INTERNATIONALIZING MANUFACTURING SMEs IN A DEVELOPING REGION: AN EXHAUSTIVE CDA-BASED EXPLORATORY APPROACH

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ABSTRACT

Internationalization of Small and Medium Enterprises (SMEs) in developing economies is a hybrid strategy where reactive remedies and proactive styles of inward/outward operations is sought by innovative and risk seeking entrepreneurs. Exporting remains the dominant mode of internationalization and entry to foreign markets by SMEs in both developing and developed economies. When data on SMEs attributes and entrepreneur's characteristic is categorical, single methodology to analyze factors influencing exporting are far from sufficient. A multi-method and exhaustive approach is necessary to explore the adequacy of factors in question. The three methods relevant to categorical data analysis (CDA) in this paper highlights the enabling role of the exploratory factors in understanding the relationship with SME's exporting. Categorical regression overcomes the limitations of both contingency table method and binary logistic regression in exploring this relationship, and provides substantive space to experiment and investigate the contributory role of export-enabling factors when data size is small.

Key words: *Internationalization, SMEs, Exports, Categorical Data Analysis, Categorical Regression*

INTRODUCTION

SMEs play an important role in modern economies because of their flexibility and ability to innovate (Marri et al., 2000; Tan et el., 2006; Gabrielsson, et el., 2004)[1,2,3]. SMEs induce social stability providing employment opportunities to millions of people around the globe. SMEs act as backbone to large scale manufacturing sector. In the EU, SMEs constitute 99% of all enterprises providing jobs to 100 million people comprising over 2/3rd of total private workforce (Leopoulos, 2006)[4]. Of these 99% SMEs, more than 90% are micro SMEs comprising workforce of at most 10 people (Audretsch et el, 2003)[5]. According to Thomas[6] (2003), SMEs in Hong Kong are 98% of total business firms and provide employment to 1.3 million people (60% of workforce). SMEs employed 70% of the workforce in the UK and, proportion of SMEs (firms with maximum workforce level of 250) in Ireland is 99.4% (Caskey et el, 2001)[7]. According to UN Trade report[8] (2005), SMEs employ 60-70% workforce in OECD countries, and in developing countries, this proportion is even greater; for example, firms with a maximum workforce size of 50 are 99% in Ecuador. In India, SMEs contribute 40% to industrial production, 35% to exports and accommodates about 80% people in the industrial sector of the country (Dangayach & Deshmukh, 2006)[9]. In Malaysia, SMEs accounts for 89.3% of all establishments in the manufacturing sector contributing 29.1% to total manufacturing and, 32.5% to employment (SMIDEC, 2002)[10]. According to Netto[11] (2005), there are 4.5 million small formal businesses in Brazil. These organizations account for 98% of industrial, commercial and service undertakings employing more than 60% of urban jobs and contributing 21% share to the GDP. SMEs, in the USA, cater for three out of every four new jobs and contribute to providing over half of the GDP (Todd & Gavalgi, 2007)[12]. US Business firms employing at most 500 people generate 50% of jobs and small business employing at most 20 people are over 88% in proportion (Prater and Ghosh, 2005)[13]. In Pakistan, SMEs account for 90% of all enterprises (Khan & Bamber[14], 2007). According to SMEDA[15] survey report (2009), there are 3.2 million small business units in Pakistan of which 52% are in wholesales/trade/hotels, and 20% in manufacturing sector. These firms provide jobs to 6.5 million people. The proportion of micro-units (employing at most 5 people) stands at 94.46%. Almost 99% of these units employ not more than 99 people

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signifying the abundance of small firms in the country. SMEs in Pakistan contribute 30% to country's GDP and generate 25% of manufacturing export earnings (Mustafa & Khan, 2005)[16]. Despite SMEs strong contribution towards human resource capitalization and economic gains in developed as well as developing economies, Prater & Ghosh[13] (2005) identify paucity of research literature on SMEs particularly in developing countries. SMEs account for more than 90% of all jobs, and yet receive little attention by academia when compared with LSM (Large Scale Manufacturing) and MNC (Multinational Corporations).

Internationalization

With globalization on the rise, trade barriers are loosening. Heat of competitive environment is melting the defensive posture of SMEs both in developed and developing countries. Free flow of goods and transactions is pushing the SMEs to adopt an aggressive and forward looking posture for survival and growth. As Tan[2] et el. (2006) posit that SME's potential to participate in global economy has significantly strengthened with technological breakthroughs coupled with erosion of trading boundaries. A popular aggressive strategy for an enterprise is to *internationalize* by extending the home-focused operational and trading activities to other regions of the world where opportunities exist. According to Ruigrok[17] (2000), "internationalization is SMEs' outward movement of international operations". Stage theory founded by Johanson and Vahlne[18] (1977) has attracted enormous attention in explaining how firms internationalize (Li & Dalgic, 2004)[19]. Gabrielsson[3] et el. (2004) regard stage theory of internationalization (popularly known as Uppsala model) substantially helpful as the theory explains how firms grow and expand internationally from initial minuscule state. The authors commend the efforts and work of researchers including Luostarinen[20] (1979), Welch[21] (1990) and Wiedersheim-Paul[22] (1978) from Scandinavian region in founding, exploring and interpreting the concepts embedded in the theory. According to the stage theory, internationalization is a step-wise process of progress and advancement when firms engage in foreign operations through evolutionary learning process. Calof and Vivers[23] (1994) augment the advocates of the stage theory by adding that "firms move sequentially through different stages as they develop their international activities". Vernon[24] (1966) product life cycle model implies that innovation in product development and economies of scale lead a firm to path of internationalization , and, it is accomplished through expansion by stages (Prater & Ghosh, 2005; Rutashobya & Jaensson, 2004)[13,25]. The theory implicitly assumes that firms internationalize in increments and, that changes occur in organizational chemistry slowly (Nummela & Loane, 2006)[26]. However, the stage theory was framed when trade barriers were stringent. Trade liberalization and breakthroughs in technologies is now coercing serendipitous firms to go global since inception (Rutashobya & Jaensson, 2004)[25]. Against criticism, Etemad[27] (2004) strongly favors stage theory and posits that it provides balanced academic guidance to SMEs intending to internationalize by overcoming knowledge deficit of international markets. The small firms commit to engage in internationalization through experiential learning in stages while closing gaps in psychic distance. Gankema[28] et el. (2000) argue that stage theory can be adapted with certain restrictions to SMEs. "Some SMEs may exhibit incremental and stable patterns of internationalization but majority lacks these characteristics often experiencing irregular and intermittent patterns of internationalization", (Westhead et el., 2002)[29]. SME's operationalization at international level is marred by acutely low levels of both financial and non-financial resources. As Lloyd-Reason and Mughan[30] (2002) argue, internationalization of SMEs entails enrichment of coordinating efforts for upgrading information systems, product development and technical facilities.

Exporting: An Internationalization Strategy

Acs[31] et el. (1997) posit exporting to be the initiation towards internationalization. "*Exporting is the single most important mechanism that manufacturing SMEs use to compete in the international market*", (Mahmood, 1996)[32]. Mtigwe[33] (2005) cites (Johanson & Mattson, 1988; Clark *et al*., 1997)[34,35] where these authors observe that 86 per cent of the all firms surveyed in U.S., the internationalization process began with the exporting mode of foreign market entry. Mtigwe[33] (2005) further concluded that all the internationalization process models are in agreement with this observation. The rise of newly industrial countries (NICs) on global economic front in late eighties is attributed to the focused export-oriented industrial development and growth in Far Eastern region of Asia (Rutashobya and Jaensson, 2004)[25].

Stage model of SME internationalization implies passive exporting as the first stage in across-the-border trading before a firm develops physical facilities abroad (Prater & Ghosh, 2005; Dollinger, 1995)[13,36]. However, SMEs export activity departs from the norms of stage theory as the exporting activities of SMEs are intermittent and pragmatic over time (Lloyd-Reason & Mughan, 2002)[30].

SMEs and Exporting

SMEs contribution towards exporting strategy needs detailed probing as various authors demonstrate that small-scale businesses can play an especially crucial role in export and employment generation in developing countries (Arinaitwe, 2006; Neupert et el., 2006)[37,38] . There is a paucity of literature on exporting experiences of SMEs once these firms start interacting across the borders. Exploration of differentiation between exporting and non-exporting firm's performance is scant (Westhead et el., 2002)[29]. Most of the research on exporting behavior of SMEs is conducted in North America and Europe, whereas investigation of SME exporters in developing countries is rare (Neupert et el., 2006; Leonidou, 2004)[38,39]. Entrepreneurs and SMEs need to probe and identify resources and capabilities to transform the organizations and start exporting their goods (Westhead et el., 2002)[29]. A firm's propensity to export is positively associated with its ability to produce high-technology differentiated products by engaging in innovative initiatives through dynamic competitive advantage (Milesi et al., 2007)[40].

Whereas, SME's contribute significantly in a country's economic growth through employment generation and GDP, its share to exports varies from low levels to significant proportions around the globe. In South American countries, SME's contribution to exports is 15% in Chile, 11% in Argentina and 9% in Colombia (Milesi et el., 2007)[40]. SME's share of exports in Brazil is 6% (Netto, 2005)[11]. Share of exports of SMEs in Tanzania varies between 5 to 20% (Rutashobya & Jaensson, 2004)[25]. Indian SME's share of exports is quite significant and has averaged around 34% (Todd & Gavalgi, 2007)[12]. SME's export share in Japan is 12.9%, but Italian SMEs contribute very strongly to country's exports with a share of 45% (Acs et el., 1997)[31]. According to OECD report[41] (1997), SMEs account for 25–35% of the world's manufactured exports and 4–6% of the OECD countries' exports (Marti´nez, 2006)[42]. In Malaysia, SME's share in total exports is around 20%, lower than many other countries such as the Philippines, Hong Kong, Taiwan and even the USA (Saleh & Ndubisi, 2006)[43].

Exporting data patterns from Pakistan are shown in Figure 1 and Figure 2. The proportion of engineering sector imports and total imports {ITI(E)} fluctuates around 32.79% with high peaks around 39.32% and low crests around 25.92% over last eleven years (see Figure 1). The imports ratios record signifies that

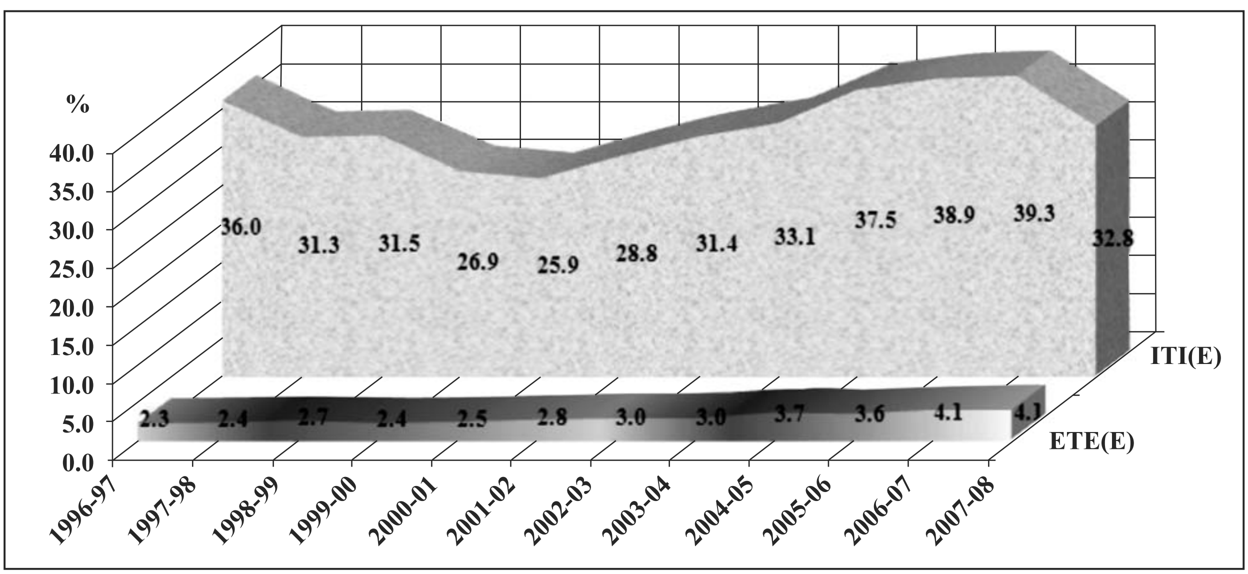


Figure 1: Engineering sector exports {ETE(E)} and imports {ITI(E)} as a percentage of total exports and imports, (Source: Engineering Development Board, 2009)[44]

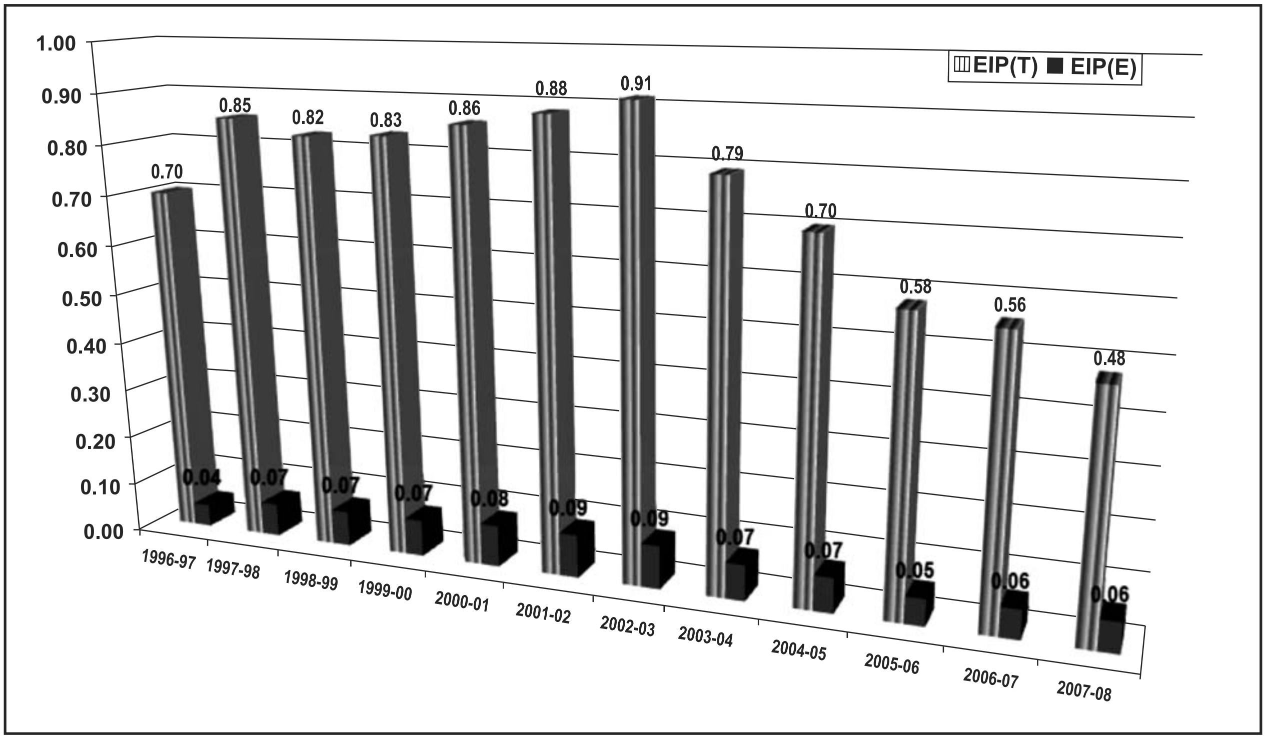


Figure 2: Total exports as a percentage of total imports {EIP(T)} and engineering exports as a percentage of engineering imports {EIP(E)} (Source: Engineering Development Board, 2009)[44].

imports for engineering sector has never been more than 40%, and are one-fourth of total imports in best case scenario. However, the exports share by engineering sector {ETE(E)} in these years has been very dismal ranging from 2% to 4% . The proportion of total exports with relation to total imports during these last eleven years has fluctuated in the range of 0.48 and 0.91 with average value of 0.75 (see Figure 2). However, the proportion of exports in engineering sector with relation to imports in engineering sector is acutely low in the range of 0.04 and 0.09 with mean value of 0.07. Both figures depict a highly demanding probe in the export-deficient manufacturing SME sector of Pakistan.

RESEARCH METHODOLOGY

A variety of approaches are in practice to study and analyze the small firm's internationalization process. Evans[45] et el. (2008) employ exploratory qualitative study method of *interviewing* executives responsible for international business. Fillis[46] (2007) favors *biography* as a research methodology and argues that biography approach is very helpful in finding the behavioral patterns of the owner/manager in the context of history. Scharf[47] et al. (2001) uses *critical incident* as a research methodology in exploring the challenges and competitions faced by entrepreneurs in conducting the international business. The *incident* is explored in a face-to-face in-depth interview by the researcher focusing on the detailed accounts of "worst nightmare" encountered by the entrepreneur in internationalization. Chetty & Campbell-Hunt[48] (2003) propose case study method for investigating internationalization process of firms. The authors cite the work of Eisenhardt[49] (1989) and Yin[50] (1989) in support of the argument. In *case study* approach, the unit of analysis is the firm, and multiple cases are studied together. According to Eisenhardt[49] (1991), multiple case study approach helps to identify patterns of behavior and actions across organizations. However, most common approach is to employ scientific methods using multivariate statistical techniques to explore joint impact of limited number of factors (McDougall and Oviatt, 2005; Burgel *et el*., 2001; Westhead *et al*., 2001a)[50,29]. Fillis[46] (2007) cites Sauley and Bedeian (1989) who criticizes researchers in overusing scientific techniques and statistical methods in analyzing the strength of relationships of parameters.

A multi-method multivariate statistical approach based on categorical data has been followed in this work to explore the enterprise and entrepreneurial factors supporting SME to internationalize through exporting activities. A total of 50 SMEs were included in the pilot study and data was collected reflecting important parameters of the enterprise and the entrepreneur as shown in Tables 1-A and 1-B at the Appendix. The data attributes have been modified so as to conform to nominal scale requirements for analysis and results. All the parameters in Tables 1-A and 1-B are predictor variables except the dichotomous variable EXPRT, which is the response variable.

THEORETICAL FOUNDATIONS

Categorical data analysis (CDA) is the analysis of data when measured quantities are in binary form (yes/no) or divided into categories (for example; high,

Table 1-A Categorical Variables for Entrepreneur

Entrepreneur's Attributes	Categories / Levels
Ownership type (OWN TYP)	0=Solo, 1=Joint
Number of particular years of formal education for a diploma (EDU YR)	8:Middle, 10:Matric, 12: Inter 13: Diploma, 14: BA/BSc 16: BE/MSc, 18: MPhil/MS(Engg) 21:PhD
Number of education years is 14 and above (DEG ABV)	1=Yes, 0=No
Type of educational discipline (EDU DSP)	0=Arts 1=Sciences2=Engineering 3-Business
Professional education {Engineering/Business - PRO EDU}	1=Yes, 0=No
Entrepreneur's age categories (ENT AGECAT)	21-30, 31-40, 41-50, 51-6061-70, 71-80, 81-90
Entrepreneur's type (ENT TYP)	0=Opportunity, 1=Necessity
Entrepreneur is founder owner (FDR OWN)	1=Yes, 0=No
Entrepreneur believes in Expansion (EXP BLV)	1=Yes, 0=No
Entrepreneur' belief in innovation (INV BLV)	0=No, 1=Poor, 2=Strong 3=Very Strong, 4=Don't know
Entrepreneur finds opportunity to innovate (INV OPR)	0=Yes, 1=No

Table 1-B Categorical Variables for Enterprise (SME)

ME's Attributes	Categories / Levels
SME Located in type of city (SME LW)	0=Small, 1=Town, 2=Large
SME Located in region (SME RGN)	1=Upper, 0=Lower
Industrial activity level of city where	0=Low, 1=Medium, 2=High
SME is located (INDLVL)	
SME's age categories (SME AGECAT)	1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80
SME's present state of life cycle (LFE CYC)	0=Introduction, 1=Growth2=Maturity, 3=Decline
SME's size in terms of employees (SME SIZ)	0=Micro, 1=Small, 2=Medium
SME's manufacturing activity (MFT TYP)	0=Components, 1=Assembly 2=Compts/Assembly, 3=Processing
SME is OEM or registered with OEM (OEMRGSTR)	1=Yes, 0=No
SME is exporting (EXPRT) ~ Response	1=Yes, 0=No

medium, low). CDA is extensively used in behavioral, social, psychological, advanced engineering and quality control studies for exploratory investigations. Three variants of categorical data analysis have been incorporated in the paper. Brief reviews of theoretical aspects of the methodologies are presented.

Contingency Tables

Pearson (1904) is attributed to have coined the term *contingency table*. The data of counts is tabulated in a two-way contingency table (see, Table 2). The dichotomous response variable EXPRT (I) is figured along the rows and one of the independent dichotomous (explanatory) variable (J) from Table 1 is listed along the columns. Let, i=response variable state, and, j=explanatory variable state. Similarly, r_i = row totals for response variable, e_j = column totals for explanatory variable, N= number of cases in the study. Let, O_{ij} = number of observed counts for i^{th} response state and j^{th} explanatory variable state. For dichotomous response variable, probabilities of affirmative and non-affirmative response will be;

$$p_r(1) = r_1 / N \tag{1a}$$

$$p_r(0) = r_0 / N \tag{1b}$$

Similarly, probabilities of affirmative and non-affirmative explanatory dichotomous variable will be;

$$p_e(1) = e_1 / N \tag{1c}$$

$$p_e(0) = e_0 / N \tag{1d}$$

Further let, E_{ij}= number of expected counts for i^{th} response state and j^{th} predictor state. Using equations (1a), (1b), (1c) and (1d), E_{ij} is expressed as;

$$E_{ij} = p_r(i)p_e(j)N \tag{2}$$

According to (Argesti, 2007)[51], Pearson's χ^2 statistics is computed by using the E_{ij} values from equation (2) as under;

$$\chi^2 = \Sigma\Sigma\left(O_{ij} - E_{ij}\right)^2 / E_{ij} \tag{3}$$

The χ^2 statistics from equation (3) is used to assess the presence or absence of *association* between response and explanatory variables. Null hypothesis (H_o) is formed stating that the explanatory variable is not associated with response variable (test of independence). Independence of variables is established if $\chi^2 \le \chi^2_{a,v}$, where $\chi^2_{a,v}$ is the critical value of χ^2; α=level of significance and n= degrees of freedom (df).

Table 2: Two-way Contingency Table structure

	J (yes)	J (no)	Total
I=Export(yes)	O_{11}	O_{10}	$r_1=O_{11+}O_{10}$
I=Export(no)	O_{01}	O_{00}	$r_0=O_{01+}O_{00}$
Total	$e_1=O_{11+}O_{01}$	$e_0=O_{10+}O_{00}$	N

When some of cell counts<5, Yates's continuity correction is applied to χ^2 expression. Yate's corrected χ^2_{Yates} is given by equation (4) as under;

$$\chi^2_{Yates} = \Sigma\Sigma\left(\left|O_{ij} - E_{ij}\right| - 0.5\right)^2 / E_{ij} \tag{4}$$

Another variant of the χ^2 test of independence (for small cell counts<5) is the likelihood-ratio χ^2_{llr}, and is expressed by equation (5) as under;

$$\chi^2_{llr} = 2\Sigma O_{ij} In\left(O_{ij} / E_{ij}\right) \tag{5}$$

The Fisher's exact test (FET)[52] is another methodology to deal with inaccuracies due to small sample sizes. Fisher's test find the probability for 2x2 contingency table whether rows data are significantly different from each other.

Three-way Contingency Tables

Extending the CDA-based exploration, let's include another explanatory variable K as 3rd dimension and develop 2x2xK table. Let k be the index for this variable. Kth variable is a nominal variable with categorical levels (say, k=1,2,3) as shown in Table 4. Modify O_{ijk} to include the observed counts for i^{th} state of response variable and two explanatory variables j and k as shown in Table 3.

As before, r_1 and r_0 are row totals (marginal frequency) for dichotomous response variable *Export*. Now J is the first explanatory dichotomous variable; let denote column totals for binary states/levels of J(yes) and J(no), respectively. Similarly, let be mar-

Table 3: Three-way Contingency Table Structure

	J (yes) K			J (no) K			
	1	**2**	**3**	**1**	**2**	**3**	
I=Export (yes)	O_{111}	O_{112}	O_{113}	O_{101}	O_{102}	O_{103}	r_1
I=Export (no)	O_{011}	O_{012}	O_{013}	O_{001}	O_{002}	O_{003}	r_0
Total	$e_{1,1}$			$e_{1,0}$			

ginal frequencies for second nominal variable K with levels k=1,2,3. As before, probabilities of affirmative and non-affirmative responses are given by equations (6a) and (6b) as follows;

$$p_r(1) = r_1 / N \quad (6a)$$

$$p_r(0) = r_0 / N \quad (6b)$$

Let's probabilities of affirmative and non-affirmative first explanatory variable are given by equations (7a) and (7b) as under;

$$p_{e1}(1) = e_{1,1} / N \quad (7a)$$

$$p_{e1}(0) = e_{1,0} / N \quad (7b)$$

Probabilities for second explanatory variable K with levels k=1,2,3 will be;

$$p_{e2}(1) = e_{2,1} / N \quad (8a)$$

$$p_{e2}(2) = e_{2,2} / N \quad (8b)$$

$$p_{e2}(3) = e_{2,3} / N \quad (8c)$$

$$\text{and, } e_{2,k} = \sum\sum\sum O_{ijn} \quad (8d)$$

Further let, E_{ijk}= number of expected counts for i^{th} response state with j^{th} and k^{th} explanatory variable states/levels. Then using equations (6a), (6b), (7a), (7b), (8a), (8b) and (8c), expression for E_{ijk} will be;

$$E_{ijk} = p_r(i)p_{e1}(j)p_{e2}(k)N \quad (9)$$

According to Argesti[51] (2007), using E_{ijk} values from equation (9), Pearson's χ^2 statistics for three-dimensional data table will be;

$$\chi^2 = \sum\sum\sum\left(O_{ijk} - E_{ijk}\right)^2 E_{ijk} \quad (10)$$

Similarly, the expression for likelihood-ratio chi square statistics is $2\sum\sum\sum O_{ijk} In\left(O_{ijk} / E_{ijk}\right)$. As before, independence of response variable (EXPORT) and any two predictor variables is established if $\chi^2 \leq \chi^2_{\alpha,v}$, where $\chi^2_{\alpha,v}$ is the critical value of χ^2; α=level of significance and v = degrees of freedom (df).

Binary Logistic Regression

Logistic regression is another variant for exploring the categorical data. It is an extended form of multiple linear regression (MLR), and is suited to the current situation as the response variable EXPRT is binary. Let y denotes the EXPRT variable, and the predictor variables are denoted by. In multiple linear regression models, the response variable $y_\beta(\vec{x})$ is related to predictor variables by the expression;

$$y_\beta(\vec{x}) = \beta_0 + \sum_{j=1}^{n}\beta_j x_j \quad (11)$$

where $\beta_j, \{j = 0,1,2,...,\}$ are the weights attributed to respective j^{th} predictor variable x_j. Note that x_0 = 1, and β_0 is interpreted as intercept. The function $y_\beta(\vec{x})$ remains within the bounds of [0,1] when relationship between y_β and predictor variables x_j's is modified using *sigmoid function* as under;

$$y_\beta(\vec{x}) = \frac{\exp(\beta_0 + \beta_1 x_1 + ... + \beta_n x_n)}{1 + \exp(\beta_0 + \beta_1 x_1 + ... + \beta_n x_n)} = \frac{1}{1 + e^{-z}} \quad (12)$$

where, $z = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + .. + \beta_n x_n$

If we let $P(Y = 1|\vec{x};\vec{\beta})$ be the probability that Y takes on the value 1 given that predictor vector is $\vec{x}$ with weight's vector $\vec{\beta}$; then

$$P(Y = 0|\vec{x};\vec{\beta}) = 1 - y_\beta(\vec{x}) \quad (13)$$

Similarly, let $P(Y=0|\vec{x};\vec{\beta})$ be the probability that Y takes on the zero value given that predictor vector is $\vec{x}$ with weight's vector $\vec{\beta}$; then Hosmer & Lemeshow[53] (2000) proves the following expression;

$$P(Y=0|\vec{x};\vec{\beta}) = 1 - y\beta(\vec{x}) \quad (14)$$

$$P(Y|\vec{x};\vec{\beta}) = \{y_\beta(\vec{x})\}^Y\{1-y_\beta(\vec{x})\}^{1-Y} \quad (15)$$

To enumerate $y_\beta(\vec{x})$ from known data comprising $\{y^{(i)}, x^{(i)}\}$, it is required to find estimated values of the weights β_j's. The method of maximum likelihood estimator (MLE) of parameters is employed to find weights β_j's. The likelihood function to find estimates of weights β_j's is;

$$L(\vec{\beta}) = P(Y|\vec{x};\vec{\beta}) = \prod_{i=1}^{m}[\{y_\beta(x^{(i)})\}^{Y(i)}\{1-y_\beta(x^{(i)})\}^{1-Y(i)} \quad (16)$$

where, m is the number of cases to be included in the estimation process and, i = 1, 2, …, m. In order to estimates the weights β_j 's, log of likelihood is taken as;

$$l(\vec{\beta}) = \log\{L(\vec{\beta})\}$$

$$= \sum_{i=1}^{m}\left[Y^{(i)}\log\{y_\beta(x^{(i)})\} + (1-Y^{(i)})\log\{1-y_\beta(x^{(i)}\}\right]. \quad (17)$$

To maximize the likelihood function, the gradient ascent method (Andrew, 2006)[54] is employed whereby values of $\beta_{j's}$ are iteratively updated till convergence is achieved. The equation for iterative updating is;

$$\beta_j \cong \beta_j + a\sum_{i=1}^{m}[y^{(i)} + y_\beta(x^{(i)})]x_j^{(i)} \quad (18)$$

Categorical regression

It is another extension of multiple linear regression (MLR) method. The classical formulation of MLR is;

$$\vec{y}(x) = \beta_1\vec{x}_1 + ... + \beta_p\vec{x}_p + e = \sum_{j=1}^{p}\beta_j\vec{x}_j + e \quad (19)$$

where, $\beta_j, \{j = 0,1,2,...,p\}$ are the weights attributed to respective j^{th} predictor variables x_j, and, $\vec{y}(x)$ is the response variable. In categorical regression, both predictor and response variables are transformed to $\varsigma(x_j)$ and $\varsigma(y_\beta)$ using optimal scaling (Leeuw, 2005)[55], so that MLR is modified to;

$$\varsigma(y_\beta) = \sum_{j=1}^{p}\beta_j\varsigma(x_j) + e \quad (20)$$

To apply transformations, indicator matrix G and *category quantification* vector $\vec{v}$ are defined so that for response variable $\vec{y}$, and, $\varsigma(x_j) = G_j\vec{v}_j$ for predictor variable x_j. Category quantification vectors $\vec{v}$ and $\vec{v}$; (j=1,2,…, p) are for response variable y and set of predictor variables $\vec{x}_j$ respectively. Indicator matrix G_j is of order n by k_j for j^{th} variable; (i=1,2,…,n; c=1,2,..k_j); where n is the number of cases in the analysis, and, k_j is the number of categories of j^{th} variable. An entry $g_{ic[j]}$ in matrix G_j will be equal to 1 when i^{th} case will be in c^{th} category, and, zero otherwise. Hence, the transformed model in terms of *category quantifications* will be;

$$G_r\vec{v}_r = \sum_{j=1}^{p}\beta_j G_j\vec{v}_j + e \quad (21)$$

Categorical regression approach encompasses the minimization of loss function $l(\vec{v}_r;\beta;\vec{v}_j)$ which is equal to $\left\|G_r\vec{v}_r - \sum_{j=1}^{p}\beta_j G_j\vec{v}_j\right\|^2$, where $\|.\|$ denotes the squared Euclidean norm. Alternating least square method is used to find a minimum value of the function $l(\vec{v}_r;\vec{\beta}_j;\vec{v}_j)$. The ALS method alternately finds the values of $((\vec{v}_{j's}, \vec{v}_r)$ and $\vec{\beta}_{j's}$ till the value of multiple regression coefficient (R^2) converges to prespecified value ε (Kooij et el, 2006)[56]

EXPERIMENTAL RESULTS AND DISCUSSION

Two-way Contingency Table

We apply the test to ascertain independence between response variable EXPRT and predictor variable OEMRGSTR. The data set for the two variables in 2-way contingency table (as per structure of Table 2) is; (O_{11}=6, O_{10}=9, O_{01}=2, O_{00}=33). The null hypothesis (H_o) of independence fails since Pearson's $\chi^2 = 9.184 \geq \chi^2_{0.05,1} = 3.841$. Hence, there is ***an*** association between EXPRT and OEMRGSTR of SMEs. Similar conclusion is reached by Yates correction, since $\chi^2_{yates} = 7.063$. Compute likelihood-ratio, χ^2_{LR}; the value is 8.444. Once again association between EXPRT and OEMRGSTR is asserted.

Three-way Contingency Table

We include INDLVL as second predictor variable to form 3-way contingency table. The data for 3-way contingency table is shown in Table 4.

Table 4: Three-way Contingency Table from Dataset

	OEM (yes) INDLVL			OEM (no) INDLVL			
	1	2	3	1	2	3	
Export (yes)	*2*	*1*	*3*	*3*	*2*	*4*	*15*
Export (no)	*0*	*2*	*0*	*9*	*19*	*5*	*35*
Total	*8*			*42*			

The value of $\chi^2 = 21.401$ for 3-dimensional dataset. Since χ^2 value is greater than critical value of $\chi_{.05,5} = 11.070$ {α=5%, v=(r-1)(c-1)=5}, we conclude that three variables are not independent. Similarly, the likelihood-ratio chi square statistics $(\chi^2_{LR}) = 2\sum\sum\sum O_{ijk} \ln\left(O_{ijk} / E_{ijk}\right) = 18.197$, since $(\chi^2_{LR}) > \chi_{.05,5} = 11.070$, test of independence fails, and association of the three variables is asserted.

Three-way table can be partitioned into two-way tables where effect of one predictor variable on EXPRT (response variable) is investigated at fixed levels of a second predictor variable called control variable. So, if *k* levels exist for the control variable, there will be *k* number of partial tables. The association in a partial table between predictor and response variables can be established as is done in two-way contingency table (Argesti, 2007)[51]. We explore the partial association between EXPRT and OEMRGSTR controlling for other predictor variables in the dataset. SPSS® CROSSTAB[57] was used to explore the conditional associations as shown in Figure 3. CRMER's V was used to measure the strength of association.

From Figure 3, entrepreneurial characteristics found significant at Fisher's 5% level include;

> '*founder* owner with *solo* ownership in the age group of 61-70 years; a *necessity* entrepreneur with *14* years of education with *engineering* background; with a mix of no belief and strong belief in innovation'

Similarly, enterprise (SME) attributes found significant at Fisher's 5% level are;

> '*small* enterprise situated in a *big* city of *upper* region of the country; *age* in the range of 21-30 years passing through *maturity* phase of life cycle and engaged in *assembly* operations'

Figure 3 also shows the category levels of control variables asymptotically significant at 5%. The entrepreneurs who *believe* in expansion and *do not* see opportunity to innovate are in the 5% asymptotic significance level. Similarly *medium-sized* SMEs located in *low industrial activity* region and engaged in *process* activities are in 5% asymptotic significance level.

There are 43 category levels in all as shown in Figure 3. Twenty two category levels are significant either as asymptotic or Fishers' exact criteria. Thirteen of these category levels exhibit a moderate-to-strong association, seven with strong association and, the rest with weak association. None of the variables demonstrate insignificant relationship (each variable exhibit *at least* one significant relationship at a category level). According to Argesti (2007)[51], when at least one significant conditional association exists for every controlling variable, no incidence of conditional independence exists in the data.

Binary Logistic Regression

Stringent condition of adequate data size is a pre-requisite for applying logistic regression technique (Hosmer & Lemeshow, 2002)[53]. Therefore, a piecemeal approach of including few variables in a model is adopted to explore factor's relationship with EXPRT

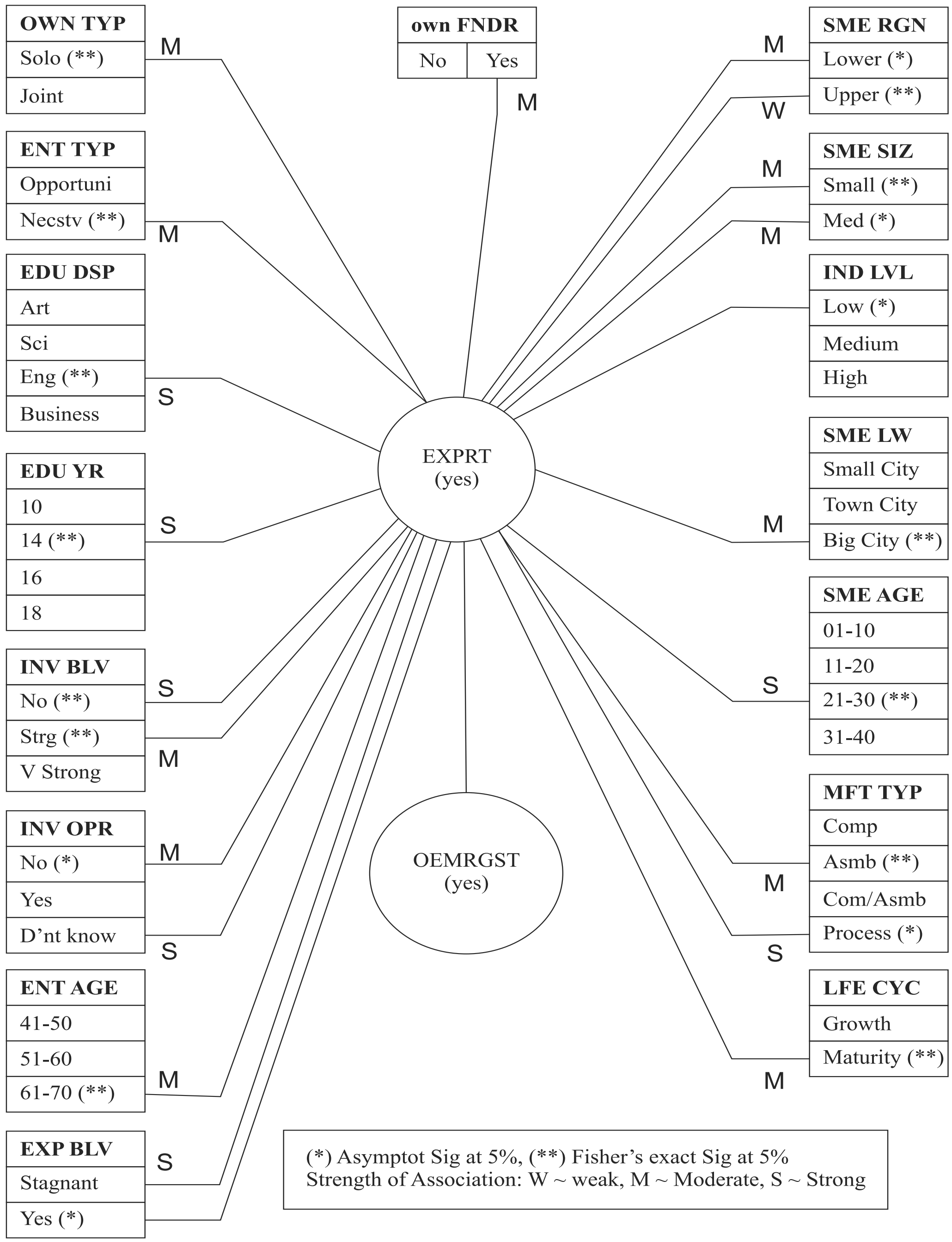


Figure 3: Significant levels of controlling variables for conditional associations between EXPRT response variable and OEMRGST predictor variable

variable. Table 5 shows various groups of predictor variables used to develop logistic regression model using SPSS[57] Logistic Regression module.

Only model A fulfills the norms of a workable logistic regression model. All other models poorly perform. Model A has INDLVL and OEMRGSTR as predictor variables. The factors are significant with Wald statistics. The model itself is significant according to ÷2 criteria of significance set by Hosmer and Lemeshow[53] (2002). Model A's classification capability to distinguish between exporting and non-exporting SME is OK. The model can account for 28% of the variation in response variable (EXPRT) according to Cox & Snell R^2 and, 39.6% of variation in EXPRT according to Nagelkerke R^2. Other models in Table 4 depict poor characteristics. For example, models D, E, F, H and I fits the data according to H & L[53] criteria, none of the models have correct classification capability, and very low R^2 values to adequately account for % variation in the variable EXPRT.

Table 5: Binary Logistic Models attributes including Correct Classification and Hosmer & Lemeshow[53] Test of Significance

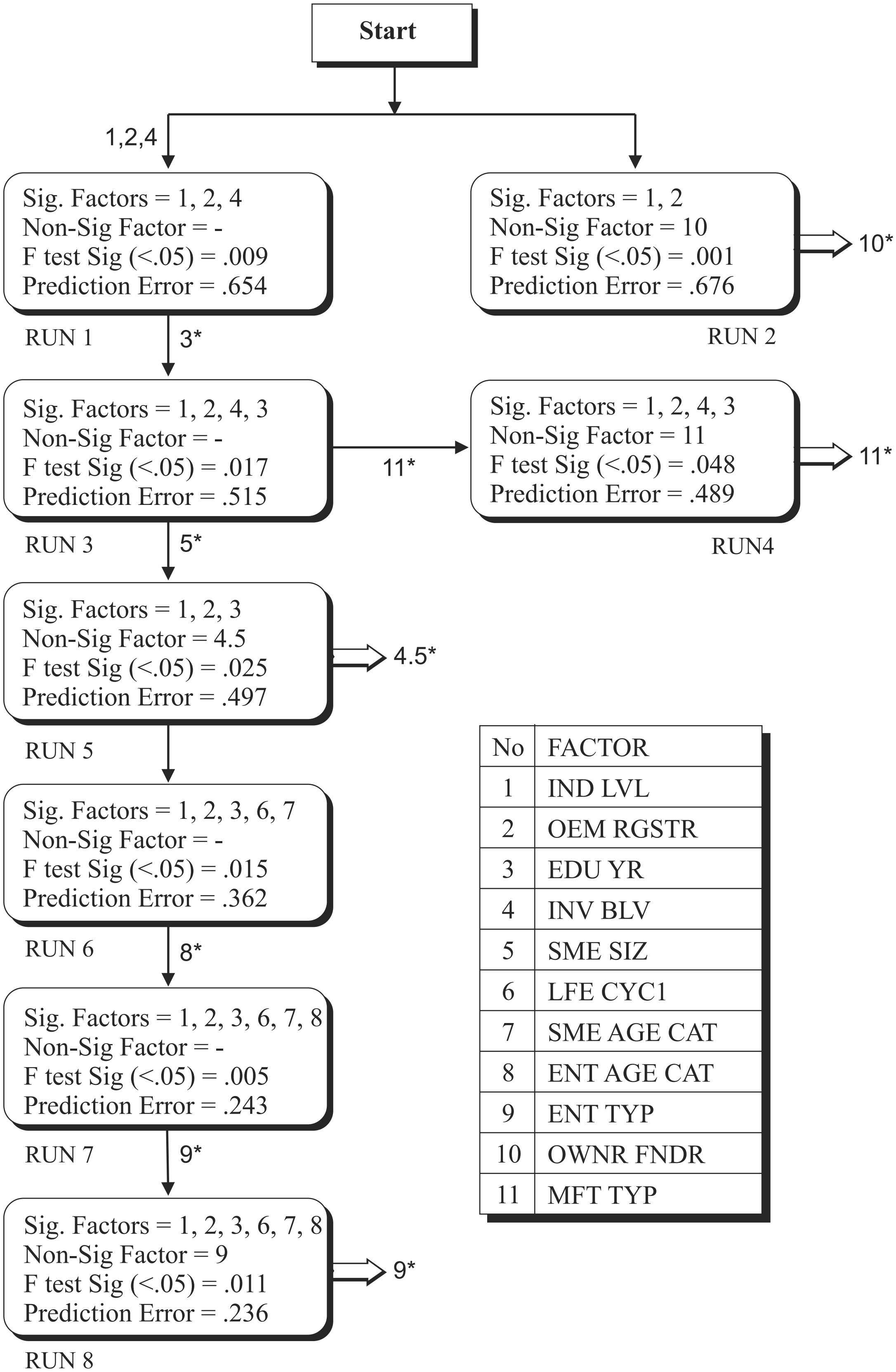
#	Parameters	B	Wald	Sig.	Exp(B)	% Correct[a]	H & L[b] Test	Model[c] Summary
A	INDLVL INDLVL (1) INDLVL (2) OEMRGSTR (1) Constant	 -.840 -2.469 -2.643 2.520	6.412 .901 6.333 6.364 4.780	.041 .343 .012 .012 .029	 .432 .085 .071 12.426	PE=72.9 PO=78.0 BC=75.6 Test-OK	χ^2=0.561 Sig.= 0.90	-2LL=44.6 CSR^2=.280 NR^2=0.396
B	MFT TYP MFT TYP (1) MFT TYP (2) MFT TYP (3) Constant	 -1.204 -.405 -.693 .000	1.135 .596 .072 .175 .000	.769 .440 .788 .676 1.000	 .300 .667 .500 1.000	PE=66.7 PO=66.7 Test-No	χ^2=0.00 Sig.= 1.00	-2LL=44.6 CSR^2=.032 N R^2=.045
C	SME SIZ SME SIZ (1) SME SIZ (2) Constant	 -20.846 -.154 -.357	.047 .000 .047 .524	.977 .999 .829 .469	 .000 .857 .700	PE=65.8 PO=65.8 Test-No	χ^2=0.00 Sig.=1.00	-2LL=44.2 CSR^2=.114 NR^2=0.158
D	EDU YR ENTAGECAT SMEAGECAT Constant	-.128 .015 -.008 .197	.764 .117 .121 .004	.382 .732 .727 .950	.880 1.015 .992 1.218	PE=73.3 PO=73.3 Test-No	χ2=4.853 Sig.= .678	-2LL=51.0 NR^2=0.035
E	OWNR FNDR Constant	1.386 -2.590	3.760 7.104	.052 .008	4.000 .075	PE=70.0 PO=72.0 BC=72.5 Test-No	χ^2=7.663 Sig.=.363	-2LL=53.4 CSR^2=.065 NR^2=0.092
F	LFE CYC1 SME SIZ MFT TYP Constant	.075 .791 .115 -3.205	.022 2.432 .115 2.494	.881 .119 .734 .114	1.078 2.205 1.122 .041	PE=69.6 PO=71.7 BC=72.1 Test-No	χ^2=0.588 Sig.=.745	-2LL=67.2 CSR^2=.073 NR^2=.104
G	ENT TYP (1) OWNR FNDR(1) Constant	-.373 -1.460 .354	.310 4.017 .268	.578 .045 .605	.688 .232 1.424	PE=70.8 PO=70.8 Test-No	χ^2=0.00 Sig.=1.00	-2LL=53.4 CSR^2=.089 NR^2=.127
H	INV BLV Constant	-.029 -.737	.205 3.989	.651 .046	.971 .479	PE=70.0 PO=70.0 Test-No	χ^2=2.745 Sig.= .433	-2LL=60.5 CSR^2=.011 NR^2=.015
I	EXP BLV Constant	-.044 -.752	.112 5.105	.738 .024	.957 .471	PE=70.0 PO=70.0 Test-No	χ^2=.226 Sig.= .635	-2LL=59.8 CSR^2=.014 NR^2=.019

\# Model number

a. % Correct classification : PE= Pre-Analysis, PO=Post-Analysis, BC= By-chance accuracy, Classification Test=OK

b. H & L Test → Hosmer and Lemeshow Test

c. Model Summary Parameters, i) -2LL ~ (-2 Log likelihood), ii) CSR^2 ~ (Cox & Snell R Square)
iii) $NR^{2\sim}$ (Nagelkerke R^2): It shows % of the variation in the response variable (EXPRT) that is explained by logistic model



No	FACTOR
1	IND LVL
2	OEM RGSTR
3	EDU YR
4	INV BLV
5	SME SIZ
6	LFE CYC1
7	SME AGE CAT
8	ENT AGE CAT
9	ENT TYP
10	OWNR FNDR
11	MFT TYP

Figure 4: Step-wise procedure of categorical regression model development

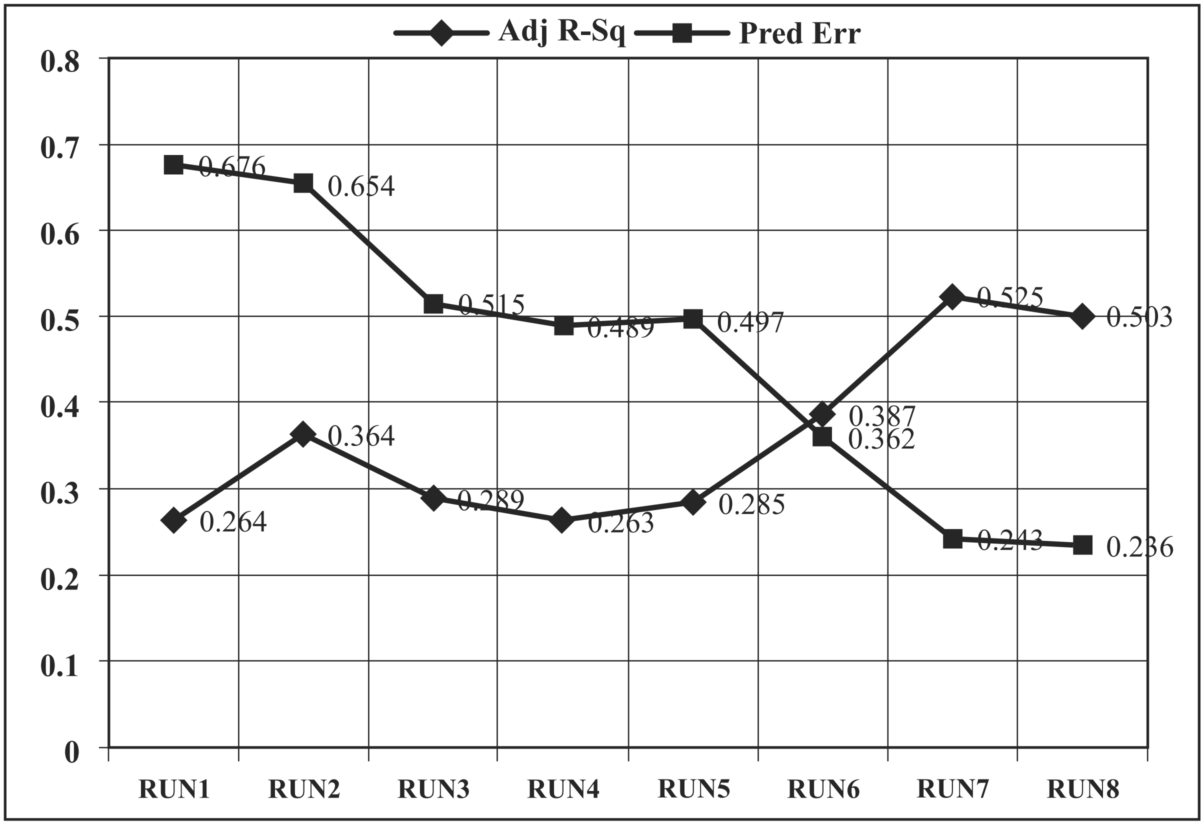


Figure 5: Variation of Adj-R^2 and prediction error in categorical regression model development.

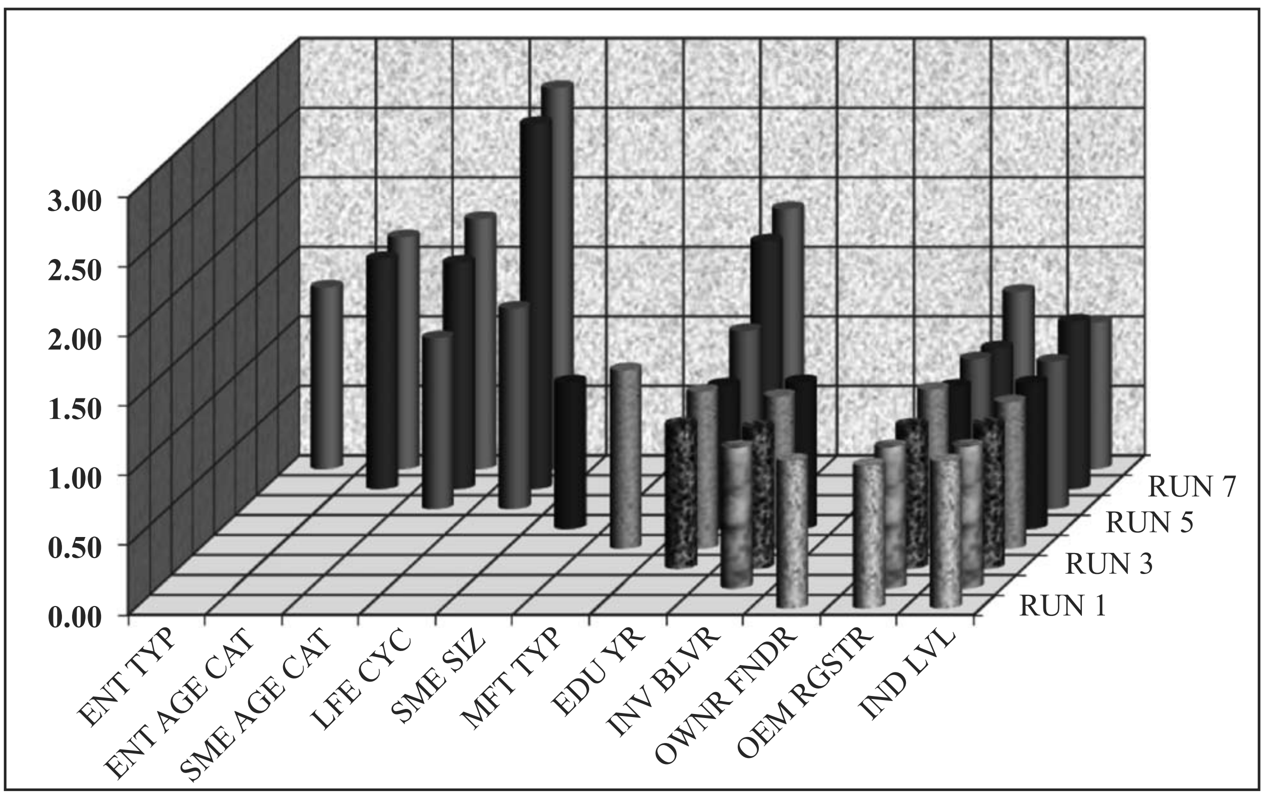


Figure 6: Distribution of variance inflation factor in categorical regression model development.

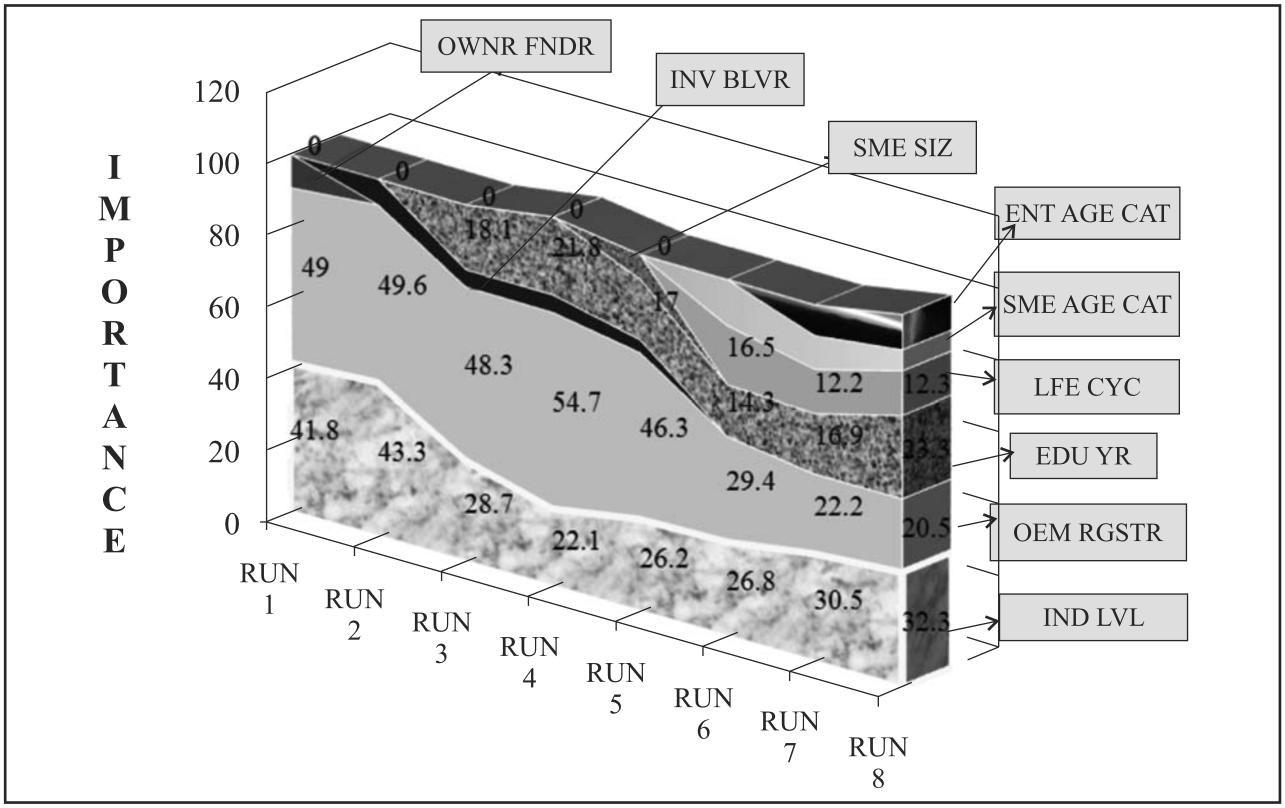


Figure 7: Distribution of importance of predictor variables during categorical regression model development (Perseverance and retention of IND LVL, OEMRGSTR and EDUYR).

Categorical Regression

Since predictor variables INDLVL(1) and OEMRGSTR(2) are the only duly significant factors in binary logistic regression (Table 4), we start developing a categorical regression model using SPSS® CATREG[57,63] module. Stepwise inclusion and exclusion of predictor variables is shown in Figure 4. At each RUN, the set of incumbent variables is tested for individual significance, positive importance and within bounds variance inflation. An incumbent significant variable in the present RUN is retained for next RUN of model. A non-significant variable is dropped accordingly, and, is not included for next RUN. A variable from among candidate list is included for next RUN. The process continues till the candidate list exhausts. As seen from Figure 4, the overall model adequately fits the data at each RUN ($p<0.05$). Variables INDLVL(1), OEMRGSTR(2), EDUYR(3), LFECYC(6), SMEAGECAT(7) and ENTAGECAT(8) are the significant predictors in the final model at the termination of RUN8. Both predictors INDLVL(1) and OEMRGSTR(2) persevere till the end reflecting firm relationship with EXPRT variable.

Figure 5 shows how the values of Adj-R^2 and prediction error (Pred Err) vary over runs from RUN1 to RUN8. As more number of significant predictor variables occupies the solution space of the model, prediction error decreases with increasing value of Adj-R^2. Since RUN7 is all-significant predictor variable model, 52.5% of variance in EXPRT is accounted for by all the variables with 24.2% prediction error.

Figure 6 shows the distribution of variance inflation factor of predictor variables over entire runs of categorical regression. The variance inflation factor (VIF) is a measure of inflation of coefficient's variance in case correlation is present among predictor variables of the model (Kock, 2010). As seen in Figure 6, both persevering predictor variables INDLVL and OEMRGSTR exhibit maximum VIF value of one. VIF values for late entrant variables EDUYR, SMEAGECAT and ENT AGECAT remain less than two. Variable LFE CYC has maximum VIF value of three in RUN8. Different viewpoints exist in literature about the magnitude of VIF. The conservative viewpoint is that the value of VIF be lower than five (Hair et al., 1987;

Kline, 1998 cited in Kock, 2010)[58,59,60]. Hence, there is no evidence of *multicollinearity among predictor variables at any stage during model development.*

Figure 7 shows the *importance* of predictor variables at each RUN. Predictor variable's importance is established by Pratt's index. It is a measure of a predictor variable's contribution to account for variance in response variable in a specific model (Thomas et el, 1998; Ochieng & Zumbo, 2001)[61,62]. The persevering predictor variables INDLVL and OEMRGSTR together account for more than 90% variance in EXPRT variable in early RUNS, lowering to 75% in middle RUNS and settling to 52% in finishing RUNS. Predictor variable EDUYR contributes steadily starting from RUN3 by accounting for almost 1/5th of variance in EXPRT. Late entrants LFECYC and SMEAGECAT together account for roughly 20% in last RUNS of categorical regression.

CONCLUSIONS AND RECOMMENDATIONS

The CDA-based methodologies applied together brings a myriad of features attributed to exploratory factors in explaining attributes of entrepreneur and enterprise supporting the export activities of SMEs in a developing region of the country. OEMRGSTR appears as a factor that singularly identifies the SME to be engaged in exporting or not. Antecedent factors and demographic factors stand strongly in differentiating between exporting and non-exporting SMEs (as is evident in categorical regression model). Both contingency table and categorical regression methods ease the statistical process of scientific search and inquiry. However, binary logistic regression yields very limited results related to understanding the role of exploratory factors towards export process of SME. More data attributes related to internal working of a manufacturing SME should be explored. In particular, functional characteristics of manufacturing SMEs including quality, design, production, sales/distribution and ICT activities should be studied in the context of exporting. A confirmatory analysis may be supplemented with exploratory modeling.

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