Using Cluster Analysis To Analyse The Reasons Why Businesses in Scottish Manufacturing Industry Failed or Succeed In The Implementation Of Enterprise Resource Planning Systems (ERPS)

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Abstract

How ERPS has affected Scottish manufacturing has been unclear. Scotland like many Western countries over the last twenty years has also seen an erosion of its manufacturing sector along with the growth in service industry. Much of the classic work of manufacturing e.g. shipbuilding, textiles, mining and steel making has transferred to the Pacific Rim. It has often been replaced with production of modern electrical goods such as cathode ray tubes and semiconductors. These new forms of manufacturing, often in factories owned by Asian or American multinationals, have required new skills from employees and introduced business practices formerly alien to the Scottish context.

In 2000 there were 20,002 manufacturing enterprises in Scotland in the manufacturing sector. 93.1% of these were small businesses with fewer than 50 employees, 4.2 % were medium sized with 50-249 employees and 2.7% were large with over 250 employees[1]. This statistic illustrates how manufacturing is dominated by small businesses within Scotland. However, this core of small businesses is unlikely to yet have the necessary capital to invest in the kind of large IT project like ERPS implementation.

In this study we have sought to extrapolate the effect ERPS have had on Scottish manufacturing and in doing so, illustrate some of the problems Scottish ERPS adopters have had. The study concentrates on Scottish businesses over 50 employees in size and look at the way ERPS users adapt to the challenges, problems and benefits that ERP brings to businesses.

1   Introduction

Organisations have been under tremendous pressure to deal with the dynamic and complex external environment. Consequently, many organisations have attempted to change their information systems strategies quickly by applying software packages from vendors rather than in house development in order to reduce costs and increase the speed of implementation. ERPS is one of the application packages used by organisations.

The term 'Enterprise Resource Planning System', first coined by the Gartner group, means to integrate many of the basic business processes[2]. Conceived as a successor to MRP and MRP II systems, Enterprise Resource Planning (ERP) systems have been viewed by many business analysts as the future way to manage business procedures. As enterprise wide systems, they are designed to bring together all of an organisation's information into one integrated system. The systems are frequently said to have a strong bias towards centralisation of the organisation[3].

ERPS are integrated complex software packages offering functionality to tasks in organisations. In manufacturing this includes production scheduling, handling of materials, human resource issues, accounting, purchasing and others, ERPS can transform the overall business structure. How this is done is dependent mainly on the choice of ERP product and the configuration of the system[4].

In theory the advantages of having an Information Technology (IT) system execute tasks in this way are numerous. ERP, for example, may facilitate increased information sharing and information dissemination among business units, or allow a company to formalise its overall business procedures. ERP can also standardise IT systems throughout a business's

various departments and subsidiaries by replacing them with a new system, one that encompasses all the functionality of the legacy systems. It should improve on legacy systems by allowing information sharing between the various business units. ERP also makes it possible for information to be stored in the system and read from it in 'real time'.

This holistic system is achieved by using a variety of modules that can be integrated into a complete suite. Modules offered are diverse and vary between software vendors. They normally include modules such as Materials Resource Planning, Human Resources, Expense Reporting and Ledgers.

The leading vendor of ERPS software is SAP AG, a German company whose sales were worth $3.3 billion US in 1997[5]. In 1999 SAP's sales reached $5.1 billion. Presently SAP is the 4th largest software company in the world based on the value of software sales[6]. Other leading providers of this software are Baan, JD Edwards, Oracle and PeopleSoft. These ERP providers grew at a rate of 61 per cent in 1999[7]. Their expected revenues in 1999 were Baan $992 million, J.D. Edwards $990 million, Oracle $1,900 million and PeopleSoft $1,400 million. Other smaller providers were expected to earn $4,800 million in total[8].

Large companies such as Siemens, Coca-Cola and Mobil have spent millions or even billions of dollars implementing ERP systems in order to gain the perceived benefits that ERP offers. These perceived benefits are data integration throughout a whole business, allowing immediate changes in data in one location to change the data in another. For example, one may imagine a scenario whereby a customer purchases a batch of items. This would then be processed in the ERP system which would carry out the billing, the ledger, the ordering of the items, the ordering of the materials required to replenish inventory and even calculate the exact cost of all of this taking account of local taxes and duties completely automatically.

How great these systems sound in theory, however, is not always the way they function in reality. Uncertainty in acquisition and hidden costs in implementation are some of the difficulties encountered. FoxMeyer a US drug company was almost driven to bankruptcy through the introduction of ERP and Mobil Europe spent hundreds of millions of dollars only to abandon the project when a merger partner strongly objected[9]. Other companies such as Dell found that the system it had purchased no longer fitted its business structure due to a new management model.

The problem of fitting the ERP system to the organisational culture of a business has been identified by writers such as Davenport, Hirt & Swanson[10], Laughlin[11] and more recently by Hong & Kim[12]. What many of these writers have argued is that ERP is a way of doing business, and not as may be expected, simply an aid to a company's incumbent business procedures. In practice this may mean that a business implementing an ERP system may require some form of restructuring in order that its ERP implementation succeeds. Due to this rigid structure imposed on business practices, it may be contested that ERP does not leave businesses with any flexibility to meet unusual changes in demands from its customers. Nor does it allow organisational structure to change without changing the ERP system. Koch and Buhl[13] suggest that companies that have implemented ERPS have project groups that struggle hard to realise even the basic features of the ERPS

Davenport argues that this rigidity within organisations using ERP renders a business unable to fulfil niche demands, especially in industries where ERP is the norm. In such industries the only way for a business to differentiate itself from others may be to forgo using ERP. In doing so it may be easier for a business to fill niche markets and have more sensitivity to changes in customer demand.

The investment required to implement an ERP system is huge. For any company to consider the implementation of a system there are a number of cost implications that range from the basic requirements of hardware, software and consultancy to the indirect staff costs implicated in staff training and preparation. In effect, the complexity of costs associated with ERP must be weighed up against potential the benefits that an ERP system will have on an organisation.

2   Scottish Manufacturing and ERPS

Little is known about Scottish manufacturing business culture in relation to ERPS. It is likely though to be related to the market sectors that Scottish manufacturing service. Scotland like many Western countries over the last twenty years has also seen an erosion of its manufacturing sector along with the growth in IT. Much of the classic work of manufacturing e.g. shipbuilding, textiles, mining and steel making has transferred to the Pacific Rim. It has often been replaced with production of modern electrical goods such as cathode ray tubes and semiconductors. These new forms of manufacturing, often in factories owned by Asian or American multinationals, have required new skills from employees and introduced business practices formerly alien to the Scottish context.

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In this study we have sought to extrapolate the effect ERP has had on Scottish manufacturing and in doing so, illustrate some of the problems Scottish ERP adopters have had. The study concentrates on Scottish businesses over 50 employees in size and look at the way ERP users adapt to the challenges, problems and benefits that ERP brings to businesses.

3   Study aims and methodology

The method of research chosen to research these areas was via questionnaire. It was thought this method would allow a broad range of manufacturing business experiences to be encapsulated in one study. The method was also thought best suited for statistical analysis. Designing a suitable questionnaire was by no means straight forward as at the time, Spring 2000, very little quantitative work had been carried out on ERP within businesses. Thus, the survey was constructed on the basis of the different hypothesis found in the literature regarding ERP. This allowed the construction six broad areas to be researched:

1. The system chosen, why it was chosen and how it was purchased

2. If the company had benefited from the system and whether weaknesses exist

3. If the ERP system had changed the amount of face to face or voice to voice contact with customers

4. How the system was implemented

5. The factors involved in successful implementation

These broad research areas were then broken down further into smaller groups of questions regarding each of the overall aims. Questions regarding the areas of interest specified were constructed using simple Yes or No responses, five point Likert Scale questions and multiple category responses that were in regard to statements that applied to the business or not. A number of open-ended responses were added to questions to ensure that respondents were able to fully answer the questionnaire. A further seventh open-ended section was added that asked what the most important advice would be to someone implementing an ERP system.

Businesses were then selected from the FAME (Financial Analysis Made Easy) Database. The businesses were chosen from the manufacturing, recycling and generation sector SIC codes. All businesses that FAME had received a report from since 1995, had a known turnover and had a known employee size were selected. Consultation with ERP vendors revealed the take up of ERP was likely to have only penetrated to larger business. For this reason it was decided to limit the research to companies with over 50 employees. This represented a total of 740 businesses: 601 medium to very large (50-499 employees), and 139 businesses with employees greater than 500.

A total of 117 companies responded. 61 of these companies were using an ERP system with the rest not using an ERP system. 33 envelopes were returned where the company had gone away (possibly gone bust) or had replied saying they were not a manufacturing company. The response rate was 15.8% including those companies that had gone bust or moved away (16.4% excluding them). This was a satisfactory response rate and much in lines with expectation due to the volume of questions in the ERPS/IT large questionnaires.

4   Cluster Analysis of Businesses Surveyed

The Likert Response scale to benefits from ERPS was used in a Principal Components Factor Analysis using Varimax rotation to extract the factors. Principal Components Factor analysis does not suffer greatly from non-normality unlike Maximum Likelihood factor analysis and no transformations were made. The covariance matrix was used due to the variables all coming from a comparable scale. The 4 factors extracted from the analysis were described as:

Factor 1: An overall efficiency factor

Factor 2: A factor related to benefits in external business relationships

Factor 3: A factor related to benefits in manufacturing efficiency

Factor 4: A factor related to increased internal business knowledge

The second set of Likert Scale variables relating to elements of organisational culture was then used in a Principal Components factor analysis using the covariance matrix. In this case Varimax rotation did not appear to produce any easily interpretable results so an alternative method of rotation was sought. Equamax rotation was applied instead and this produced some interpretable results while ensuring the factors had no shared covariance. Equamax rotation maximises the variance on both the rows and columns of the loading matrix. It is a payoff between Varimax and Quartimax rotation.

The interpretation of the factors was:

Factor 1: A standardisation of procedures
(High loadings on made jobs routine and formalisation of procedures)

Factor 2: A change in staffing structure
(High loading on the control of staff and restructuring of staff)

Factor 3: A change in organisational direction
(High loadings on organisational resistance and change in the way strategic decisions are made)

The above mentioned 7 factors gleaned from the previous analysis of all users is used as a basis for clustering the groups. A Hierarchical clustering method was used for this procedure with the cut off deemed at 5 clusters from analysis of the exploratory dendrogram. Ward's method was used in this analysis with the clustering carried out using the Squared Euclidean Distance as a measure of similarity/dissimilarity (see Johnson & Wichern 1998 [15] for discussion of cluster analysis techniques). 55 cases were used in the clustering process. The agglomeration schedule is shown in the appendix.

Functions at Group Centroids

Ward Method	Function			
	1	2	3	4
1	1.040	1.123	.578	-.977
2	2.613	-1.346	-1.113	.241
3	-2.188	.569	-1.837	-.241
4	-.473	.168	.700	1.007
5	-2.351	-2.980	1.290	-1.367

Unstandardized canonical discriminant functions evaluated at group means

Fig 1

Prior Probabilities for Groups

Ward Method	Prior	Cases Used in Analysis	
		Unweighted	Weighted
1	.255	14	14.000
2	.164	9	9.000
3	.164	9	9.000
4	.345	19	19.000
5	.073	4	4.000
Total	1.000	55	55.000

Fig 2

These clusters were then tested for appropriate differentiation using Discriminant analysis to see how well the clustering had achieved the goal of separating the businesses into groupings. The discriminant function was calculated using the prior probabilities calculated from the groups' sizes. The weights are shown in figure 2 and the discriminant function in figure 1.

The effectiveness of the procedure was checked using the 'Hold Out' procedure of analysis that calculates the discrimination function's success without one observation in the model. The model proved to be 85.5% effective at predicting group membership on this basis (Fig 3).

Classification Results[b,c]

	Ward Method		Predicted Group Membership					Total
			1	2	3	4	5	
Original	Count	1	11	0	0	3	0	14
		2	0	9	0	0	0	9
		3	0	0	8	1	0	9
		4	0	0	0	19	0	19
		5	0	0	0	0	4	4
	%	1	78.6	.0	.0	21.4	.0	100 0
		2	.0	100.0	.0	.0	.0	100 0
		3	.0	.0	88.9	11.1	.0	100 0
		4	.0	.0	.0	100.0	.0	100 0
		5	.0	.0	.0	.0	100.0	100 0
Cross-validated [a]	Count	1	10	1	0	3	0	14
		2	0	8	0	1	0	9
		3	0	0	7	2	0	9
		4	0	0	1	18	0	19
		5	0	0	0	0	4	4
	%	1	71.4	7.1	.0	21.4	.0	100 0
		2	.0	88.9	.0	11.1	.0	100 0
		3	.0	.0	77.8	22.2	.0	100 0
		4	.0	.0	5.3	94.7	.0	100 0
		5	.0	.0	.0	.0	100.0	100 0

a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

b. 92.7% of original grouped cases correctly classified.

c. 85.5% of cross-validated grouped cases correctly classified.

Fig 3

The groups were then profiled on the basis of whether they had failed or not at implementation and the other variables that measured their experiences with ERP. It was shown by cross-tabulation with the variable 'fail' that clusters 3 and 5 were businesses that were more likely to think their implementation a failure (Fig 4).

Ward Method   * FAIL Crosstabulation

Count

		Did the implementation fail in any way?		Total
		Yes	No	
Ward Method	1	7	7	14
	2	4	5	9
	3	8	1	9
	4	9	10	19
	5	4	.00	4
Total		32	23	55

Fig 4

5   Results of Analysis

The cluster analysis produced two sets of clusters of companies i.e. companies that are likely to succeed and companies that are likely to fail. The sets are discussed below:

Set 1 - The companies that are most likely to succeed with implementation:
Cluster 1, The ERP Enthusiasts: These companies tend to be users of top end ERP packages. ERPS has no effect on these companies competitive edge. Their implementation does not tend to go over budget. Their ERP system increases

control of their staff and ERP causes large changes in staff structure. These organisations publicise their use of ERP. When implementing ERP they think planning is very important. Although these companies score high on the efficiency factor they are not high on the manufacturing efficiency factor. When these companies do fail at implementation it is more likely to be for technical reasons.

Cluster 2, ERP As An Enabler: ERP has little effect on these companies' competitive edge. These companies are likely to go over budget and this is perhaps related to the fact they tend to customise their systems more. These companies prefer strong leadership when implementing ERP. ERP does slightly change the strategic decision-making of these companies. They do advertise their use of their ERP system. These companies score very high on the overall efficiency. They do not score very high on the manufacturing efficiency factor. They don't change their staff structure a great deal. When implementing ERP they do make larger changes in organisational direction. These companies are unlikely to fail for organisational reasons.

Cluster 4, The Decentralised ERP Users: ERP has little effect on these companies' competitive edge. These companies have a higher control of staff through ERP although ERP hasn't changed the way their strategic decisions are made or their organisational direction. They do a little publicity of their use of ERP systems. They do not think strong leadership is so important in ERP. They tend to think phased implementation is important. They have gained only medium overall efficiency from ERP but have gained high manufacturing efficiency from ERP. When these businesses do fail it is usually for organisational reasons.

Set 2 - The Companies Very Likely to Have Failed With Implementation

Cluster 3, We don't want ERP boss!: 7 of the 9 of these companies in this cluster had serious problems with organisational resistance to the introduction of ERP. Although these companies have not suffered much effect on their competitive edge they are very likely to have failed in implementation and get low efficiency from their ERP. These companies are all smaller, sized 50-250 users, and have a lower turnover. They are more likely to customise their system. They do not publicise their use of ERP. Retrospectively they think that a clearly defined mission is important in implementation suggesting that their implementation may have suffered from a lack of direction. However, they do tend to get a lot of internal business knowledge from their ERP system that was not there before.

Cluster 5, Oops Wrong ERPS!: In 3 of the 4 cases in this cluster the ERP system was recommended by a consultant and in all cases these failures say that matching the software's functionality to their organisation was a major issue. These failures are more likely to be bigger businesses. These companies do not like their ERP at all. They are likely to have gone over budget and their ERP has affected their competitive edge. Their ERP system has not increased their control of staff and not affected the way their strategic decisions are made. Unsurprisingly they do not publicise their use of ERP. They don't think having a motivated staff is as important. They retrospectively think that leadership is important in ERP implementation suggesting suggest poor management may have been to blame for their failure. On the whole, ERP has failed to standardise their procedures and ERP has failed to increase the amount of internal business knowledge. Their belief is that their system has failed them.

6 Discussion

The factor analysis carried out on the questions posed to those businesses that failed in implementation does suggest that there may be good reason for concern if organisational resistance is not taken seriously. There was graphical correlation of loss of competitive edge on the "organisational reasons for failure" factor. This factor, being related to a loss of a company's competitive edge, strongly suggests that unlike technical reasons for failure, organisational reasons for failure can be far more damaging.

Just how a company overcomes this problem is not totally clear but certain elements seem to help in improving a company's viability having implemented ERP. The factor, which was loaded high on changes in staff structures, showed that those who had not restructured staff in some way to embrace ERP were more likely to fail in implementation.

The cluster named "We don't want ERP boss!" seems illustrative of how ERP will fail when companies fail to muster support for ERP or make the correct staff changes necessary to implement it. Interestingly these companies rated a clearly defined mission as more important than those who had not failed in the introduction of ERP. This perhaps suggests that they had not received sufficient information regarding what kind of benefits ERP was meant to bring to their company or what the aim of the system was. However, these businesses seemed to improve in in-house information sharing through ERP more than most. It may be a case in these businesses that the integration of organisational structure was absent before

ERP and that ERP failure is simply symptomatic component of a wider malaise.

Although integration with present systems has been cited as a reason why implementation may fail (Laughlin, 1999), only 42.4% of the respondents stated this was a reason for failure in their company. This reason was dwarfed by organisational resistance (73.5%) and matching functionality (76.5%). 64.7% agreed or strongly agreed staff training was an issue in failure and staff training seems to transcend organisations who fail for technical or organisational reasons.

Curiously no pattern could be discerned whatsoever in the SIC code business sector of the company in any of the failure or non-failure factors in implementation. Neither could it be related to the clusters. This finding suggests than ERP failure or success is more about what type of culture and organisational dynamics there is within a company has rather than what sector of business a company is.

The issue of phasing implementation seems to be a dividing one between those companies who feel it is right to go for the 'big bang' of implementation all at once and those who feel implementation should be slower and more organic. Unlike the other responses to the questions relating to what is successful in implementation phased implementation was less certain. Only 67.2% agreed or strongly agreed with this as important when implementing ERP.

Smaller businesses may not have the necessary financial capital to go out and buy in a whole system at once. Larger businesses may feel it is too much of a risk going with the 'big bang' strategy. However, there are many issues that muddy exactly what makes phasing implementation important to one business and not to others. This is likely due to the different ways companies see their ERP in strategic terms. Thus, it still remains unclear from this analysis exactly why some organisations prefer phased implementations and some do not. The results though do give some insight for further research in this area.

7   Conclusion

In this research clear indications were found that organisational resistance was a serious danger in ERP implementation and one which organisations should take serious notice of. This issue above all others stood out as a reason for failure that could result in serious and catastrophic problems for those unaware of its danger or unwilling to try and prevent it.

The fact that so much research has concentrated on SAP and other large ERP providers has been found by this study to be a flawed research strategy. In the Scottish context SAP is certainly not the characteristic of ERP nor are top end ERP products. Instead many smaller companies are filling the gaps in ERP provision and these smaller companies are often former providers of MRP II systems.

Internet enabled ERP may have come too late for many businesses who have already had to find different products from smaller ERPS providers. It is the finding of this study that far from ERP existing only in top tier high grossing companies, it has already began to make big waves in smaller companies. These companies are already using ERP in different and constructive ways without fully initiating large-scale projects.

Some of the differences seen in the analysis may be due to the way ERP is sometimes viewed as one kind of system for all different kind of companies. This research has underlined that many different kinds of companies make use of ERP in different ways. In this sense discussion of ERP can now move on to reflect which strategies are best for what kinds of companies.

Appendix

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	35	45	.372	0	0	20
2	11	42	.757	0	0	15
3	29	30	1.326	0	0	7
4	9	61	1.942	0	0	19
5	19	25	2.612	0	0	20
6	7	40	3.485	0	0	22
7	24	29	4.466	0	3	30
8	37	43	5.451	0	0	45
9	13	48	6.455	0	0	19
10	20	57	7.518	0	0	31
11	18	26	8.848	0	0	14
12	22	58	10.256	0	0	29
13	14	39	11.788	0	0	41
14	18	53	13.367	11	0	26
15	1	11	15.034	0	2	31
16	4	36	16.729	0	0	27
17	10	21	18.621	0	0	21
18	31	52	20.569	0	0	37
19	9	13	22.539	4	9	25
20	19	35	24.554	5	1	23
21	8	10	26.577	0	17	35
22	7	55	28.845	6	0	38
23	19	51	31.405	20	0	38
24	15	47	34.002	0	0	34
25	9	44	36.987	19	0	39
26	18	59	40.093	14	0	33
27	4	54	43.296	16	0	36
28	28	56	46.762	0	0	50
29	3	22	50.434	0	12	44
30	6	24	54.130	0	7	39
31	1	20	57.982	15	10	35
32	17	27	61.861	0	0	43
33	18	60	65.794	26	0	46
34	15	34	70.281	24	0	42
35	1	8	75.480	31	21	40
36	4	38	81.000	27	0	47
37	31	46	86.873	18	0	47
38	7	19	93.211	22	23	43
39	6	9	99.581	30	25	49
40	1	50	106.508	35	0	46
41	14	49	113.580	13	0	45
42	15	23	121.263	34	0	53
43	7	17	128.979	38	32	49
44	3	5	138.059	29	0	48
45	14	37	149.063	41	8	48
46	1	18	162.719	40	33	51
47	4	31	176.735	36	37	50
48	3	14	193.654	44	45	51
49	6	7	211.037	39	43	52
50	4	28	234.816	47	28	52
51	1	3	263.923	46	48	54
52	4	6	295.653	50	49	53
53	4	15	332.527	52	42	54
54	1	4	377.013	51	53	0

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