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Environmental Turbulence in the Credit Union Industry: A Multiple Correspondence Analysis Approach

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Abstract

Recent development of strategic management has proven that classical methodology for measuring the environment in terms of complexity, munificence, and dynamism (Dess and Beard, 1984) is unsuitable for one-industry studies (Dimovski, 1994). Instead, as in this paper, an expanded and refined measure of perceived environmental turbulence has been adopted and operationalised. One of the techniques that can further verify the perceived environmental turbulence construct is the multiple correspondence analysis (MCA) that has been used in this paper.

An investigation has been conducted on the population of credit unions in Ohio, USA. Construct of perceived environmental turbulence has been operationalised by five variables designated as different aspects of environmental turbulence (level of competitiveness within the industry, rate of services absolence, predictability of the competitors, predictability of consumer preferences, service/product technology changes). Variables are ordinal and have been measured on a five-point Likert scale.

Using MCA the original five-dimensional variable space has been reduced to a two-dimensional subspace explaining about 58% of the total variance. The categories of the investigated variables have been represented as points in the two-dimensional map according to the values of the first two principal coordinates. Given the ordinal nature of the variables used, it was meaningful to connect the points belonging to the same variable.

The map shows a bi-polarization with most of the points representing categories with low level of environmental turbulence on one side and with high level of environmental turbulence on the other side. The general orientation of the majority of connecting lines on the graph is parallel to the first principal axis.

The parallel pattern of the connecting lines supports our initial hypothesis of having strong relationships among the variables of environmental turbulence. Such a result can also imply that most of the analysed variables measure the degree of environmental turbulence.

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1 Introduction

The main purpose of this paper is to investigate the environmental turbulence and its impact on internal organisational processes and their adjustments to the environment. In the first part of the paper, we introduce the construct of environmental turbulence and its operationalization by constructing variables that represent different aspects of environmental turbulence. Then, to further verify the proposed construct multiple correspondence analysis (MCA) has been used. The results of MCA improve the interpretation of environmental turbulence and illustrate how to use MCA for strategic management field research.

2 Measuring environmental turbulence

The environment is broadly defined as a residual category of "everything else" but the organisation (Thompson, 1967). The environment is generally classified into macroenvironment, industry-specific environment, and firm-specific environment (Glazer, 1990).

The macroenvironment can have a significant impact on industry and organisations, and includes an almost limitless variety of potentially important factors. These factors can be summarised into five major forces: regulatory, economic, global, social, and technological (Reimann, 1987). The industry-specific environment has three major dimensions: munificence, dynamism, and complexity (Dess and Beard, 1984). Environmental munificence is the extent to which the environment can support sustained growth. This means that organisations search for the environments that provide opportunities for growth and stability (Day, 1977). Environmental dynamism relates to environmental stability-instability characteristics (Miles, Snow, and Pfeffer, 1974). Environmental complexity reflects the heterogeneity of organisational activities and their range (Tung, 1979). The firm-specific environment consists of "market attractiveness," such as location, size, market share, and product life-cycle (Glazer, 1990). The latter is an important concept due to its presence of information inflows.

The changes and riskiness of macroenvironment and industry-specific environment can force organisations to adjust by translating the environmental changes to the various processes in organisations and to individuals in organisations. Such changes can be referred to as environmental turbulence (Fiol and Lyles, 1985) which is also defined as "more events per unit time" (Glazer, 1990, p.7). A turbulent environment requires larger scales and more intensive internal organisational processes such as information acquisition and information interpretation particularly due to a higher rate of organisational changes and riskiness.

3 Operationalisation of the environmental turbulence construct

As Cool and Schendel point out the operationalisation of the construct under observation "is always a function of industry under study" (Cool and Schendel, 1988, p.212). For this paper the credit union industry was selected [2] .

Credit unions are not-for-profit organisations in which members who are also the owners share a common bond in depositing funds and obtaining credit. The unique feature of credit unions is this common bond. The bond is usually the place of employment or the occupation of the members (occupational bond) but it can also be based on association ties, such as church or union membership (associational bond), or area of residency (community bond).

One possible approach in operationalisation of environmental turbulence in terms of dynamism, munificence, and complexity has been proven unsuitable for one-industry studies (Dimovski, 1994). Therefore, a different approach has been taken by operationalising environmental turbulence as a measure with various aspects of perceived environmental turbulence. The aspects of environmental turbulence: level of competitiveness within the industry, rate of services absolence, predictability of the competitors, predictability of consumer preferences and service/product technology changes serve as a basis for items of research instrument - questionnaire. We combined the questions that have been developed for other studies as well as our own questions originally developed for this study. Finally, a five-item questionnaire was used, where each of the variable is ordinal and has been measured on a five-point Likert scale.

4 Data collection

The questionnaire was sent to 200 credit unions in Ohio, USA. This sample was selected through a stratified sampling procedure with the size of credit union used as the stratification criterion. After collecting the data (response rate was 42.5%), the questionnaire was submitted to validity and reliability assessment. The validity

[2] The reasons for selecting the credit union industry were the following:

(a) it is a fast growing service-related industry with an expanding range of offered services;

(b) the consumer banking market in which credit unions operate requires a high level of adaptability to external change and a high level of alertness to environmental information;

(c) not-for-profit organizations are "one of the most fruitful areas for researching strategic management" (Wortman, 1979, p.353);

(d) prior surveys indicate a high level of cooperativeness of general managers and CEOs of credit unions (Reichert and Rubens, 1994); and

(e) detailed data bases are available through Ferguson and company.

assessment includes construct validity and assessment of reliability that was tested by using Cronbach's alpha (alpha value was 0.858).

Construct validity [3] is a degree to which a construct achieves theoretical and empirical meaning. For construct validity we used factor analysis with loadings more than 0.45 considered adequate for establishing convergent validity. Those variables that fullfiled these criteria were used in our MCA.

The observed univariate distributions of the five variables are given in Table 1. The univariate frequency distributions show that the categories D1 and E1 contain only one observation. For that reason these two categories were included into the following categories D2 and E2 in MCA.

Table 1: Indicate your degree of agreement or disagreement with the following statements that refer to actual conditions in the credit union industry.

Questions (aspects of environmental turbulence)	Strongly disagree 1	2	3	4	Strongly agree 5
A. Our credit union must change its marketing practices frequently to keep up with market competitors		12	17	45	11
B. The rate at which new services are getting obsolete is very high	3	23	41	18	
C. Actions of competitors are unpredictable		25	25	29	6
D. Demand and consumer preferences are unpredictable	1	32	21	26	5
E. The service/product technology changes very frequently	1	12	25	35	12

5 Burt table

MCA can be defined as the CA of the so-called "Burt table". It is a partitioned symmetric matrix containing all pairs of crosstabulations among a set of categorical variables. Each crosstabulation $\mathbf{F}_{qq}$ $(q = 1,2,\dots,Q)$ on the diagonal is a diagonal matrix of the marginal frequencies (i.e., a crosstabulation of a variable with itself). Each off-diagonal crosstabulation is an ordinary two-way contingency table $\mathbf{F}_{qq'}$

[3] Details on validity are described in Dimovski (1994).

$(q,q'=1,2,\ldots,Q,\ q\neq q')$. Each contingency table above the diagonal has a transposed counterpart below the diagonal.

$$\mathbf{B}=\begin{bmatrix}\mathbf{F}_{11} & \mathbf{F}_{12} & \cdots & \mathbf{F}_{1Q}\\ \mathbf{F}_{21} & \mathbf{F}_{22} & \cdots & \mathbf{F}_{2Q}\\ \vdots & \vdots & & \vdots\\ \mathbf{F}_{Q1} & \mathbf{F}_{Q2} & \cdots & \mathbf{F}_{QQ}\end{bmatrix} \tag{1}$$

The data of our example are displayed in the form of Burt table given in Table 2 .

Table 2: Burt table.

	A2	A3	A4	A5	B1	B2	B3	B4	C2	C3	C4	C5	D2	D3	D4	D5	E2	E3	E4	E5
A2	12	0	0	0	2	5	5	0	2	4	5	1	6	0	4	2	5	5	1	1
A3	0	17	0	0	1	6	7	3	7	6	3	1	9	3	5	0	4	7	4	2
A4	0	0	45	0	0	11	24	10	14	10	18	3	14	14	15	2	4	12	23	6
A5	0	0	0	11	0	1	5	5	2	5	3	1	4	4	2	1	0	1	7	3
B1	2	1	0	0	3	0	0	0	1	1	1	0	2	0	1	0	0	3	0	0
B2	5	6	11	1	0	23	0	0	8	6	8	1	11	4	8	0	6	8	4	5
B3	5	7	24	5	0	0	41	0	12	14	14	1	14	13	11	3	6	12	19	4
B4	0	3	10	5	0	0	0	18	4	4	6	4	6	4	6	2	1	2	12	3
C2	2	7	14	2	1	8	12	4	25	0	0	0	20	2	3	0	3	11	8	3
C3	4	6	10	5	1	6	14	4	0	25	0	0	9	10	6	0	6	5	11	3
C4	5	3	18	3	1	8	14	6	0	0	29	0	3	8	16	2	4	9	12	4
C5	1	1	3	1	0	1	1	4	0	0	0	6	1	1	1	3	0	0	4	2
D2	6	9	14	4	2	11	14	6	20	9	3	1	33	0	0	0	9	12	9	3
D3	0	3	14	4	0	4	13	4	2	10	8	1	0	21	0	0	0	6	13	2
D4	4	5	15	2	1	8	11	6	3	6	16	1	0	0	26	0	3	6	12	5
D5	2	0	2	1	0	0	3	2	0	0	2	3	0	0	0	5	1	1	1	2
E2	5	4	4	0	0	6	6	1	3	6	4	0	9	0	3	1	13	0	0	0
E3	5	7	12	1	3	8	12	2	11	5	9	0	12	6	6	1	0	25	0	0
E4	1	4	23	7	0	4	19	12	8	11	12	4	9	13	12	1	0	0	35	0
E5	1	2	6	3	0	5	4	3	3	3	4	2	3	2	5	2	0	0	0	12

6 Dimensionality of MCA solution

Based on the Burt table we can form the matrix $\frac{1}{Q^2}\mathbf{D}_f^{-1}\mathbf{B}\mathbf{D}_f^{-1}\mathbf{B}$, where Q is the number of variables (here $Q=5$) and $\mathbf{D}_f$ is a diagonal matrix with the frequencies of the J categories on the main diagonal ($J=20$). Spectral decomposition of the nonsymmetric matrix $\frac{1}{Q^2}\mathbf{D}_f^{-1}\mathbf{B}\mathbf{D}_f^{-1}\mathbf{B}$ results in a diagonal matrix $\mathbf{D}_\lambda$ and the matrix of standard coordinates $\mathbf{Y}$. The number of nontrivial principal inertias is J-Q ($J-Q=15$). The values of principal inertias λ_k $(k=1,2,\ldots,J-Q)$, the percentages of inertia and the cumulative percentages of inertia are presented in Table 3 .

Table 3: The values of principal inertias λ_k , the percentages of inertia and the cumulative percentages of inertia.

	Principal inertia	Percentage of inertia	Cumulative percentage of inertia	5 10 15 20 25 % ----+----+----+----+----+---
1	0.1882	24.70	24.70	*************************
2	0.1167	15.31	40.01	***************
3	0.0941	12.35	52.37	************
4	0.0710	9.32	61.68	*********
5	0.0646	8.48	70.16	********
6	0.0524	6.87	77.04	*******
7	0.0437	5.74	82.77	******
8	0.0364	4.78	87.56	*****
9	0.0296	3.88	91.44	****
10	0.0227	2.97	94.41	***
11	0.0149	1.95	96.37	**
12	0.0121	1.59	97.96	**
13	0.0073	0.95	98.91	*
14	0.0044	0.58	99.05	*
15	0.0038	0.50	100.00	*
	0.7618			

$1/Q = 1/5 = 0.2000$

MCA includes the fitting of the diagonal submatrices $\mathbf{F}_{qq}$ $(q = 1,2,\ldots,Q)$ of the Burt table. As a result, the total inertia is inflated and thus the proportions of the first few principal inertias as the parts of the total inertia are reduced. One of the ways to address this problem, proposed by Benzécri (1979), is to consider only those principal axes whose inertias are higher than $1/Q$ (i.e. 0.2000 in this application, see Table 3). Let us calculate these modified inertias according to Benzécri's formula

$$\tilde{\lambda}_k = \left[\frac{Q}{Q-1}\left(\sqrt{\lambda_k} - \frac{1}{Q}\right)\right]^2 \qquad k = 1,2,\ldots \qquad (2)$$

with the condition that these be calculated for $\sqrt{\lambda_k} > 1/Q$ only.

The number of inertias has been reduced from 15 to only 7, with strongly dominating values of the first two principal inertias. The values of the inertias $\tilde{\lambda}_k$ are shown in Table 4.

Table 4: The values of modified inertias $\tilde{\lambda}_k$, the respective percentages of inertia and the cumulative percentages of inertia.

	Principal inertia	Percentage of inertia	Cumulative percentage of inertia	10 20 30 40 % ----+----+----+----+---
1	0.085411	44.22	42.22	*********************
2	0.031310	15.48	57.70	********
3	0.017804	8.80	66.50	****
4	0.006888	3.41	69.90	**
5	0.004589	2.27	72.17	*
6	0.001301	0.64	72.82	
7	0.000128	0.06	72.88	

$\bar{\phi}^2 = 0.202250$

The next question is the quality of the presentation of the position of the profiles based on a few first principal coordinates. M. Greenacre (1994, pp. 155) calculates the percentage of inertia as follows

$$\tilde{\lambda}_k\% = 100\frac{\tilde{\lambda}_k}{\bar{\phi}^2} \qquad k = 1,2,\ldots \tag{3}$$

where $\bar{\phi}^2$ is an average of the off-diagonal inertias $\phi^2_{qq'}$, i.e.

$$\bar{\phi}^2 = \frac{1}{Q(Q-1)}\sum_{q=1}^{Q}\sum_{\substack{q'=1 \\ q'\neq q}}^{Q}\phi^2_{qq'} = \frac{Q}{Q-1}\left(\sum_{j=1}^{J-Q}\lambda_j - \frac{J-Q}{Q^2}\right) \tag{4}$$

The values of percentages of inertia and the cumulative percentages of inertia are also shown in Table 4 . According to the above mentioned Greenacre's refinement of the MCA solution (3), 57.70% of the total inertia is explained by the first two principal axes. It seems that the representation of the positions of the profiles based on the first two principal coordinates can serve as a good basis for the analysis of our example.

We have already calculated the matrix **Y** of standard coordinates. Next, we need to transform the first 7 columns of **Y** , denoted by $\mathbf{Y}^*$ into principal coordinates using the modified inertias given by formula (2)

$$\mathbf{G}^* = \mathbf{Y}^*\mathbf{D}_{\tilde{\lambda}}^{1/2} \tag{3}$$

where $\mathbf{D}_{\tilde{\lambda}}$ is the diagonal matrix of the 7 modified inertias. The matrix $\mathbf{G}^*$ is given in Table 5 .

Table 5: The matrix of principal coordinates $\mathbf{G}^{*}$.

		1.PC	2.PC	3.PC	4.PC	5.PC	6.PC	7.PC
1	A2	-0.4382	0.3614	-0.2060	0.1313	0.0872	-0.0116	-0.0073
2	A3	-0.3108	-0.0195	0.1204	-0.0015	-0.0389	0.0471	0.0020
3	A4	0.1288	-0.0891	-0.0389	-0.0618	-0.0157	-0.0355	-0.0001
4	A5	0.4314	0.0004	0.1978	0.1118	0.0291	0.0853	0.0050
5	B1	-0.8357	0.2184	-0.1813	-0.0632	0.4382	0.1622	-0.0162
6	B2	-0.2863	0.0687	-0.0574	-0.0181	-0.1185	0.0173	0.0112
7	B3	0.0352	-0.1064	-0.0183	0.0385	0.0396	-0.0418	0.0044
8	B4	0.4250	0.1181	0.1452	-0.0541	-0.0117	0.0460	-0.0216
9	C2	-0.3075	-0.0528	0.2006	-0.1239	-0.0098	-0.0216	-0.0007
10	C3	-0.0059	-0.1151	0.0389	0.1901	0.0060	0.0261	0.0043
11	C4	0.1267	0.0004	-0.2530	-0.0473	-0.0067	0.0022	-0.0029
12	C5	0.6933	0.6978	0.2247	-0.0474	0.0483	-0.0296	-0.0011
13	D2	-0.3401	0.0187	0.1782	-0.0085	-0.0085	-0.0094	-0.0059
14	D3	0.2975	-0.2572	-0.0023	0.0659	0.0559	-0.0060	0.0172
15	D4	0.0897	0.0155	-0.2315	-0.0485	-0.0582	0.0359	-0.0097
16	D5	0.5285	0.8763	0.0367	0.0315	0.1241	-0.0998	0.0170
17	E2	-0.4418	0.1639	-0.0350	0.1996	-0.1179	-0.0470	-0.0168
18	E3	-0.3222	-0.0416	-0.0368	-0.0925	0.1022	0.0075	0.0104
19	E4	0.3203	-0.1251	0.0354	0.0061	0.0093	-0.0049	-0.0136
20	E5	0.2156	0.2739	0.0113	-0.0412	-0.1122	0.0496	0.0362

The position of the projections of profilepoints in the optimal subspace of chosen dimensionality is defined by the principal coordinates.

The next question that should be answered is whether the position of an individual profile is well represented in the optimal subspace. The first 7 dimensions determine the modified full space, so we need to calculate how much of the representation of the position of an individual profile is accounted for by the first principal coordinate, the first two principal coordinates, the first three principal coordinates, etc. For that reason, we need to calculate the matrix of cumulative proportions of inertias of profiles as part of the total inertias of profiles (Rovan, 1991). For our investigation this matrix is shown in Table 6 .

Table 6: The matrix of cumulative proportions of inertias of profiles as part of the total inertias of profiles.

		1.PC	2.PC	3.PC	4.PC	5.PC	6.PC	7.PC
1	A2	0.4923	0.8271	0.9359	0.9800	0.9995	0.9999	1.0000
2	A3	0.8384	0.8417	0.9676	0.9676	0.9807	1.0000	1.0000
3	A4	0.5290	0.7821	0.8303	0.9519	0.9597	1.0000	1.0000
4	A5	0.7570	0.7570	0.9161	0.9669	0.9703	0.9999	1.0000
5	B1	0.6974	0.7450	0.7778	0.7818	0.9735	0.9997	1.0000
6	B2	0.7824	0.8274	0.8589	0.8620	0.9960	0.9988	1.0000
7	B3	0.0700	0.7092	0.7282	0.8120	0.9004	0.9989	1.0000
8	B4	0.8162	0.8792	0.9745	0.9877	0.9884	0.9979	1.0000
9	C2	0.6161	0.6343	0.8964	0.9963	0.9970	1.0000	1.0000
10	C3	0.0007	0.2569	0.2863	0.9858	0.9865	0.9996	1.0000
11	C4	0.1951	0.1951	0.9721	0.9993	0.9998	0.9999	1.0000
12	C5	0.4696	0.9454	0.9947	0.9969	0.9991	1.0000	1.0000
13	D2	0.7812	0.7836	0.9982	0.9987	0.9992	0.9998	1.0000
14	D3	0.5448	0.9520	0.9520	0.9787	0.9979	0.9982	1.0000
15	D4	0.1166	0.1200	0.8967	0.9308	0.9799	0.9986	1.0000
16	D5	0.2598	0.9740	0.9752	0.9762	0.9905	0.9997	1.0000
17	E2	0.6984	0.7945	0.7989	0.9414	0.9911	0.9990	1.0000
18	E3	0.8235	0.8373	0.8480	0.9159	0.9987	0.9991	1.0000
19	E4	0.8563	0.9868	0.9972	0.9975	0.9983	0.9985	1.0000
20	E5	0.3328	0.8698	0.8708	0.8829	0.9730	0.9906	1.0000
Total		0.5793	0.7917	0.9125	0.9592	0.9903	0.9991	1.0000

7 Map and analysis

The representation of the profiles based on their first two principal coordinates is shown in Figure 1.

When the proportion of inertia of the first two dimensions as part of the total inertia is relatively high, then most of the profiles are well represented in a two-dimensional map (by their projections onto a plane). The two-dimensional solution of our example explaining 57.70% of the total inertia can serve as a good basis for the display of the profiles.

However, this general conclusion is not valid for every profile. For complete analysis every single profile should be well represented which gives the reason for some profiles to be represented by a higher number of principal coordinates (Rovan, 1994). The cumulative proportions of inertias of the profiles as the parts of the total inertias of profiles, given in Table 7, are the basis for the conclusion, whether some profiles are well represented in a two-dimensional map. In our investigation 17 out of 20 profiles have cumulative proportions of inertias above 0.75 and we believe they are well represented in a two-dimensional map. This is not the case for profiles C3, C4,and D4 that load on higher dimensions.

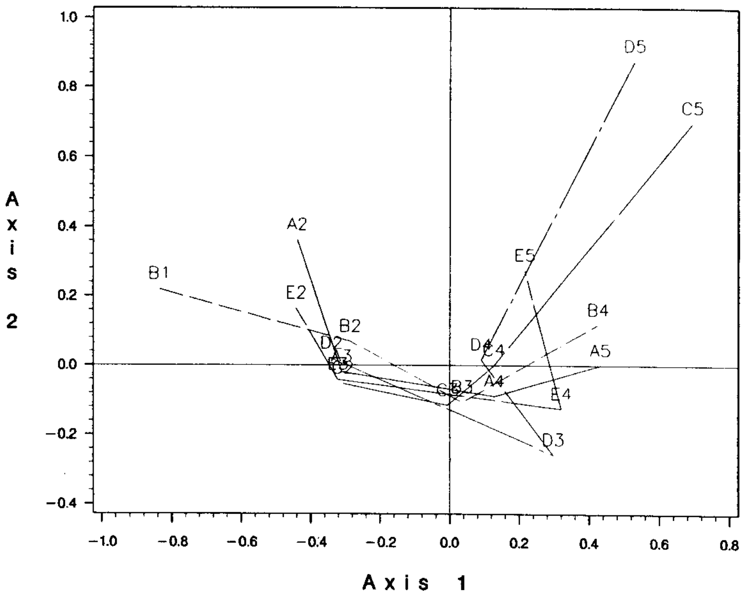

Figure 1: Two-dimensional map (data from Table 5).

In the analysis of a set of ordinal variables it is meaningful to connect the successive category points of each ordinal variable. An approximately parallel pattern of the two lines belonging to two ordinal variables reveals a close relationship between these two variables.

The position of the profilepoints can lead to the following conclusions:

- The map shows a strong bi-polarization, with most of the profile points representing categories with low environmental turbulence on one side and with high environmental turbulence on the other side. Therefore, the first axis with the prevailing proportion of the total inertia represents the direction of low-to-high environmental turbulence.
- The majority of the connecting lines on the map is parallel to the first principal axis. This pattern supports our initial hypothesis of having strong relationships among the variables of environmental turbulence. This result also implies that most of the variables measure the degree of environmental turbulence.

8 Conclusion

Environmental turbulence has been conceptualised as "more events per unit time". To verify the developed operationalised construct of environmental turbulence, MCA has been used.

We have investigated the population of credit unions in Ohio. The construct of environmental turbulence has been operationalised by five ordinal scale variables.

Using MCA the original five-dimensional variable space has been reduced into two-dimensional subspace explaining about 57.70% of the total variance.

Two-dimensional map of the profilepoints have shown strong bipolarization with most of the profilepoints representing categories with low environmental turbulence on one side and with high environmental turbulence on the other side. Therefore, the first axis with the prevailing proportion of the total inertia represents the direction of low-to-high environmental turbulence.

MCA has confirmed our initial hypothesis of having strong relationships among the variables of environmental turbulence. This result also implies that most of the variables measure the degree of environmental turbulence.

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