

## **Examining the Issue of Size and the Small Business: A Self Organizing Map Approach**

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### **Abstract**

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This research argues that differences in firm size must be considered in attempting to predict antecedents of firm success or firm survival, since there are vast differences in the behavior patterns of firms across size, as measured by number of employees. This position is based in part on the concepts of the organization life cycle (Howard and Hine 1997), and the financial growth cycle (Berger and Udell 1998). Therefore, we tested the hypothesis that small firms will classify into multiple groups with regard to a set of commonly studied small firm and business owner constructs. Using a self organizing map (SOM) approach we found that small businesses fall into two distinct groups. Implications for further research are discussed.

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### **INTRODUCTION**

The belief that small businesses are at the root of economic stability in the United States has gained more momentum in recent years, particularly in light of the fact that small firms account for approximately two-thirds of all newly created jobs (Capell 1995). Most notably, small businesses have been vital to the flourishing success of the computer, biotechnology and other high technology industries (Berger & Udell 1998). With an estimated 95 percent of all American businesses classified as *small*, more attention has been given to this business sector in both the popular press and the academic literature (Gimeno, Folta, Cooper & Woo 1997; Ibrahim & Goodwin 1986; Cragg & King 1988; Perry, Meredith & Cunnington 1988). In recent years there has been a surge of interest and research on what factors make a small business successful. Interestingly, most of the research to date has treated small businesses as a single, homogenous group. Most commonly, small businesses are studied as belonging to a single group fitting the Small Business Administration (SBA) criteria of 500 employees or less.

In this research we contend that there is a vast difference between firms within this population of small businesses. We suggest that antecedents of firm success or firm survival differ greatly based on the number of individuals employed by the small business. Specifically, it is obvious that a firm with one or two employees will exhibit different behaviors than a firm of 500 employees. Therefore, we contend that to classify small business as a homogenous group is inappropriate because the predictors of success will differ based on subsets within the greater population.

Organization life cycle theory (Howard and Hine 1997) and financial growth cycle theory (Berger and Udell 1998) bears this out. We use a self organizing map (SOM) to prove our contention and identify sub-categories which we argue have greater utility.

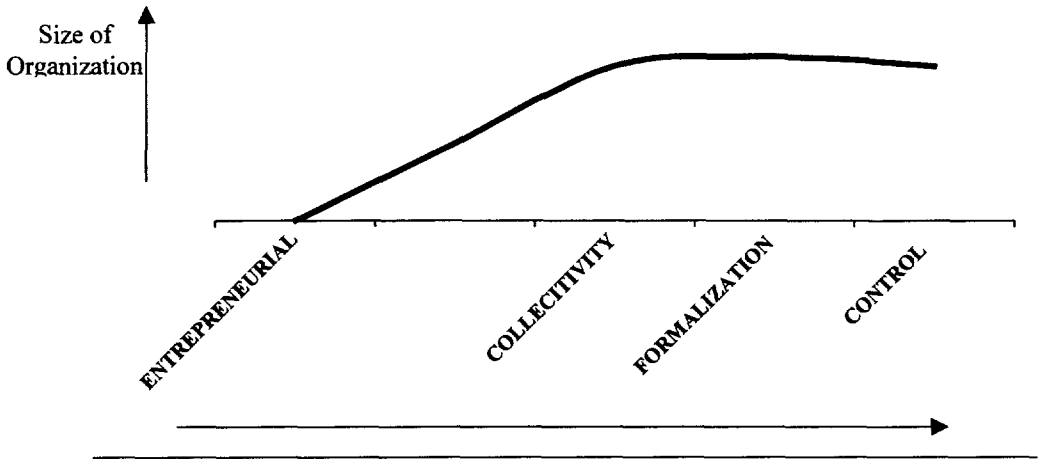
## **THEORETICAL FRAMEWORK**

The sociology literature is rich with evidence that organizational size impacts both structure and behavior. The general viewpoint held by these scholars is that organizational mass leads to improved organizational learning, bureaucratization and structural change (Weber 1958; Kimberly 1976; Downs 1967; Scott 1992). This would imply that as a company becomes larger, the antecedents of success are likely to change because the levels of sophistication are different in a larger firm than in a smaller firm. According to Penrose, "the differences in the administrative structure of the very small and the very large firms are so great that in many ways it is hard to see that the two species are of the same genus" (Penrose 1959: 19). Caplow (1957) also observed that large organizations in different industries resemble each other more than small and large firms in the same industries. The business literature also supports this idea in the theories of organizational life cycles.

## **ORGANIZATION LIFE CYCLE THEORIES**

Life cycle theories have experienced a long history in business and economic research. While there are numerous multi-stage models that use a wide range of characteristics to explain the natural development of organizations, all generally posit that organizations follow a common and predictable progression through distinct phases of development (Dodge, Fullerton and Robbins 1994). "While the organizational life cycle has been variously reported to consist of between three and ten stages, there is a substantial agreement about a consistent pattern of development and the differing characteristics associated with the various stages" (Dodge, Fullerton and Robbins 1994). Thus, theorists agree that organizations evolve from an innovative firm with little or no competition to a mature entity existing in a competitively rich environment (Stanworth and Curran 1976). Quinn and Cameron (1983) more succinctly categorized this pattern into four stages: entrepreneurial; collectivity; formalization and control; and structure elaboration and adaptation (Figure 1).

Figure 1. Organizational Life Cycle



No matter what terms are used to define these distinct stages and no matter how many stages are proposed, a key element is that there should be distinct differences between the stages. One notable difference in an organization as it moves through its life cycle is a change in size. Small emerging firms lack organizational learning and, therefore, have no experience on which to draw. As the market begins to emerge, production begins to expand, bringing with it the need for more employees and a higher level of management competency (Dodge, Fullerton and Robbins 1994; Steinmetz 1969). The organization continues to perfect itself until a point when the market niche matures. As the market matures, the organization's behavior changes to a more internal focus (Stanworth and Curran 1976; Dodge et al. 1994). Several authors have empirically examined the Organizational Life Cycle (OLC) with relation to specific size parameters in terms of employees and sales (Gupta and Chin 1994; Hanks and Chandler 1994; Kazanjian and Drazin 1989; Smith, Mitchell, and Summer 1985). A review of the literature examining size at different stages of the OLC, along with type of sample and methodology used, is presented in Table 1. Our study adds to this body of literature by using an unconventional methodology, a larger sample, and a more representative sample.

Adizes (1979) suggests that at different stages of development in the life of an organization certain roles or patterns of behavior are more appropriate. If, as previously suggested, organizations change in employee size at different stages in the life cycle, then by extension it seems that the size of the business highly correlates with these patterns of behavior. Specifically, one might conclude that organizations of differing sizes require different behaviors or attributes to be successful. Just as it is difficult to apply a universal life cycle model to all types of organizations, it seems equally as difficult to categorize small businesses with vastly different numbers of

employees into one universal group (Penrose 1952; Dodge, Fullerton and Robbins 1994). This contention is further supported by Berger and Udell's (1998) financial growth cycle model.

**Table 1.** Summary of Organizational Life Cycle/Size Relationship

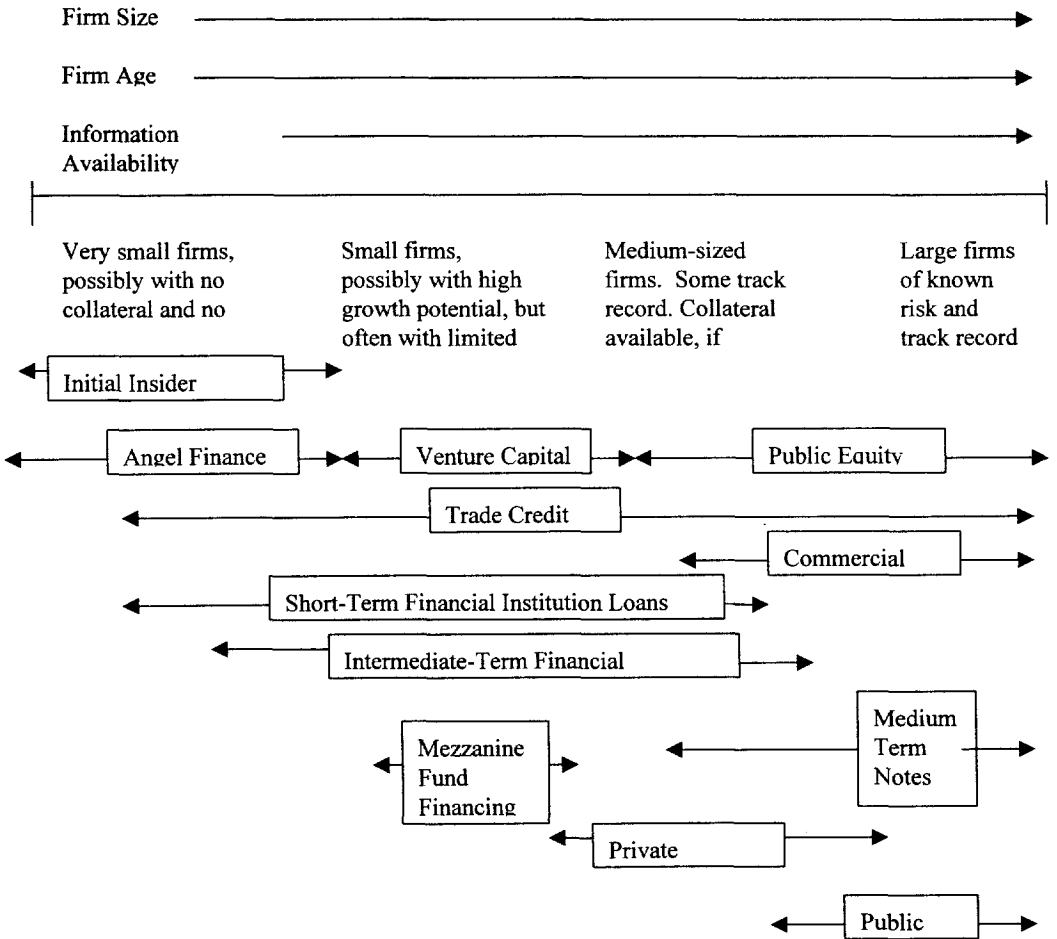
Author	Year	Method	Sample	Stage 1	Stage 2	Stage 3	Stage 4
Gupta and Chin	1994	Cluster Analysis	105 Canadian firms	1911 Emp	3240 Emp	4447 Emp	
Hanks and Chandler	1994	Chi-square	133 high tech firms	6.45 Emp	23.64 Emp	62.76 Emp	495.4 Emp
Kazanjian and Drazin*	1989	Del procedure	71 computer/electronics firms	58.1 Emp	68.1 Emp	345.6 Emp	423.4 Emp
Smith, Mitchell, and Summer	1985	Cluster analysis, ANOVA and MANOVA	7 electronics firms; 128 students	14 Emp	1066 Emp	532 Emp	

**FINANCIAL GROWTH CYCLE THEORY**

Adapted from Carey, Prowse, Rea and Udell (1993), Berger and Udell's financial growth cycle model posits that small business financing needs and abilities differ with firm size (Figure 2). Just as an organization follows a life cycle, it likewise evolves through a financial growth cycle. The generally held belief is that smaller firms have a much more difficult time obtaining any type of intermediate financing because they have no collateral or track record. Thus, the smaller firm is going to be more dependent on insider financing (Sahlman 1990), and would, by extension experience more frequent cash-flow problems. At a point where the firm has been tested in the marketplace and may need financing to expand production levels outside of a test market, venture capitalists may enter the picture. The Berger and Udell model classifies this middle category as medium-sized firms with either some track record or a high potential for growth. Conventional wisdom would further suggest that as the business grows to a point where it shows tangible business assets, then commercial lending opportunities might be available. Berger and Udell (1998) further suggest that this final group would consist of large firms with a known track record. The literature is rich with anecdotal and empirical evidence that at a certain point the entrepreneur may grow him or herself out of the business (e.g. Apple Computer and Steven Jobs). This evidence implies that the necessary attributes for

firm success at a point where the entrepreneur may outgrow the business are likely to differ from the earlier stages. Once again, size seems to be an important factor that must not be overlooked when studying small business.

**Figure 2: Financial growth cycle**



Based on the above literature review, it appears that classifying small firms as a single entity, may lead to false conclusions in application. While there may be less of a difference in a large firm with 1,000 versus 15,000 employees, the same

argument cannot be made between firms of one employee versus 500 employees. While some work has been done in this area (Berger and Udell, 1998; Hanks and Chandler 1994; Kazanjian and Drazin 1989), there is still no agreed upon classification with regard to size and small firms. It is our intent to propose a number without imposing restrictions on the data. Since this must be an entirely exploratory endeavor, we posit the following:

**Hypothesis: *With regard to thirteen commonly researched variables small firms will classify into more than one homogenous group.***

## METHODOLOGICAL FRAMEWORK

To test our theory that small businesses should not be categorized as one homogenous group, a type of Artificial Neural Network—a self organizing map (SOM)—is employed. An Artificial Neural Network emulates neural activity of an intelligent organism to perform functions, which are not always objective in nature. They can be complex, subjective functions. Specifically, an unsupervised learning algorithm is employed here to classify the data into groups, when the database uses  $k$  variables for classification. In the context here, unsupervised learning refers to a procedure where there is no prior knowledge of how the data should be classified. It is intended then to use this unsupervised learning for classification so that there are no classification biases of any type.

The SOM classification procedure works as follows:

A  $j \times k$  matrix of weights is generated ( $w(j \times k)$ ) — each value in the matrix is a uniformly distributed random number on the interval  $[0,1]$ . Also, an iteration counter,  $t$ , is initialized to zero. The database is converted to  $i \times k$  matrix form with the identification of  $x(i \times k)$ . For the  $i^{\text{th}}$  record in the database, the dissimilarity, or squared distance between itself and the  $j^{\text{th}}$  weight is determined:

$$(1) \quad d_{i,j} = \sum_{h=1}^k (x_{ih} - w_{jh})^2, \text{ for each of the } j \text{ groups.}$$

This distance calculation is made for all  $j$  groups. The group having the smallest distance from the  $i^{\text{th}}$  record is deemed the “winner,” and has its weight values adjusted so that these values are “closer” to the  $i^{\text{th}}$  record. This weight adjustment is done according to the following:

$$(2) \quad w_{winner,h}(t) = w_{winner,h}(t-1) + \eta (x_{i,h} - w_{winner,h}), \text{ where } 0 < \eta < 1.$$

The value  $\eta$  is referred to as the learning rate, and controls the rate at which the newly adjusted weights converge to the values of  $x_{i,h}$ .

After this adjustment is complete, the next record in the database is processed in the same way. Once all records have been processed in this way, the

learning rate is adjusted according to the following relationship:

$$(3) \quad \eta = \eta * \text{Adjustment Rate, where } 0 < \text{Adjustment Rate} < 1.$$

This iterative procedure continues until  $t$  epochs, or iterations have been completed. It should be noted that the actual data used for classification,  $x_{(i \times k)}$  is standardized for all  $k$  attributes so that scaling differences do not bias classification. Standardization, of course, is done prior to SOM classification so that each of the  $k$  attributes has a mean of zero and a standard deviation of unity.

This particular type of unsupervised learning is frequently referred to as Kohonen learning (Kohonen 1990; Mehrotra et al. 1997). An interesting feature of such a classification procedure is that the user specifies the *maximum* number of groups that should be formed ( $j$ ). Upon execution of the SOM classification procedure, however, fewer groups may be formed if the database does not exhibit enough "separation" to justify  $j$  groups. This highlights an important difference between this SOM approach and a k-means clustering approach. The k-means clustering approach forces  $k$  unique groups regardless of whether or not the database warrants this many groups. The SOM approach does not fall into such a trap.

#### **SAMPLE**

The sample used in this study is taken from the National Survey of Small Business Finances (NSSBF). The target population is the population of all for-profit, non-financial, non-farm business enterprises that had fewer than 500 employees and were in operation as of year-end 1992. The sample was drawn from firms listed on the Dun's Market Identifier file as of November 1993. The public use data set contains 4,637 firms. These data are broadly representative of 5 million small businesses operating in the US as of year-end 1992.

#### **INDICATOR VARIABLES**

The key indicator variable selected for our analysis is organizational size as defined by the number of full-time equivalent employees (FTE). As previously noted, size is arguably the dominant variable used in both the sociology and the business literature as indicators of organization behavioral and structural change (Weber 1958; Dodge, Fullerton and Robbins 1994; Berger and Udell 1998). In order to determine if antecedents of success differ with the size of the small business, we include those variables generally held in the literature to be indicators of small business success. To explore how variables across different fields and disciplines classify, we include a number of firm and owner constructs. (See Table 2.)

**Table 2.** Independent Variable Definitions

<b>Variable</b>	<b>Definition</b>
<b>Independents</b>	
<i>Individual</i>	
Education	Education of owner. 1= <8 <sup>th</sup> grade; 2 = Some HS; 3= HS Diploma; 4 = Some Coll; 5 = Coll. Degree; 6 = Post grad.
Owner age (ownage)	Owner's age (in years)
Owner Experience (exper)	Owner's experience in managing or owning a business (in years)
<b>Firm</b>	
Owner/Manager (manage)	Firm is managed by owner = 1; Firm is managed by manager = 2
Founded	Firm was founded by owner = 1; Firm was purchased = 2; Firm was inherited = 3; Public = 4
Firm Age	The time (in years) since the firm was founded, purchased, or acquired
Profit	Profit level (in dollars) of firm
Source of Funding	Source of funding (see table 3)
Pension	Firm has pension plan = 0; firm does not have pension plan = 1
Capital Structure (debteq)	Capital structure of firm (see table 4)
Family	Firm is family owned = 1; Firm is not family owned = 2
Firm Size (totemp)	The number of full time equivalent employees at firm
Informational Availability (inindex)	An index with possible value 0 to 1

## **INDIVIDUAL CHARACTERISTICS**

Individual characteristics are those attributes possessed by the owner/manager. The primary demographic characteristics found important in previous research include age, education, and experience (Foley 1985; Begley and Boyd 1986; Lussier 1995a; Steiner and Solem 1998).



## **FIRM CHARACTERISTICS**

Firm characteristics commonly identified in the literature as contributing to firm success are business planning, human resource issues, financial control, structure, firm age, and family ownership (Lussier 1995b; Cragg and King 1988). In this study we use a record keeping variable as a proxy for business planning. We believe this to be an appropriate proxy since, as noted by Mintzberg (1987), financial recording keeping and budgeting is a form of planning. Therefore, we developed an index to estimate the importance of the respective financial statements (McMahon and Davies 1994). We rated the statements in order of usefulness as follows:

- 1. Financial statements, accounting audits, or financial software (x1)**
- 2. Tax records (x2)**
- 3. Worksheets (x3)**
- 4. Bank statements (x4),**

**Where information index =  $.4(x1) + .3(x2) + .2(x3) + .1(x4)$ .**

Firms were assigned a value of zero if the respondent indicated no records available. Therefore the index had a possible range of 0 to 1.

The Human Resource (HR) to performance link is increasingly complex and difficult to understand, but potentially holds the greatest competitive advantage for the small firm (Latham and Whyte 1994). Here we included only the option of a pension plan as our HR variable. While it is realized that this variable alone does not cover the host of HR variables, e.g. compensation, pension plans are considered integral to keeping experienced workers loyal. Assuming that retaining experienced workers lowers turnover costs, which can be devastating to the bottom-line of a small company, a pension plan may be seen as a strategic HR policy (Ehrenberg & Bognanno 1990; Holzer 1990).

Much of the attention surrounding small business has focused on small firm financing. This has taken the form of legislative debate over whether or not capital availability has been restricted to the smaller firms because of new banking regulations (Weinberg 1994). Anecdotal and empirical studies describe inadequate capital budget as the primary cause of stifled growth or even failure (Wucinich 1979; Jones 1979; Welsch and White 1981). These issues in the small firm arena are among the under-researched areas in finance (Berger and Udell 1998; Rosen 1998).

Funding sources and capital structure for small business are listed in Tables 3 and 4.

**Table 3.** Sources of Funding Classification

<b>Variable</b>	<b>Definition</b>
<b>Independents</b>	
Group 1	<ul style="list-style-type: none"> <li>• Respondent named family member as a source of funding</li> <li>• Firm raised money from angels</li> <li>• Firm raised money from family friends</li> <li>• Firm raised equity from angel</li> </ul>
Group 2	<ul style="list-style-type: none"> <li>• Respondent name venture capital as a source of funding</li> <li>• Firm raised money from venture capital</li> <li>• Firm raised money from venture capitalist</li> <li>• Firm has a mid-term loan with a financial institution</li> </ul>
Group 3	<ul style="list-style-type: none"> <li>• Firm raised public equity</li> <li>• Firm obtained public equity financing</li> <li>• Firm has long term loan with a financial institution</li> </ul>

**Table 4.** Capital Structure Classification

<b>Variable</b>	<b>Definition</b>
<b>Independents</b>	
Debt Group (1)	<ul style="list-style-type: none"> <li>• Firm has obtained additional debt in the last three years</li> <li>• Firm has not obtained additional equity in the last three years</li> </ul>
Equity Group (2)	<ul style="list-style-type: none"> <li>• Firm has obtained additional equity in the last three years</li> <li>• Firm has not obtained additional debt in the last three years</li> </ul>

Small business studies predicting performance/survival generally include a measure of firm age (Delaney and Huselid 1996). Older firms generally have had more time to develop sales, equity, assets, and cash (Dyke, et al. 1992). Firm age (years since the firm was founded, purchased or acquired) was also included in the model.

There is some research which suggests that method of entry and conditions at the founding may be a distinguishing variable in the eventual success of the small firm (Jitendra, House, and Tucker 1986; Romanelli 1992). It is assumed that firms which are acquired or inherited are less likely to have start-up problems because of existing processes, markets, etc. Additionally, firms that are inherited are family run firms and may have different goals than non-family owned firms (Johnson, Conway, and Kattuman 1998). Therefore, we also include a variable for family-owned firms in our model.

We also included a variable which considers whether or not a firm is controlled by its owner is different from a firm primarily controlled by a hired manager. The

literature reports that the entrepreneurial structure is dependent upon the personality of the entrepreneur; a founder not directly communicative to the staff could result in an identity problem (Mintzberg 1979). A small firm's competitive advantage lies in its ability to focus quickly. This advantage is undermined by layers of management which add a bureaucratic quality to the small firm.

## **RESULTS**

As previously noted, an unsupervised learning algorithm is employed here to classify these 4,637 records ( $i = 4,637$ ).

Two groups provide a parsimonious, yet informative solution. Group 1 has 3,311 members, while Group 2 has 1,326 members.

Table 5 shows means, standard deviations and ANOVA statistics for the two-group solution when the Kohonen Unsupervised Learning grouping approach is used. Inspection of the means and ANOVA statistics shows that the SOM approach was effective in finding differences between groups. Furthermore, MANOVA showed that the Kohonen grouping approach also has a significant multivariate effect on the fifteen variables shown here (Wilks'  $\lambda = 0.2473$ ,  $F=937.83$ ). For all tests (univariate and multivariate), p-values are  $<0.001$ .

**Table 5.** Learning Grouping--Self Organizing Map

<b>Variable</b>	<b>Group 1</b>	<b>Group 2</b>	<b>Univariate F</b>
<b>Individual</b>			
Education	4.2963 (1.211)	4.7783 (1.0614)	160.63
Owner Age	48.295 (10.923)	54.847 (11.055)	338.34
Owner Experience	17.456 (10.273)	25.726 (11.613)	568.46
<b>Firm</b>			
Owner/Manager	1.1241 (0.3298)	1.3582 (0.4797)	361.72
Founded	1.2824 (0.5326)	1.5686 (0.8025)	200.62
Firm Age	12.513 (9.497)	22.308 (18.833)	547.88
Profit	1,608,865 (2,097,397)	5491861 (14,707,694)	219.70
Source of Funding	0.73837 (0.33698)	.8481 (0.3875)	91.96
Pension Plan	0.10873 (0.31135)	0.7089 (0.4544)	2659.0
Capital Structure (debt/eq)	1.4312 (0.3401)	1.2785 (0.3568)	185.42
Family/Non-family	1.1259 (0.3318)	1.3363 (0.4726)	294.16
Firm Size (employees)	7.21 (11.708)	92.35 (88.90)	2911.68
Availability of Information	0.14497 (0.20915)	0.24193 (0.24428)	184.29
	0.35035 (0.47715)	0.97134 (0.16691)	2140.85

## DISCUSSION

We can not state causal relationships or weight the importance of the variables in any way since the nature of the SOM is exploratory. Linear analysis might be an appropriate direction for future work. Additionally, our variables covered the literature in general terms. A more focused approach would prove insightful. Furthermore, the proxy for record keeping has not been established in the literature. It is possible that the owner/managers keep records, but not in a formal manner. Thus, our variable may not adequately portray the actual record-keeping behavior. Care should be used when interpreting this result. These results challenge those interested in small business development to examine their own paradigms.

## CONCLUSION

This work examined differences across a thirteen variable profile utilizing a self organizing map. The data bifurcated into two categories called "small firms" and "large firms"; all variables were significant as well as the overall model. When the parameters for the network training were chosen, an upper limit of twenty groups (or neurons) was specified. Thus, as many as twenty groups could have been formed during the training process. As shown earlier, this data set formed exactly two groups via the Kohonen SOM. ANOVA and MANOVA show that these two formed groups are statistically unique from each other and have their own characteristics.

A possible line of inquiry for future research is to explore each of these two groups further and find subgroup structure. For example, one could examine the varying degrees of firm "smallness" in terms of number of employees, annual revenue, etc.

Researchers from human resources, strategy, finance, and entrepreneurship can explore relationships with variables of interest and firm size. Our hypothesis is supported: small firms will fall into two groups using the constructs specified.

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