Fuzzy Clustering in Context

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Fuzzy Clustering

- A fuzzy cluster analysis breaks a population of cases down into groups.
- It gives each case a measure of its distance from the core, or central point, of each hypothetical ‘group’ in the typology.
- The data-reduction which occurs uses cluster analysis principles.

Summary of Presentation

- Comparison with QCA
- Procedures used, and software
- Assumptions necessary to Fuzzy Clustering
- Illustration using time-use patterns
- Example using Sri Lankan Data
- Exploration of another example

Characteristics of a fuzzy cluster analysis

- The group centres are hypothetical, and membership is fuzzy.
- Each group of cases has a central point in space, which is the ‘centre of gravity’ that minimises the distance from its members to its centre.
- The technique is spatially based and multi-dimensional
- Measurement metrics matter!

Caveat on FS/QCA vs. Fuzzy Cluster

- FS/QCA refers to Fuzzy set qualitative comparative analysis (Ragin, *Fuzzy Set Social Science*).
- Fuzzy cluster is a technique. By contract, FS/QCA is a methodology.
- Fuzzy clustering is much more closely related to cluster analysis than to fuzzy set theory.

FS/QCA: What is being covered in the September 22/23 workshop

- The FS/QCA methodology is first and foremost qualitative and comparative.
- You create a series of cases which are substantively differentiated.
- Some comparative ‘variables’ take the form of non-crisp ‘sets’, with 0,.2,.5, 1.0 being values put into the table. 0.5 means ‘not in either set’.
  - (rather than 0 and 1, numbers implying a crisp set)
  - For K dimensions, QCA has K crisp sets, giving through permutations the no. of possible configurations.
  - For K dimensions, fuzzy set QCA has K fuzzy sets, giving an infinite number of permutations as configurations.
- FS/QCA examines which factors are necessary and/or sufficient to the outcome.

What procedures are used in fuzzy ***clustering***?

- We have several algorithms to choose from (Everitt). None are available in SPSS but K-cluster analysis using Classify menu option in SPSS [i.e. Quick Cluster] will give a typology somewhat similar to what you will get from FCLUSTER or CLUSTAN.
- Ideally you would have overlapping cluster memberships, but using SPSS K-Cluster you have mutually exclusive memberships and only 1 distance per case, even if you have some number of clusters >1.
- Some algorithms minimise the distance to the centre of gravity, and others maximise the likelihood of having placed each case correctly either ‘in’ a cluster or near its related centres of gravity.
- CLUSTAN is needed to do true fuzzy cluster analysis. You then get multiple distance variables: each case has a distance to the centre of gravity of each cluster.

The K-means method

- The mean distance between cases and their cluster centres are minimised.
- The number of clusters must be specified by you, the user, in advance. This is a disadvantage but, through iterations, you may find that you need fewer clusters.
  - (More clusters takes longer.)

The CLUSTAN method

- CLUSTAN is a package aimed precisely at doing cluster analysis and visualising the results. It is worth getting if you intend to use the cluster analysis for any audience other than experts.
- You can then demonstrate the ‘clouds’ to them using graphics.

Connections with related techniques

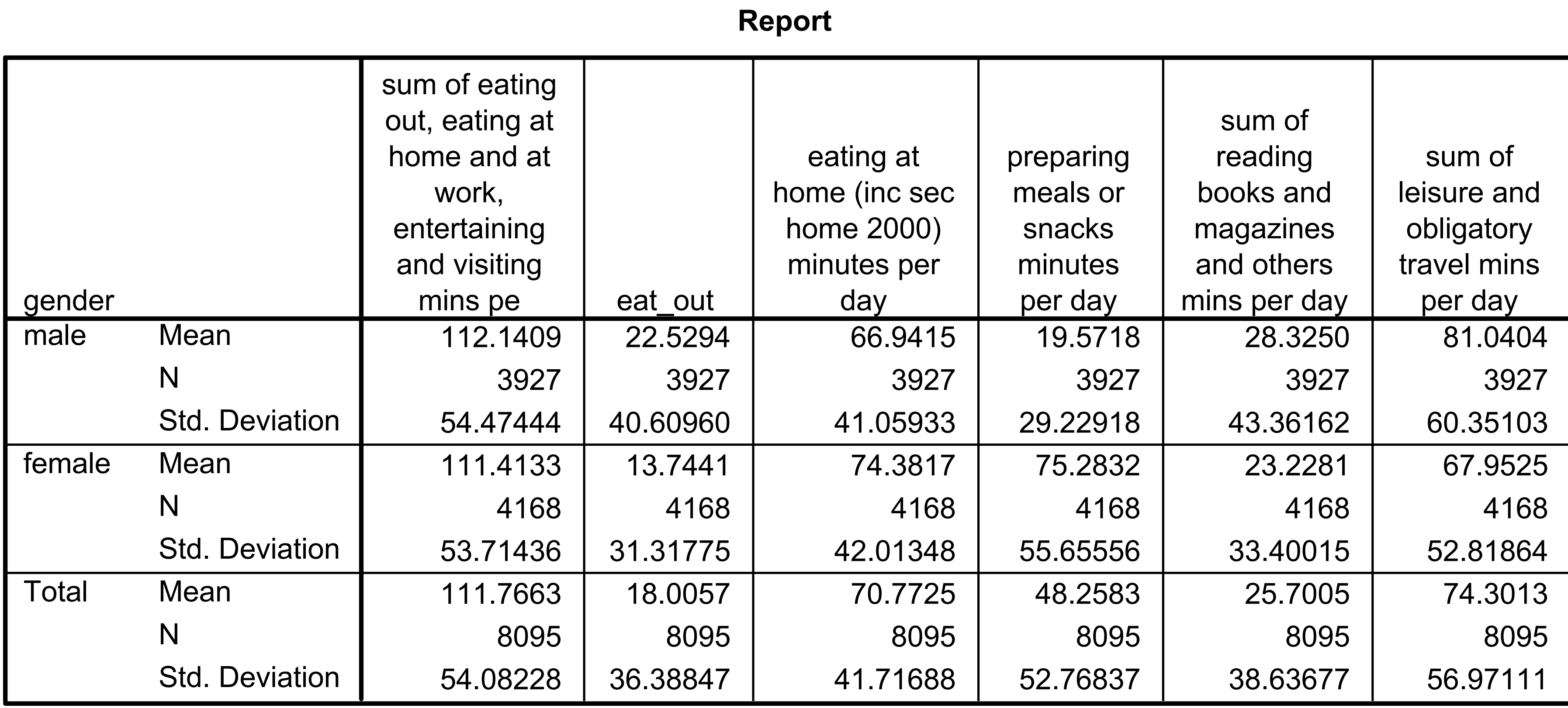
- Correspondence analysis allows us to consider not only the rows (i.e. placing the cases in the space) but also the variables (e.g. placing the high values of age into the space too, allowing variables to become part of the definition of a latent dimension, Axis 1)
- Principal components analysis and ANOVA are closely related but give us factors discriminating amongst the *whole* population of cases, rather than giving a typology.

How to do FCLUSTER

- Choose your variables.
  - For K-clustering, you need to use only normally distributed variables.
  - In CLUSTAN you have the option to use categorical variables.
  - Ordinal variables must be binarised or converted to a measurement metric.
- Decide on how many clusters (max) you want.
- Run Classify > K-Cluster.
- Examine results.

An Exemplar – in Brief

- Time use diaries record various activities over the course of one weekday and one weekend day for 8000 persons, UK 2000.
- The individual minutes-per-day spent on each non-work activity is the topic of a study of *practices of consumption* (Warde, Olsen, et al.)

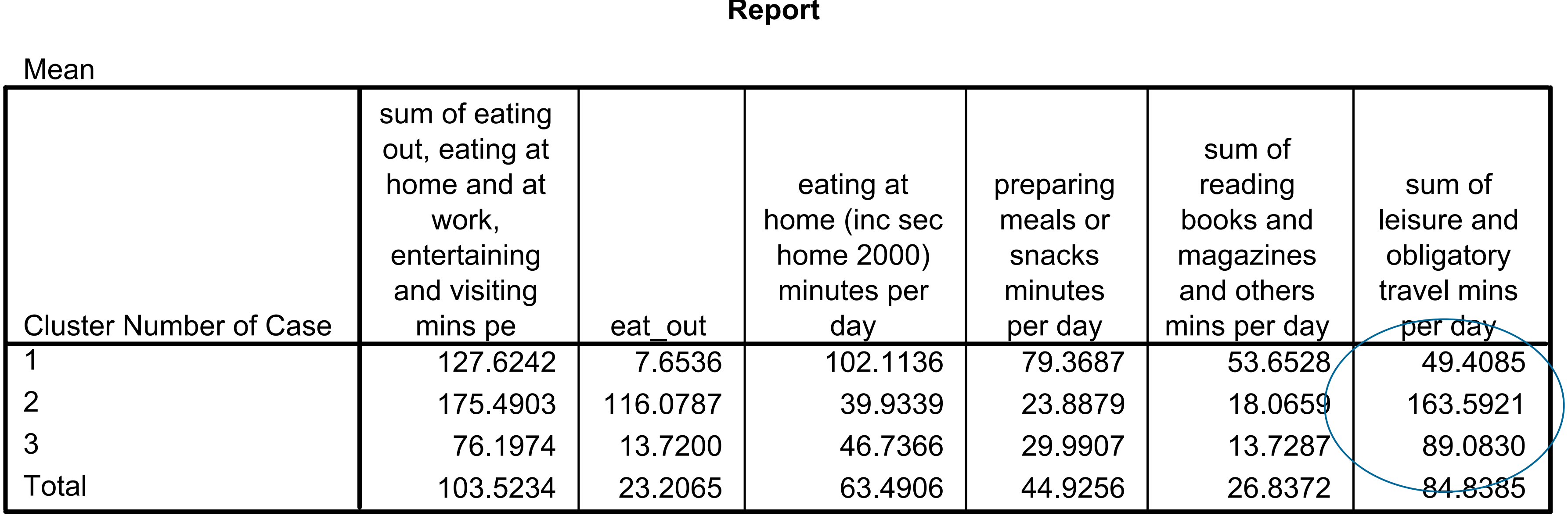


Report

gender		sum of eating out, eating at home and at work, entertaining and visiting mins pe	eat_out	eating at home (inc sec home 2000) minutes per day	preparing meals or snacks minutes per day	sum of reading books and magazines and others mins per day	sum of leisure and obligatory travel mins per day
male	Mean	112.1409	22.5294	66.9415	19.5718	28.3250	81.0404
	N	3927	3927	3927	3927	3927	3927
	Std. Deviation	54.47444	40.60960	41.05933	29.22918	43.36162	60.35103
female	Mean	111.4133	13.7441	74.3817	75.2832	23.2281	67.9525
	N	4168	4168	4168	4168	4168	4168
	Std. Deviation	53.71436	31.31775	42.01348	55.65556	33.40015	52.81864
Total	Mean	111.7663	18.0057	70.7725	48.2583	25.7005	74.3013
	N	8095	8095	8095	8095	8095	8095
	Std. Deviation	54.08228	36.38847	41.71688	52.76837	38.63677	56.97111

FCLUSTER Results

- Examine the means of the clusters for each continuous variable. These describe how different they are.
- You can ‘save’ the cluster membership and the distance variable. Now you can use the results to see which cases are typical, and which atypical (regress distance on some X var’s, using Cluster dummy QCL-1
- Examine the results.



Report

Mean

Cluster Number of Case	sum of eating out, eating at home and at work, entertaining and visiting mins pe	eat_out	eating at home (inc sec home 2000) minutes per day	preparing meals or snacks minutes per day	sum of reading books and magazines and others mins per day	sum of leisure and obligatory travel mins per day
1	127.6242	7.6536	102.1136	79.3687	53.6528	49.4085
2	175.4903	116.0787	39.9339	23.8879	18.0659	163.5921
3	76.1974	13.7200	46.7366	29.9907	13.7287	89.0830
Total	103.5234	23.2065	63.4906	44.9256	26.8372	84.8385

Naming the clusters: seeking to label and describe the groups which best typologise the people, which are perhaps:

Cluster 1: Elder people who cook a lot and don’t eat out; there are more women here; ‘elderly’

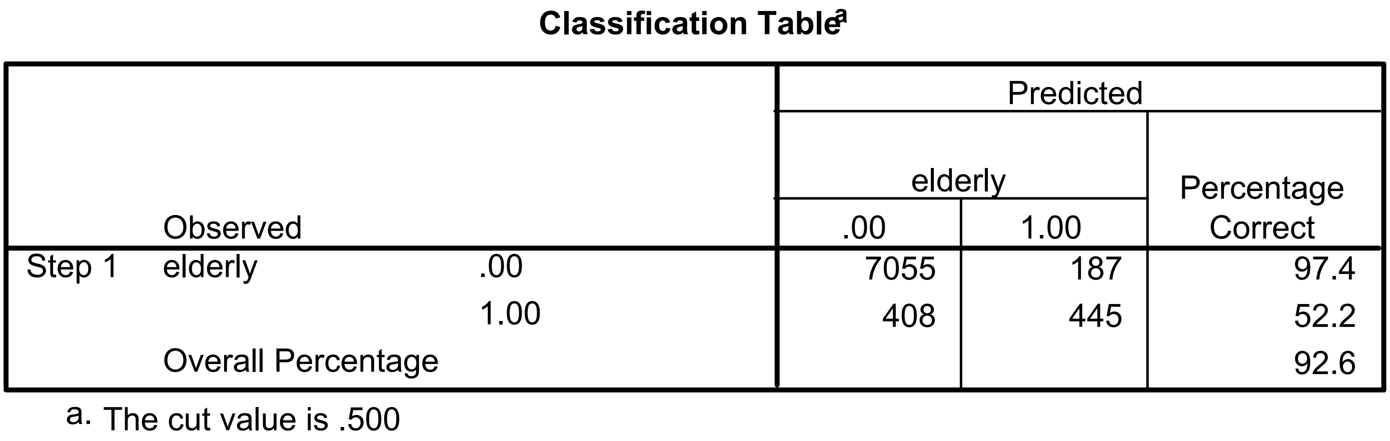
Cluster 2: Younger people who eat out lots and do lots of *leisure travel* such as walking or cycling.

Cluster 3: Younger people who spend ages travelling to work or school and have no leisure travel

Final Cluster Centers

	Cluster		
	1	2	3
sum of reading books and magazines and others mins per day	53.65	18.07	13.73
eating at home (inc sec home 2000) minutes per day	102.11	39.93	46.74
household income band (gross ie before deductions) - per year (source: hhld qstn	6	7	7
preparing meals or snacks minutes per day	79.37	23.89	29.99
age last birthday	59	41	39
Gender	.66	.46	.47
Leisure travel minutes per day	19.68	122.29	23.23
obligatory travel minutes per day	29.73	41.31	65.85
eat_out	7.65	116.08	13.72

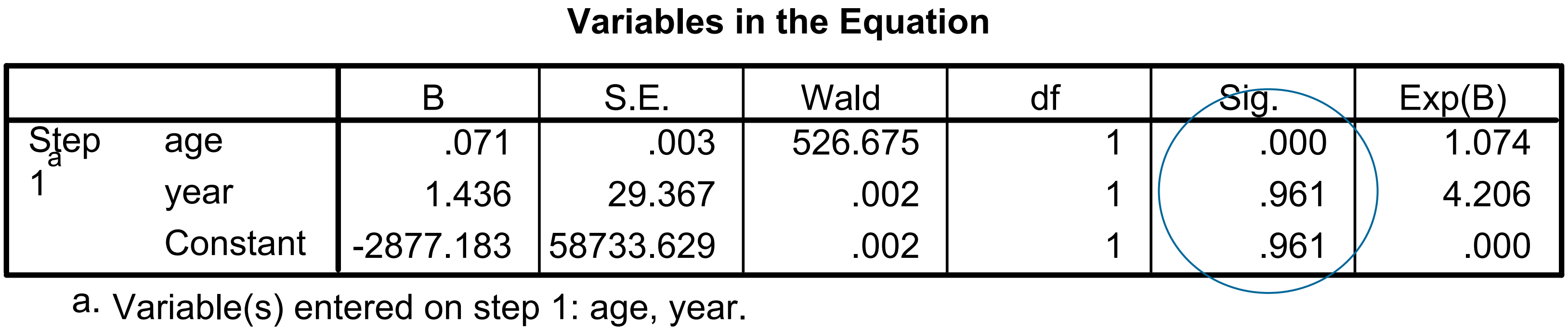
Test for change over time:



Classification Table[a]

			Predicted		
			elderly		Percentage Correct
	Observed		.00	1.00	
Step 1	elderly	.00	7055	187	97.4
		1.00	408	445	52.2
	Overall Percentage				92.6

a. The cut value is .500



Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	age	.071	.003	526.675	1	.000	1.074
	year	1.436	29.367	.002	1	.961	4.206
	Constant	-2877.183	58733.629	.002	1	.961	.000

a. Variable(s) entered on step 1: age, year.

Assumptions of F Cluster

- Fuzzy cluster assumptions vary depending upon which software you are using.
  - If you use K-Means in SPSS, all variables must be continuous and normally distributed. However if you break this rule, your results might be durable (compared with meeting this rule)
  - In other packages, you can have a mixture of categorical and Gaussian variables.
- Your ordinal variables' measurement metrics are highly influential if you put the variables in as if they were continuous.
  - Such matters are the subject of FS/QCA.

Fuzzy Cluster: WHY?

- Integrating qualitative and quantitative analysis may require a two-stage approach.
  - First reduce a large data set using clusters, and locate ideal types and/or typical cases.
  - Then gather or re-examine qualitative small-scale data on similar cases! use QCA or FS/QCA
  - Draw conclusions which are generalisable.

How to Test Whether an Ordinal Variable is Ordinal or Nominal

- For a variable to be ordinal with respect to the other variables that are in the set, i.e. in the causal complex you are exploring [or which together proxy for some latent factor or factors that discriminate cases], you can run a test.
- Use correspondence analysis or HOMALS. Find the weights that correspond to each element in your ordinal variable after putting it in 'as if' it were nominal.
- If they rise monotonically, or vice versa, then you have a good argument for ordinality.
- However, since the variable is not normally distributed, you still 'break the rules' of K-means clustering if you put the variable in.

Help with HOMALS

- An intriguing set of slides assists you in using correspondence analysis or HOMALS,
- And also introduces PRINCALS via CATPCA, an SPSS 11 and 12 menu item which allows for ordinal variables in principal components analysis. See rcb@unimelb.edu.au
- Richard Bell (also via RM website)

Example using Sri Lankan Data

- Context: financial exclusion is a form of social exclusion.
- A theoretical model – 3 theories:
  - T1: Structural divisions lead to financial exclusion, so gender (feminist theory), class (Marxist), and location (geographers) influence the odds of having a bank loan
  - T2: Furthermore, religion and culture influence one's interest in bank loans Lunt and the sociologists and market researchers; JournEconPsych.
  - T3: Other loan sources offer an alternative to bank loans, too. (Substitutes economics; social policy)

Variables Operationalising Theories T1 and T3

- Household income
- Land owned
- Gender
- Age and age-squared
- Whether teetotal
- Religion: Sinhala Buddhist / Muslim
- Personal use of banks
- Others in household using banks
- Personal use of non-bank credit
- Others in hhold using non-bank credit

Variables Operationalising Theory T2

- Attitudes, as reflected in a series of Likert scale questions.

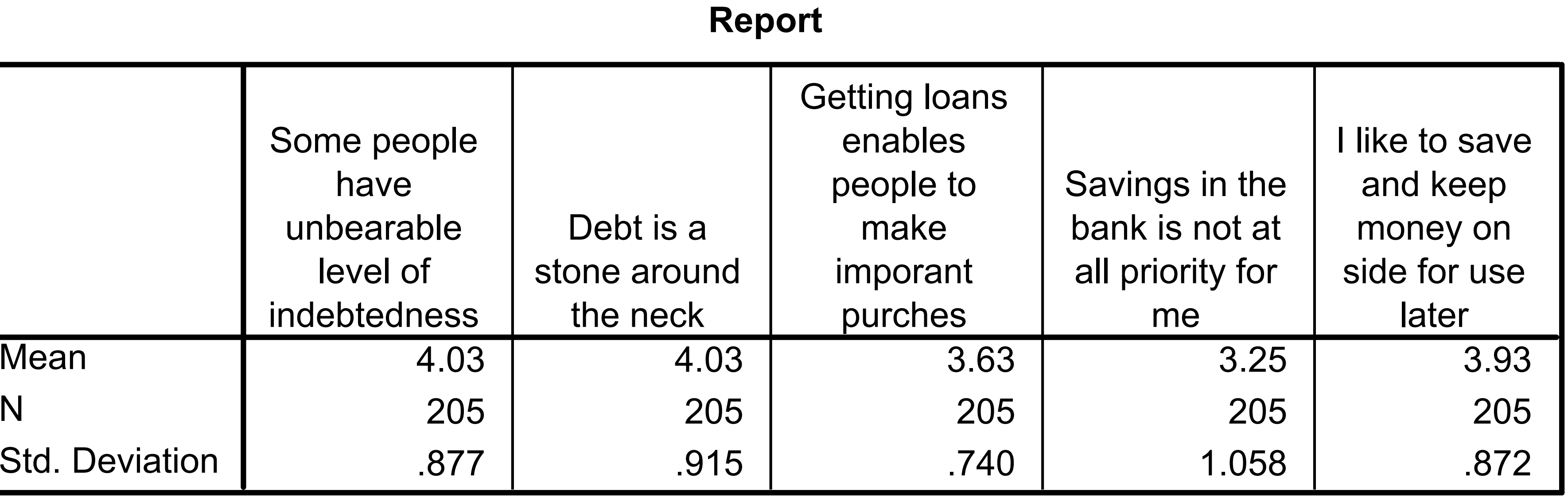
- Each is scaled 1 to 5.

- With this ‘metric’ taken as if it were a continuous distribution, we do apparently get ‘normal distributions’

Exercise: Cluster the cases by the attitudes expressed

- You would be working on the sociological and economic-psychology aspects of the underlying reality.
  - Market research is closely related to these.
- Please refer to the web site for the sample data set on Sri Lankan attitudes to banking.
- There are 21 Likert Scales and a few demographics.
- Do a cluster analysis after carefully selecting just five or ten attitude Q's.
- Use K-means to examine the distance of cases from their cluster means.

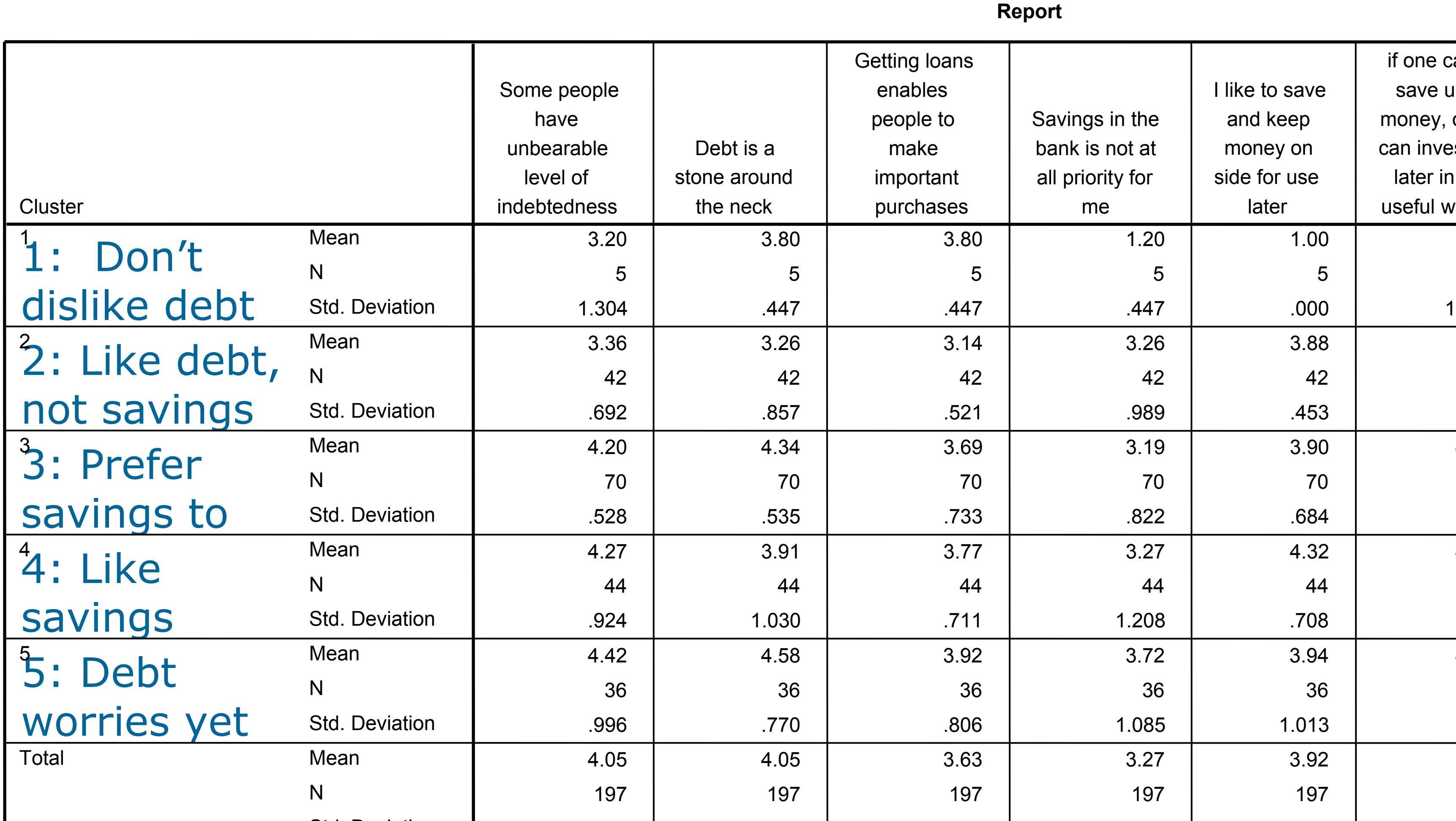
Means of Selected Variables



Report

	Some people have unbearable level of indebtedness	Debt is a stone around the neck	Getting loans enables people to make imporant purches	Savings in the bank is not at all priority for me	I like to save and keep money on side for use later
Mean	4.03	4.03	3.63	3.25	3.93
N	205	205	205	205	205
Std. Deviation	.877	.915	.740	1.058	.872

Results of Cluster Analysis



Report

Cluster		Some people have unbearable level of indebtedness	Debt is a stone around the neck	Getting loans enables people to make important purchases	Savings in the bank is not at all priority for me	I like to save and keep money on side for use later	if one ca save u money, c can inves later in useful w
1 1: Don’t dislike debt	Mean	3.20	3.80	3.80	1.20	1.00	
	N	5	5	5	5	5	
	Std. Deviation	1.304	.447	.447	.447	.000	1
2 2: Like debt, not savings	Mean	3.36	3.26	3.14	3.26	3.88	
	N	42	42	42	42	42	
	Std. Deviation	.692	.857	.521	.989	.453	
3 3: Prefer savings to	Mean	4.20	4.34	3.69	3.19	3.90	
	N	70	70	70	70	70	
	Std. Deviation	.528	.535	.733	.822	.684	
4 4: Like savings	Mean	4.27	3.91	3.77	3.27	4.32	
	N	44	44	44	44	44	
	Std. Deviation	.924	1.030	.711	1.208	.708	
5 5: Debt worries yet	Mean	4.42	4.58	3.92	3.72	3.94	
	N	36	36	36	36	36	
	Std. Deviation	.996	.770	.806	1.085	1.013	
Total	Mean	4.05	4.05	3.63	3.27	3.92	
	N	197	197	197	197	197	

Sample Results from K-means Clustering

Each row represents one actual case.

Cluster	Distance from centre
1	3.94968
1	3.34664
1	2.60768
1	5.19615
1	3.66060
2	1.81484
2	2.10630
2	2.55573
2	2.55573
2	2.54639

Why not choose a case near the centre of each cluster for further study?

Another exemplar

- You may wish to use data-reduction merely for the purpose of generating an outcome-variable across lots of cases
- This outcome-variable, which is a typology, can be used in QCA with small-N in a qualitative study.
- The typology from fuzzy cluster procedures would be a fuzzy set!

Variables To Be Used to Proxy the Outcome Types

- Personal use of nationalised bank(s)
- Personal use of private or rural bank(s)
- Personal savings in banks
- Others in household using banks etc.
- Personal use of non-bank credit etc.
- Others in hhold using non-bank credit etc.
  - More variables at this stage doesn’t matter
  - Using categorical instead of continuous variables is fine as long as you use the appropriate form of cluster analysis
  - Exploring the results helps you decide whether there is one outcome or two or three. (how large a typology)

Note: in the national data-set for Sri Lanka 1996-97, we have explicit indicators of all the same variables, i.e. use of each type of banking service. I could derive the clusters from this set before going to villages.

An analogy with labour-market research

- Labour market participation occurs in several forms – employment contracts, casual piecework, paid overtime, unpaid overtime, temporary jobs, and self-employment. The outcome might require clustering. Types-of-worker exist.
- You can then engage in qualitative research, comparative research, etc.
- You have successfully integrated quantitative analysis at stage 1 with qualitative analysis at stage 2, and yet the latter is not made marginal.

Further reading

- Everitt’s book is good on cluster analysis.
- See Warde, et al., working papers on the web regarding ‘changing practices in the UK using time-use data’ (Cultures of Consumption programme of ESRC)
- See Olsen, chapter on triangulation, on our website, for background to mixed methods.
- See Olsen, background paper on the Sri Lankan research, consisting of a chapter, on our website.