability to perform weaving related activities eight hours per day.

(v) **Locality of the weaver**: Reachable distance (0-6 kilo-meter) of weaver's residence from Khadi institution.

(vi) **Personality**: Personality refers the five factors of personality traits of five factor model of McCrae & Costa [14].

(vii) **Economic condition**: The ability of purchasing Khadi raw materials for amount rupees ten thousand.

4. Grey relational analysis

Let $\Re$ be a factor set of grey relation, $\Re = \{\Re_0, \Re_1, \ldots, \Re_p\}$, where $\Re_0 \in \Re$ denotes the referential sequence and $\Re_i \in \Re$, i = 1, 2, …, p represents the comparative sequence. $\Re_0$ and $\Re_i$ comprise of q elements and can be presented as: $\Re_0$ = ($z_0(1)$, $z_0(2)$, …, $z_0(k)$, …, $x_0(q)$) , $\Re_i$ = ($z_i(1)$, $z_i(2)$, …, $z_i(k)$, …, $z_i(q)$), where i = 1, …, p; k = 1, …, q; q ∈ N , and $z_0(k)$ and $z_i(k)$ are the numbers of referential sequences and comparative sequences at point k, respectively. The grey relational coefficient of the referential sequences and comparative sequences at point k is $\Delta(z_0(k), z_i(k))$, then the grey relational grade for $\Re_0$ and $\Re_i$ will be $\Delta(\Re_0, \Re_i)$ subject to the four conditions:

1. **Normal interval:**

$0 < \Delta(\Re_0, \Re_i) \leq 1$,

$\Delta(\Re_0, \Re_i) = 1 \Leftrightarrow \Re_0 = \Re_i$,

$\Delta(\Re_0, \Re_i) = 0 \Leftrightarrow \Re_0, \Re_i \in \Theta$, where Θ represents the empty set.

2. **Dual symmetry:**

$\Re_0, \Re_i \in \Re$

$\Delta(\Re_0, \Re_i) = \Delta(\Re_i, \Re_0) \Leftrightarrow \Re = \{\Re_0, \Re_i\}.$

3. **Wholeness:**

$\Delta(\Re_0, \Re_i) \overset{\text{often}}{\neq} \Delta(\Re_i, \Re_0)$

4. **Approachability:**

If $|z_0(k) - z_i(k)|$ getting larger, $\Delta(z_0(k), z_i(k))$ becomes smaller. The grey relational coefficient of the referential sequences and comparative sequences at point k can be expressed as follows:

$$\Delta(z_0(k), z_i(k)) = \frac{\min_i \min_k |z_0(k), z_i(k)| + \zeta \max_i \max_k |z_0(k), z_i(k)|}{|z_0(k), z_i(k)| + \zeta \max_i \max_k |z_0(k), z_i(k)|} \quad (1)$$

The symbol ζ denotes the "environmental coefficient" or the "distinguishing coefficient".

$\zeta \in [0, 1]$ is a free parameter. In general, ζ is considered as 0.5.

5. Intuitionistic trapezoidal fuzzy MCGDM based on GRA

For a MCGDM problem, let $\alpha = \{\alpha_1, \alpha_2, ..., \alpha_p\}$ $(p \geq 2)$ be a finite set of alternatives, $\varepsilon = \{\varepsilon_1, \varepsilon_2, ..., \varepsilon_q\}$ $(q \geq 2)$ be a finite set of Khadi decision makers (DMs) and $\beta = \{\beta_1, \beta_2, ..., \beta_r\}$ $(r \geq 2)$ be the set of criteria. Also let, W = {w_1, w_2, ..., w_r} be the weighting vector of the criteria β_j (j = 1, 2, ..., r). The weights of the attribute criteria is provided by the Khadi domain experts in linguistic terms, which can be expressed by ITFNs such that $\sum_{j=1}^{r} w_j = 1$, where $w_i \in [0, 1]$.

We now describe the procedure for intuitionistic trapezoidal fuzzy MCGDM using GRA method by the following steps.

Step 1. Construct an intuitionistic trapezoidal fuzzy decision matrix $\tilde{P}$ of the DMs. Suppose that the rating of alternative α_i (i = 1, 2, ..., p) with respect to the attribute criteria β_j (j = 1, 2, ..., r), provided by the Khadi DMs, can be represented by the linguistic variable ε_{ij}^k (i = 1, 2, ..., p; j = 1, 2, ..., r; k = 1, 2, ..., q) that can be presented in terms of ITFNs $\tilde{p}_{ij}^k = ([a_{ij}^{1k}, a_{ij}^{2k}, a_{ij}^{3k}, a_{ij}^{4k}]; t_{ij}^k, f_{ij}^k)$, i = 1, 2, ..., p; j = 1, 2, ..., r; k = 1, 2, ..., q . Therefore, the decision matrix can be explicitly formulated as follows:

$$\tilde{P} = (\tilde{p}_{ij}^{k})_{p\times r} = \begin{bmatrix} \tilde{p}_{11}^{k} & \tilde{p}_{12}^{k} & \cdots & \tilde{p}_{1r}^{k} \\ \tilde{p}_{21}^{k} & \tilde{p}_{22}^{k} & \cdots & \tilde{p}_{2r}^{k} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ \tilde{p}_{p1}^{k} & \tilde{p}_{p2}^{k} & \cdots & \tilde{p}_{pr}^{k} \end{bmatrix} \quad (2)$$

Step 2. To eliminate the effect from different physical dimensions to decision results, the decision making matrix should be standardized [15] at first. Suppose that the standardized decision matrix is $\tilde{D} = (\tilde{d}_{ij}^{k})_{p\times r}$, $\tilde{d}_{ij}^{k} = ([d_{ij}^{1k}, d_{ij}^{2k}, d_{ij}^{3k}, d_{ij}^{4k}]; t_{ij}^{k}, f_{ij}^{k})$. For two common types of criteria, namely, benefit type and cost type, the standardized methods are shown as follows:

i) For cost type of criteria: $d_{ij}^{mk} = \dfrac{\max\limits_{j} a_{ij}^{4k} - a_{ij}^{mk}}{\max\limits_{j} a_{ij}^{4k} - \min\limits_{j} a_{ij}^{1k}}$, m =1, 2, 3, 4; k = 1, 2, ..., q (3)

ii) For benefit type of criteria: $d_{ij}^{mk} = \dfrac{a_{ij}^{mk} - \min\limits_{j} a_{ij}^{1k}}{\max\limits_{j} a_{ij}^{4k} - \min\limits_{j} a_{ij}^{1k}}$, m =1, 2, 3, 4; k = 1, 2, ..., q (4)

Step 3. Suppose the decision making group comprises of q Khadi DMs. In the selection process, the importance of the DMs may not be equal. The importance of the Khadi DMs is provided by Khadi domain experts. Also, the importance of the Khadi DMs is presented by linguistic variables that can be expressed by ITFNs (see Table 2).

Table 2

Transformation between linguistic variables and the ITFNs for the importance of the DMs

linguistic variables	ITFNs
very important	([0.85, 0.90, 0.95, 1.00]; 0.95, 0.05)
Important	([0.75, 0.85, 0.90, 0.95]; 0.90, 0.05)
Medium	([0.70, 0.75, 0.80, 0.90]; 0.85, 0.05)
Unimportant	([0.60, 0.65, 0.75, 0.80]; 0.75, 0.10)
Very unimportant	([0.50, 0.55, 0.60, 0.65]; 0.65, 0.15)

The expected weight λ_k (k = 1, 2, ..., q) for an intuitionistic trapezoidal fuzzy weight is determined by definition (4). Then we normalize the expected weight value λ_k (k = 1, 2, ..., q) by the following formula [12]:

$$\lambda_k = \frac{Ev(\lambda_k)}{\sum_{k=1}^{q} Ev(\lambda_k)} \quad (5)$$

Step 4. Formulate the aggregated trapezoidal fuzzy decision matrix based on the opinion of the Khadi DMs. Let $\tilde{P} = (\tilde{p}_{ij}^{k})_{p\times r}$ be an trapezoidal fuzzy decision matrix of the k-th Khadi DM and $\lambda = (\lambda_1, \lambda_2, \ldots, \lambda_q)$ be the weight set of Khadi DMs such that $\sum_{k=1}^{q} \lambda_k = 1$. Now

all individual decisions need to be fused into group opinion to formulate an aggregated trapezoidal fuzzy decision matrix. In order to do this, we use intuitionistic trapezoidal fuzzy weighted arithmetic average (ITFWAA) operator of Jianquian and Zhang [11] as follows:

Let $\tilde{d}_k = ([d_{1k}, d_{2k}, d_{3k}, d_{4k}; t_{\tilde{d}_k}, f_{\tilde{d}_k}])$ (k = 1, 2, ..., q) be a set of standardized ITFNs, then

ITFWAA $(\tilde{d}_1, \tilde{d}_2, ..., \tilde{d}_q) =$

$$([\sum_{k=1}^{q}\lambda_k d_{1k}, \sum_{k=1}^{q}\lambda_k d_{2k}, \sum_{k=1}^{q}\lambda_k d_{3k}, \sum_{k=1}^{q}\lambda_k d_{4k}]; 1-\prod_{k=1}^{q}(1-t_{\tilde{d}_k})^{\lambda_k}, \prod_{j=1}^{q}(f_{\tilde{d}_k})^{\lambda_k}) \quad (6)$$

Here $\tilde{\lambda} = (\lambda_1, \lambda_2, ..., \lambda_q)^T$ is the weight vector of $\tilde{d}_k$ (k = 1, 2, ..., q) and $\lambda_k \in [0, 1]$, $\sum_{k=1}^{q}\lambda_k = 1$.

Also we can use intuitionistic trapezoidal fuzzy weighted geometric average (ITFWGA) operator of Jianquian and Zhang [11] as follows:

Let $\tilde{d}_k = ([d_{1k}, d_{2k}, d_{3k}, d_{4k}; t_{\tilde{d}_k}, f_{\tilde{d}_k}])$ (k = 1, 2, ..., q) be a set of standardized ITFNs, then

ITFWGA $(\tilde{d}_1, \tilde{d}_2, ..., \tilde{d}_q) =$

$$([\prod_{k=1}^{q}\lambda_k d_{1k}, \prod_{k=1}^{q}\lambda_k d_{2k}, \prod_{k=1}^{q}\lambda_k d_{3k}, \prod_{k=1}^{q}\lambda_k d_{4k}]; \prod_{j=1}^{q}(t_{\tilde{d}_k})^{\lambda_k}, 1-\prod_{k=1}^{q}(1-f_{\tilde{d}_k})^{\lambda_k}) \quad (7)$$

Here $\tilde{\lambda} = (\lambda_1, \lambda_2, ..., \lambda_q)^T$ is the weight vector of $\tilde{d}_k$ (k = 1, 2, ..., q) and $\lambda_k \in [0, 1]$, $\sum_{k=1}^{q}\lambda_k = 1$.

But, Zhang et al. [15] found some errors in ITFWGA operator of Jianquian and Zhang [11] and they [15] modified the ITFWGA operator.

The modified form of ITFWGA operator [15] is presented as follows:

ITFWGA $(\tilde{d}_1, \tilde{d}_2, ..., \tilde{d}_q) =$

$$([\prod_{k=1}^{q}(d_{1k})^{\lambda_k}, \prod_{k=1}^{q}(d_{2k})^{\lambda_k}, \prod_{k=1}^{q}(d_{3k})^{\lambda_k}, \prod_{k=1}^{q}(d_{4k})^{\lambda_k}]; \prod_{j=1}^{q}(t_{\tilde{d}_k})^{\lambda_k}, 1-\prod_{k=1}^{q}(1-f_{\tilde{d}_k})^{\lambda_k}) \quad (8)$$

Here $\tilde{\lambda} = (\lambda_1, \lambda_2, ..., \lambda_q)^T$ is the weight vector of $\tilde{d}_k$ (k = 1, 2, ..., q) and $\lambda_k \in [0, 1]$, $\sum_{k=1}^{q}\lambda_k = 1$.

Step 5. Determine the reference sequence based on ITFNs. In intuitionistic fuzzy environment, $\tilde{p}^+ = ([p^+, q^+, r^+, s^+]; \mu^+, \nu^+) = ([1, 1, 1, 1]; 1, 0)$ is used as the reference value. So the reference sequence $\tilde{p}_0$ is presented as follows:

$$\tilde{p}_0 = (\tilde{p}_{0j})_{1\times r} \quad (9)$$

Step 6. Determine the grey relational coefficient (χ_{ij}) using the following formula:

$$\chi_{ij} = \frac{\min_{1\le i\le p}\min_{1\le j\le r} d(\tilde{d}_{ij}, \tilde{p}_{0j}) + \zeta \max_{1\le i\le p}\max_{1\le j\le r} d(\tilde{d}_{ij}, \tilde{p}_{0j})}{d(\tilde{d}_{ij}, \tilde{p}_{0j}) + \zeta \max_{1\le i\le p}\max_{1\le j\le r} d(\tilde{d}_{ij}, \tilde{p}_{0j})} \quad (10)$$

Here $\zeta \in [0,1]$, however, in general, ζ is considered as 0.5.

Step 7. Calculate of the degree or grade of grey relational coefficient (κ_i) using the following equation:

$$\kappa_i = \sum_{j=1}^{r} w_j \chi_{ij} \text{ , } i = 1, 2, \ldots, p \quad (11)$$

Here w_i (j = 1, 2, …, r) is the weight of the j-th criterion.

Step 8. Rank the alternatives α_1, α_2, ..., α_p based on the degree or grade of grey relational coefficient κ_i. The alternative corresponding to the highest value of κ_i denotes the most desirable alternative.

6. Relevant example for weaver selection problem

Let us suppose that in a Khadi institution, a Khadi Mahajan wants to recruit three weavers from a list of four weavers. During the weavers' selection process, a committee of three Khadi DMs (the experts) has been formed to select two most appropriate weavers based on selected seven criteria namely skill (β_1), previous experience (β_2), honesty (β_3), physical fitness (β_4), locality of the weaver (β_5), personality (β_6), economic condition (β_7). The criteria are selected based on opinions of Khadi domain experts (Khadi Mahajans from Chak, a Gram Panchayet area of Murshidabad, West Bengal, India). In the selection process, the Khadi DMs consider the above mentioned seven selection criteria. The three Khadi DMs ε_j (j = 1, 2, 3) use the linguistic variables to represent the rating of the alternatives (weavers) α_i (i = 1, 2, ..., 4) with respect to the criteria β_j (j = 1, 2, ..., 7) as shown in the Table 3, Table 4, Table 5.

Table 3. Decision matrix for DM_1

Criterion / Alternative	β_1	β_2	β_3	β_4	β_5	β_6	β_7
α_1	VG	VG	MG	MG	M	MG	G
α_2	G	MG	MG	G	M	ML	M
α_3	MG	G	M	M	VG	M	M
α_4	G	G	MG	G	ML	M	G

Table 4. Decision matrix for DM_2

Criterion / Alternative	β_1	β_2	β_3	β_4	β_5	β_6	β_7
α_1	G	VG	G	MG	G	MG	G
α_2	MG	ML	MG	VG	G	M	M
α_3	M	MG	MG	M	M	MG	ML
α_4	MG	MG	M	G	M	ML	G

Table 5. Decision matrix $Z^{(3)}$ for DM_3

Criterion / Alternative	β_1	β_2	β_3	β_4	β_5	β_6	β_7
α_1	G	G	MG	M	M	MG	VG
α_2	EG	G	G	VG	M	ML	M
α_3	G	VG	G	MG	VG	G	M
α_4	G	G	M	MG	ML	MG	VG

We now present the procedure for intuitionistic trapezoidal fuzzy MCGDM using GRA method for weaver selection in Khadi institution by the following steps:

Step 1. Formulate the intuitionistic trapezoidal fuzzy decision matrix of each Khadi DM_i (i = 1, 2, 3). We convert the linguistic variables into ITFNs by using Table 1. The intuitionistic trapezoidal fuzzy decision matrices $\tilde{P}^k = (\tilde{p}_{ij}^k)_{p\times r}$ (k = 1, 2, 3) are formulated as in Table 6, Table 7, Table 8.

Table 6. The intuitionistic trapezoidal fuzzy decision matrix $(\tilde{p}_{ij}^1)_{4\times7}$

([0.70,0.75,0.80,0.90];0.85,0.10)	([0.70,0.75,0.80,0.90];0.85,0.10)	([0.55,0.60,0.65,0.70];0.70,0.15])	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.60,0.70,0.75,0.80];0.80,0.10)
([0.60,0.70,0.75,0.80];0.80,0.10)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.40,0.45,0.50,0.55];0.50,0.25)	([0.45,0.50,0.55,0.60];0.60,0.20)
([0.55,0.60,0.65,0.70];0.70,0.15)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.70,0.75,0.80,0.90];0.85,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.45,0.50,0.55,0.60];0.60,0.20)
([0.60,0.70,0.75,0.80];0.80,0.10)	([0.60,0.65,0.70,0.80];0.80,0.10)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.40,0.45,0.50,0.55];0.50,0.25)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.60,0.70,0.75,0.80];0.80,0.10)

Table 7. The intuitionistic trapezoidal fuzzy decision matrix $(\tilde{p}_{ij}^2)_{4\times7}$

([0.60,0.70,0.75,0.80];0.80,0.10)	([0.70,0.75,0.80,0.90];0.85,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10])	([0.55,0.60,0.65,0.70];0.80,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.60,0.70,0.75,0.80];0.80,0.10)
([0.55,0.60,0.65,0.70];0.70,0.15)	([0.40,0.45,0.50,0.55];0.50,0.25)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.70,0.75,0.80,0.90];0.80,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.45,0.50,0.55,0.60];0.60,0.20)
([0.45,0.50,0.55,0.60];0.60,0.20)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.40,0.45,0.50,0.55];0.50,0.25)
([0.55,0.60,0.65,0.70];0.70,0.15)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.60,0.70,0.75,0.80];0.70,0.15)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.40,0.45,0.50,0.55];0.50,0.25)	([0.60,0.70,0.75,0.80];0.80,0.10)

Table 8. The intuitionistic trapezoidal fuzzy decision matrix $(\tilde{p}_{ij}^3)_{4\times7}$

([0.60,0.70,0.75,0.80];0.80,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.55,0.60,0.65,0.70];0.70,0.15])	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.70,0.75,0.80,0.90];0.85,0.10)
([0.80,0.85,0.90,0.95];0.95,0.05)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.70,0.75,0.80,0.90];0.85,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.40,0.45,0.50,0.55];0.50,0.25)	([0.45,0.50,0.55,0.60];0.60,0.20)
([0.60,0.70,0.75,0.80];0.80,0.10)	([0.70,0.75,0.80,0.90];0.85,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.70,0.75,0.80,0.90];0.85,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)
([0.60,0.70,0.75,0.80];0.80,0.10)	([0.60,0.70,0.75,0.80];0.80,0.10)	([0.45,0.50,0.55,0.60];0.60,0.20)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.40,0.45,0.50,0.55];0.50,0.25)	([0.55,0.60,0.65,0.70];0.70,0.15)	([0.70,0.75,0.80,0.90];0.85,0.10)

Step 2. Construct the standardized decision matrix $\tilde{D}$ using benefit type of criteria by using equation (4) [See Table 9, Table 10, Table 11].

Table 9. The normalized intuitionistic trapezoidal fuzzy decision matrix $(\tilde{d}_{ij}^1)_{4\times7}$

([0.43,0.57, 0.71,1.00];0.85,0.10)	([0.43,0.57, 0.71,1.00];0.85,0.10)	([0.40,0.60,0.80,1.00];0.70,0.15])	([0.28,0.43,0.57,0.71];0.70,0.15)	([0.10,0.20,0.30,0.40];0.60,0.20)	([0.50,0.67,0.83,1.00];0.70,0.15)	([0.43,0.71, 0.86,1.00];0.80,0.10)
([0.14,0.43,0.57,0.71];0.80,0.10)	([0.00,0.14,0.28,0.43];0.70,0.15)	([0.40,0.60,0.80,1.00];0.70,0.15)	([0.43,0.71, 0.86,1.00];0.80,0.10)	([0.10,0.20,0.30,0.40];0.60,0.20)	([0.00,0.17,0.33,0.50];0.50,0.25)	([0.00,0.14,0.28,0.43];0.60,0.20)
([0.00,0.14,0.28,0.43];0.70,0.15)	([0.14,0.43,0.57,0.71];0.80,0.10)	([0.00,0.20,0.40,0.60];0.60,0.20)	([0.00,0.14,0.28,0.43];0.60,0.20)	([0.60,0.70,0.80,1.00];0.85,0.10)	([0.17,0.33,0.50,0.67];0.60,0.20)	([0.00,0.14,0.28,0.43];0.60,0.20)
([0.14,0.43,0.57,0.71];0.80,0.10)	(0.14,0.43,0.57,0.71];0.80,0.10)	([0.40,0.60,0.80,1.00];0.70,0.15)	([0.43,0.71, 0.86,1.00];0.80,0.10)	([0.00,0.10,0.20,0.30];0.50,0.25)	([0.17,0.33,0.50,0.67];0.60,0.20)	([0.43,0.71, 0.86,1.00];0.80,0.10)

Table 10. The normalized intuitionistic trapezoidal fuzzy decision matrix $(\tilde{d}_{ij}^{2})_{4\times7}$

([0.43,0.71,0.86,1.00];0.80,0.10)	([0.60,0.70,0.80,1.00];0.85,0.10)	([0.43,0.71,0.86,1.00];0.80,0.10])	([0.22,0.33,0.44,0.56];0.80,0.10)	([0.43,0.71,0.86,1.00];0.80,0.10)	([0.50,0.67,0.83,1.00];0.70,0.15)	([0.50,0.75,0.88,1.00];0.80,0.10)
([0.28,0.43,0.57,0.71];0.70,0.15)	([0.00,0.10,0.20,0.30];0.50,0.25)	([0.28,0.43,0.57,0.71];0.70,0.15)	([0.56,0.67,0.78,1.00];0.80,0.10)	([0.43,0.71,0.86,1.00];0.80,0.10)	([0.17,0.33,0.50,0.67];0.60,0.20)	([0.12,0.25,0.38,0.50];0.60,0.20)
([0.00,0.14,0.28,0.43];0.60,0.20)	([0.30,0.40,0.50,0.60];0.70,0.15)	([0.28,0.43,0.57,0.71];0.70,0.15)	([0.00,0.11,0.22,0.33];0.60,0.20)	([0.00,0.14,0.28,0.43];0.60,0.20)	([0.50,0.67,0.83,1.00];0.70,0.15)	([0.00,0.12,0.25,0.38];0.50,0.25)
([0.28,0.43,0.57,0.71];0.70,0.15)	([0.30,0.40,0.50,0.60];0.70,0.15)	([0.00,0.14,0.28,0.43];0.60,0.20)	([0.33,0.56,0.67,0.78];0.70,0.15)	([0.00,0.14,0.28,0.43];0.60,0.20)	([0.00,0.17,0.33,0.50];0.50,0.25)	([0.50,0.75,0.88,1.00];0.80,0.10)

Table 11. The normalized intuitionistic trapezoidal fuzzy decision matrix $(\tilde{d}_{ij}^{3})_{4\times7}$

([0.00,0.28,0.43,0.57];0.80,0.10)	([0.00,0.33,0.50,0.67];0.80,0.10)	([0.28,0.43,0.57,0.71];0.70,0.15])	([0.00,0.11,0.22,0.33];0.60,0.20)	([0.10,0.20,0.30,0.40];0.60,0.20)	([0.38,0.50,0.62,0.75];0.70,0.15)	([0.56,0.67,0.78,1.00];0.85,0.10)
([0.57,0.71,0.86,1.00];0.95,0.05)	([0.00,0.33,0.50,0.67];0.80,0.10)	([0.43, 0.71, 0.86,1.00];0.80,0.10)	([0.56,0.67,0.78,1.00];0.85,0.10)	([0.10,0.20,0.30,0.40];0.60,0.20)	([0.00,0.12,0.25,0.38];0.50,0.25)	([0.00,0.11,0.22,0.33];0.60,0.20)
([0.00,0.28,0.43,0.57];0.80,0.10)	([0.33,0.50,0.67,1.00];0.85,0.10)	([0.43, 0.71, 0.86,1.00];0.80,0.10)	([0.22,0.33,0.44,0.56];0.70,0.15)	([0.60,0.70,0.80,1.00];0.85,0.10)	([0.50,0.75,0.88,1.00];0.80,0.10)	([0.00,0.11,0.22,0.33];0.60,0.20)
([0.00,0.28,0.43,0.57];0.80,0.10)	([0.00,0.33,0.50,0.67];0.80,0.10)	([0.00,0.14,0.28,0.43];0.60,0.20)	([0.22,0.33,0.44,0.56];0.70,0.15)	([0.00,0.10,0.20,0.30];0.50,0.25)	([0.38,0.50,0.62,0.75];0.70,0.15)	([0.56,0.67,0.78,1.00];0.85,0.10)

Step 3. Determine the weights of the Khadi DMs. The expected weight value λ_k (k = 1, 2, 3) for an intuitionistic trapezoidal fuzzy weight is determined by definition (5).The importance of the Khadi DMs in the decision-making situation is considered by Khadi domain expert (Khadi Mahajan) as very important ([0.85, 0.90, 0.95, 1.00]; 0.95, 0.05), very important ([0.85, 0.90, 0.95, 1.00]; 0.95, 0.05), important ([0.75, 0.85, 0.90, 0.95]; 0.90, 0.05) respectively (see Table 2). Using Eq. (5), we obtain the weights of the Khadi DMs as follows:

$\lambda_1 = 0.341,\ \lambda_2 = 0.341,\ \lambda_3 = 0.318.$

The weights of the criteria are obtained from Khadi domain expert's opinion. The average weight of each criterion is given by w = (w_1, w_2, w_3, w_4, w_5, w_6, w_7) = (0.28, 0.13, 0.20, 0.12, 0.07, 0.15, 0.05) with $\sum_{j=1}^{7} w_j = 1$.

Step 4. Formulate the aggregated trapezoidal fuzzy decision matrix based on the opinion of the Khadi DMs. Using the ITFWAA operator given by Eq. (6) we obtain aggregate intuitionistic trapezoidal fuzzy decision matrix[1] (see Table 12).

Table 12. The aggregate intuitionistic trapezoidal fuzzy decision matrix[1] $(\tilde{x}_{ij})_{4\times7}$

([0.29,0.52,0.67,0.86];0.82,0.10)	([0.35,0.54,0.67,0.90];0.84,0.10)	([0.37,0.58,0.75,0.91];0.74,0.13)	([0.17,0.28,0.41,0.54];0.67,0.16)	([0.21,0.37,0.49,0.60];0.68,0.16)	([0.46,0.62,0.76,0.92];0.70,0.15)	([0.50,0.71,0.84,1.00];0.82,0.10)
([0.32,0.52,0.66,0.80];0.85,0.09)	([0.00,0.19,0.32,0.46];0.69,0.16)	([0.37,0.58,0.74,0.90];0.74,0.13)	([0.52,0.68, 0.81,1.00];0.83,0.10)	([0.21,0.37,0.49,0.60];0.68,0.16)	([0.06,0.21,0.36,0.52];0.54,0.23)	([0.04,0.17,0.30,0.42];0.60,0.20)
([0.00,0.18,0.33,0.47];0.71,0.14)	([0.25,0.44,0.58,0.76];0.79,0.11)	([0.23,0.44,0.60,0.76];0.71,0.14)	([0.07,0.19,0.31,0.44];0.63,0.18)	([0.40,0.51,0.62,0.80];0.79,0.13)	([0.39,0.58,0.73,0.89];0.71,0.14)	([0.00,0.12,0.25,0.38];0.57,0.22)
([0.14,0.38,0.52,0.66];0.77,0.11)	([0.15,0.39,0.52,0.66];0.77,0.11)	([0.14,0.30,0.46,0.52];0.64,0.18)	([0.33,0.54,0.66,0.78];0.77,0.11)	([0.00,0.11,0.23,0.34];0.54,0.23)	([0.14,0.29,0.48,0.64];0.61,0.20)	([0.50,0.71,0.84,1.00];0.82,0.10)

Step 5. Determine the reference sequence $\tilde{p}_0 = (\tilde{p}_{0j})_{1\times7}$ based on ITFNs. The reference sequence is presented as follows:

$\tilde{p}_0 = (\tilde{p}_{0j})_{1\times7}$ = {[1, 1, 1, 1]; 1, 0), ([1, 1, 1, 1]; 1, 0), ([1, 1, 1, 1]; 1, 0), ([1, 1, 1, 1]; 1, 0), ([1, 1, 1, 1]; 1, 0), ([1, 1, 1, 1]; 1, 0), ([1, 1, 1, 1]; 1, 0)}.

Step 6. To obtain the grey relational coefficient χ_{ij}, we first calculate the distance σ_{ij} between $\tilde{d}_{ij}$ and $\tilde{p}_{0j}$ (see Table 13). Comparing the distances, we determine the maximum distance σ_{max} and minimum distance σ_{min} (see Table 13). Then substitute these values into Eq. (10) to obtain the grey relational coefficient matrix (see Table 14).

Table 13. Calculation of the distances and determination of σ_{max} and σ_{min}

	b_1	b_2	b_3	b_4	b_5	b_6	b_7	$\min \sigma_{ij}$	$\max \sigma_{ij}$
σ_{1j}	0.4969	0.4650	0.4747	0.7358	0.6827	0.4652	0.3442	0.3442	0.7358
σ_{2j}	0.4940	0.8145	0.4788	0.3491	0.6827	0.8117	0.8372	0.3491	0.8372
σ_{3j}	0.8077	0.5737	0.6016	0.8169	0.5165	0.4917	0.8734	0.4917	0.8734
σ_{4j}	0.6472	0.6431	0.7226	0.5207	0.8886	0.7268	0.3442	0. 3442	0.8886
σ_{max}									0. 8886
σ_{min}								0.3442	

Table 14. Grey relational coefficient matrix[1]

$$= \begin{bmatrix} 0.8378 & 0.8672 & 0.8580 & 0.6682 & 0.6996 & 0.8670 & 1.0000 \\ 0.8403 & 0.6264 & 0.8542 & 0.9938 & 0.6996 & 0.6278 & 0.6153 \\ 0.6298 & 0.7746 & 0.7539 & 0.6252 & 0.8207 & 0.8424 & 0.5984 \\ 0.7224 & 0.7251 & 0.6757 & 0.8171 & 0.5916 & 0.6733 & 1.0000 \end{bmatrix}$$

Step 7. We obtain the degree or grade of grey relational coefficient κ_i (i = 1, 2, ..., 4) by using the equation (11) as follows:

$\kappa_1 = 0.8281$, $\kappa_2 = 0.7807$, $\kappa_3 = 0.7166$, $\kappa_4 = 0.7221$.

Step 8. Rank the alternatives (weavers) according to the descending order of κ_i (i = 1, 2, ..., 4):

$\kappa_1 > \kappa_2 > \kappa_4 > \kappa_3$.

Therefore, the merit panel of the weavers is presented as follows:

$\alpha_1 > \alpha_2 > \alpha_4 > \alpha_3$.

Therefore, Khadi Mahajan selects the three weavers α_1, α_2 and α_4.

Note 1: It is to be noted that using ITFWGA operator [15] as given by Eq. (8), we get aggregate intuitionistic trapezoidal fuzzy decision matrix[2] (see Table 15).

Table 15. The aggregate intuitionistic trapezoidal fuzzy decision matrix[2] $(\tilde{x}_{ij})_{4\times7}$

([0.00,0.49,0.65,0.84];0.82,0.10)	([0.00,0.51,0.66,0.88];0.83,0.10)	([0.37,0.57,0.74,0.90];0.73,0.13)	([0.00,0.25,0.38,0.51];0.67,0.17)	([0.16,0.31,0.43,0.55];0.66,0.17)	([0.46,0.61,0.76,0.91];0.70,0.15)	([0.49,0.71,0.84,1.00];0.82,0.10)
([0.28,0.50,0.65,0.79];0.81,0.10)	([0.00,0.16,0.30,0.44];0.65,0.17)	([0.36,0.56,0.73,0.89];0.73,0.13)	([0.51,0.68,0.81,1.00];0.83,0.10)	([0.16,0.31,0.43,0.55];0.66,0.17)	([0.00,0.19,0.35,0.51];0.53,0.23)	([0.00,0.16,0.29,0.42];0.60,0.20)
([0.00,0.17,0.32,0.47];0.69,0.15)	([0.24,0.44,0.57,0.75];0.78,0.12)	([0.00,0.39,0.58,0.75];0.69,0.15)	([0.00,0.17,0.30,0.43];0.63,0.18)	([0.00,0.40,0.56,0.75];0.75,0.14)	([0.35,0.54,0.71,0.87];0.69,0.15)	([0.00,0.12,0.25,0.38];0.56,0.22)
([0.00,0.38,0.52,0.66];0.76,0.12)	([0.00,0.38,0.52,0.66];0.76,0.12)	([0.00,0.23,0.40,0.57];0.63,0.18)	([0.32,0.51,0.64,0.76];0.77,0.12)	([0.00,0.11,0.22,0.34];0.53,0.23)	([0.00,0.30,0.46,0.63];0.59,0.20)	([0.49,0.71,0.84,1.00];0.82,0.10)

To obtain the grey relational coefficient, we determine the distance σ_{ij} between $\tilde{d}_{ij}$ and $\tilde{p}_{0j}$ (see Table 16).

Table 16. Calculation of the distances and determination of σ_{max} and σ_{min}

	b_1	b_2	b_3	b_4	b_5	b_6	b_7	$\min \sigma_{ij}$	$\max \sigma_{ij}$
σ_{1j}	0.5743	0.5567	0.4840	0.7862	0.7299	0.4691	0.3464	0.3464	0.7862
σ_{2j}	0.5255	0.8335	0.4920	0.3512	0.7299	0.8294	0.8478	0.3512	0.8478
σ_{3j}	0.8152	0.5850	0.6689	0.8389	0.6559	0.5245	0.8744	0.5245	0.8744
σ_{4j}	0.6802	0.6802	0.7825	0.5401	0.8911	0.7585	0.3464	0.3464	0.8911
σ_{max}									0.8911
σ_{min}								0.3464	

Comparing the distances, we obtain the maximum distance σ_{max} and minimum distance σ_{min} (see Table 16). Then substitute these values into Eq. (10), we get the grey relational coefficient matrix (see Table 17).

Table 17. Grey relational coefficient matrix[2]

$$= \begin{bmatrix} 0.7765 & 0.7902 & 0.8520 & 0.6429 & 0.6737 & 0.8658 & 1.0000 \\ 0.8156 & 0.6192 & 0.8447 & 0.9940 & 0.6737 & 0.6212 & 0.6123 \\ 0.6282 & 0.7685 & 0.7106 & 0.6175 & 0.7190 & 0.8164 & 0.6000 \\ 0.7035 & 0.7035 & 0.6449 & 0.8035 & 0.5925 & 0.6577 & 1.0000 \end{bmatrix}$$

Next, using the Eq. (11), the degree or grade of grey relational coefficient κ_i (i = 1, 2, ..., 4) are obtained as follows:

$\kappa_1 = 0.7947$, $\kappa_2 = 0.7680$, $\kappa_3 = 0.6948$, $\kappa_4 = 0.7040$.

Therefore, we rank the alternatives according to the descending order of κ_i (i = 1, 2, ..., 4) as follows:

$\kappa_1 > \kappa_2 > \kappa_4 > \kappa_3$.

And the four weavers are ranked as follows:

$\alpha_1 > \alpha_2 > \alpha_4 > \alpha_3$.

Finally, we observe that the most suitable weavers are α_1, α_2 and α_4.

7. Conclusion

Selection of weavers is one of the key factors for a Khadi institution in the increasing open competitive markets. We have investigated MCGDM approach for weaver selection in Khadi industry. Linguistic variables are transformed into equivalent intuitionistic trapezoidal fuzzy numbers. Intuitionistic trapezoidal fuzzy weighted arithmetic average operator and intuitionistic trapezoidal fuzzy weighted geometric average operator are used to aggregate individual opinions of Khadi DMs into a group opinion. Intuitionistic trapezoidal fuzzy MCGDM based on GRA is presented. Finally, an illustrative example for weaver selection is

provided in order to demonstrate the practicality of the proposed approach. We hope that the proposed approach can be effective for dealing with the other MCGDM problems such as teacher selection, investment, personnel selection, medical diagnosis, supplier selection and many other areas of management decision problems.

References

1. Anjum, D. **An analysis of khadi and village industry sector in J &K**, International Journal of Multidiciplinary Research, Vol. 1, No. 8, 2011, pp. 213-220
2. Atanassov, K. T. **Intuitionistic fuzzy sets**, Fuzzy Sets and Systems, Vol. 20, No. 1, 1986, pp. 87–96
3. Zadeh, L. A. **Fuzzy Sets**, Information and Control, Vol. 8, No. 3, 1965, pp.338-353
4. Deng, J. L. **Introduction to grey system theory**, The Journal of Grey System, Vol. 1, No. 1, 1989, pp. 1–24
5. Zhang, S. and Liu, S. **A GRA-based intuitionistic fuzzy multi-criteria group decision making method for personnel selection**, Expert Systems with Applications, Vol. 38, No. 9, 2011, pp. 11401-11405
6. Pramanik, S., and Mukhopadhyaya, D. **Grey relational analysis based intuitionistic fuzzy multi-criteria group decision-making approach for teacher selection in higher education**, International Journal of Computer Applications, Vol. 34, No. 10, 2011, pp. 21-29
7. Baskaran, V., Nachiappan, S., and Rahman, S. **Indian textile suppliers' sustainability evaluation using grey approach**, International Journal of Production Economics, Vol. 135, No. 2, 2012, pp. 647-658
8. Wang, J. Q. **Overview on fuzzy multi-criteria decision-making approach**, Control and Decision, Vol. 23, No. 6, 2008, pp. 601-606
9. Wang, J. Q., and Zhang, Z. H. **Programming method of multi-criteria decision-making based on intuitionistic fuzzy number with incomplete certain information**, Control and Decision, Vol. 23, No. 10, 2008, pp. 1145-1148
10. Wang, J. Q., and Zhang, Z. H. **Multi-criteria decision-making method with incomplete certain information based on intuitionistic fuzzy number**, Control and Decision, Vol. 24, No. 2, 2009, pp. 226-230
11. Jianqiang, W., and Zhang, Z. **Aggregation operators on intuitionistic trapezoidal fuzzy number and its application to multi-criteria decision making problems**, Journal of Systems Engineering and Electronics, Vol. 20, No. 2, 2009, pp. 321-326
12. Ye, J. **Expected value method for intuitionistic trapezoidal fuzzy multicriteria decision-making problems**, Expert Systems with Applications, Vol. 38, No. 9, 2011, pp. 11730-11734
13. Wei, G. **Some arithmetic aggregation operators with intuitionistic trapezoidal fuzzy numbers and their application to group decision making**, Journal of Computers, Vol. 5, No. 3, 2010, pp. 345-351
14. Costa, P.T., and McCrae, R.R. **Revised NEO personality inventory (REO-PI-R) and Neo five-factor inventory (NEO-FFI)**, Professional manual. Odessa, FL: Psychological Assessment Resources, 1992

15. Zhang, X., Jin, F., and Liu, P. **A grey relational projection method for multi-attribute decision making based on intuitionistic trapezoidal fuzzy number**, Applied Mathematical Modelling, Vol. 37, No. 5, 2012, pp. 3467-3477

[1] **Acknowledgement**
The authors are grateful to the Weavers and Khadi Mahajans of Chak, Murshidabad, W. B., India for their sincere help in conducting the study.

CAN AFRICA'S YOUNG DRIVE INNOVATION? INVESTIGATING THE EFFECT OF ENTREPRENEURIAL INNOVATION ON ECONOMIC GROWTH IN AFRICA[1]

Paul I. OJEAGA
PhD, Industrial Economics
Federal University of Agriculture Abeokuta Nigeria

E-mail: drpaulojeaga@gmail.com

Abstract

Innovation shocks are known to have strong and significant effect on growth particularly when such shocks are attributable to technology changes. Literacy rates in Africa appear to have significantly improved compared to those of the 1970s (World Bank literacy rate statistics 2013). There also appears to be significant use of high level technology in information access across Africa despite poor infrastructure and in many instances impediments to technology, use attributable to high cost of access to telecommunication infrastructure and devices. Growth for Africa has also been mostly attributable to exports in commodities and a gradual development of local markets. This study investigates the effect of Africa's growing demographic composition on growth and innovation. Quantile regression technique is utilized in the analysis of the results, specifically the Qreg2 Wrapper by Parente and Silva (2013) allowing us to derive covariance matrix estimators that are valid when there is heteroskedasticity and intra-cluster correlation. Results show that Africa's young and their innovative capacity have strong implications for growth.

Keywords: *Quantitative Economics, Entrepreneurship, Innovation and Demographic Composition*

1.0. Background of The Study

In this section some background statements are made on the subject under study. What exactly are the ramifications of -improved innovation trends- for –growth- in –Africa-? To what extent is Africa's current -demographic composition- improving growth in many -sub Saharan African- (SSA) countries? Innovation can be defined as the employment of new ideas and ways of doing old tasks. Innovation can have strong implicative effects for growth in many African countries that are still largely developing and have not yet achieved a significant level of industrial growth. Few studies have tried to study in a quantitative manner the implicative effects of a vibrant, young and innovative population for growth in Africa. Trends already depict that above 41 percent of the total population of sub Saharan Africa are between the ages of 0 to 24 (World Bank Statistics 2013). Therefore Africa has quite a significant young population that can inject some energy into nation building. Many among this young category are also beginning to engage in innovative and entrepreneurial activities therefore a clear understanding of how this vibrant segment of the population can affect growth could offer significant insight into their contribution to the current growth trend across the continent.

There exist various channels through which a thriving, healthy and young segment of the African populace can affect growth. For instance many young people in Africa are more likely to have a secondary and tertiary school education unlike their parents thereby improving labour quality across the continent. There is also the tendency for the literate young to take advantage of recent technologies utilizing telecommunication networks and the internet to sharpen their skills increasing learning and the flow of knowledge among the highly literate segment of the African population. There is also the energy associated with youths: they are more likely to work longer hours and engage in rigorous brainstorming and energy sapping activities that are likely to lead to firm start-ups and new product generation. However there is no significant result to show that innovation has significantly increased in Africa compared to the results obtained in other parts of the world.

There is evidence that a low amount of patents turn out from Africa compared to those from other regions of the world, with South Africa alone accounting for over 73 percent of all total patents on the continents (World Bank Statistics 2013), with a significant decline in number of patents noticeable from 1990 with the end of the apartheid regime in South Africa. There are also significant indications that industrialization is also eluding Africa. Africa still remains the industrial raw material power house for the global economy with only a little share of World industrial activity taking place on the continent. It is highly unlikely that Africa will catch up with the rest of the World without a clear path to industrialization.

1.1. Scope and Objectives of the Study

In this sub section the scope and objective of the study is presented. This study investigates the effect of innovation and Africa's young population on economic growth on the continent with special emphasis on sub Saharan Africa (SSA). The method of estimation used is the quantile estimation technique, this is based on the premise that the sample median will converge that to that of the population. It is valid in the presence of heterscedasticity and it allows for the utilization of other measure of dispersion other than the mean (in this case the median). Data for 54 years (1960 to 2013) were utilized but many years of data are missing in the observation.

The specific objectives of the study include:

a) To determine if Africa's current demographic composition comprising of over 41% of the population between the ages of 0 to 24 has a positive significant effect on growth?

b) To determine if the level innovation as provided for, by available investment in telecommunication technologies that is known to improve knowledge sharing and drive skill has any significant effect on economic growth in Africa?

c) And finally to examine the nature of and state of this innovation in helping this young and very literate segment of the population to promote growth.

The rest of the study is divided into the data sources and empirical analysis, discussion of results and conclusion.

2.0. Data Sources and Empirical Analysis

In this section the data sources and the empirical foundations of the study is discussed. In study the relationship between innovation, Africa's young population and growth is examined, different intuitive arguments are considered. They include the evidence from past studies that have utilized different methodologies and estimation techniques on eco-

nomic growth as well as other empirical papers that have investigated the effect different economic variables and their causal implicative effects on economic growth. They include the study by Aghion P. and Howitt P. (2004) who studied the effect of quality innovation with growth enhancing capabilities on economic growth, OjeagaP., Odejimi D., George O. and Azuh D. (2014) who argue that innovative and modern utilization of renewable energy production plants can drive economic growth using panel data and generalized method of moment estimation technique, Ojeaga P., Odejimi D. O., Okhiku J. and Ojeaga D. (2013) who study the effect of commercial lending on growth utilization time series data and non-parametric estimation techniques (with special emphasis on quantile regression by Silva et al 2013) finding strong relationship between lending and economic growth which is negative for Nigeria etc.

Fig. 1

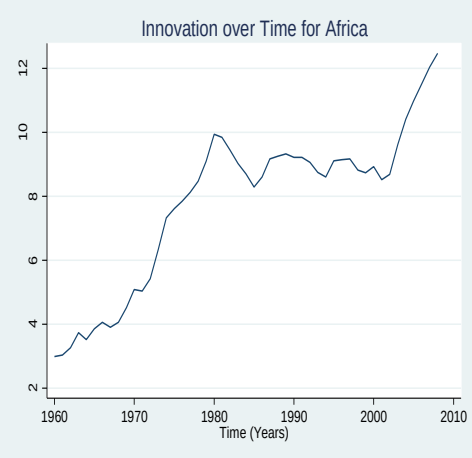
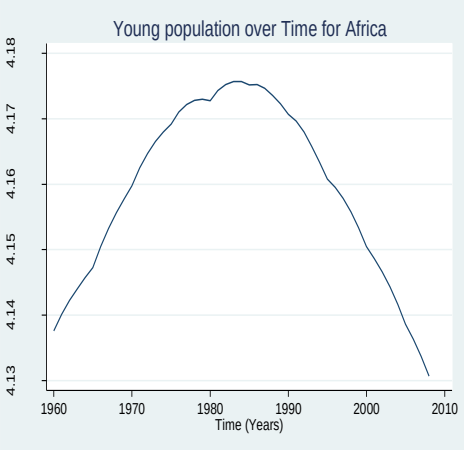


Fig. 2



Note: Fig. 1 and 2 depicts innovation young population between 0-24 years of age over time in Africa. It reveals that innovation is on the increase with increased wave of knowledge and information sharing unfortunately the African business environment remains risky.

Other studies Ojeaga P., Odejimi D. and Ikpefan O. (2014) have also used quantile regression and time series data to study the relationship between deposit and fraud finding strong relationship between the two variables. The study, by Ojeaga P. (2014), also finds that foreign inflow also affects exporting capabilities utilizing panel data. Trends show that innovation is increasing as the use of knowledge sharing devices appears to be on the increase even though the nature and depth of the use are still quite questionable (see Fig. 1). This is attributable to improved living conditions and the influx of telecommunication gadgets from China of low and cheap quality etc. However fewer children utilize these facilities compared to children in other regions of the world. There also exist poor learning environment and poor access to credit in Africa for young people to implement their ideas. The share of young population between 0-24 years of age in sub Saharan Africa is around 41 percent of the total population meaning that 4 out 10 Africans are between the ages of 0 to 24. The share of young workable people that can drive growth can therefore be said to be high which can have strong implicative effects on growth if properly channeled (see Fig. 2).

Fig.3

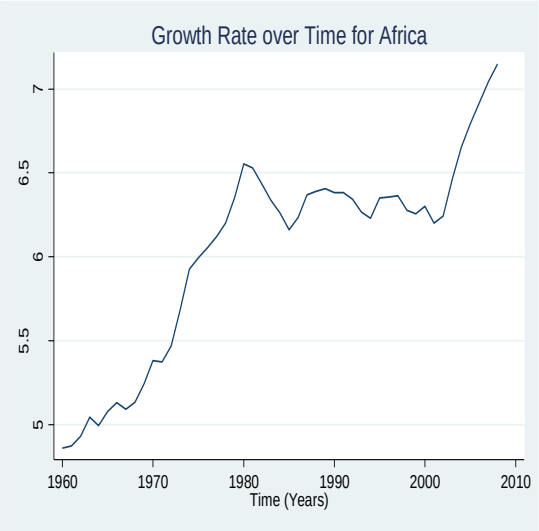
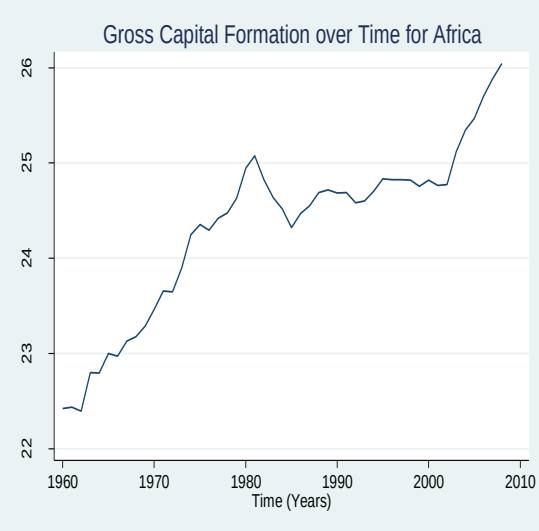


Fig.4



Note: Fig.3 and 4 depict that growth has increased for Africa so also is gross capital formation. The growth of over 7% remains unsustainable as most African countries are raw material exporting countries and have not managed to promote significant industrialization. Gross capital formation stands at about 26 billion dollars as at 2009, which is still low compared to those of other regions of the world.

There appears to have been significant economic growth on the continent. With growth surpassing 7 percent by 2008 even amidst a severe global interconnected financial crisis, depicting once again the disconnection of the African financial system from those of the developed north (see fig. 3). Gross capital formation for sub Saharan Africa also surpassed 25 billion dollars for the first time in 2004 (World Bank Statistics 2013 see fig. 4) depicting increase access to capital for firms in the private sector..

All data for the study are obtained from the data market of Iceland, which in turn archives data from the World Bank and United Nation data. Data for 54 years (1960 to 2013) were utilized but many years of data are missing in the observation. The growth variable is GDP growth rate which is GDP per capita. GDP is gross domestic product and is defined as the total goods and services produces in Africa over time, in this case yearly data is utilized. Other explanatory variables utilized include innovation which is measured as fixed and mobile phone use as a percentage of the young population, gross capital formation in constant United states dollars which measure the total available flow of capital in banks and in the private sector of the African economy, the percentage illiterate population as a percentage of the total population in Africa.

The model estimated is the endogenous growth model which accounts for human capital, labour quality, and capital and assumes that technology is fixed. Therefore growth can be expressed as

Growth f (Tech, Human Capital, Capital)

The model is extended to include unskilled labour in this case illiterate population as a percentage of total population, therefore allowing us to express three different model specifications below as

$$Growth_t = \alpha_0 + \alpha_1 Inn_t + \alpha_2 X_t + u_t \qquad (1)$$

Where growth is a function of innovation (innv.) and a set of other explanatory variables which will include gross capital formation and illiteracy level. The year variable is also

included to control for annual variation in innovation levels and other variables not included in the model specification.

$$Growth_t = \alpha_0 + \alpha_1 Ypop_{\ t} + \alpha_2 X_t + u_t \quad (2)$$

In the second model specification in equation 2 growth is a function of youth population, gross capital formation and illiteracy level. The year variable is also included to control for annual variation in innovation levels and other variables not included in the model specification.

$$Growth_t = \alpha_0 + \alpha_1 Inn * Ypop_{\ t} + \alpha_2 X_t + u_t \quad (3)$$

In the third model specification in equation 3 growth is a function of an interactive variable in this case innovation* youth population, this is necessary to understand the extent to which youth can utilize innovation in Africa. The extent of which will be the level to which they actually innovate and will be a function of the level of education, access to technical facilities, the rate of flow of knowledge in the Africa region and its link to the global community while not neglecting country specific innovation policy, in conjunction with other variables such as gross capital formation and illiteracy level. The year variable is also included to control for annual variation in innovation levels and other variables not included in the model specification. (It should be noted that X_t represents other explanatory variables which include gross capital formation, illiterate population and the year variable for all three model specifications).

The method of estimation utilized as stated earlier is the quantile regression which estimates the median as a measure of central tendency. It is a non-parametric estimation technique therefore the assumption of Gaussian normality and choice of functional form do not significantly limit the choice of the estimation technique. It also produces heteroscedastic robust standard errors especially with the quantile regression 2 (qreg 2) handle implementable in Stata 11 see Silva et al 2013.

2.1 Results

In this sub section the results of the study is presented systematically. The results of the regression of innovation and growth are shown in table 1 using the quantile regression 2 handle in Stata 11. The R-Squared depicts that the model fits the data well with an R-Squared of 0.99. The objective function is .00044761 depicting the convergence to the sample median is achieved. The results below depicts that innovation (lnshphoneuse) with P-Value 0.000 has strong significant effect on economic growth in Africa using the measure of access to fixed and mobile phone lines. Gross capital formation (lngcf) and illiterate population as a percentage of youth population (lnyillpopafc) both had no significant effect on economic growth for Africa.

Table 1. Regression of Innovation on Growth Rate for Africa

Median regression					
R-squared = .99996802					
Number of obs = 24					
Objective function = .00044761					
Heteroskedasticity robust standard errors					
lngdppercap	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf. Interval]**
lnshphoneuse	1.001509	.0078429	127.70	0.000	.9850934 1.017924
lngcf	-.0052024	.0067375	-0.77	0.450	-.0193041 .0088993

lnyillpopafc	-.0327627	.0697839	-0.47	0.644	-.1788221	.1132966
Year Effect	-.0016873	.0004983	-3.39	0.003	-.0027303	-.0006442
_cons	7.790102	.6285926	12.39	0.000	6.474443	9.105762

Machado-Santos Silva test for heteroskedasticity

Ho: Constant variance
Variables: Fitted values of lngdppercap and its squares
chi2(2) = 6.486
Prob > chi2 = 0.039

Note: The above results shows the regression of innovation gross capital formation and illiterate youth population as a percentage of total youth population on economic growth for sub Saharan Africa. It was found that innovation has positive significant effect on economic growth in sub Saharan Africa.

The result of the regression of youth population, on economic growth is also depicted in the regression table of Table- 2. The results depict that the youth population has no significant effect on growth. In this case gross capital formation has strong positive effect on growth with (P-value 0.000). The R- Squared is reasonably high and the objective function (with value of .01234785) in this case depicts convergence of data used.

Table 2. Regression of Young Population on Growth Rate for Africa

Median regression

R-squared = .98157682
Number of obs = 24
Objective function = .01234785

Heteroskedasticity robust standard errors

lngdppercap	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnafrica	-2.197519	5.610783	-0.39	0.700	-13.94102	9.545985
lngcf	.8033851	.043785	18.35	0.000	.7117421	.895028
lnyillpopafc	-1.103577	1.209525	-0.91	0.373	-3.635143	1.427989
Year Effect	-.0162338	.0100541	-1.61	0.123	-.0372772	.0048096
_cons	32.61901	41.74685	0.78	0.444	-54.75814	119.9962

Machado-Santos Silva test for heteroskedasticity

Ho: Constant variance
Variables: Fitted values of lngdppercap and its squares
chi2(2) = 1.611
Prob > chi2 = 0.047

Note: The above results shows the regression of youth population gross capital formation and illiterate youth population as a percentage of total youth population on economic growth for sub Saharan Africa. It was found that gross capital formation has positive significant effect on economic growth in sub Saharan Africa (see p-value of 0.000).

The results of the regression of the interactive variable (youth population* innovation) on economic growth is depicted in Table-3. The use of the interactive variable allows us to gauge the level of youth engagement of innovative technology to drive growth and enterprise build up in Africa. It was found that the interactive variable (lnshphone~ca) has positive significant effect on economic growth in Africa.

Table 3. Regression of the Interaction (Young Population * Innovation)
on Growth Rate For Africa

Median regression					
R-squared	**= .9999771**				
Number of obs	**= 24**				
Objective function	**= .0005057**				
	Heteroskedasticity robust standard errors				
lngdppercap |	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
lnshphone~ca |	.2442787	.0020727	117.86	0.000	.2399551 .2486022
lngcf |	-.0118693	.0070382	-1.69	0.107	-.0265508 .0028122
lnyillpopafc |	-.1076503	.0323649	-3.33	0.003	-.1751622 -.0401384
_cons |	4.871293	.0664857	73.27	0.000	4.732606 5.00998
Machado-Santos Silva test for heteroskedasticity					
Ho: Constant variance					
Variables: Fitted values of lngdppercap and its squares					
chi2(2) = 1.326					
Prob > chi2 = 0.515					

Note: The above results shows the regression of the interactive variable (innovation*youth population) gross capital formation and illiterate youth population as a percentage of total youth population on economic growth for sub Saharan Africa. It was found that gross capital formation has positive significant effect on economic growth in sub Saharan Africa (see p-value of 0.000).

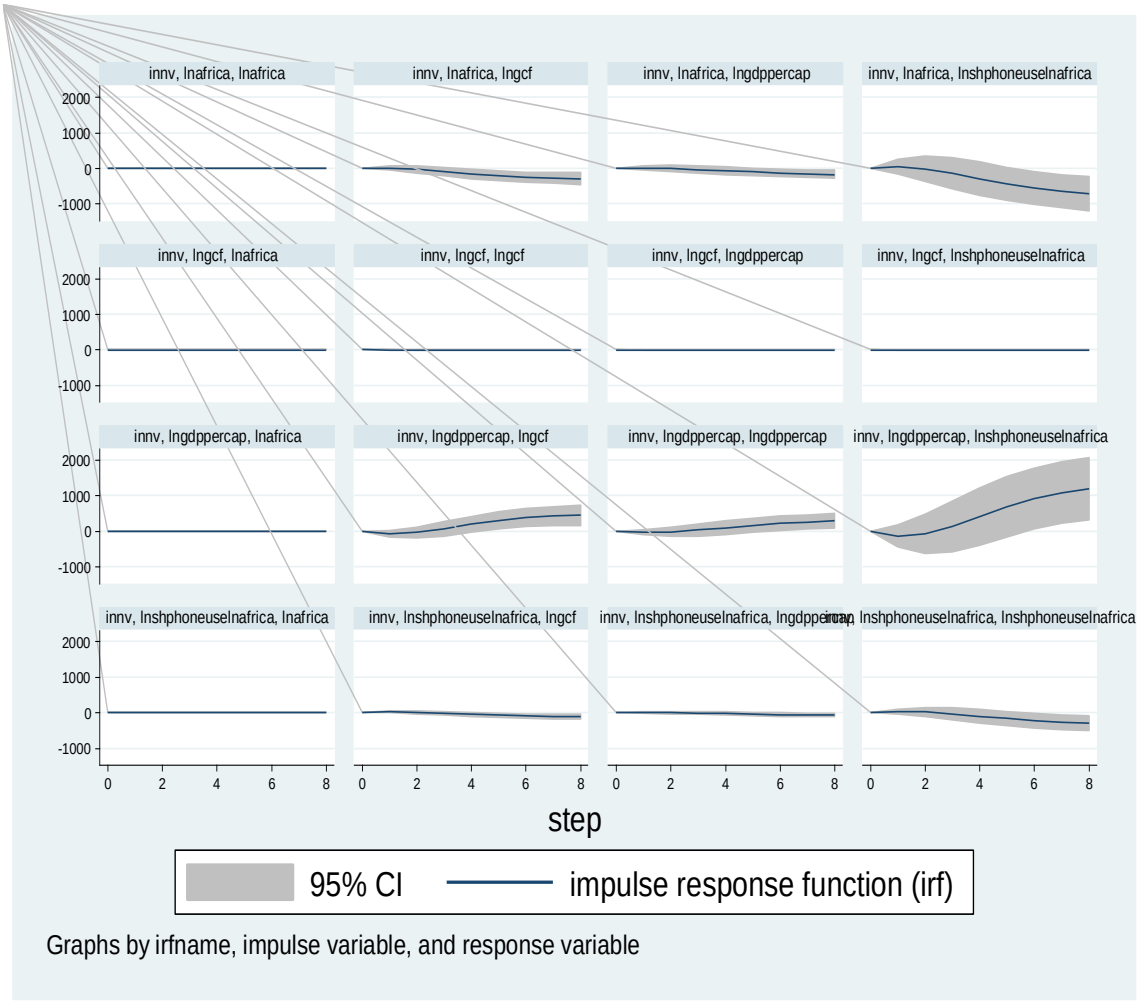
Table 4. Vector Auto-regression of innovation gross capital formation and youth population

Vector auto regression					
Sample: 1962 - 2008			**No. of obs**	**= 47**	
Log likelihood = 675.7256			**AIC**	**= -27.22236**	
FPE	**= 1.80e-17**		**HQIC**	**= -26.68909**	
Det(Sigma_ml) = 3.82e-18			**SBIC**	**= -25.80523**	
Equation	**Parms**	**RMSE**	**R-sq**	**chi2**	**P>chi2**
Gross Capital Formation	9	.098443	0.9884	4018.344	0.0000
phone use as a % Pop	9	.318865	0.9851	3115.524	0.0000
Young Population	9	.00059	0.9983	28211.58	0.0000
GDP per Capital	9	.076567	0.9853	3142.87	0.0000

Note: The above results shows the vector auto regression results

Shocks transmitted from innovation to growth is also examined using the Vector Auto regression model in the case the error is assume to follow an AR (1) process and that variance accounts for transmitted shocks from the set of interdependent variables to one another. The results are shown above in Table-4. It was found that innovation shocks to economic growth (GDP) were positive and that such shocks where significantly affecting growth (GDP) in Africa. The impulse response function depicts that such shocks lasted up to the eight periods showing that innovation was likely a more sustainable way of driving growth in many African countries. Although positive shocks were noticeable from gross capital formation to growth the effect were not as significant as that of innovation (see the third row of Fig. 5 of impulse response function among variables). Fund the Stata 11 results tables in the appendix.

Fig. 5. Impulse Response among Variables



Note: The above figure shows the impulse response function among variable using the Vector Auto Regressive (VAR) model. The results interpreted here are those of the third column. It depicts that gross capital formation extend positive shocks to economic growth, this is noticeable between the second to eighth periods see graph on row 3 column 2. There are also noticeable shocks from entrepreneurship to economic growth also noticeable from the secon to eighth periods see row three column 4.

3.0. Discussion of Results

In this section the results of the study are discussed in detail. Interestingly, the results show that Africa's current demographic composition has no significant effect on growth. Depicting that it was rather a burden because they are mainly unproductive given the hostile environment which is often a limitation to the extent to which they could be productive. Infrastructure remains a strong driver for growth particularly telecommunication infrastructure which helps improve knowledge sharing and connect people with ideas to likely venture capitalists enabling them to access funds for either new start-ups or bringing such ideas onboard existing firms. There is also suggestive evidence from the results that an innovative young population could be a strong advantage to countries on the continent since the interactive variable (young population * Innovation) had strong positive influences on economic growth. Making platforms for knowledge sharing more accessible and affordable is likely to contribute significantly to growth in many African countries.

Innovation shocks across the continent were found to be positively contributing to growth, in countries. This depicted that improving knowledge flow is likely to have meaning

effects on economic growth on the continent. It was also found that capital access were also transmitting positive shocks to growth, however the increment to growth were not as noticeable as those from innovation. These shocks in general were found to last up to 6 periods respectively with the shocks starting from the second and lasting to the 8 periods respectively for innovation and gross capital formation respectively (see fig. 4 in the results presentation section).

The share of illiterate population in the African workforce had no significant effect on economic growth. This was likely to be true since most people in this segment of the population where likely to be engaged in subsistence farming and petty trade with little consequence for GDP increases. The implication of the above results are that innovation and gross capital formation had strong positive effect on economic growth, therefore strengthening knowledge flow and increasing the flow of capital to the real sector of the African economy could had strong positive effects for growth.

4.0. Conclusion and Recommendation

In this section we conclude and make useful recommendations. In the study, the implicative effects of Africa's young population and innovation, on economic growth, were investigated. The question that the study tries to answer include to what extent does Africa's current youth demographic composition influence growth across the continent and the second question was to what extent does the innovation influence economic growth on the continent. Finally it was also necessary to ask if, youths were substantially driving economic growth utilizing innovative skills across the continent allowing for a clear understanding of how the current young and vibrant population can drive growth due to the obvious advantages that the current generation of Africa's youth have over the predecessors. Which include that they are more literate, have more access to knowledge sharing devices such as telecommunication services etc.

It was found that Africa's young population had no effect on economic growth on the continent. It was also found that innovation had positive significant effect on economic growth in Africa. Finally it was found that utilizing innovative skills which improve knowledge sharing was likely to make Africa take advantage of its young population composition to drive growth. The vector auto regression results also provided an understanding of the nature of innovation and capital flow shocks transmitted to growth in Africa. It was found that innovation and capital flows transmit shocks lasting up to six periods and that it takes at least two periods for government policy regarding innovation and capital flow improvements to take effect in many African countries. This depicts that policies designed by government to improve innovation and knowledge access as well as increase capital flow to the private sector of the African economy are not likely to yield meaningful results for growth until after two periods.

A policy to drive and increase the flow of knowledge among the young vibrant population through training, skill acquisition and knowledge sharing is therefore recommended for many African economies wishing to take advantage of their current demographic composition. It is also recommended that ease of access to capital should be encouraged in order to facilitate start-ups and link potential ideas that can lead to increase in patents would also have reaching implicative effects for many African economies. Patents are likely to increase if the business environment is made more friendly through infrastructure devel-

opment particularly telecommunication infrastructure, which can increase knowledge flow. The future remains bright if only innovative policies and sound monetary policies to drive invention and innovation, leading to patents are developed and sustained in Africa.

References

1. Aghion, P. and Howitt, P. **Growth with Quality-Improving Innovations: An Integrated Framework**, Working Paper Harvard University Press 2004. Available at http://scholar.harvard.edu/aghion/files/growth_with_quality.pdf
2. Ojeaga, P., Odejimi, D., George, O. and Azuh, D. **Energy and Economic Growth, Is There a Connection? Energy Supply Threats Revisited,** Open Journal of Energy Efficiency, 2014
3. Ojeaga, P., Odejimi, D. and Ikpefan, O. **Do High Customer Bank Deposits Incite Management Fraud? Examining Causes of Management Fraud in the Nigerian Banking Sector,** Journal of Education and Social Research Vol. 4, No. 6, 2014
4. Ojeaga, P. and Odejimi, D. **The Impact of Interest Rate on Bank Deposit: Evidence from the Nigerian Banking Sector,** Mediterranean Journal OF Social Sciences, Vol. 5, No 16, 2014, pp. 232-238
5. Ojeaga, P., Odejimi, D. O., Okhiku, J. and Ojeaga, D. **Does Commercial Bank Lending Incite Growth? The Impact of Commercial Lending on Real Sector Growth in Nigeria**, 2013
6. Ojeaga, P. **Foreign Aid and African Exporters: Help or Harm?,** Developing Country Studies Vol. 4, No. 12, 2014
7. Parente, P.M. and Santos Silva, J. **Quantile regression with clustered data,** Journal of Econometric Methods, Vol. *5, No.* 1, 2016, pp.1-15
8. * * * **World Bank Statistics**, 2013

Appendix

Appendix I. Regression of Youth Population (0-24) on Economic Growth without the Year Effect Controls

VARIABLES	(1) GDPPERCAP	(2) GDPPERCAP	(3) GDPPERCAP	(4) GDPPERCAP
Young Population (0-24)	4.980			
	(3.213)			
Gross Capital	0.822***	0.832***	0.813***	0.806***
	(0.0461)	(0.0699)	(0.0868)	(0.0510)
Illiterate Population/Total Population SSA	-1.566	-1.700	-2.440**	-1.789*
	(0.941)	(1.140)	(0.974)	(0.892)
Young pop SSA ex South Africa &Nigeria		10.13		
		(9.906)		
Young pop SSA ex South Africa			5.603	
			(10.83)	
Young pop SSA Developing				6.289
				(5.539)
Constant	-28.16	-49.61	-26.98	-32.36
	(17.90)	(47.70)	(51.09)	(27.64)
Observations	24	24	24	24
R-squared	0.978	0.975	0.973	0.975

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Appendix II. Regression of Youth Population across SSA with Year Effect Control

VARIABLES	(1) GDPPERCAP	(2) GDPPERCAP	(3) GDPPERCAP	(4) GDPPERCAP
Youth Population Africa	-2.198			
	(5.611)			
Gross Capital	0.803***	0.786***	0.777***	0.804***
	(0.0438)	(0.0445)	(0.0454)	(0.0435)
Illiterate Population/Total Pop	-1.104	-1.072	-1.082	-1.109
	(1.210)	(1.127)	(1.096)	(1.225)
Year Effect	No	Yes	Yes	Yes
	(0.0101)	(0.00555)	(0.00571)	(0.00742)
SSA Pop exc. SA & Nigeria		-4.401		
		(6.023)		
SSA Pop exc. SA			-3.854	
			(4.977)	
Pop exc. SA Developing only				-2.285
				(5.756)
Constant	32.62	38.67	33.59	29.40
	(41.75)	(30.03)	(23.49)	(33.37)
Observations	24	24	24	24
R-squared	0.982	0.980	0.981	0.981

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Appendix III *Regression of Innovation (Fixed and Mobile Phone Access as a % of total Youth population) on Growth in Africa.*

VARIABLES	(1) GDPPERCAP	(2) GDPPERCAP	(3) GDPPERCAP	(4) GDPPERCAP	(5) GDPPERCAP
Innovation all of Africa (Phone Use)	1.032***				
	(0.0121)				
Gross Capital Formation	-0.0331***	-0.0119	-0.0223**	-0.0234*	-0.0218**
	(0.0102)	(0.00704)	(0.0105)	(0.0114)	(0.0104)
Illiterate population	-0.205***	-0.108***	-0.185***	-0.183***	-0.147***
	(0.0512)	(0.0324)	(0.0449)	(0.0481)	(0.0443)
Innovation all of SSA (Phone Use)		0.244***			
		(0.00207)			
Innovation all of SSAEX. S.A. &Nig.			0.245***		
			(0.00308)		
Innovation all of SSAEX. S.A.				0.245***	
				(0.00334)	
Innovation all of SSA Dev.					0.245***
					(0.00304)
Constant	5.773***	4.871***	5.433***	5.450***	5.264***
	(0.118)	(0.0665)	(0.103)	(0.116)	(0.104)
Observations	24	24	24	24	24
R-squared	0.97	0.97	0.98	0.97	0.98

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Appendix IV. Regression of Innovation on Economic Growth Including the Year Effect Control

VARIABLES	(1) GDPPERCAP	(2) GDPPERCAP	(3) GDPPERCAP	(4) GDPPERCAP	(5) GDPPERCAP
Innovation All of Africa	1.002***				
	(0.00784)				
Gross Capital Formation	-0.0052	0.00461	-0.00233	-0.00229	-0.00202
	(0.00674)	(0.00439)	(0.00279)	(0.00234)	(0.00325)
Illiterate Population	-0.0328	-0.0281	-0.0912***	-0.0748***	-0.0434
	(0.0698)	(0.0199)	(0.0239)	(0.0203)	(0.0279)
Year Effect	Yes	Yes	Yes	Yes	Yes
Innovation all of SSA		0.240***			
		(0.00124)			
Innovation all of SSA EX. S.A. & Nig.			0.239***		
			(0.000811)		
Innovation all of SSA EX. S.A.				0.240***	
				(0.000686)	
Innovation all of SSA Developing					0.240***
					(0.000947)
Constant	7.790***	5.848***	6.512***	6.770***	6.538***
	(0.629)	(0.184)	(0.173)	(0.144)	(0.202)
Observations	24	24	24	24	24
R-squared	0.97	0.97	0.98	0.97	0.98

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

[1] **Acknowledgement**
I acknowledge members of my family for their patience with me, while I was writing this paper.

JOB SATISFACTION AND UNIVERSITY ADMINISTRATIVE STAFFS: AN EXPLORATORY STUDY[1]

Abul Fazal Md SALAHUDDIN
Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh

E-mail: salauddinj@yahoo.com

M.M.A. KHAN
Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh

E-mail: muhshin92@gmail.com

Mohamamd Ohid ULLAH
Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh

E-mail: ohidullah@gmail.com

Nasrin JAHAN
Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh

E-mail: ratryecosust@yahoo.com

Abstract

This study was conducted with a view to examine the level of job satisfaction among the administrative staffs of different public universities and determine the significant factors affecting their job satisfaction. To achieve the goals, relevant information were collected using a structured questionnaire. The chi-square test was used to ascertain the association between job satisfaction and other demographic as well as work related factors. The ANOVA and Welch's test were used to check whether the results obtained were biased by the variability of means and sample sizes or not. The Partial Least Squares Path Model was used to detect potential causal relationship between job satisfaction and other work related factors. Results showed that most of the officers working in the universities were satisfied with their job. They usually worked under less stress with no ambiguity in organizational goal and expectation. Job satisfaction was also found to be significantly associated with different age groups, education levels, service length at the current employment and current position. Finally, the path model revealed that job satisfaction was significantly and positively linked with expectations, goal and feedback factors.

Keywords: *Job satisfaction, Administrative Staffs, University, Causal Relationship, Partial Least Square Path Model*

1. INTRODUCTION

Education is the most important factor contributing to the development of the nations for their survival in global competitive environment. Quality education is almost impossible without satisfaction and commitment of the teachers. However, through their timely and essential support, administrative staffs working in the offices of registrar, planning and development, finance and accounts, controller of examination, engineering and facility planning, medical centre, physical education, library, and vice-chancellor contribute indirectly to achieve quality in university education and research. They play constructive roles in arranging necessary financial support for the academicians and researchers; facilitating the academic activities by processing and publishing the semester results on time; implementing various academic and administrative decisions taken by academic council and university syndicate, making ease of building research and teaching facilities through infrastructural development; providing continuous development program for academic and administrative staffs, and so on. Thus the efficient workforce, teaching and administrative, is one of the most important resources in a university. The central core of university activities, in fact, is based on these human resources and the way they are employed to perform different tasks to achieve organization goals.

Management specialists believe that the increase in job satisfaction leads to human resources development, and that satisfaction is directly related to productivity so that higher satisfaction will cause higher productivity and will consequently elevate the organization. In contrast, with reduction in employees' job satisfaction, administrative derelictions increase causing much lossfor the organization (Amiri, 2010).

Because of the important functions that the university administrative staffs perform and the importance of their job satisfaction for the achievement of the organization's goals, the level of job satisfaction and its influential factors should precisely be investigated so that the university top management can plan to eradicate the influencing factors and therefore pave the way for employees' satisfaction. Moreover, there is a dearth of research in this particular direction. This study, therefore, aims at investigating the job satisfaction among all those employees involved in administrative duties in the public sector university set up and tries to determine the factors that might influence employees' job satisfaction. This study focuses on:

- measurement of the level of job satisfaction among university administrative staffs,
- association of work (psychosocial job characteristics) and demographic (age, education level, and length of job at job) factors on the job satisfaction amongst university administrative staffs, and
- estimation of the combined causal relationships among the selected work variables and job satisfaction using partial least squares path model.

1.1 Literature Review

1.1.1 Job Satisfaction

Job satisfaction is considered one of the most prominent attitudinal variables that have been handled by researchers within the field of organizational behavior (Mahmoud, 2012; AL-Hussami, 2008; Astrauskaité et al., 2011; Borooah, 2009; Byrne, 2010; Paul, 2011; Hasnain et al., 2011; Spector, 1985) especially when it comes to empirical investiga-

tion conducted in the service sectors (healthcare, banking, and education) where service quality is indicated by customer satisfaction (Al-Khalil and Mahmoud, 2012; Demir 2002) refers job satisfaction to employees' feel of contentment and discontentment for a job.

Job satisfaction is found to be either positively or negatively associated with job characteristics that include autonomy (Moyle et al., 2003), workload (Khowaja et al., 2005), professional status (Dunn et al., 2005), task requirements (Campbell et al., 2004), job demands (Moyle et al., 2003) and decision making or job control (Campbell et al., 2004). Moreover, work environmental factors such as organizational system (Campbell et al., 2004); communication with peers (Dunn et al., 2005); chances for a promotion (Tyson et al., 2002); support from managers and relationships with coworkers (Seo et al., 2004); and personal variables i.e. age, race, educational level, and length of time at job (Gleason-Wynn and Mindel, 1999) are found to have significant effects on job satisfaction. Besides, the job stresses (work-related stress) are negatively related to job satisfaction (Noblet and Rodwell, 2009).

1.1.2 Job Satisfaction in University

Asl et al. (2013) investigated the job satisfaction rate and its related factors on the faculty members of Semnan University of Medical Sciences (SUMS) in Iran. They reported the nature of the work (work itself) and the lack of encouragement and appropriate feedback system as reasons for the highest and lowest level of job satisfaction respectively. Asgari et al. (2012) studied the level of job satisfaction among the operating room technician of Hamadan University of medical sciences hospitals and found no significant relationship between job satisfaction and factors such as age, background, gender, marital status and shift. Syed et al. (2012) explored the effects of motivation, hygiene and personal life factors on job satisfaction of faculty members of universities in Pakistan. The faculty members were found to be most satisfied with nature of their job (work itself) and more concerned about the issues of dearth in personal security in the campus. Khirade and Baviskar (2012) studied the Job satisfaction among the North Maharashtra University campus teachers and no significant differences were found between the job satisfaction and the factors such as gender and nature of appointment (permanent and contract basis). However, the results obtained from the researches (Islam et al., 2012) revealed that married and female teachers were more satisfied with their institutions and the teachers' job satisfaction increased with the increase in experience. Quinn and Chandan (2012) examined the role of gender and ethnicity of the faculty members' job satisfaction and showed significant difference in subscales of job satisfaction for faculty members between ethnicity: promotion, supervision, contingent rewards, operating procedures, co-workers, nature of work, and communication. However, they found no significant gender based difference in faculty members' job satisfaction. Ghazi et al. (2010) tried to explore the level of job satisfaction of university teachers in the North West Frontier Province of Pakistan. Teachers were found to be neutral with dimensions: working conditions, organizational policies and practices, recognition, supervision technical and promotion opportunities. However, they were satisfied with work variety, compensation, work itself, colleagues' cooperation, responsibility, ability utilization, authority, job security, and achievement. Alam et al., (2005) examined the relationships between job satisfaction, individual job facets, and socio-demographic variables for in the public universities in Bangladesh. Female employees were found to be more satisfied with promotion, fringe benefits

and supports of teaching but less satisfied with interpersonal relationship with colleagues than their male counterparts. Both the male and female teachers were found to have least satisfaction with pay.

2. METHODOLOGY:

2.1 Questionnaire Construction and Administration

Well-established and validated questionnaires (Söderberg, 1993; Lindström et al., 1997; Vischer, 1996) were used to collect data in this study. For each job characteristic, a 5-point Likert-type scale was used. Depending on the wording of the item, the Likert scale wording ranged from 1 = very little to 5 = very much, or 1 = a minimum amount to 5 = a maximum amount. The internal consistency in this study is measured by Cronbach's alpha. The lower limit of 0.6 is considered acceptable for newly developed scales and 0.7 for established scales (Nunnally, 1978; Fornell and Larcker, 1981). Cronbach's coefficient alphas were calculated for the items of each survey construct.

An introductory letter describing the project included information about the voluntary nature of the questionnaire, and confidentiality of responses was assured. The questionnaires were distributed randomly to the participants either directly or by email. The completed questionnaires were collected by the authors in ceiled. The respondents filled in the questionnaires at their workplaces. They were instructed to fill in the questionnaire at a quiet place with no other people around and not to consider the answers too long but always stick with the first spontaneous answer that came to their mind.

2.2 Data Collection

The study includes an Educational Institution. The sample list consisted of individuals working at executive and decision making levels (Registrar, Planning and Development, Finance and Accounts, Controller of Examination, Engineering Office, Medical Centre, Physical Education, Library, and Vice-Chancellor's Office). To test the non-response bias, the responses of those who returned early were compared with those who returned late to determine if there are any statistical differences. There were no statistical differences between the early and late responses. A total of 285 survey questionnaire were sent (interviewed and mailed). Of the 262 returned questionnaires, 258 were usable. The response rate was approximately 91%. The data analysis is based on the 258 useable questionnaires.

2.3 Partial Least Squares Path Model

Partial least squares path model (PLSPM) (Sanchez, 2012; Lohmoller, 1989) was developed using partial least squares (PLS) (Wold, 1985; Wold et al., 2001) to structural equation modeling (SEM) which is also known as SEM-PLS or soft modeling. The PLSPM does not depend on any distribution pattern and a few cases can suffice (Tenenhaus et al., 2005). Furthermore, it is a components based approach and robust against missing values, misspecification and multi co linearity problems. The maximum likelihood method in SEM is known as SEM-ML or hard modeling. It is a covariance based approach and depends on a specific distribution pattern and need more cases (Joreskog, 1970). Most of our collected data based on Likert scale, i.e., ranged between 1 to 5, therefore, we have applied a well-known non-parametric multivariate approach (PLSPM) in our data to find out the potential causal relationships among the dimensions related with job satisfaction.

3. RESULTS AND DISCUSSIONS

3.1 Reliability Testing

The analysis of the data is initiated with the determination of instrument's internal consistency. This was found through application of reliability test i.e. Cronbach's alpha coefficient. The scale's reliability was determined through sample of 258 respondents each of them answered 61 questions. The coefficient for the sixty one items in the study was 0.861. This is considerably above the recommended 0.70 (Nunnally, 1978; Fornell and Larcker, 1981).

Table 1. Descriptive statistics of different factors (dimensions).

	Mean	(±)SD
Job Satisfaction	2.1293	0.76
Stress at work	2.0466	0.82
Work demand	2.8914	1.07
Expectation, goal and feedback	3.4954	0.92
Control at work	2.3908	1.27
Skill in work	4.0517	0.77

3.3 Descriptive Statistics

As shown in Table 1, the average rating for 'job satisfaction' by the respondents is 2.13 ('1'= 'very satisfactory'), which shows that the majority of the officers working in the university are satisfied with their job. Again, average rating for 'stress at work', 'expectation, goal and feedback', and 'skill in work' are 2.04 ('1' = 'Never/Rarely'), 3.5 ('5' = 'Very often') and 4.05 ('5' = 'very often'/'always') respectively. These rated values indicate the facts that the officers usually work under less stress with no ambiguity in organizational goal and expectation. Moreover, they are satisfied with the way they are getting the feedback on the quality of their work. However, they have rated their work less demanding and intellectually less stimulating (rating for 'work demand' is found to be 2.89). Besides, the officers are found to have lower control over their work (rating for 'control at work' is 2.39).

Table 2. Frequency distribution of different demographic and service length variables.

Age group	Frequency	Percentage (%)
26-30	53	20.7
31-35	80	31.0
36-40	13	5.2
41-45	44	17.2
46-50	18	6.9
51-55	18	6.9
56-60	31	12.1
Education		
Bachelor	31	12.1
Masters	214	82.8
Others	13	5.2

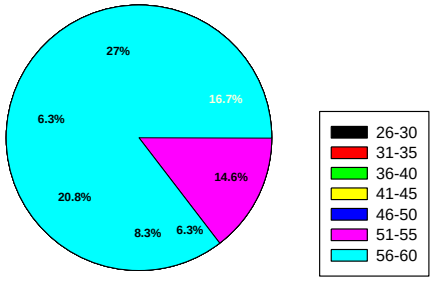
Marital Status		
Married	214	82.8
Single	44	17.2
Service length at current position		
1 – 5 yrs	138	53.4
6 – 10 yrs	18	6.9
11 – 15 yrs	76	29.3
16 yrs and above	27	10.3
Service length at current employment		
1 – 5 yrs	214	82.8
6 – 10 yrs	18	6.9
11 – 15 yrs	22	8.6
16 yrs and above	4	1.7

An individual's function within the university includes administration and human resources, planning and development, finance and accounts, controlling examination, infrastructure development, medical, physical education, and library facility development. The Table 2 shows that our sample consists of more married (82.8%) than single (17.2%). All the respondents are educationally well qualified: 82.8% of them have post-graduate degree and remaining 17.2% have bachelor and other degrees. Of 258 respondents, 51.7% are identified as young adults (25-35 years), 22.4% as early middle age (36-45 years) and 13.8% as late middle age (46-55 years). Besides, 89.7% of the total respondents have been employed in their organization for an average of 3.31 years with a range of 1 – 10 years wherein 44.8% and 41.4% of them have the work experience in the range of 1 – 3 years and more than 3 – 8 years respectively in the current position.

Table 3. Association between job satisfaction and different demographic and service related variables

	Satisfied (%)	Dissatisfied (%)
How would you rate your current position in terms of level of satisfaction?	82.8	17.2

Fig. 1: Satisfaction with the job in general among the respondents with different age-groups. (*Chi-square Test:* p- value of linear-by-linear association: 0.006)



Figs 1-4 illustrate the distribution of level of satisfaction among the officers working in the university with their current job positions. As shown in the table 3, 82.8% of the total

respondents have rated their current job as 'satisfactory to very satisfactory', whereas remaining 17.2% are not at all satisfied. As shown in Fig 4, 83.3% of the satisfied respondents are found to have an academic master's degree indicating the fact that respondents with higher academic degree have higher satisfaction with their current job. However, this result is influenced by the variability of means and sample sizes. Fig 3 shows that, even though the young adults have less control at work, they (43.7%) are satisfied with their job more than the early and the late middle age groups (for ANOVA test, F = 8.33 and p = 0.001; for Welch's test, F = 7.438 and p = 0.002). This is because every new appointment and/or promotion comes to the university officers as a new challenge and motivates them to perform effectively and enthusiastically as well. Though the respondents (18.7%) working for more than ten years in the same position do their job under less stress with no ambiguity in organizational goal and expectation, they think that their performance is not being properly evaluated. Moreover, they find their job monotonous and less stimulating over time. As a result, they get no motivation to perform their day-to-day functions better resulting in less satisfaction with their job in general. Interestingly 14.6% of satisfied respondents in the range of 56 – 60 years are found to have satisfaction with their job positions. This is because of the fact that they are actively involved in decision and strategy making process, and find their job more demanding and intellectually stimulating. Moreover, they have total control at their work. Taken together, results show that job satisfaction is significantly associated with different age groups, education levels, and different service length at the current employment and at the current position as well.

Fig. 2: Satisfaction with the job in general among the respondents with different service length at the current employment.
(*Chi-square Test:* p-value of linear-by-linear association: 0.006)

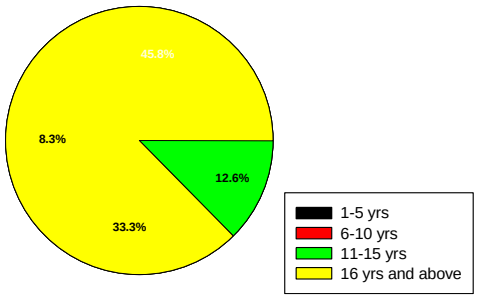
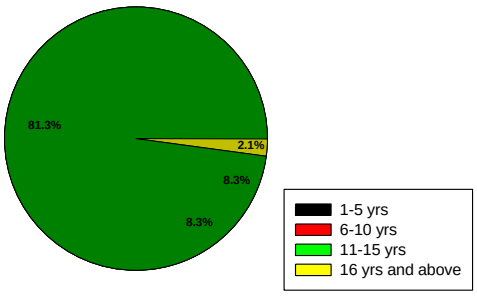


Fig. 3: Satisfaction with the job in general among the respondents with different service length at the current position.
(*Chi-square Test:* p-value of linear-by-linear association: 0.007)



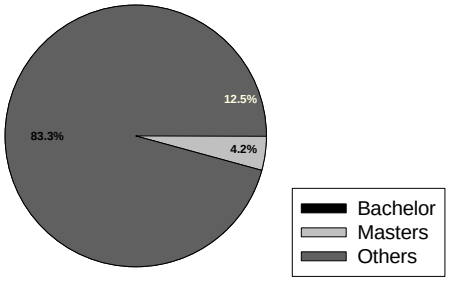


Fig. 4: Satisfaction with the job in general among the respondents with different education level.
(*Chi-square Test:* p-value of linear-by-linear association: 0.0125)

3.4 Potential Causal Relationship among Different Dimensions of Job Satisfaction

The potential causal relationships have been investigated among the dimensions related with job satisfaction through PLSPM. It is assumed that the latent variable 'Job satisfaction' might be influenced by the latent variables " work demand", "expectations, goal and feedback", "skill", "stress", "control at work". Furthermore, each latent variable is a linear combination of several factors. The influential factors in each latent variable or dimension have been depicted in the Fig. 5.

The path diagram illustrated in Fig. 5 reveal that job satisfaction is significantly associated with expectations, goal and feedback (coefficient = 0.47) as well as work demand (coefficient = -0.12). Thus these outcomes indicate that expectation, goal and feedback have a significant positive impact on job satisfaction, whereas increasing work demand results in job dissatisfaction. Moreover, job satisfaction increases with the increase in control at work and skill requirements, whereas job satisfaction decreases with the increase in stress. No significant association is found between job satisfaction and control at work and skill in this path model. This is because, in the path model, the dimensions are interconnected and none has one-to-one relationship with job satisfaction. However, simple linear regression models show the significant association of each of the dimensions (skill, control at work and stress) with job satisfaction. Moreover, the results shown in path diagram indicate the fact that aggregate effect of the dimensions under consideration on the employees' job satisfaction exists and shows a pattern different from individual effects. The most influential variables of each dimension are given in the Appendix-A.

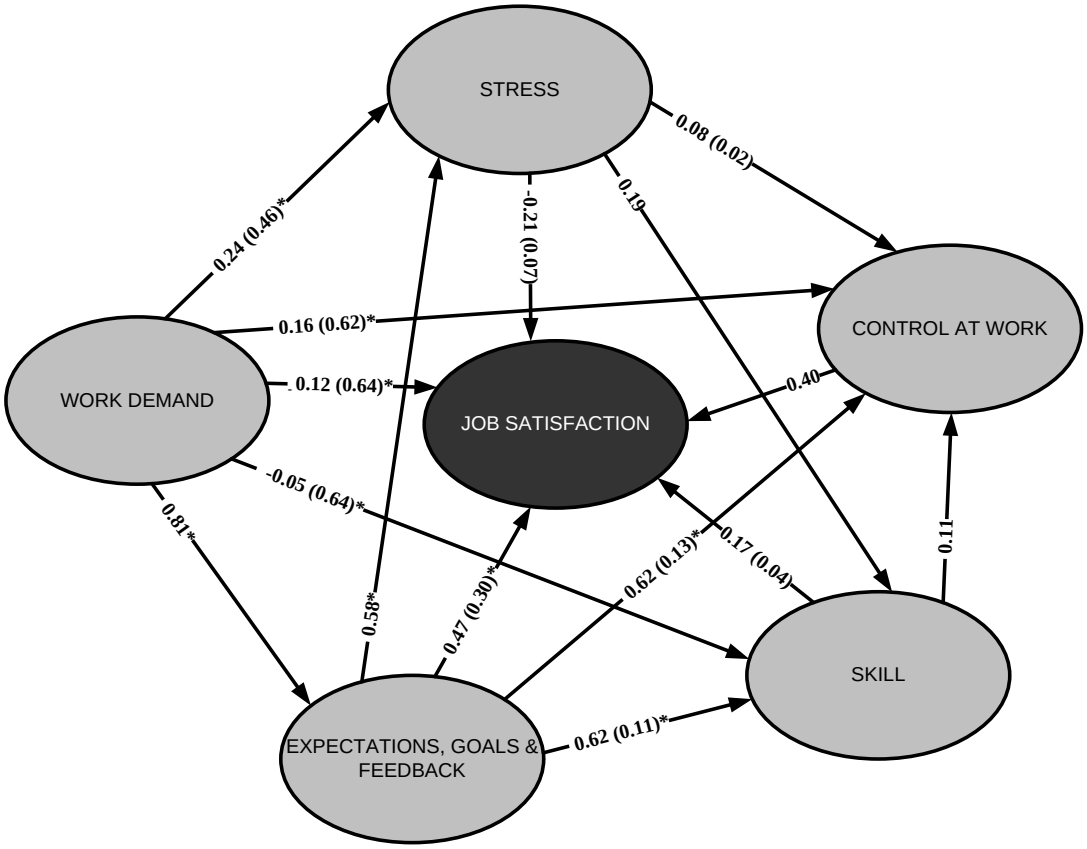


Fig. 5: Path diagram with direct and indirect path coefficients. Indirect path coefficients were presented in the parentheses. Star (*) mark indicates the significant at 5% level. The goodness of fit of this model is: absolute = 0.42, relative = 0.67, Outer model = 0.82 and inner model = 0.82. The results of the path diagram were obtained by using 'plspm' package in R statistical program.

4. CONCLUSIONS

The study has examined the level of job satisfaction among the administrative staffs working indifferent public universities and its association with the various psychosocial job characteristics. Based on the results and discussion, following conclusions can be drawn:

- Job satisfaction is significantly associated with different age groups, education levels, service length at the current employment and current position.
- Despite of less control at work, the young adults are satisfied with their jobs more than the early and the late middle age groups.
- Expectation, goal and feedback is the most influential factor affecting the university staffs' job satisfaction positively, whereas work demand has the negative effects on their job satisfaction.
- University staffs working under less stress with no ambiguity in organizational goal and expectation are satisfied with their current jobs. However, negative effect is observed for the staffs working for more than a decade in the same position.

- University staffs with higher academic degree have higher satisfaction with their current jobs. However, this result is influenced by the variability of means and sample size.

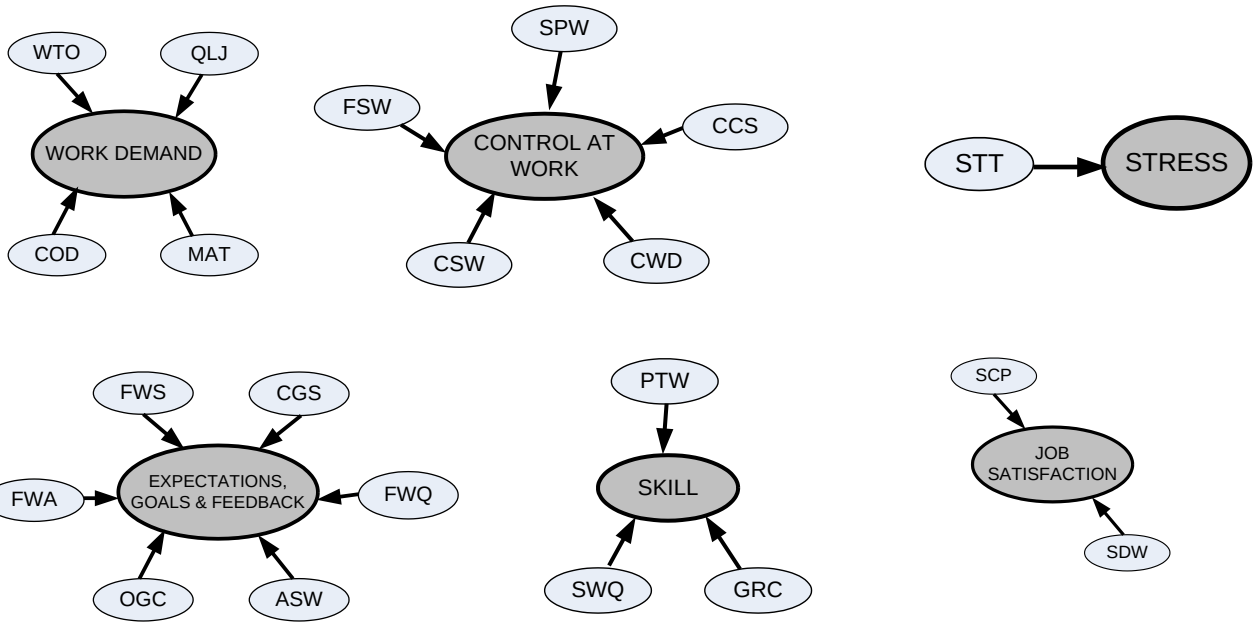
References

1. Alam, S.S., Talha, M., Sivanand, C.N. and Ahsan, M.N. **Job Satisfaction of University Woman Teachers in Bangladesh,** J. Soc. Sci., Vol. 1, 2005, pp. 88-91
2. Al-Hussami, M. **A Study of Nurses' Job Satisfaction: The Relationship to Organizational Commitment, Perceived Organizational Support, Transactional Leadership, Transformational Leadership, and Level of Education**. European Journal of Scientific Research, Vol. 22, No. 2, 2008, pp. 286-295
3. Al-Khalil, A. and Mahmoud, A. B. **The role of demographics in patients' perceptions towards the quality of health care services provided at public hospitals in Damascus,** European Journal of Economics, Finance and Administrative Sciences, No. 48, 2012, pp. 113-121
4. Amiri, M., Khosravi, A. and Mokhtari, A. A. **Job satisfaction and its influential factors,** Journal of Research in Health Science, Vol. 10, No. 1, 2010, pp. 42-46
5. Asgari, M., Rafat, A. and Rashedi, V. **Job Satisfaction in Operating Room Technician of Hamadan University of Medical Sciences' Hospitals,** Pajouhan Scientific Journal, Vol. 11, No. 1, 2012, pp. 37-40
6. Asl, N.S., Ghorbani, R., Alghajani, S.H. and Rashidy-Pour, A. **Job satisfaction and its contributing factors among faculty members of Semnanuniversity of medical sciences,** Journal of Semnanuniversity of medical sciences (Koomesh), Vol. 14, No. 2, 2013, pp. 232-239
7. Astrauskaité, M., Vaitkevičius, R. and Perminas, A. **Job Satisfaction Survey: A Confirmatory Factor Analysis Based on Secondary School Teachers' Sample,** International Journal of Business & Management, Vol. 6, No. 5, 2011, pp. 41-50
8. Borooah, V. K. **Comparing levels of job satisfaction in the countries of Western and Eastern Europe**, International Journal of Manpower, Vol. 30, No. 4, 2009, pp. 304-325
9. Byrne, B. M. **Structural equation modeling with AMOS: basic concepts, applications, and programming**, New York: Routledge: Taylor and Francis Group, LLC., 2010
10. Campbell, S., Fowles, E. and Weber, B. **Organizational structure and job satisfaction in public health nursing**, Public Health Nursing, Vol. 21, 2004, pp. 564–571
11. Demir, M.C. **Job satisfaction of nurses, working at Turkish Military Forces Hospitals,** Military Medicine, Vol. 167, 2002, pp. 402-404
12. Dunn, S., Wilson, B. and Esteman, A. **Perceptions of working as a nurse in an acute care setting**, Journal of Nursing Management, Vol. 13, 2005, pp. 22–31
13. Edwin, Q. Jr. and Harish, C. **Demographical Differences in Perceptions of Leadership Practices for Department Chairs and Job Satisfaction of Faculty Members at a Historically Black University**, International Journal of Academic Research in Business and Social Sciences, Vol. 2, No. 9, 2012

14. Fornell, C. and Larcker, D.F. **Structural equation models with unobservable variables and measurement error: algebra and statistics**, Journal of Marketing Research, Vol. 18, No. 3, 1981, pp. 382-388
15. Ghazi, S.R., Ali, R., Shahzada, G. and Israr, M. **University teachers' job satisfaction in the North West Frontier province of Pakistan,** Asian Social Science, Vol. 6, No. 11, 2010, pp.188
16. Gleason-Wynn, P. and Mindel, C. **A proposed model for predicting job satisfaction among nursing home social workers,** Journal of Gerontological Social Work, Vol. 32, 1999, pp. 65-79
17. Hasnain, T., Khan, B., Awan, Z., Tufail, M. and Ullah, F. **Job Satisfaction among Bank Employees: A Pakistan Perspective,** Interdisciplinary Journal of Contemporary Research in Business, Vol. 3, No. 6, 2011, pp. 693-704
18. Islam, T., Ahmad, Z. and Ahmed, I. **Does Compensation and Demographical Variable Influence on Teachers Commitment and Job Satisfaction? A Study of University of the Punjab, Pakistan,** International Journal of Business and Management, Vol. 7, No. 4, 2012, pp. 35-43
19. Joreskog, K.G. **A general method for analysis of covariance structure,** Biometrika, Vol. 57, 1970, pp. 239-251
20. Khirade, S. K. and Baviskar, M. H. **Job Satisfaction among the North Maharashtra University Campus Teachers, Golden Research Thoughts,** Academic Journal, Vol. 2, No. 2, 2012, pp. 1
21. Khowaja, K., Merchant, R. and Hirani, D. **Registered nurses perception of work satisfaction at a tertiary care university hospital,** Journal of Nursing Management, Vol. 13, 2005, pp. 32–39
22. Lindström, K., Dallner, M., Elo, A.-L., Gamberale, F., Knardahl, S. and Skogstad, A. **Review of Psychological and Social Factors at Work and Suggestions for the General Nordic Questionnaire (QPSNordic)**. Copenhagen, Denmark, 1997
23. Lohmoller, J.B. **Latent variable path modeling with partial least squares**, Heidelberg: Physica-Verlag, 1989
24. Mahmoud, A. B. **The influence of gender and job description on job satisfaction: An empirical study within public hospitals in Damascus,** Damascus University Journal of Economics & Law Sciences, 2012
25. Moyle, W., Skinner, J., Rowe, G. and Gork, C. **Views of job satisfaction and dissatisfaction in Australian long-term care,** Journal of Clinical Nursing, Vol. 12, 2003, pp 168–176
26. Noblet, A. J. and Rodwell, J. J. **Integrating job stress and social exchange theories to predict employee strain in reformed public sector contexts,** Journal of Public Administration Research and Theory, Vol. 19, 2009, pp. 555-578
27. Nunnally, J.C. **Psychometric theory**, 2nd edition, New York: McGraw-Hill, 1978
28. Paul, E. P. **Lecturers' job satisfaction in a public tertiary institution in Singapore: ambivalent and non-ambivalent relationships between job satisfaction and demographic variables,** Journal of Higher Education Policy & Management, Vol. 33, No. 2, 2011, pp. 141-151
29. Sanchez, G. **Plspm: Partial least squares data analysis methods**, 2012 http://cran.r-project.org/web/packages/plspm.

30. Seo, Y., Ko, J. and Price, J. **The determinants of job satisfaction among hospital nurses: a model estimation in Korea,** International Journal of Nursing Studies, Vol. 41, 2004, pp. 437–446
31. Söderberg, I. **Grupporganisationochinremiljöisamspel (The Interplay between Group Organization and Interior Design**). in Westlander, G. (Ed.) "Välkommen till Teletjänsten…- Organisation, lokaler, arbetstiderochar-betsinnehållförnyelse (Welcome to Teletjänsten - A renewal of an organization)", Göteborg: Arbetsmiljöinstitutet (The Swedish National Institute for Working Life), 1993
32. Spector, P. E. **Measurement of human service staff satisfaction: development of the Job Satisfaction Survey,** American Journal of Community Psychology, Vol. 13, No. 6, 1985, pp. 693-713
33. Syed, A.A.S.G., Bhatti, N., Michael, S., Shaikh, F.M. and Shah, H. **Job satisfaction of faculty members of university in Pakistan: A case study of university of Sindh-Jamshoro,** Modern Applied Science, Vol. 6, No. 7, 2012, pp. 89-95
34. Tenenhaus, M., Esposito Vinzi, V. Y.M. C and Lauro, C. **PLS path modeling**, Comput. Stat. Data. An., Vol. 48, 2005, pp. 159-205
35. Tyson, P., Pongruengphant, R. and Aggarwal, B. **Coping with organizational stress among hospital nurses in Southern Ontario**, International Journal of Nursing Studies, Vol. 39, 2002, pp. 453–459
36. Vischer, J. **Workspace strategies: Environment as a Tool for Work**, New York: Chapman and Hall, 1996
37. Wold, H. **Partial least squares**, NewYork: Wiley, 1985
38. Wold, S., Sjostrom, M. and Eriksson, L. **PLS-regression: a basic tool of chemometrics**, ChemomIntell Lab Syst., Vol. 58, 2001, pp.109-130

APPENDIX-A: The influential variables of each dimension



Abbreviation			
WTO	Work Over Time	STT	Saying Things Without Thinking
QLJ	Qualified Job	SWQ	Satisfaction With Work Quality
MAT	Maximum Attention	PTW	Provision of Training At Work
COD	Complicated Decision	GRC	Good Relations With Colleagues
FWA	Feedback: Work Achievement	FSW	Free To Select Own Work Procedure
FWS	Freedom For Work Procedure	SPW	Set Pace of Work
CGS	Contribution To Goal Setting	CCS	Contribution To Coworkers Selection
FWQ	Feedback: Work Quality	CWD	Contribution To Work-related Decision
ASW	Access To See The Work Quality	CSW	Contribution To Setting Work Schedule
OGC	Organizational Goal Clarity	SCP	Satisfaction With Current Position
		SDW	Satisfaction With Day To Day Work

[1] **Acknowledgements**

The authors are grateful to the Shahjalal University of Science and Technology (SUST) for providing the administrative support to carry out this research. The support provided by the Department of Industrial and Production Engineering, SUST at various stages of this research is also sincerely acknowledged.

JOURNAL OF APPLIED QUANTITATIVE METHODS

Quantitative Methods Inquires

APPROXIMATING THE POISSON PROBABILITY DISTRIBUTION BY THE CONWAY-MAXWELL POISSON DISTRIBUTION

N. E. ARUA
Graduate Student
Department of Statistics, University of Botswana

E-mail: eke2892@yahoo.com

R. M. SAKIA
Associate Professor of Statistics
Department of Statistics, University of Botswana

E-mail: sakiar@mopipi.ub.bw

Abstract

The aim of this research was to approximate the Poisson distribution by the COM-Poisson as a way to induce equi-dispersion in the model and hence, make some inferences by taking advantage of the close-form moments of the Poisson distribution. This was achieved by relating the approximate moments of the COM-Poisson distribution to that of the Poisson distribution to determine the relationship between their respective parameters. The estimates of the Poisson parameters were found to induce equi-distribution to the observed data. The advantage of the estimation is that closed-form moments of the Poisson can then be used to make inferences on the data. It is recommended that the COM-Poisson distribution should be applied to induce equi-distribution when the data does not conform to the Poisson distribution.

Keywords: *Poisson distribution, COM-Poisson distribution, equi-dispersion*

Introduction

When counting items that arise independently of one another at random in space (or time), the Poisson distribution may be appropriate. If the items (for example, insects, lesions on a leaf, or weeds) occur at a constant average rate of θ per unit area, and if a large number of unit areas are counted, the actual number of items in each unit being X, then the distribution of X follows the Poisson distribution. If the rate per unit area θ does not remain constant over a complete population of units being studied then the Poisson distribution will not be a suitable model. Another case where it does not work is when the items being counted are not fully independent of one another but tend to arise in groups. Theoretically, the mean and variance of the Poisson are equal, so we can say that the Poisson distribution has equal dispersion or equi-dispersion. According to Sellers, Borle and Shmueli (2012), this is hardly the case in real life count data. This has led to the popularization of the negative

binomial distribution which can capture over-dispersion. Feng-Chang and Bo-Cheng (2010) declare that for over dispersed-data, the negative binomial can be used, and, further, that the generalized Poisson regression model is one of the few distributions that can be used for both under- and over-dispersed count data. Berk and MacDonald (2008) conclude that if apparent over-dispersion results from specification errors in the systematic part of the Poisson model, resorting to the negative binomial distribution does not help. It can make things worse by giving a false sense of security when the fundamental errors in the model remain.

It is ideal to avoid over-dispersion or under-dispersion in count data. Hinde and Demetrio (1998) discuss the consequences of over-dispersion. They state that, firstly, the standard errors obtained from the model will not be correct and may be seriously underestimated and, consequently, that we may incorrectly assess the significance of individual regression parameters. Also, changes in deviance associated with model terms will be too large and this will lead to the selection of overly complex models. Finally, our interpretation of the model will be incorrect and any predictions will be too precise. Cameron and Trivedi (2001) state that over-dispersed and under-dispersed data will lead to the standard errors of model parameters being inconsistent.

Of particular focus in this study is the Conway-Maxwell-Poisson (COM-Poisson). The Conway-Maxwell-Poisson (COM-Poisson) model is another such technique for such count data. The distribution was first introduced in 1962 by Richard W. Conway and William L. Maxwell, but only recently have the statistical and probabilistic properties of the distribution been published by Shmueli, Minka, Kadane, Borle and Boatwright (2005). So it can be said to be a relatively new distribution. The COM-Poisson distribution adds a new parameter ν which governs the rate of decay of successive probability ratios (Shmueli et al, 2005). Since then, further advancements on the distribution have been produced. Sellers and Shmueli (2010) used COM-Poisson regression to predict censored count data. Lord, Guikema and Geedipally (2008) applied the generalized COM-Poisson linear model to the analysis of motor vehicle crashes using a flexible GLM that could model both under-dispersed and over-dispersed data sets. Rodrigues et al (2009) developed a flexible cure rate survival model by assuming that the number of competing causes of the event of interest follows a COM-Poisson distribution.

The assumption of equi-distribution of a Poisson data does not hold in most experimental situations. To circumvent this problem, the COM-Poisson probability model has been proposed because of its assumed ability to remedy the violation of equi-distribution. A major hurdle in its use is the lack of a closed form moment generating function for which the exact moments could be obtained (Shmueli et al, 2005). This problem also arises in deriving some closed form estimates of the model parameters (for example, MLEs) as well as deriving some inferential results from the model, such as, best critical region of a test and tests of hypotheses. An attempt is therefore made to relate the COM-Poisson parameters to the Poisson parameters by using the approximate moments of the COM-Poisson in order to induce equi-distribution to some count data.

Methodology

Poisson Model

The Poisson distribution is a discrete probability distribution used to describe the number of occurrences in a given small interval of time and/or space if these events occur

with a known average rate and the occurrence of one event is independent of the occurrence of others.

The probability mass function of the Poisson distribution is:

$$P(X = x) = \frac{\theta^x e^{-\theta}}{x!} \qquad x = 0,1,2,\ldots, \quad \theta > 0 \qquad (1)$$

The mean and variance of the Poisson distribution is given by:

$$E(X) = Var(X) = \theta \qquad (2)$$

The limitation of the Poisson model is that it requires the variance to be equal to the mean which, as was stated earlier, is hardly satisfied in real life count data.

COM-Poisson Model

The COM-Poisson probability function according to Shmueli et al (2005) is given as:

$$P(X = x) = \frac{\lambda^x}{(x!)^\nu} \frac{1}{Z(\lambda, \nu)} \qquad \lambda > 0, \quad \nu \geq 0 \quad x = 0,1,2,\ldots, \qquad (3)$$

where $Z(\lambda, \nu) = \sum_{j=0}^{\infty} \frac{\lambda^j}{(j!)^\nu} \qquad \lambda > 0, \ \nu \geq 0 \qquad (4)$

This satisfies the conditions for a probability function. The formulation allows for a non-linear decrease in the ratios of successive probabilities in the form:

$$\frac{P(X = x-1)}{P(X = x)} = \frac{x^\nu}{\lambda} \qquad (5)$$

υ is the shape parameter of the COM-Poisson distribution. The condition $\upsilon > 1$ corresponds to under-dispersed data, $\upsilon < 1$ to over-dispersed data, and $\upsilon = 1$ to equi-dispersed (Poisson) data. The series $\frac{\lambda^j}{(j!)^\nu}$ converges for any $\lambda > 0$ and $\nu > 0$ as the ratio of the subsequent terms of the series $\frac{\lambda}{j^\upsilon}$ tends to 0 as $j \to \infty$.

The first central moment of the COM-Poisson distribution is given by:

$$E(X) = \frac{\partial log Z}{\partial log \lambda} \qquad (6)$$

The second central moment is given by:

$$Var(X) = \frac{\partial^2 log Z}{\partial log^2 \lambda} \qquad (7)$$

The COM-Poisson distribution does not have a closed-form expression for its moments in terms of the parameters λ and ν. By using an asymptotic expression for Z in (4) the mean and variance can be approximated (Shmueli et al, 2005) in the form:

$$E(X) \approx \lambda^{1/\upsilon} + \frac{1}{2\upsilon} - \frac{1}{2} \qquad (8)$$

$$Var(X) \approx \frac{1}{\nu} \lambda^{1/\nu} \qquad (9)$$

The approximations are especially good for $\nu \leq 1$ and $\lambda > 10^\nu$ (Shmueli et al, 2005).

Estimation of the poisson parameter

The moments of the COM-Poisson will be related to that of the Poisson distribution to determine the relationship between them by equating equation (2) to (8) and (9) as:

$$\theta = \lambda^{1/\nu} + \frac{1}{2}\left(\frac{1}{\nu} - 1\right) \qquad (10)$$

$$\theta = \frac{1}{\nu}\lambda^{1/\nu} \quad (11)$$

Solving for θ in terms of λ as well as ν:

$$\hat{\theta}_1 = \frac{1}{2\upsilon} \quad (12)$$

$$\hat{\theta}_2 = \frac{0.5\ln(0.5)}{ln\lambda} \quad (13)$$

As noted by Shmueli et al (2005), a simple and computationally efficient method of finding estimates of λ and ν is the linearizing of equation (5) as:

$$ln\left[\frac{P(X=x-1)}{P(X=x)}\right] = -ln\lambda + \nu\ln(x) \quad (14)$$

Ignoring all counts with zero frequencies in the data, the ratio $r = \frac{P(X=x-1)}{P(X=x)}$ is to be computed and displayed in Table 1.

Table 1. A layout of the data

X	x_1	x_2	…	x_n
P(x)	p_1	p_2	…	p_n
r	-	r_1	…	r_{n-1}

A simple linear regression of (14) will enable one to obtain estimates of $\hat{\lambda}$ and $\hat{\nu}$ where $P(X=x)$ and $P(X=x-1)$ are replaced by the respective relative frequencies. Note that $p_i = \frac{f_i}{\sum f_i}$ where f_i is the corresponding non-zero frequency.

Considering the two estimates of θ, then the corresponding Poisson distributions are:

$$P_j(X=x) = \frac{e^{-\hat{\theta}_j}\hat{\theta}_j{}^x}{x!} \text{ for j=1,2} \quad (15)$$

We compute the estimates of the probabilities for the two cases above and deduce the corresponding frequencies $\hat{f}_i$. Then we compute the mean and variance of the Poisson using the estimates $\hat{f}_i$ for the two cases and note the extent of the closeness (or lack of it) of the mean and variance.

Description of the datasets

The following data sets were used in the study because of the varying inherent different levels of dispersion.

Dataset 1

The data set consists of quarterly sales of a well known brand of a particular article of clothing at stores of a large national retailer. This data set was published by Shmueli et al (2005) and is available at http://www.stat.cmu.edu/COM-Poisson/sales-data.html

Dataset 2

Gilchrist (1984) refers to an experiment in which a total of 33 insect traps were set out across sand dunes and the number of insects caught in a fixed time was counted. The data consists of the number of traps containing various numbers of the taxa ***staphylinoidea***.

Dataset 3

The data gives the fertility of eggs of the CP strain of ***Drosophila melanogaster*** raised in 100 vials of 10 eggs in a study by Sokal (1966) and reproduced in Sokal and Rohlf (2003; pp. 96)

Dataset 4

It is well known that there is a tendency for unisexual sibships to result in a clumped distribution of observed frequencies. In an extensive study by Geissler (1889), the sex ratio of 6115 sibships of 12 children were recorded from actual hospital records in Saxony, Germany. The data consists of the number of females per sibship X. The data is reproduced in Sokal and Rohlf (2003; pp 80)

Results and discussion

Dispersion of the original data

Table 2 gives the extent of dispersion of the raw datasets on the basis of their mean and variance. Note that over-dispersion occurs when the variance exceeds the mean.

Table 2. Means and Variances for the data sets

Dataset	Mean	Variance	**Dispersion**
Shmueli	3.56	11.31	Over-dispersed
Gilchrist	1.64	2.74	Moderately Over-dispersed
Geissler	5.77	3.49	Under-dispersed
Sokal	5.91	5.56	Moderately under-dispersed

Estimates for λ, ν and the corresponding θ

The estimates were obtained using the regression run in equation (14) and substituted in equations (15) and (16). The results are shown in Table 3 below.

Table 3. Estimates of λ, ν and the corresponding $\theta's$

Data Set	Estimate of ν	Estimate of λ	Estimate of θ_1	Estimate of θ_2
Shmueli	0.135	0.887	3.704	2.890
Gilchrist	0.109	0.768	4.587	1.310
Geissler	1.476	10.890	0.339	-0.145
Sokal	0.557	2.889	0.897	-0.330

It should be noted that the $\hat{\theta}_2$ estimates for the Geissler and Sokal dataset do not provide valid estimated of a Poisson parameter since they are negative and hence are ignored.

Assessment of the means and variances for the estimated Poisson model

The means and variances for all the data sets were recomputed using the estimated probability for a Poisson parameter $\hat{\theta}$. The results are presented in Table 4 for $\hat{\theta}_1$ and Table 5 for $\hat{\theta}_2$.

Table 4. Means and Variances for the datasets after calculating frequency estimates for $\hat{\theta}_1$

Data Set	Mean	Variance
Shmueli	3.704	3.705
Gilchrist	1.310	1.340
Geissler	0.339	0.339
Sokal	0.910	0.907

Table 5. Means and Variance for the data sets after calculating frequency estimates for $\hat{\theta}_2$

Data set	Mean	Variance
Shmueli	2.89	2.89
Gilchrist	3.156	3.173
Geissler	-	-
Sokal	-	-

In comparison to results in Table 2, the empirical results clearly shows that the Poisson parameters estimated by the COM –Poisson to have effectively induced the equi-distribution property of the Poisson probability distribution which is a prerequisite for analysing count data which is assumed to follow that distribution.

Conclusions

Despite its usefulness when it comes to handling count data, the Poisson distribution is impractical to use because its assumptions of equi-distribution are rarely met in real-life count data. The COM-Poisson has been found to be flexible when handling count data as it caters for both over- and under-dispersion. However, a major deficiency for the distribution is the lack of closed form moments which in turn renders it impossible for use in testing hypotheses about the parameters λ and ν. For example, the test statistic for the Neyman-Pearson lemma is impossible to derive. In this case, the test may be approximated by the estimated Poisson model. In view of the results in this study it is recommended that care be taken when analyzing data that is deemed to follow a Poisson process. Exploratory analysis should be undertaken to check whether the data indeed conform to the Poisson distribution. If not, then the COM-Poisson distribution should be applied to induce equi-distribution which is a key requirement for any Poisson process.

References

1. Berk, R. and MacDonald, J. **Overdispersion and Poisson Regression**. Journal of Quantitative Criminology, Vol. 24, No. 3, 2008, pp. 269-284
2. Cameron, A. C. and Trivedi, P. K. **Essentials of Count Data Regression**, in Baltagi, H. B. (Ed.) "A Companion to Theoretical Econometrics", Blackwell Publishing, 2001
3. Feng-Chang, X. and Bo-Cheng, W. **Influence analysis for count data based on generalized Poisson regression models,** Statistics, Vol. 44, 2010, pp. 341–360
4. Geissler, A. **Beitraege zur Frage des Geschlechtshaeltisses der Geborenen**. Z. K. Saechs. Stat. Bur., Vol. 35, 1889, pp. 1-24
5. Gilchrist, W. **Statistical modelling,** Statistical Modelling, London: Wiley, 1984
6. Hinde, J. and Demetrio, C. G. **Overdispersion: Models and Estimation,** Computational Statistics & Data Analysis, Vol. 27, No. 2, 1998, pp. 151-170
7. Lord, D., Guikema, S. D. and Geedipally, S. R. **Application of the Conway-Maxwell-Poisson Generalized Linear Model for Analyzing Motor Vehicle Crashes,** Accident Analysis & Prevention, Vol. 40, No. 3, 2008, pp. 1123–1134
8. Rodrigues, J., de Castro, M., Cancho, V. G. and Balakrishnan, N. **COM-Poisson cure rate survival models and an application to cutaneous melanoma data,**

Journal of Statistical Planning and Inference, Vol. 139, No. 10, 2009, pp. 3605-3611

9. Sellers, K. F. and Shmueli, G. **Predicting Censored Count Data with COM-Poisson Regression,** Robert H. Smith School of Business, 2010
10. Sellers, K. F., Borle, S. and Shmueli, G. **The COM-Poisson Model for Count Data: A Survey of Methods and Applications,** Applied Statistic Models in Business and Industry, Vol. 28, No. 2, 2012, pp. 104-116
11. Shmueli, G., Minka, T. P., Kadane, J. B., Borle, S. and Boatwright, P. **A useful distribution for fitting discrete data: revival of the Conway-Maxwell-Poisson distribution,** Applied Statistics, 2005, pp. 127-142
12. Sokal, R. R. **Pupation site difference in Drosophila melanogaster,** Univ. Kansas Sci. Bull., Vol. 46, 1966, pp. 697-715
13. Sokal, R. R. and Rohlf, F. J. **Biometry: The Principles and Practice of Statistics in Biological Research,** New York: W.H. Freeman and Company, 2003
14. Winkelmann, R. and Zimmerman, K. F. **Recent Developments in Count Data Modelling: Theories and Applicatons,** Journal of Economic Surveys, Vol. 9, No. 1, 1995, pp. 1-24
15. Zou, Y. **Over- And Under-Dispersed Crash Data: Comparing the Conway-Maxwell-Poisson and Double-Poisson Distributions,** Msc Thesis, Texas A&M University, 2012

KNOWLEDGE MANAGEMENT IN ROMANIAN ITC SMES

Sebastian Ion CEPTUREANU
PhD, Assistant Professor,
The Bucharest University of Economic Studies

E-mail: ceptureanu@yahoo.com

Abstract:
This paper investigates how SMEs use ICT in order to obtain competitive advantage. We developed a questionnaire to which 79 companies responded. The main result obtained refers to the fact that there are connections between the uses of ICT and competitive advantage. Majority of respondents consider ICT a key factor in company development and building competitive advantage on domestic or international markets. Also, there is remnant potential in SMEs strategy regarding ICT who is not used appropriately. The research highlights the main tools of ICT used by Romanian SMEs and because it identifies the need for a frame of reference coherent for SME to manage and use the tools of knowledge economy in the future.

Key words: Knowledge management, Small to medium-sized enterprises, Management

Introduction

The studies investigate the use of ICT in SMEs, with particular reference to the use of such technology to gain competitive advantage (Ceptureanu SI, 2015) are rather scarce in academic areas of investigation. Current literature highlights the importance of constructing an IS/IT strategy in conjunction with the overall plan of the business. Though early studies have concentrated on large organisations, more recent studies have begun to consider the situation in SMEs (Ceptureanu EG, Ceptureanu SI, 2014). The paper will analyse the results and discuss the main findings. The first part of the study concentrated on the traditional uses of ICT. The second highlighted instances where SMEs are taking advantage of those techniques regarded as leading edge. The paper reviews the current literature on the various methods regarding competitive use of ICT, then, through the use of questionnaires and interviews investigates whether SMEs are in fact able to use ICT to take advantage of the various tools, techniques, and methodologies or whether certain impediments apply to them as a group. The research identifies that although impediments do exist to prevent some SMEs formulating an IS/IT strategy, in some cases they may be able to utilise new applications to gain competitive advantage. However, as such use is not found to be widespread, SMEs would benefit from assistance in the development of new models, tools, techniques, and methodologies to make the best possible use of the opportunities provided by ICT.

Literature review

SMEs are generally not utilising ICT fully, so as to gain competitive advantage. In some cases they are lacking the resources, and skills to do so. This lack of skills applies in

both the technical and business areas, and makes the introduction of knowledge management to gain competitive advantage largely unworkable in SMEs. There are ways that SMEs can overcome these constraints and these issues are discussed later in this section. It was clear from previous research that the area of competitive use of ICT in SMEs needed more research. Large organisations do not have a monopoly on the use of information and knowledge (Ceptureanu SI, 2015). SMEs need to make operational, tactical, and strategic decisions and without accurate information they will struggle to undertake this role. In some instances knowledge is seen as the capacity to recognize what information would be useful for making decisions. This would allow organisations to utilise a knowledge base enabling managers to interpret information and use it in decision making (Watson, 2002). This has led many organisations to view the archiving of best practices for later reference by other employees as a sensible means towards the end of efficient problem solving. It is also hoped that effective knowledge management will prevent unnecessary resources being tied up undertaking inefficient search processes (Malhotra, 2000). Traditionally, data stored within company databases came from transactions and did not include knowledge that employees may have gained from working in the organisation (Simon, 2001, Ceptureanu SI et al, 2015a).

SMEs are certainly not excluded from knowledge management initiatives and when one considers the entrepreneurial input into these organizations they are in a good position to exploit this potential. Furthermore, knowledge management systems can be developed on universally available software at low cost to the organisation (Jessup and Valacich, 2003, Ceptureanu SI et al, 2015b). However, it is still often difficult to justify the development of knowledge management systems on cost-benefit grounds (Skyrme, 1998). Most barriers to the development of knowledge management systems are non-technical (Awad and Ghaziri, 2003). It is expected that in the next few years commerce based on knowledge will overtake that based on tangible products and SMEs must position themselves firmly in this marketplace. This may entail the setting up of a successful learning organisation underpinned by an effective, shared corporate knowledge base (Wilson, 1997).

ICT has also advanced, enabling systems to be linked together within and across organisations and national boundaries (Menzies, 1993). However, changes in technology with their impact on the numbers and skills of the workforce, pose a major challenge (Ceptureanu EG, 2015a), for most organisations and those responsible for the human resources of their organization (Bee and Bee, 1994). Small organizations may find it difficult to justify a substantial financial commitment in an area that they do not recognise as being a core element of their business. An outsourcing relationship may be financially prohibitive as well as having the organisation reliant on third parties (Mylott, 1995). It may be necessary to recruit an expert similar to a knowledge engineer who is used to building expert systems (Watson et al., 1997). Different authors have different perspectives on the scope of knowledge management. If one considers that it could include workflow, document control, e-mail, intranets, extranets, e-business, CRM, data mining and business intelligence (Regan and O'Connor, 2001), there is no reason why SMEs should be excluded on a technical or intellectual level.

A major constraint for small firms in the area of e-business and knowledge management may be their inability to make the necessary investment to take advantage of the new concepts and ICT (Ceptureanu SI, 2014). They may have to rely on outside consultants and significant knowledge transfer to make a viable contribution to their business. This is

very problematical as most small firms cannot afford to employ private consultants (Soriano et al., 2002). The current assistance offered to SMEs is fragmented, of variable quality, and in the case of certain providers, of suspect independence and motivation. Small companies even tend to rely on formal and informal networks rather than utilising publicly funded sources of support (Anderson and Boocock, 2002).

The question of whether these changes have affected ICT use in SMEs needs to be answered by first considering how SMEs use ICT (Ceptureanu EG, 2015b). The use of IT in SMEs has also seen significant changes. Poutsma and Walravens (1989) suggest that small firms used their computers as tools rather than communications media. Kagen et al. (1990) in their later survey of 884 small firms in the USA found that the majority of small businesses still used mostly word processing, payroll applications, and inventory packages. Since, then, however, the increasing availability of new IT and applications suggests that SMEs may have changed their use of ICT (Ceptureanu EG, 2015c). There may be economic reasons for this potential change. Pollard and Hayne (1998) highlighted this, and stated that in the last 15 years hardware costs have fallen dramatically, while processing power and storage capacity have grown.

There has also been an increase in the range of affordable, "off-the-shelf" packages, which has given small businesses the potential to take advantage of the opportunities offered by ICT. With the introduction of personal computers, file servers and networks, small firms have the potential to take advantage of the same technology that large business has access to (Pollard and Hayne, 1998). This suggests that the gap in usage between large and small firms has narrowed. This is further enhanced when one considers the possibilities that the use of communications technology can have for SMEs, i.e. electronic data interchange (EDI) could allow SMEs to link up with customers and suppliers.

Research methodology

The research method used consisted of mailed. Firms were selected on the basis of number of employees less than 250, so complying with the official definition. For the first part of the study a total of 121 questionnaires were despatched to Romanian SMEs. Of the respondents, 79 indicated that they would provide follow-up information. Confidentiality was maintained in the analysis of the data. A mixture of the sample used in the overall study provided a more randomised sample and thus minimized bias. A total of 121 questionnaires were sent to the IT managers, entrepreneurs or equivalent, and 79 responses were received. However, these achieved a response rate of 65,28%.

Results, analysis, and discussion

The following section gives an analysis of various areas covered by the questionnaire.

Table 1.

	Survey sample (N=79)
Micro	9
Small	43
Medium	27
Total	79

As can be seen from Table 2, networked PC's were the most popular choice for SMEs. However, this does not yet have the totality of a rule as there are clear exceptions where eight organisations still relied on a mainframe environment. As one would expect the only evident difference due to size was that small firms were more likely to have a single format of computer, and that none of the medium sized respondents had only standalone PC's.

Table 2.

PCs			Networked PCs			Mainframe		
Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium
5	38	27	4	33	27	1	11	25

Table 3 shows the concept of using ICT to gain some form of competitive advantage. ICT's most useful role was seen as cost reduction. The use of ICT for the improvement of products or services was recognised by 36 companies and 26of the respondents thought ICT could help market specialisation.

Table 3.

Cost			Specialize			Improve		
Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium
7	38	22	2	11	12	3	13	19

In order to assess the feasibility of this approach, the ability of SMEs to produce a business plan of the requisite time horizon, considered necessary to underpin an IS/IT strategy by Silk (1991) and Hickey (1993), is examined. The analysis in Table 4 showed the length of time that these firms were currently planning ahead. Only 3 small firms stated they had no prepared business plans. A number of 16 firms had a 2-3 year plan with 24 adopting a 1-2 year plan. Ten organisations adopted a 4-5 year planning cycle. Only three respondents had plans extending over five years, one being a small firm.

Table 4.

1 year	1-2 years	2-3 years	4-5 years	5 years	None
21	24	16	10	8	3

To examine whether SMEs are utilizing their resources to gain competitive advantage the current use of ICT applications was assessed in Table 5. Only two small firms use RER, 3 Case Studies. As can be seen, a significant number of firms used Expert searcher techniques and knowledge collections technique.

Table 5

Social Network Analysis	Knowledge Matrix	"Expert searcher" technique	Knowledge Collection technique	White pages technique	Trandus er	K profile	Know-net technique	Case study	Rapid evidence review (RER)
11	8	16	16	2	9	6	6	3	2

Table 6 shows that the lack of time to take advantage of ICT was by far the most significant impediment cited by 57 of the respondents. The next most significant impediments were skills and trained staff shortage. It should be noted that small firms cited less impediments than the medium-sized firms.

Table 6.

Time			Skills			Staff			Hardware			Software			Services			Speed		
Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium
7	38	22	4	31	21	6	33	19	4	33	18	3	29	17	15	2	26	2	21	11

Owing to the nature of these high technology and highly e-business aware SMEs we further investigated the use of knowledge management in such enterprises. We envisaged that knowledge management is a relatively new concept for SMEs. Although it has been successfully applied in large enterprises, it would be interesting to find out whether the SMEs community accepts such recognition. Table 7 shows the use of knowledge management in SMEs. The results showed no difference between SMEs in the use of knowledge management. Some 86 per cent of these enterprises do not use knowledge management and further interviews with the respondents found that this is the core problem in the enterprises in that expertise's are lost and a method to retain the expertise is not available. During the interviews, we also found that these enterprises do not create knowledge from existing information and business processes, and hence if the expert is not available, and the same problem arises, no alternatives can be used to resolve the problem effectively. This finding showed that these enterprises are rigid, inflexible, non-agile and non-responsive to change and uncertainty in business and manufacturing environments.

Table 7.

Use of knowledge management	Do not use knowledge management
11	68

Discussion and conclusions

Though many writers such as Robson (1997) had developed the idea of using ICT competitively by forming an IS/IT strategy aligned with an underlying business plan, few if any of such writers had specifically considered the application of the idea to smaller firms. The research indicates that SMEs have relatively short-term planning horizons, so confirming Hall's (1995) view. The research concurs with the suggestion of Laverick et al. (1995) and Pollard and Hayne (1998) that lack of skills, training, and trained staff were indeed significant impediments. Comments expressed during the interviews also indicate that the remedy of getting extra training or recruiting staff is hampered by financial constraints so confirming Pritchard's (1998) view. The high response to this lack of skilled staff raises the possibility that SMEs do not have the business and technical skills Feeny and Willcocks (1998) consider necessary to fully exploit their ICT. These factors suggest that Henderson and Venkatraman's (1999) idea of "communities of expertise" within firms may still be difficult for SMEs. The results appear to directly contradict Poutsma and Walravens' (1989) view that communications applications were under-utilised by small firms. However, this may have occurred by

the technology becoming available to smaller firms through lower costs and more widespread knowledge, rather than as a direct initiative of the firms themselves. Some of the fundamental barriers have been removed. Despite the increasing availability of technology the other methods of using ICT competitively by developing the use of current applications are also poorly represented. The majority of such uses were taken advantage of by less than half the respondents, confirming the suggestion of Kagen et al. (1990) that applications were not being fully utilised, and as such, failing to fulfil what Boshyk (1999) considers a necessary use of ICT. However, the correlation between size of company and its competitive use of ICT appears more complex than a direct relationship. It appears that whilst medium-sized firms used ICT more competitively their impediments were, in some cases, also greater. SMEs generally are not utilising ICT fully, so as to gain competitive advantage, lacking the resources, and skills to do so. This lack of skills applies in both the technical and business areas, and makes the IS/IT strategy approach to gaining competitive advantage largely unworkable in SMEs, in its current format. Therefore, this result suggested that these SMEs require support in knowledge management to achieve the goal. This support may be in terms of education and training, and developing new tools and methods to acquire and manage knowledge in SMEs. In relation to knowledge management, we found that these SMEs tend to create tacit knowledge although a method to capture and acquire such knowledge has not been used. The tacit knowledge was derived from personal experience and wisdom, organically created and shared amongst individuals in the relevant department. The tacit knowledge created includes practical approaches in dealing with certain tardy supply of material, cutting tools substitution when a specific tool is not available and appropriate manner to deal with certain types of customer. We also found no evidence that a method to capture and acquire cultural knowledge has been used by these enterprises. This research found that SMEs are prone to use tacit and cultural knowledge due to the low level of complexity in acquiring, creating and managing such knowledge. In the manufacturing environment of high technology and highly e-business aware small enterprises, many work and processes can be dealt with quickly using a combination of authoritarian approach and ad hoc manner. Therefore, sharing of information and knowledge in such environment becomes easier and less complex. However, SMEs will have more difficulty in acquiring, creating and managing explicit

It is clear from the study and its review that the area of competitive use of ICT in SMEs needs more research; with the bulk of previous research applying to large companies and the general assumption that the same resultant ideas apply to smaller companies is not adequate. The trading of information is very topical, though few if any authors have assessed the influence that deliberate misinformation could have on the idea. This research does evidence the use of applications such as EDI being used as a competitive weapon, but by larger companies to force changes on smaller companies. The possible economic effects of such developments require further study. The applicability of other methodologies seeking to gain competitive advantage by aligning ICT with the aims of an SME needs to be explored.

References

1. Anderson, V. and Boocock, G.**Small firms and internationalisation: learning to manage and managing to learn,** Human Resource Management Journal, Vol. 12, No. 3, 2002, pp. 5-24.

2. Awad, E.M. and Ghaziri, H.M. **Knowledge Management,** Prentice-Hall, Englewood 3. Cliffs, NJ, 2003
3. Bee, F. and Bee, R. **Training Needs Analysis and Evaluation,** Institute of Personnel Management, London, 1994
4. Boshyk, Y. **Beyond knowledge management: how companies mobilise experience**, Financial Times, 8 February, 1999, pp. 12-13
5. Ceptureanu, S.I. **Knowledge Based Economy in Romania: Comparative Approach**, Journal of Applied Quantitative Methods, Vol. 9, No. 4, 2014, pp. 51-61
6. Ceptureanu, E.G. **Survey regarding resistance to change in Romanian innovative SMEs from IT Sector**, Journal of Applied Quantitative Methods, Vol. 10, No. 1, 2015, pp. 105-116
7. Ceptureanu, E.G. **Employee's reaction to change in Romanian SMEs**, Review of International Comparative Management, Vol. 16, No. 1, 2015, pp. 77-87
8. Ceptureanu, S.I. **Competitiveness of SMEs**, Business Excellence and Management Review, Vol. 5, No. 2, 2015, pp. 55-67
9. Ceptureanu, E.G. **Research Regarding change management tools on EU SMEs**, Business Excellence and Management Review, Vol. 5, No. 2, 2015, pp. 28-32
10. Ceptureanu, E.G. and Ceptureanu S.I. **Change management survey on innovative ITC Romanian SMEs**, Quality- Access to success, Vol. 16, No. 144, 2014, pp. 62-65
11. Ceptureanu, S.I. and Ceptureanu, E.G. **Knowledge management in Romanian companies**, Quality- Access to success, Vol. 16, No. 145, 2015a, pp. 61-66
12. Ceptureanu, S.I. and Ceptureanu, E.G. **Challenges and Barriers of European Young Entrepreneurs**, Management Research and Practice, Vol. 7, No. 3, 2015, pp. 34-58
13. Ceptureanu S.I. **Knowledge management in Romanian young SMEs**, Review of International Comparative Management, Vol. 16, No. 1, 2015, pp. 5-22
14. Feeny, D.F. and Willcocks, L.P. **Core IS capabilities for exploiting information technology**, Sloan Management Review, Spring, 1998, pp. 9-21
15. Mason, C. (Eds) **Small Firms: Entrepreneurship in the Nineties**, Paul Chapman, London
16. Hall, G. **Surviving and Prospering in the Small Firm Sector,** Routledge, London, 1995
17. Henderson, D.J. and Venkatraman, N. **Five principles for making the most of IT**, Financial Times, 1999
18. Jessup, L. and Valacich, J. **Information Systems Today**, Prentice-Hall, Englewood Cliffs, NJ, 2003
19. Kagen, P., Lau, K. and Nusgart, K. **Information systems usage within small business firms**, Entrepreneurship, Theory and Practice, Spring, 1990, pp. 25-37
20. Laverick, F., Littler, D., Bruce, M. and Wilson, D. **Information Technology and Business Planning**, Manchester School of Management, Manchester, 1995
21. Malhotra, Y. **From information management to knowledge management: beyond the hi-tech hidebound systems**, in Srikantaiah, T.K. and Koenig, M.E.D. (Eds), "Knowledge Management", Information Today, Medford, NJ, 2000 pp. 37-61

22. Menzies, R. **Information systems security**, in Peppard, J. (Ed.), "IT Strategy for Business", Pitman, Boston, MA, 1993
23. Mylott, T.R. **Computer Outsourcing: Managing the Transfer of IS**, Prentice-Hall, Englewood Cliffs, NJ, 1995
24. Pollard, C.E. and Hayne, S.C. **The changing face of information system issues in small firms**, International Small Business Journal, Vol. 63 No. 16, 1998, pp. 71-87
25. Poutsma, E. and Walravens, A. **Technology and Small Enterprises: Technology, Autonomy and Industria**, Delft University Press, Delft, 1989
26. Pritchard, S. **Network: IT for the SME**, The Independent, Item 104: Q1, 12 May, 1998
27. Regan, E.A. and O'Connor, B.N. **End-user Information Systems**, Prentice-Hall, Englewood Cliffs, NJ, 2001
28. Simon, J.C. **Introduction to Information Systems**, Wiley, New York, NY, 2001
29. Skyrme, D. **Measuring the Value of Knowledge**, Business Intelligence Limited, London, 1998
30. Soriano, D.R., Roig, S., Sanchis, J.R. and Torcal, R. **The role of consultants in SMEs**, International Small Business Journal, Vol. 20, No. 1, 2002, pp. 95-103

A NEW PARADIGM FOR MODELLING ORDINAL RESPONSES IN SAMPLE SURVEYS[1]

Maria IANNARIO[2]
Department of Political Sciences, University of Naples Federico II

E-mail: maria.iannario@unina.it

Domenico PICCOLO[3]
Department of Political Sciences, University of Naples Federico II

E-mail: domenico.piccolo@unina.it

Abstract:

A growing interest in the current surveys is focused on human and relational issues collected as ordinal variables. Standard approaches interpret them as manifest expressions of a continuous latent variable and the current methodology is based on the relationship between the cumulative function of the ratings and the subjects' variables. A different class of models, called CUB, is based on the statement that ordinal responses are a weighted combination of a personal feeling and an inherent uncertainty surrounding the decisional process. In this paper, the novel paradigm is presented and applied to real data sets to show the advantages of this method for analyzing big data in the context of official statistics.

Key words: Ordinal responses, Cumulative models, CUB models

1. Introduction

The paper is concerned with the analysis of ordinal variables which are common in official statistical surveys. Some relational variables such as happiness, job satisfaction, quality of life, trust in the others, etc. are frequently considered as the main responses. They are collected as variables expressed on a discrete ordinal scale and are characterized by phenomena where several factors affect human behaviour, in connection or apart from the usual economic variables [3, 20]. Their study is justified by the awareness that the human well-being is an essential component of the economic development and it represents an important indicator of economic performance and social progress [21].

Current methodologies include the study of these data in the context of Generalized Linear Models [17]. They assume that the discrete response is obtained by grouping the latent variable surrounding individual choice in classes of values by means of cutpoints. Moreover, they are based on the relationship between the cumulative function of the ratings and the subjects' variables. However, the departure from this usual practice could be necessary. First, because it is often difficult to summarize and visualize hundredths of expressed scores on several items by using plots and functions which are not immediately related to the latent constructs and second, because the estimation of several cutpoints worsens the model parsimony.

This paper tackles a different approach [18]. It is based on the direct analysis of the mechanism of choice with some advantages in the estimation process [19] since it adheres to latent variables paradigm without the need to estimate cutpoints. This line of reasoning may be convenient when ordinal responses are collected and visualization and communication are important objectives.

The framework denoted as CUB models is useful for a parametric assessment of the psychological process of selection of a grade on a Likert scale. It weights the two main latent components that characterize selection: the feeling expressed by an individual and the uncertainty which marks out the selection.

The recent interest in well-being and happiness measurements has inspired the application of this class of models for the selection of response categories in a number of several research areas related to these topics ([4, 5], for instance). There are also examples in other contexts. A comprehensive reference list is presented in [14] where it is possible also to refer for the estimation of the models by means of the open source R environment [16]. Notation and inferential aspects have been carried out in [12].

In the next section, notations and extensions are proposed. Then, in section 3 the description of case studies is presented in order to show the advantages of this method for analysing big data in the context of official statistics. Finally, some conclusions end the paper.

2. Specification and extension of CUB models

The mixture model we will propose is motivated by the circumstance that people transform own internal perception into an expressed score according to a given ordinal sequence of categories. This mixture may consist of a Combination of discrete Uniform and shifted Binomial random variables (CUB). It mimics the uncertainty in the process selection and the motivations derived by individual characteristics/background. Main aspects concerning the link among the two main components and the chosen probability distributions have been proposed in [10].

Briefly, the Uniform distribution is considered because it is the most extreme and uninformative case among the discrete random variables. Instead, the shifted Binomial is used as an approximation of a counting process of selection among categories, in the sense that each response may be interpreted as the result of cumulated choices against different alternatives.

Formally, given explanatory variables t ∈ T , let Yi be the ordinal response take values in {1, 2, . . . , m}. Then, the CUB mixture has been defined for each respondent by:

$$Pr(Y_i = j \mid \mathrm{C}_i, \theta) = \pi_i\, b_j(\xi_i) + (1-\pi_i)\, p_j{}^U,\ j = 1, 2, \ldots, m. \qquad (1)$$

We set $\mathrm{C}_i = (y_i, \mathrm{t}_i)$ the information set; $b_j(\xi_i) = \binom{m-1}{j-1} \xi_i{}^{m-j} (1-\xi_i)^{j-1}$ and $p_j{}^U = 1/m$, for $j = 1, 2, \ldots, m$, the probability mass functions of the shifted Binomial and discrete Uniform random variables, respectively. If we consider the information on subjects' covariates extracted from T and a logistic link used to preserve the mapping between parameters and covariates, we have:

$$logit(\pi_i) = \mathrm{x}_i\beta\ ; \qquad logit(\xi_i) = \mathrm{w}_i\gamma; \qquad i = 1,2,...,n.$$

Here, $\mathrm{t}_i, = (\mathrm{x}_i{}', \mathrm{w}_i{}')'$ is the information set useful to specify the relationship of π_i and ξ_i with the corresponding subjects' covariates x_i and w_i. Given the chosen parameteri-

zation, the covariates in x_i and w_i may coincide, overlap or be distinct. Then, the parameter vector $\theta = (\beta', \gamma')'$ is split with respect to the impact of uncertainty and feeling components, respectively.

In case of multi-items, the structure may be extended with the inclusion of objects' or contexts' characteristics of the $h = 1, 2, \ldots, H$ items. The K covariates $z_h = (z_{h1}, z_{h2}, \ldots, z_{hK})$ related to the h-th context imply that each row vector of the model is replicated n_h times for $i = 1, 2, \ldots, nh$; and $h = 1, 2, \ldots H$,

$$(y_i^{(h)} \mid 1, x_{i1}^{(h)}, x_{i2}^{(h)}, \ldots, x_{ip}^{(h)} \mid 1, w_{i1}^{(h)}, w_{i2}^{(h)}, \ldots, w_{iq}^{(h)} \mid z_{h1}, z_{h2}, \ldots, z_{tK}).$$

Thus, we have:

$$logit(\pi_i^{(h)}) = x_i^{(h)} \beta + z_h \nu; \qquad logit(\xi_i^{(h)}) = w_i^{(h)} \gamma + z_h \eta;$$

where $\nu = (\nu_1, \nu_2, \ldots, \nu_K)'$ and $\eta = (\eta_1, \eta_2, \ldots, \eta_K)'$ are the parameter vectors which measure the impact of the context characteristics on *uncertainty* and *feeling* components, respectively. For analysing the possibility of random effects caused by the group membership on individual behaviour, a hierarchical CUB model (HCUB) has been proposed [9].

To interpret the standard CUB model (1) we consider the probability distribution for a given subject by letting $\pi_i = \pi$ and $\xi_i = \xi$. It can be considered as a global model which gives a synthetic measure of feeling and uncertainty for the whole sample of respondents.

$$Pr(Y = j \mid \theta) = \pi b_j(\xi) + (1 - \pi) p_j^U, \; j = 1, 2, \ldots, m, \qquad (2)$$

where $\theta = (\pi, \xi)'$ and the parameter space is the unit square. The identifiability of the model has been proved [7] for any $m > 3$; notice that $m = 3$ implies a saturated model.

According to (2), each respondent acts with a *propensity* to adhere to a thoughtful and to a completely uncertain choice with weights measured by (π) and ($1 - \pi$), respectively.

Thus ($1 - \pi$) is a measure of uncertainty. The level of *feeling*, instead, a component which needs to be specified on the basis of the survey, may be interpreted as a measure of agreement towards the item and it is measured by ($1 - \xi$). Then, the visualization of the models are shown as points in correspondence with ($1 - \pi$, $1 - \xi$).

Moreover, if a subset of respondents selects a specific option to simplify a more demanding choice it is possible to consider the extension of CUB models with a *shelter effect* [8]:

$$Pr(Y = j \mid \theta) = \delta[D_j^{(c)}] + (1 - \delta)[b_j(\xi) + (1 - \pi) p_j^U] \qquad j = 1, 2, \ldots, m. \quad (3)$$

For a given c, the presence of a possible *shelter* effect is introduced by a dummy variable $D_j^{(c)}$ which is 1 if $j = c$ and 0 otherwise. This circumstance is quite frequent when respondents are attracted by a peculiar wording of the questionnaire or when they would avoid critical options, for instance. The extension with inclusion of covariates for all parameters in (3) has been also implemented leading to GeCUB models [15].

Inference of CUB models is obtained by means of Maximum likelihood (ML) theory [19]. Specifically, ML estimates are obtained by the EM algorithm, whereas fitting measures are based on deviance and BIC criterion, among others. A dissimilarity index, which represents the proportion (=relative frequency) of subjects to move among the cells of the frequency distribution to achieve a perfect fit, is a very useful measure.

Extensions and generalizations of this class of models concern also variants of univariate distributions and of the probability distributions of components. In this respect we mention CUBE models [10, 11] which allow to capture overdispersion and CUB models with varying uncertainty [6].

A multivariate approach for the joint modelling of items has been pursued by means of a multi-objects approach [20] and via copula functions [1]. Multivariate CUB models via latent variables approach is an alternative task under scrutiny.

3. Empirical analysis

For presenting the main characteristics of the approach we consider two data sets which stem from big surveys. In the first case the standard model with significant covariates is involved to show the usefulness of the approach for the visualization of the results. In the second case an extension to the contextual structure, commonly present in official statistics, is found to be significant.

3.1 *Perceived happines* from SHIW data

Data stem from the Survey on Household Income and Wealth (SHIW) freely available on http://www.bancaditalia.it/statistiche/indcamp.

The survey conducted since 1965 by the Bank of Italy collects several information on the economic behaviour of Italian households. Specifically it measures income and wealth components. It also gathers information regarding job, health, perceived happiness, economic perceived conditions, family choices, capital gains, inheritance, financial information, and so on. Details on the survey design and on the content of the questionnaire can be found in [2]. In this context, the *perceived happiness* is expressed on a Likert scale from 1 to 10 by means of the analysis of respondents' behaviour and characteristics. We refer to 2012 wave with a validated sample of 8, 148 respondents.

In Figure 1, the observed distributions of relative frequencies and the estimated probabilities by CUB models are shown. Standard and CUB models with *shelter effect* are represented in left and right panels, respectively. From the empirical distribution a concentration of score at category 8 can be detected; thus, a sensible improvement is obtained by fitting the model with a *shelter choice* at $c = 8$. The dissimilarity index, which compares observed and fitted distributions, decreases from 0.075 to 0.048.

Fig. 1 CUB model (left) and CUB model with *shelter effect* (right) for *perceived happiness*

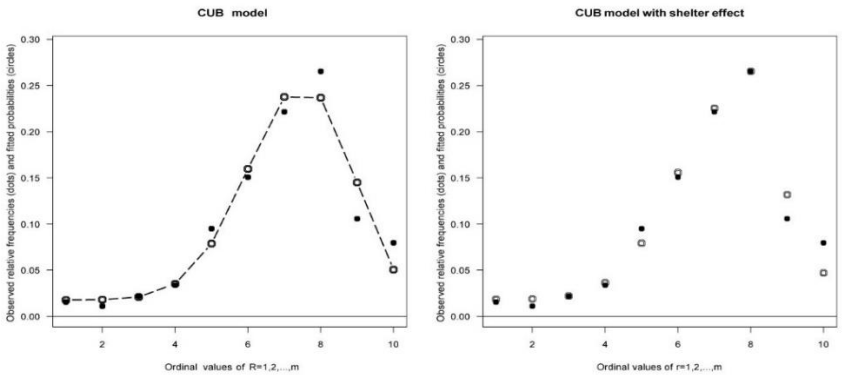


Table 1 summarizes the estimation of both models. It points out a high level of *perceived happiness* with a low uncertainty in this survey and improved fitting results for the second model.

Table 1. Estimation of CUB model (left) and CUB model with shelter effect (right) for *perceived happiness*.

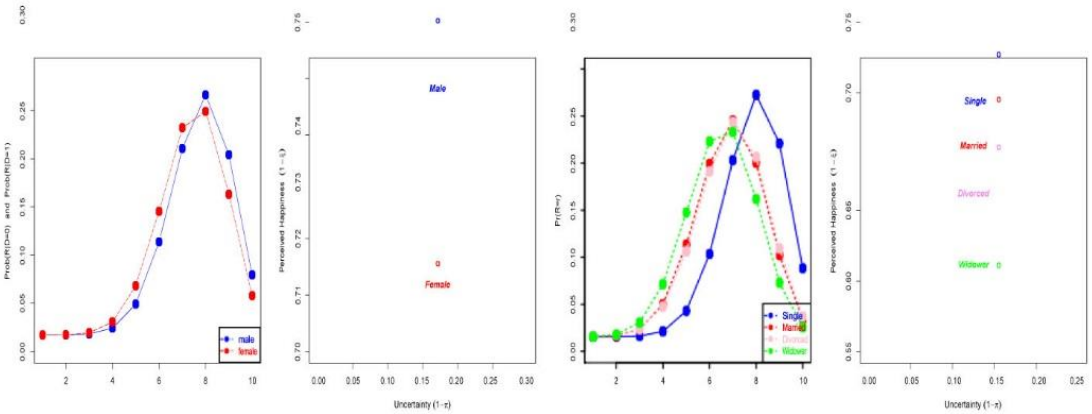
Models	Uncertainty parameters	Feeling parameters	*Shelter* parameter	$\ell(\theta)$	*BIC*
CUB	$\hat{\pi} =$ 0.823 *(0.008)*	$\xi =$ 0.301 *(0.002)*		−16005.95	32029.90
CUB+*shelter*	$\hat{\pi} =$ 0.807 *(0.008)*	$\xi =$ 0.307 *(0.002)*	$\delta =$ 0.046 *(0.007)*	−15983.40	31993.83

For a better understanding of this class of models, the introduction of covariates is considered. First, we introduce a *gender* variable for the feeling component with a constant uncertainty. On the first panel of Figure 2 we report the estimated distributions of men and women (men are happier than women) which are represented (second panel) by two points in the parameter space (higher position implies higher feeling). These results are summarized by:

$$logit(\pi) = 0.828; \qquad logit(\xi_i) = -1.100 + 0.177\, gender_i.$$

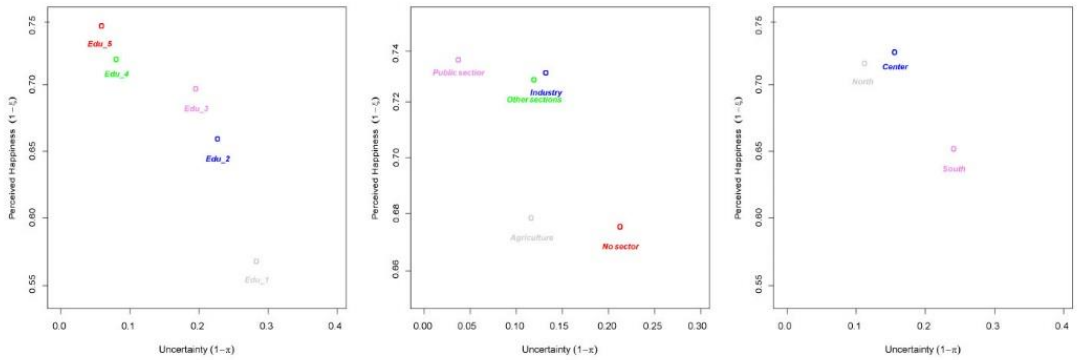
It is possible to observe a further simplification when we consider a nominal covariate as *marital status* (third panel). For a fixed level of uncertainty ($1 - \pi = 0.156$), different probability distributions are summarized by four points in the parameter space (Figure 2, forth panel). It turns out that single are happier than the others.

Fig. 2 CUB models for *perceived happiness* vs *gender* and *marital status*



In addition, the *perceived happiness* for subsample of respondents related to *education*, *sector of activity* and *geographical area* may be easily represented. In Figure 3 it is possible to observe higher scores for higher educated interviewees (first panel), who work in public sector (second panel) and live in the Center of Italy (third panel).

Fig. 3 CUB models for *perceived happiness* vs nominal/factor covariates (*education, sector of activity, geographical area*).



As an instance of continuous covariates we select *age* and *income*. Figure 4 (first panel) concerns a model in which the *age* covariate (more specifically, $age_i = \log(age_i) - \overline{\log(age_i)}$, for $i = 1, 2, \ldots, n$) has an impact on both parameters.

Also age^2, a parabolic effect, turns out to be significant on the feeling. By increasing the *age* of the respondent the level of satisfaction reduces. A peculiar feature of this approach is the simultaneous visualization of both effects in the parameter space (Figure 4, first panel) by varying the *age* of the respondents: young are happier than elderly people and are more resolute in their responses.

Income is another significant covariate for both components (second panel, Figure 4): the *perceived happiness* decreases with lower *income* whereas the level of uncertainty increases. The behaviour of the *income* covariate mimics an ordinal variable concerning the answer on the household income; specifically, survey asks if respondents consider sufficient to see the family through to the end of the month: this covariate is named *family condition* and ranges from 1 (with great difficulty) to 6 (very easily). The third panel of Figure 4 underlines the negative perception for people who express a lower expectation about this covariate.

The changing levels of *perceived happiness* may be shown in the same parameter space if we compare responses for the waves: 2008, 2010, 2012 (Figure 5, first panel). A higher *perceived happiness* in 2012 with respect to the 2010 wave (characterized by a higher uncertainty in the responses) is observed.

Another possible representation is to create some profiles of respondents for the analysis of *perceived happiness* as reported in Table 2 (the model concerns the 2012 wave).

In this more complex model, a significant impact of *education* and *family condition* for uncertainty, and of *gender* and *age* for feeling has been found. For an average *age* of 59 years the *perceived happiness* increases for higher educated women whereas the level of uncertainty increases for lower level of *education* and perceived *family condition*. The right panel of Figure 5 visualizes two selected profiles and shows how the effect of covariates appreciably changes the expected distribution of the responses.

Fig. 4 CUB models for *perceived happiness* vs continuous (first and second panel) and ordinal covariates (third panel)

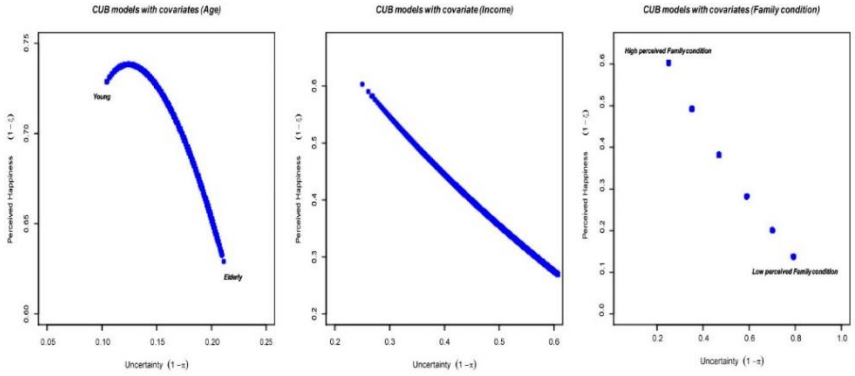


Table 2. CUB model for *Perceived Happiness* (wave 2012)

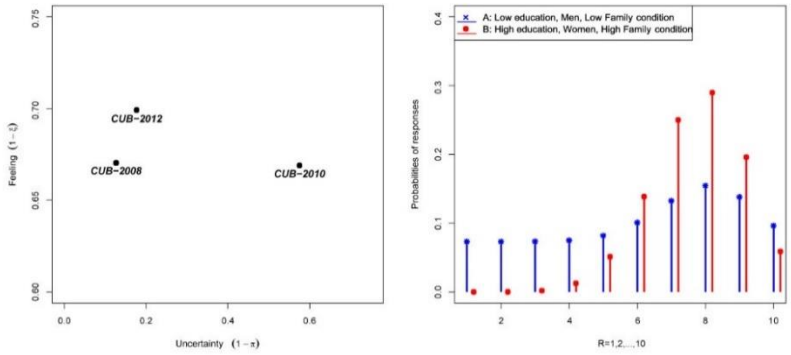
Components	Covariates	CUB model parameters	Wald-test
Uncertainty	constant	$\hat{\beta}_0 = -2.710(0.263)$	−10.291
	education	$\hat{\beta}_1 = 1.373(0.075)$	18.234
	family condition	$\hat{\beta}_2 = 0.323\ (0.074)$	4.467
Feeling	constant	$\hat{\gamma}_0 = -1.162\ (0.0$	−37.093
	gender	$\hat{\gamma}_1 = 0.167\ (0.020)$	8.203
	age	$\hat{\gamma}_2 = 0.417\ (0.037)$	11.301

3.2 *Perceived political trust* from European Social Survey

Data stem from European Social Survey (the ESS-Round 4 Project) available on www.europeansocialsurvey.org. It is an academically-driven social survey designed to visualize and explain the interaction between Europe's changing institutions and attitudes, beliefs and behaviour patterns of populations. The survey covers more than 30 nations and employs rigorous sample methodologies. Aims of this analysis is to explain the *perceived political trust* by means of the analysis of citizenship, involvement and democracy of different European Countries.

We analyse the perceived political action and the beliefs in Government projects by means of the *contextual* approach of CUB models. For each country (interpreted as a contextual covariate), the covariates we found significant to explain the perception of *political trust* are *education* (as an individual effect covariate) and *Gross Domestic Product* (*GDP*).

Fig. 5 CUB models for *perceived happiness* in three waves 2008, 2010, 2012 (left panel), and with respect to two specified profiles (right panel).



For m = 11 categories (from low to high political trust), a subsample size of n = 25, 000 citizens has been selected by a random draw from the whole sample of more than 35, 000 units from 21 countries. The estimated CUB model for the perceived political trust is reported in Table 3. A moderate level of uncertainty in the responses has been found since $1 - \hat{\pi} = 0.374$.

Table 3. CUB model with contextual effect for the perceived *Political trust*.

Components	Covariates	CUB model parameters	Wald-test
Uncertainty	constant	$\hat{\pi} = 0.626$ *(0.006)*	99.72
Feeling	constant	$\hat{\gamma}_0 = 0.269$ *(0.029)*	9.14
	education	$\hat{\gamma}_1 = -0.036$ *(0.002)*	−18.52
	GDP	$\hat{\gamma}_2 = 0.120$ *(0.004)*	26.35

This model predicts that the expected perception increases with the level of *education* of the *i*-th subject, and reduces with the *GDP* of the *j*-th country. It should also be possible to expand the inference in a *hierarchical* framework by considering mixed effects.

4. Conclusions

We start from the idea that methods for analysing a large amount of ordinal data (concerning the latent components of human well-being stemming from different sources in the context of official statistics) are a useful contribution to economic and social research. We have presented a framework which mimics the data generating process obtained by means of the selection of a category in a sequence of ordinal data. We have shown the relevant features of this class of models in terms of visualization and communicating statistics. The new approach for the analysis of collected data presents high flexibility and more parsimony with respect to the standard models.

The extended class suggests further studies aimed at analysing operational tools which regard the development of the European Statistical System towards 2020. The ability to summarize thousands of responses in a parameter space by means of an immediate idea of comparative feeling and uncertainty of several countries simplifies the presentation of the results. Finally, the philosophy of the approach is that data are used to derive the whole probability distribution of expected results. It simplifies the understanding of human behaviour when faced to a questionnaire or an interview in an effective way.

References

1. Corduas, M. **Analyzing bivariate ordinal data with CUB margins**, Statistical Modelling, Vo. 15, 2014, pp. 411-432
2. Faiella, I., Gambacorta, R., Iezzi, S. and Neri, A. **Italian Household Budgets in 2006**, Supplements to the Statistical Bulletin (new series), Vol. 7, 2008
3. Frey, B. S. and Stutzer, A. **Happiness and economics: how the economy and institutions affect well-being**, Priceton University Press, Priceton, 2002
4. Gambacorta, R. and Iannario, M. **Measuring job satisfaction with CUB models**, Labour, Vol. 27, 2013, pp. 198–224

5. Gambacorta, R., Iannario, M. and Valliant, R. **Design-based inference in a mixture model for ordinal variables for a stage stratified design**, Australian & New Zealand Journal of Statistics, Vol. 56, No. 2, 2014, pp. 125–143
6. Gottard, A., Iannario, M. and Piccolo, D. **Varying uncertainty in CUB models**. **Advances in Data Analysis and Classification**, DOI 10.1007/s11634-016-0235-0, 2016
7. Iannario, M, **On the identifiability of a mixture model for ordinal data**, Metron, Vol. LXVIII, 2010, pp. 87–94
8. Iannario, M. **Modelling shelter choices in a class of mixture models for ordinal responses**, Statistical Methods and Applications, Vol. 21, 2012, pp. 1–22
9. Iannario, M. **Hierarchical CUB Models for ordinal variables**, Communications in Statistics. Theory and Methods, Vol. 41, 2012, pp. 3110–3125
10. Iannario, M. **Modelling Uncertainty and Overdispersion in Ordinal Data**, Communications in Statistics. Theory and Methods, Vol. 43, 2014, pp. 771–786
11. Iannario, M. **Detecting latent components in ordinal data with overdispersion by means of a mixture distribution**, Quality & Quantity, Vol. 49, 2015, pp. 977–987
12. Iannario, M. and Piccolo, D. **CUB models: Statistical methods and empirical evidence**, in: Kenett, R.S. and Salini, S. (eds.) "Modern Analysis of Customer Surveys: with applications using R", Chichester: J. Wiley & Sons, 2012, pp. 231–258
13. Iannario, M. and Piccolo, D. **A comparative analysis of alternative frameworks for modelling ordinal data**, Working paper, 2014
14. Iannario, M. and Piccolo, D. **Inference for CUB models: a program,** R. Statistica & Applicazioni, Vol. XII, 2014, pp. 177-204
15. Iannario, M. and Piccolo, D. **A Generalized Framework for Modelling Ordinal Data**, Statistical Methods and Applications, 2015, DOI 10.1007/s10260-015-0316-9
16. Iannario, M. and Piccolo, D. **CUB: a class of mixture models for ordinal data. R package version 0.0.539,** 2015, http://CRAN.R-project.org/package=CUB
17. McCullagh, P. and Nelder, J. A. **Generalized linear models**. 2nd edition, Chapman and Hall, London, 1989
18. Piccolo, D. **On the moments of a mixture of uniform and shifted binomial random variables**, Quaderni di Statistica, Vol. 5, 2003, pp. 85–104
19. Piccolo, D. **Observed information matrix for MUB models**, Quaderni di Statistica, Vol. 8, 2006, pp. 33–78
20. Piccolo, D. and D'Elia, A. **A new approach for modelling consumers' preferences**, Food Quality and Preference, Vol. 19, 2008, pp. 247–259
21. Stiglitz, J., Sen, A. and Fitoussi, J. P. **Report of the Commission on the Measurement of Economic Performance and Social Progress**, Discussion paper, CMEPSP, 2009

[1] **Acknowledgements**
The authors gratefully acknowledge Editor and referees. This research has been supported by the SHAPE project within the frame of STAR Programme (CUP E68C13000020003) at University of Naples Federico II and by FIRB 2012 project (code RBFR12SHVV) at University of Perugia.

[2] Associate Professor in Statistics at University of Naples Federico II. She earned the PhD in 2005. She has been Visiting Researcher at Iowa University (USA), the University of Lancaster (UK), the University of Geneva (CH) and at Le Centre Européen des Sciences et du Goût (Dijone, France). She received the Fulbright Research scholarship for 2012. She collaborated to several national and international projects concerning methodological and applied re-

searches on mixture models for ordinal data a related estimation methods. Among them she is the Principal Investigator of the "Statistical Modelling of Human Perception" – Programme STAR. Her publication appeared on refereed journals and she has been invited to give some talks and seminars in several Universities and Center of Research. Recently, she performed a joint cooperation with the Bank of Italy with reference to modelling job satisfaction in a complex sample design.

[3] Full Professor of Statistics at Department of Political Sciences, University of Naples Federico II, since 1986. Senior Researcher of the Centro di Ricerche (Portici) from 1970 to 1986. Member of the Evaluation Board of University of Naples Federico II (2003 – 2008). Elected member of National Council of Italian Statistical Society. Chief of the projects VER01 and VER02: "Monitoring and Evaluating Orientation services", co-funded by the EU (FSE). Responsible of several research projects financed by MURST and CNR. Scientific Director of DESEC Project (1982-85) and ISTAT SARA Project (1997-98) which led to select a seasonal adjustment procedure for Italy. Visiting Fellow at Lancaster (UK), Madison (USA), Genève (CH), Madrid (E), Christchurch (NZ) Universities. Author of several papers on statistical inference, time series analysis, models for ordinal data. He is also author of some popular textbooks

PITFALLS IN TESTING WITH LINEAR REGRESSION MODEL BY OLS. THE RECENT CASE STUDY OF RAMADAN FASTING EFFECTS ON SEX-RATIO AT BIRTH, AND BIRTH WEIGHT IN GERMAN MUSLIM BABIES[1]

Claudiu HERTELIU
PhD, Professor, Department of Statistics and Econometrics,
Bucharest University of Economic Studies, Bucharest, Romania

E-mail: hertz@csie.ase.ro, claudiu.herteliu@gmail.com

Bogdan-Vasile ILEANU
PhD, Assistant Professor, Department of Statistics and Econometrics,
Bucharest University of Economic Studies, Bucharest, Romania

E-mail: bogdan.ileanu@csie.ase.ro

Marcel AUSLOOS
PhD, Professor, School of Management, University of Leicester, Leicester, UK
eHumanities Group, Royal Netherlands Academy of Arts and Sciences, Amsterdam,
The Netherlands

E-mail: marcel.ausloos@ulg.ac.be

Giulia ROTUNDO
Associate Professor, Department of Methods and models for Economics,
Territory and Finance,
Sapienza University of Rome, Rome, Italy

E-mail: giulia.rotundo@gmail.com

Abstract:

This is a comment on "Ramadan fasting, sex-ratio at birth, and birth weight: No effects on Muslim infants born in Germany" [Economic Letters, 2015] DOI http://dx.doi.org/10.1016/j.econlet.2015.10.015. We show that due to some methodological aspects the main conclusions of the above mentioned paper should be a little bit altered.

Key words: Fasting, birth characteristics, quantitative methods

We read with great interest Jürges (2015) regarding Ramadan fasting effects on births on babies born in Muslim families. This report appears to be an interesting one since it is based on a very large database obtained from administrative sources and correlated to

additional factors (such as day length). As the report's title mention the author found almost no evidence of Ramadan effects on births. Subsequently the author suggests that other previous conclusions based "on smaller samples from other countries must be interpreted with caution". We believe that, in our opinion, a number of issues need to be raised:

(i) The author fails to give credit to other recent (and very interesting) papers on this and highly related topics topic (Friger et al., 2009 or Herteliu et al., 2015); in the latter about 100 years, 35 429 days, and 24 947 061 births were recorded and analyzed!

(ii) The "samples" term is a little bit ambiguous since the paper which the author is much referring to, i.e. Almond and Mazumder (2011) is focused on whole populations (and not on a sample – which usually implies a selection process). A population could be smaller but this does not mean that the conclusions based on an exhaustive database could be biased such as it can be in a voluntarily selected sample.

(iii) Since the Ordinary Least Squares (OLS) method was used, except for t-tests on regression parameters there is no other econometrical test (or vital information such as R^2 regression analysis, models validity-Fisher test etc.) presented. Moreover there is no evidence about data statistical homogeneity, or about the distribution of variables used.

(iv) Depending on the distribution of assumed as continuous variables (e.g. birth weight) a semi-logarithmic approach could be a better solution instead of the presented-linear one. In the case of a non-linear approach the statistical significance of the covariates and the OLS assumption may have a significant impact on the practical results.

(v) Since the data used by Jürges (2015) study contains birthdays, there is a lack of precision induced by an over use the dichotomization (13 dummy variables!). Other papers took into consideration the overlap proportion of Ramadan (Almond and Mazumder, 2011) or a countdown approach (Herteliu et al., 2015) or a little bit more sophisticated models, as a cosinor (Friger et al., 2009, Cancho-Candela et al., 2007).

While the scientific sound of the paper and its topic maintain it to a high academic level, a part of the claimed conclusions could be a little bit inaccurate. We warn readers of Economic Letters, authors, reviewers, and editors to take the Jürges (2015) conclusion with caution. In fact, in (Herteliu et al., 2015), noticeable effects dues to Lent and Nativity fast periods in which sexual activity is reprimanded by church leaders were demonstrated. Maybe, Muslim babies (in Germany) are different from Eastern Orthodox ones (in Romania)! A major question seems to be related to baby "production": concerning "Ramadan" per se, Friger et al. (2009) found a systematic increase in the number of births (200 009) during the Ramadan, in the Muslim population, - but not in the Jewish population in Israel. The findings suggest a high sexual activity during the Hajj pilgrimage. Thus, cultural constraints or psychological (Akuchekian *et al.*, 2004) have to be taken during such analyses. Notice, for completeness, that data analyzed by Roehner (2014) revealed a fall of about 15% in suicide numbers during the month of Ramadan (with respect to same-non-Ramadan months). Alas, there is no gender discussion on suicide of Muslims, then. Thus, to take into account baby

deaths is another interesting question. Let our comment be also considered as a set of questions, beside a methodological one, raised by Jurges (2015) contribution.

References

1. Almond, D., and Mazumder, B. **Health capital and the prenatal environment: The effect of Ramadan observance during pregnancy,** American Economic Journal: Applied Economics, Vol. 3, No. 4, 2011, pp. 56–85
2. Akuchekian, S., Ebrahimi, A. and Alvandian, S. **Effect of the holy month of Ramadan on coping strategies,** Journal of research in medical sciences, Vol. 9, No. 2, 2004, pp. 65-68
3. Cancho-Candela, R., Andres-de Llano, J. M and Ardura-Fernandez, J. **Decline and loss of birth seasonality in Spain: analysis of 33 421 731 births over 60 years,** Journal of Epidemiology & Community Health, Vol. 61, 2007, pp. 713–18. DOI 10.1136/jech.2006.050211
4. Friger, M., Shoham-Vardi, I. and Abu-Saad, K. **Trends and seasonality in birth frequency: a comparison of Muslim and Jewish populations in southern Israel: daily time series analysis of 200,009 births, 1988–2005,** Human Reproduction, Vol. 24, No. 6, 2009, pp. 1492-1500
5. Herteliu, C., Ileanu, B.V. Ausloos, M. and Rotundo, G. **Effect of religious rules on time of conception in Romania from 1905 to 2001,** Human Reproduction, Vol. 30, No. 9, 2015, pp. 2202-14, DOI: 10.1093/humrep/dev129
6. Jürges, H. **Ramadan fasting, sex-ratio at birth, and birth weight: No effects on Muslim infants born in Germany,** Economics Letters, Vol. 137, 2015, pp. 13-16, DOI: http://dx.doi.org/10.1016/j.econlet.2015.10.015
7. Roehner, B. M. **Is the month of Ramadan marked by a reduction in the number of suicides?** arXiv preprint arXiv:1401.3525, 2014

[1] **Acknowledgement**
This paper was submitted on October 27th, 2015 to Economics Letters (EL), and rejected on November 7th, 2015 because "The points raised are not important enough to warrant a publication in EL". Thanks to Prof. Jürges who encouraged us (about our endeavor and (re)submission to JAQM) writing that this is a "great idea. Looking forward to seeing this in print."

RESILIENCE IN ROMANIAN SMALL FAMILY BUSINESSES

Eduard Gabriel CEPTUREANU
PhD, Assistant Professor, Department of Management,
The Bucharest University of Economic Studies, Romania

E-mail: eduard_ceptureanu@yahoo.com

Abstract:

One of the key characteristics of small family businesses who could enhance profitability frequently mentioned in last years by the academic literature refers to resilience. Increased competition, shift to knowledge based economy, changes in customer behavior and managerial practices are factors that influence significantly SMEs performances. This article analyze the connections between resilience- change management strategy- performances for Romanian small family businesses. The research found that family firms are more likely to emphasize performance using change management strategy than other small and medium companies and also that relationship between change strategy and both turnover and profitability is stronger for these companies.

Key words: Resilience, family-owned firms, change strategy, SMEs performance

Introduction

Only few studies have examined family firms in use of change strategies to develop resilience. Family firms are credited as the engine of entrepreneurship all over European Union (Rogoff et al. 2003, Castillo and Wakefield 2006). Despite this important role, not much is known about how they build resilience capabilities. Family firms adopt a long-term focus, are cooperative with stakeholders and tend to hire long-term employees (Miller et al. 2009). However, family firms don't have managerial knowledge, lack skilled employees and capital and face family conflicts in managing the business (Schulze et al. 2003, Miller 2006, Ceptureanu SI, 2015). Thus, change are likely to impact family firms differently from other types of organizations. Resilience is generally thought of as „the ability of a firm to persist in the face of substantial changes in the business and economic environment and/or the ability to withstand disruptions and catastrophic events" (Sheffi and Rice 2005). Resilience has also been conceptualised at the organisational level as „the power of organisational units to resume, bounce back or positively adjust to untoward events, disruptions and external shocks" (Powley 2009). In this article, "resilient capabilities imply the ability of firms to align their change strategies to the market resulting in superior performance" (Ceptureanu, E.G, 2015).

This is important because "developing resilience should be conceived as a strategic initiative aimed at reducing the vulnerabilities brought about by the changes in the competitive environment" (Sheffi and Rice 2005, Ceptureanu SI, 2015). Little attention has been payed to analyse the impact of change strategy on small family company performance. Anderson and Reeb (2003) and Villalonga and Amit (2006) researches demonstrated that family-controlled firms outperform other types of SMEs. The relationship between change strategy and firm performance is likely to be different for the two types of firms. Organisations are better able to develop resilience capabilities when they have business models that fit the needs of the competitive environment (Ceptureanu E et al., 2014). Therefore, one way of responding effectively to crises for businesses is the alignment of change strategy with performance. We argue that change strategy and its relationship with performance represent ways to achieve resilience. This is because change strategy influences the structural and infrastructural decisions that build flexibility in resource acquisition and deployment that in turn reduce vulnerabilities against severe economic changes (Sheffi and Rice 2005).

Theoretical background

In defining a family firm, researchers have focused on characteristics such as family vision; family control and involvement in ownership and management (Anderson and Reeb 2003, Chrisman et al. 2004). Accordingly to the international literature, we define family firm accordingly as a "small business that is owned by a specific family which is involved in the firm's management processes"(Chua, 1999). Entrepreneurs in this companies have "the freedom and motivation to pursue bold strategic initiatives that are devised with long-term capabilities development, performance and reputation of the business in mind" (Miller and Le Breton-Miller 2003, Ceptureanu SI et al, 2015). Recent studies have produced contradictory evidence with respect to the performance effects of family ownership. Some investigations didn't find any relationship between family ownership and company performance (Castillo and Wakefield 2006, Westhead and Howorth 2006) but others have shown that family-owned companies outperform classic ones (Anderson and Reeb 2003, Villalonga and Amit 2006). For economic sustainability, SMEs are increasingly playing a key role being the engines of employment, according to Ceptureanu S et al. (2010), in Romania SMEs represent over 95% on total enterprises, contribute to 66, 2% of employment and 57, 9% on turnover. Unfortunately, only 2 out of 10 SMEs have introduced or significantly improved new products, process or organizational/marketing methods (Ceptureanu S.I., 2014). Such facts have led to the conception of sustainable SMEs that should be 'robust in face of anticipated and unanticipated economic, environmental and social challenges' (Moore and Manring, 2009). Hence, the development of sustainable SMEs that are able to change and adapt to a turbulent environment is a concern for SME managers and practitioners alike. Change strategy in small business is considered to be enacted in a highly personalised manner and is strongly influenced by the actions, abilities and personality of the key people in the company (Beaver and Prince, 2004). Hence, a central, directive decision making, top-down, stiff type of management style is prevalent (Dean, 1986). This kind of behaviour is encouraged due to the fact that SME entrepreneurs often own the company or have personal investment in the business (Duchesneau and Gartner, 1990). Customer pressure in supply chains for low-cost-

based competition and the need for rapid, innovative responses, as well as new product development, are important drivers for change in SMEs (Sheffi 2005, 2006, Hudson-Smith and Smith, 2007). Also, increased competition based on overall product and service quality and increasing demand for just-in-time delivery, flexibility and responsiveness are among other key drivers for change in SMEs (Sheffi and Rice, 2005). In summary, we can identify the following characteristics having an impact on SME behaviour in change management: (1) Lack of strategic planning. (2) Hasty approach to solve day-to-day problems. (3) Greater focus on operational and technical issues. (4) Stiff organizational culture. (5) Tacit knowledge and informal decision making. (6) Poor management skills as the SME grow. (7) Entrepreneurial orientation and opportunity seeking.

Method and results

The sample consisted of small and medium companies drawn from a list of companies available with support from National Trade Register Office. We contacted the entrepreneurs, explained the purpose of the study, gave the questionnaires and obtained promissory dates when we would receive the completed questionnaires. The entire data collection process took 2 months. A total of 79 completed surveys were obtained representing a response rate of 45.14%. We checked for nonresponse bias by testing the size and ownership structure and found no statistical differences between early and late respondents (Lambert and Harrington 1990). Change strategy was assessed using 5 items derived from Inner-Work organization model (www.innerworkcompany.com). We assessed performance using two items: company's turnover and profitability. We chose to use self-reported performance measures (Youndt et al., 1996). Firms in Romania are not often called upon to provide financial data to researchers and as such, gaining access to objective data from company sources was extremely difficult. For each measure, the respondent was asked to indicate the extent to which the actual performance of his/her firm compared to the firm's competitors over the last years. The reliability and validity of the measures were assessed through the determination of the Cronbach alpha coefficients, content validity and the use of factor analyses. The reliability coefficients are shown in the diagonal in Table 1 (Swink et al. 2005). There are several significant relationships between the change strategy and performance variables.

Table 1. Research statistics

No.	Variable	Mean	SD	1	2	3	4	5	6
1	Assess for Change	5.51	0.91	**0.68**	-	-	-	-	-
2	Prepare for change	6.27	0.59	0.32**	**0.55**	-	-	-	-
3	Plan for change	6.21	0.92	0.26**	0.41**	**0.69**	-	-	-
4	Implement the change	5.52	0.83	0.32**	0.45**	0.42**	**0.61**	-	-
5	Sustaining the change	6.18	0.89	0.22**	0.53**	0.45**	0.44**	**0.72**	-
6	Turnover	5.21	1.02	0.28**	0.32**	0.47**	0.48**	0.42**	**0.66**
7	Profitability	0.32	0.44	-0.01	-0.06	-0.09	-0.02	0.01	0.00

Table 2. Impact of change strategy on performance

	Change strategy		Performance	
Variables	Family small businesses	Classic small businesses	Family small businesses	Classic small businesses
Firm size	0.069	0.099	0.070	0.099
Ownership structure	-0.011	-0.242*	-0.011	-0.237*
Assess for Change	**0.309***	0.041	0.249	0.029
Prepare for change	0.10	**0.248**	**0.372***	0.038
Plan for change	**0.329***	**0.362****	-0.191	0.108
Implement the change	0.144	-0.021	0.209	0.067
Sustaining the change	0.121	0.018	0.299	0.052
R2	0.565	0.321	0.371	0.007
Change in R2	0.551	0.292	0.312	0.04
Model F	9.918***	4.089**	4.488***	0.419
N	79			

Conclusion

This paper has proposed to investigate the link between change strategy performance and resilience on small and medium companies. The results confirm that family SMEs obtain better results than other types of firms due to greater influence on business owners on creation and implementation of change management. The change strategy is a mechanism through which a firm makes strategic competitive choices to generate growth. Thus, strong relationships are expected to exist between change strategy choices and resilience. Under this logic, the firm makes structural decisions that provide the capabilities that the firm needs to develop resiliency and achieve competitive goals. Firms are better able to build resilience when they have change models that fit the needs of the existing competitive environment. Because family firms have different resources and capabilities comparative with other types of SMEs it might build resiliency differently in response to the business environmental conditions. Our study found that family firms are more likely than classic firms to emphasise performance. This is perhaps a consequence of the ability of family company to better respond to their stakeholders needs. Moreover, because family firms have less span of control, they will be more agile and likely to gain cooperation from their employees to recognise the ability to change quickly and adapt to objectives changes as important aspects of a change strategy in their drive to achieve resilience. Our findings show that the relationship between change strategy and both turnover and profitability is stronger for family firms than classic ones. We consider additional studies are needed in this area; specifically those using data from other UE countries to understand how firms in those countries can use change strategy to build resilient capabilities.

References

1. Anderson, R.C. and Reeb, D.M. **Founding-family ownership and firm performance: evidence from the S&P 500,** Journal of Finance, Vol. 58, 2003, pp. 1301–1328
2. Beaver, G. and Prince, C. **Management, strategy and policy in UK small business sector: a critical review,** Journal of Small Business and Enterprise Development, Vol. 11, No. 1, 2004, pp. 34–49

3. Castillo, J. and Wakefield, M.W. **An exploration of firm performance factors in family business: do family value only the "bottom line,** Journal of Small Business Strategy, Vol. 17, No. 2, 2006, pp. 37–51
4. Ceptureanu, E.G. and Ceptureanu, S.I. **Change management survey on innovative ITC Romanian SMEs**, Quality- Access to success, Vol. 16, No. 144, 2014, pp. 62-65
5. Ceptureanu, E.G. **Survey regarding resistance to change in Romanian innovative SMEs from IT Sector**, Journal of Applied Quantitative Methods, Vol. 10, No. 1, 2015, pp. 105-116
6. Ceptureanu, S.I. **Knowledge Based Economy in Romania: Comparative Approach**, Journal of Applied Quantitative Methods, Vol. 9, No. 4, 2014, pp. 51-61
7. Ceptureanu, S.I. **Knowledge management in Romanian young SMEs**, Review of International Comparative Management, Vol. 16, No. 1, 2015, pp. 5-22
8. Ceptureanu, S.I. **Competitiveness of SMEs**, Business Excellence and Management Review, Vol. 5, No. 2, 2015, pp. 55-67
9. Ceptureanu, S.I. and Ceptureanu, E.G. **Challenges and Barriers of European Young Entrepreneurs**, Management Research and Practice, Vol. 7, Issue 3, 2015, pp. 34-58
10. Chrisman, J.J., Chua, J.H. and Litz, R.A. **Comparing agency costs of family and classic firms: conceptual issues and exploratory evidence,** Entrepreneurship Theory and Practice, Vol. 28, No. 4, 2004, pp. 335–354
11. Chua, J.H., Chrisman, J.J. and Sharma, P. **Defining the family-owned firm by behaviour,** Entrepreneurship: Theory and Practice, Vol. 23, No. 4, 1999, pp. 19–39
12. Dean, B.V. **The project-management approach in the "systematic management" of innovative start-up firms,** Journal of Business Venturing, Vol. 1, No. 2, 1986
13. Duchesneau, D.A. and Gartner, W.B. **A profile of new venture success and failure in an emerging industry,** Journal of Business Venturing, Vol. 5, No. 5, 1990
14. Hudson-Smith, M. and Smith, D. **Implementing strategically aligned performance measurement in small firms,** International Journal of Production Economics, Vol. 106, No. 2, 2007
15. Jennings, P. and Beaver, G. **The performance and competitive advantage of small firms: a management perspective,** International Small Business Journal, Vol. 15, No. 2, 1997, pp. 34–58
16. Lambert, D.M. and Harrington, T.C. **Measuring nonresponse bias in customer service mail surveys,** Journal of Business Logistics, Vol. 11, No. 2, 1990, pp. 5–25
17. Miller, D. **Priorities, practices and strategies in successful and failing family businesses: an elaboration and test of the configuration perspective,** Strategic Organization, Vol. 4, No. 4, 2006, pp. 379–407
18. Miller, D., Lee, J., Chang, S. and Le Breton-Miller, I. **Filling the institutional void: the social behavior and performance of family vs. classic technology firms in emerging markets,** Journal of International Business Studies, Vol. 40, 2009, pp. 802–817
19. Miller, D. and Le Breton-Miller, I. **Challenge versus advantage in family business,** Strategic Organization, Vol. 1, 2003, pp. 127–134
20. Moore, S.B. and Manring, S.L. **Strategy development in small and medium sized enterprises for sustainability and increased value creation,** Journal of Cleaner Production, Vol. 17, 2009, pp. 276–282

21. Powley, E.H. **Reclaiming resilience and safety: resilience activation in the critical period of crises,** Human Relations, Vol. 62, No. 9, 2009, pp. 1281–1326
22. Rogoff, E.G., Kay, R. and Heck, Z. **Evolving research in entrepreneurship and family business: recognizing family as the oxygen that feeds the fire of entrepreneurship,** Journal of Business Venturing, Vol. 18, 2003, pp. 559–566
23. Sheffi, Y. **The resilient enterprise: overcoming vulnerability for competitive advantage,** Cambridge, MA: MIT Press, 2005
24. Sheffi, Y. **Resilience reduces risk,** Logistics Quarterly, Vol. 12, No. 1, 2006, pp. 12–14
25. Sheffi, Y. and Rice Jr, J.B. **A supply chain view of the resilient enterprise,** MIT Sloan Management Review, Vol. 47, No. 1, 2005, pp. 41–48
26. Swink, M., Narasimhan, R. and Kim, S.W. **Manufacturing practices and strategy integration: effects on cost efficiency, flexibility, and market-based performance,** Decision Sciences, Vol. 36, No. 3, 2005, pp. 427–457
27. Villalonga, B. and Amit, R. **How do family ownership, control and management affect firm value?,** Journal of Financial Economics, Vol. 80, 2006, pp. 385–417
28. Westhead, P. and Howorth, C. **Ownership and management issues associated with family firm performance and company objectives,** Family Business Review, Vol. 19, No. 4, 2006, pp. 301–316
29. Youndt, M.A., Snell, S.A., Dean, J.W. and Lepak, D.P. **Human resource management, manufacturing strategy, and firm performance,** Academy of Management Journal, Vol. 39, 1996, pp. 836–866
30. * * * **www.innerworkcompany.com**