SME INNOVATOR TYPES AND THEIR DETERMINANTS

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Abstract

The distinction between innovating and non-innovating firms masks important differences between innovating firms in terms of the intensity, orientation and persistence of their innovation activities, the type and novelty of their innovations, and the rate at which their product innovations are taken up by markets. Applying factor and cluster analysis to a specially constructed database of UK SMEs, the paper identifies different types of SME innovator based on indicators of their innovation "outputs". These groups are then compared in terms of their use of a variety of "inputs" to innovation. Novel product innovators are more innovation intensive than non-novel innovators, spending a higher proportion of turnover on R&D and having a significantly higher proportion of staff who are technologists, scientists or higher professionals. An important benefit of this to novel product innovators is a more rapid take-up of product innovations in the market by comparison with other innovators. Despite differences between different types of innovators, however, the gap in innovation capability and intensity between innovators and non-innovators is far larger.

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1. Introduction

The role of small and medium enterprises (SMEs) in the innovation process has become an important component of the policy interest in small firms in the UK (see for example ACOST 1990) and in the Europe Union as a whole (see European Commission 1995). The reason for this appears to be the mounting evidence that SMEs, here defined to be firms with fewer than 500 employees, play a vital role in the innovation process. Cohen & Levin (1989) suggest that it is far from clear that large firms are now the most important source of innovations. Recent empirical studies have highlighted the important and growing contribution of SMEs to total innovation output (Pavitt et al. 1987, Acs and Audretsch 1988, 1991). Mueller (1988, 40) argues that "the small or newly-born firm is a primary source of new products and innovations".

Nevertheless, some doubt remains about the depth of technological capability within the SME sector. Bolton (1971, 84) argues that "small firms, in spite of relatively low expenditure on research and development by the sector as a whole, are an important source of innovation in products, techniques and services". More recently, Winter (1984, 293) suggested that "in a small firm, inward-looking (technological) search might better be typified by a look in the suggestion box. Change then involves insightful solutions to recurring difficulties with the existing routines, fine-tuning of process parameters, better adaptation to the idiosyncratic strengths and weaknesses of the firm's personnel or equipment, or minor design improvements in process or product".

Just what proportion of SMEs are characterised by a "suggestion box" approach to innovation, what proportion are engaged in any R&D activity and how R&D intensive are they, however, seem not to have received adequate attention. The aim here is twofold. In addition to evaluating the importance of key inputs to SME innovation including amongst others R&D activity, the paper provides a detailed analysis of the patterns of innovative output from the UK SME sector. The reason for the latter is the growing evidence, discussed below, on the variety of different types of innovative strategy, both in terms of innovation input and output. It will be argued that identifying groups of firms with similar innovation output characteristics helps to distinguish which innovation inputs are important and to what kind of firm.

Section 2 provides an overview of the methods and findings of previous research in this area. Section 3 analyses innovation patterns in the UK SME sector using cluster analysis to identify different types of innovating firm according to their innovation output. Section 4 evaluates how the importance of different inputs to the innovation process varies across different types of SME innovator.

2. The Pattern and Determinants of Innovation: Methodological Approaches

2.1 The development of research methodologies

A major challenge facing researchers of innovation activity is to measure innovative activity in all its complexity and multiple dimensions. A large literature utilised R&D and patent data to analyse innovation patterns (for a review, see Cohen and Levin 1989). Patel and Pavitt (1992, 93-4) argued that the "assumption that R&D expenditures measure 'inputs' of innovative activities, and patents the resulting 'outputs', has become increasingly fragile, as more has been understood empirically about the nature of innovative activities, and about the means that firms use to appropriate their results". 'Inputs' into innovative activities include design, testing, production and marketing, the relative importance of which varies significantly according to the firm's size and its principal sector of activity (see Mansfield et al. 1971, quoted in Patel and Pavitt 1992, 94). The technology transfer process also consists of a complex mix of patenting, licensing, purchase of equipment, external R&D services, and formal and informal collaborative agreements.

In the past ten years, a number of large scale company surveys in Europe and North America have provided an enormous variety of measures of both the inputs to and outputs from innovative activity. Having achieved this important step in measuring innovation, researchers have been presented with the new challenge of finding appropriate methods of analysing this breadth of information. After having to make do with one or two indicators of innovative activity, researchers working on these innovation surveys typically have well in excess of 100 variables measuring the importance of different aspects of the innovation process.

Broadly speaking, there are two alternative approaches to an analysis using a large number of variables on innovative activity. One alternative is a large number of separate, unrelated or partially related runs with a small number of variables in each. This enables one to draw precise conclusions about particular aspects of the innovation process. It does, however, have the disadvantage of making it more difficult to obtain an overview of the innovation process. An alternative is a small number of runs with a large number of variables in each. The number of variables which can be included in standard regression models is limited by the problem of multicollinearity in the explanatory variables and by degrees of freedom. Two techniques are commonly used to cope with a large number of variables in a particular run. In one, information from a large number of variables is compressed into a smaller number of uncorrelated variables, typically using principal component analysis. In the other, information from a large number of variables is used to create a smaller number of groups of cases, using cluster analysis. The advantage of these latter approaches is that they provide an overview of a large amount of information, but they suffer from the disadvantages of reduced precision, limited robustness and possibly also difficulties in interpretation.

A large number of separate, mostly unrelated, runs of the Centre for Business Research (CBR) innovation data on UK SMEs has already been carried out (see Cosh and Hughes 1996). That analysis provided extremely detailed and precise information on how the extent and nature of the inputs to and outputs from innovation activity varied by, for example, firm size, firm age, broad industrial sector and growth rate. We build on that analysis here by using a combination of the above two approaches on the same data to provide an overview of the patterns of innovation output as well as a univariate analysis of the importance of different inputs to innovation. The next section reviews previous research which has adopted this broad approach.

2.2. Recent empirical research on the patterns of innovation

Using the Science Policy Research Unit (SPRU) innovation data on major innovations in the UK between 1945 and 1983, Pavitt (1984) developed a taxonomy for classifying companies according to the precise emphasis of their innovation activities. This work identifies common features of the innovation activities in particular industries and then groups a large number of industries into a smaller number of groups each with similar features of the innovation activities. This procedure relies on a range of information on inputs to and outputs from the innovation activities in each industry. The four patterns of industry innovation are supplier dominated, specialised equipment suppliers, scale intensive, and science based. The model was subsequently developed further by Pavitt et al. (1989).

A similar methodology was adopted by Archibugi et al. (1991) for business units contained in the Italian innovation database. Archibugi et al. used information on both inputs to and outputs from the innovation process. Regarding inputs to innovation, they used data on a range of internal and external sources of information and how prominent they were in the innovation process. As with Pavitt, Archibugi et al. (1991) group firms according to their industry innovation characteristics rather than the firm's own innovation characteristics. Their analysis identified five distinct groups of innovation types; producers of traditional consumer goods, suppliers of traditional intermediate goods, specialised suppliers of intermediate goods and equipment, mass-production assemblers, and R&D based.

Cesaratto et al. (1995) used 17 variables on inputs to and outputs from innovation to identify five main types of innovator. A difference between their work and the previous work is that Cesaratto et al. did not consider the specific industrial sector to which a firm belonged. This means that they classified a firm to a group in which its individual innovation characteristics match rather than one which necessarily matches the innovation characteristics of its industry.

Diagram 1 shows a comparison of the results of the clustering analyses of Pavitt et al. (1984), Archibugi et al. (1991) and Cesaratto et al. (1995). The comparison was made on the basis of the characteristics of the different categories of innovator types as described by the different authors, chiefly the level of innovativeness of the different categories of innovator, the description of the primary inputs to their innovations, and the main industries which each category covered. The diagram indicates the similar categories identified by Pavitt et al. (1984) and Archibugi et al. (1991). The only substantive difference is that Archibugi et al. split the Pavitt et al. category of "supplier dominated firms" into "producers of traditional consumer goods" and "suppliers of traditional intermediate goods". Given the similarity of their approaches, the close match in their results is not entirely surprising.

The categories identified by Cesaratto et al. (1995), on the basis of a firm's own innovation characteristics, are rather different from the other categorisations. There is no simple one to one correspondence between the categories identified by Archibugi et al. and those identified by Cesaratto et al. For example, the Cesaratto et al. category "complex innovators" would appear to draw firms from "suppliers of traditional intermediate goods", "specialised suppliers of intermediate goods and equipment", "mass production assemblers" and "R&D based". Given the differences in methodology between Cesaratto et al. and the others, the results of the comparison are consistent with each industrial sector containing a variety of different types of innovator. This suggests that it is not entirely appropriate to classify a firm to a particular innovation type simply on the basis of the industry in which the firm operates as the firm's innovation activity may be rather different from others in its industry.

A common feature of all of the above attempts to identify distinctive types of innovator is that information on both the inputs to and outputs from innovation are used to group firms or industries. This makes it difficult to characterise the strength of relationships between particular inputs and types of innovation output. At best, one has to make deductions regarding such relationships; for example, it could be argued that there is a positive relationship between the level of R&D expenditure and a firm's propensity to introduce a product innovation or the probability that it will be a highly innovating business unit (see Table 6 in Archibugi et al. 1991). A similar pattern is suggested by Cesaratto et al., who show that the categories in which R&D is a characteristic innovation source are more likely than others to produce "absolute product innovations", i.e. "the number of products that business units regarded as new for the world or the Italian market" (p. 122). However, it is difficult to test these propositions statistically simply on the basis of their description of each group.

By utilising both the variables on innovation inputs with those on innovation output in the clustering procedure, these approaches may also make it more difficult to isolate either particular categories of innovation output or differences in the importance of particular categories of innovation input across the different types of innovation output. In deciding which variables to include in a cluster analysis, a crucial question concerns the ease of interpretation of the groups created by the cluster analysis, i.e. the extent to which it is possible to identify the key distinguishing features of each group in such a way that they can be related directly to business strategies and managerial choices. On the basis that interpretation of the groups is easier the fewer the variables used in their creation, we adopt the approach of analysing the inputs to and outputs from innovation separately. The variables for innovation outputs are used to create groups of distinctive innovator types, whereas the variables for innovation inputs are used to create a smaller number of uncorrelated variables summarising the key features of innovation input.

In the analysis in section 3 below, cluster analysis is used to group firms according to the innovation output that they report.

3. Types of Innovating Firm in the UK SME Sector

The CBR database provides information on several aspects of a firm's innovation output including data on whether or not a firm introduced product (goods or service as appropriate) and process innovations, whether or not their innovations were new to the firm only or new to their industry or all industries and the proportion of their sales which are made up of upgraded products and newly innovated products. The database provides information on whether or not firms introduced either product or process innovations both in the 1986-91 and 1992-95 periods. All of this information was used in the cluster analysis. The full list of variables used in the cluster analysis is shown in the first column of Table 1. Appendix 1 shows the questions that were used to generate these variables.

The main purpose of the cluster analysis is to see whether it is possible to identify distinctive types of innovating firm by the kind of innovation output which they report. To avoid making prejudgements about which firms are innovators and which are non-innovators, however, all firms for which there was a complete set of responses to the questions on innovation output were included in the analysis. In all, it was possible to include 600 firms. As will be seen below, the clustering procedure did identify a group which contains all the firms which could be considered non-innovators. A total of 94 firms had to be excluded owing to item non-response for one or more of the variables. It is important to note that the available innovation data for these firms suggests that were it possible to include them they would not have been split across the final cluster groups in the same proportions as those cases which could be included. A significantly higher proportion of excluded cases (67%) reported no innovations in the period 1992-95 by comparison with included cases (28%) and are likely to have been classified to one of the six clusters which the analysis generated. Thus, the cases which are included in the cluster analysis cannot be said to be entirely representative of the sample. In addition, it should be noted that the entire sample of 694 which responded to the full questionnaire in the 1995 survey is itself not representative of the population. The reason for this is that there was no refreshing of the sample between the 1991 and 1995 surveys and, due to attrition, the 1995 sample contains a disproportionately high number of innovating firms as those firms that died were significantly less likely to have reported innovations in the period 1986-91 (see Bullock et al. 1996). Finally, it is worth noting that the original sample of firms included in the 1991 survey was stratified according to size, weighted towards larger SMEs (see SBRC 1992). This has the effect of increasing the proportion of innovating firms in the sample, as smaller firms are less likely than larger ones to innovate (Cosh et al. 1996).

Following Morrison (1967), principal component analysis was applied to the ten variables chosen for creating the groups of different types of innovator before conducting the cluster analysis. Using principal component analysis in this way helps to overcome the problem of "double counting" whereby variables that are highly correlated carry excessive weight in a cluster analysis. An additional advantage of applying principal component analysis prior to the cluster analysis is that it makes it possible to include a combination of interval and binary variables which could otherwise not be used in the cluster analysis.

The four factors generated in the principal components analysis are shown in Appendix 2, together with the tests that were conducted on the ten variables to ensure that they were suitable for a principal component analysis. The four factors account for 67.5% of the variance in the sample. In all but one variable, the four factors account for over 60% of the variance. The only exception is the variable which measures the proportion of sales in 1995 made up of "newly marketed products whose intended use, performance characteristics, technical construction, design, or use of materials and components was new or substantially changed in the last three years" for which the variance explained is only 24%. The reason for this is not entirely clear. Despite the poor explanatory power of the four factors in the case of this variable, however, the cluster analysis was able to generate groups for which there were significant differences in the average values of this variable. The main features of the four factors shown in Appendix 2 could be summarised as follows:

- Factor 1 "Novel product and process innovations and proportion of new products in total 1995 sales of primary importance"
- Factor 2 "Product innovation activity, mostly non-novel, of primary importance"
- Factor 3 "Process innovation activity, mostly non-novel, of primary importance"
- Factor 4 "Proportion of upgraded products in total 1995 sales dominant"

Appendix 3 shows the results of the cluster analysis which was applied to the above four factors and how the cluster centre values vary across the clusters and factors. Intend of identifying the distinctive features of the clusters in terms of their scores for the different factors, however, an easier way is to analyse the variation between the clusters with respect to the original ten variables which were used in the principal component analysis. Table 1 provides such an analysis for the six cluster groups, showing a measure of both the within- and between-groups distances. The within-groups distances are indicated by the standard deviation of the variables across the cases within each cluster. The between groups distances are measured using the Bonferroni One Way ANOVA test. This is a multiple comparison procedure to determine which means are significantly different. The Bonferroni test adjusts the significance level to the number of comparisons one is making.

In general, the within-groups distances are relatively high, i.e. the standard deviations are large. Despite this, it is clear that there are significant differences between the groups. Table 1 shows that there are significant differences between different groups with respect to all variables. A different presentation of the same information on between-groups distances as in Table 1 is shown in Table 2. The advantage of Table 2 is that it provides a better indication of the overall distance between groups. It can be seen from Table 2 that in all cases, significant between-group differences exist with respect to at least two variables and in most cases, significant differences exist with respect to at least 4 variables.

Firms in Cluster 1 can be distinguished from all others in that they are significantly more likely to have introduced both a novel product and a novel process innovation (novel meaning that the firm judged their innovation to be new either to their industry, or to all industries). Another distinctive feature of this group is that it has the highest average proportion of newly innovated products in its 1995 sales at 23.5%. This group could be termed "product and process originators". Cluster 2 firms are also likely to have introduced novel product innovations, though less so than Cluster 1 firms. Unlike Cluster 1 firms, however, no Cluster 2 firms reported novel process innovations. It can be seen from Table 1 that Cluster 2 firms are less likely than most others to have introduced any process innovations, at least in the period 1992-95. Cluster 2 firms have a marginally but not significantly lower proportion of their 1995 sales made up of newly innovated products (18.8%) by comparison with Cluster 1 firms. This group will be referred to as "product originators". Cluster 3 firms are likely to have introduced a novel process innovation, though less so than Cluster 1 firms. Only a small proportion of Cluster 3 firms introduced a novel product innovation. Cluster 3 firms have a similar proportion of their 1995 sales made up of newly innovated products (17.1%) by comparison with Cluster 2 firms. Cluster 3 will be referred to as "process originators".

Firms in Clusters 4 and 5 have a similarly low probability of having reported either novel product or novel process innovations. 11% of firms in Cluster 4 report product innovations new to the firm's own industry, while 10% of firms in Cluster 5 report product innovations new to all industries. (The latter appears contradictory as an innovation new to all industries by definition needs also to be new to the firm's own industry, yet only 3% of firms in Cluster 5 report product innovations new to the firm's own industry). Despite the relatively low probability of novel innovations, more than 60% of firms in both groups reported a product or process innovation (or both) in the period 1992-95. Cluster 4 firms reported a higher proportion of 1995 sales made up of newly innovated products (15.0%) than those in Cluster 5 (11.7%).

One feature which distinguishes these two groups is that Cluster 4 firms are significantly more likely than Cluster 5 ones to have introduced an innovation, particularly a process innovation in the period 1986-91. (Firms in Cluster 5 are in fact less likely to have reported a process innovation in the period 1986-91 than those in

Cluster 6 which, as will be seen below, appears to be the least innovative group by all other measures). This does not seem entirely in line with the relative probabilities of firms in these groups introducing such innovations in the period 1992-95. It is probable that the reason for the particularly low probability of process innovations in 1986-91 in Cluster 5 is partly due to differences in the way that the innovation questions were asked between the 1991 and 1995 surveys (see Appendix 1). We will return to a discussion of this point below. The pattern for product innovations is similar. Cluster 5 firms are slightly less likely than Cluster 4 firms to have introduced a product innovation in 1992-95 and dramatically less likely than Cluster 4 firms to have done so in 1986-91. Differences in the way the questions were asked in the 1991 and 1995 surveys may also account for this discrepancy, as will be seen below.

Another feature which distinguishes these two groups is the proportion of 1995 sales made up of "upgraded products". Cluster 5 firms reported a significantly higher proportion on average (48.1%) than those in Cluster 4 (29.7%) and in fact all of the other groups. On the basis that the primary difference between these groups is the proportion of 1995 sales made up of upgraded products, the following descriptions were chosen for these groups; "incremental product and process imitators" for Cluster 5 and "product and process imitators" for Cluster 4.

Firms in Cluster 6 are distinctive by almost every measure of innovativeness. No firms in this cluster reported a novel innovation. They are also significantly less likely to have reported either product or process innovations in 1992-95 than firms in all other groups and significantly less likely to have reported either product or process innovations in 1986-91 than those in most other groups. They report a significantly lower proportion (on average) of 1995 sales made up either of upgraded or newly innovated products (4.9% and 2.7% respectively) than all other groups. The term chosen to summarise this group is "occasional imitators".

Table 3 shows how this sample of 600 firms is split across the different cluster groups. As noted above, these 600 cases are not representative of the UK SME population due to a combination of stratification, attrition and item non-response. Therefore, it is not possible on the basis of these results to draw conclusions about the pattern of innovation in the SME population as a whole. 30% of this sample of SMEs appear to be "occasional imitators", i.e. innovate only sporadically, producing no novel innovations and have a negligible proportion of their sales made up of recently improved or new products. The smallest group of consistently innovative firms is Cluster 1 ("product and process originators"), followed by Cluster 3 ("process originators"). Roughly half of firms in clusters which are typified by novel innovations are in Cluster 2 ("product originators"). The clusters which are typified by novel innovations, namely Clusters 1, 2 and 3, account for around 40% of innovators in this sample. Clusters 4 and 5, which account for the remaining 60% of innovating firms, contain few firms which introduce novel innovations. Cluster 4 is the largest of these, accounting for 38% of consistent innovators.

Table 4 provides a univariate analysis of the differences between the clusters across a number of other factors which have been shown to influence the probability of innovation in SMEs (see Cosh et al. 1996, Cosh et al. 1997a, Cosh et al. 1997b). These variables include firm size in terms of number of employees, age, whether or not the firm is in manufacturing or business services, whether or not the firm is in a high technology industry (based on the Butchart 1987 definition), whether or not the firm exports and finally, whether or not the firm reports serious overseas competitors. A more detailed analysis of the industry classification of different cluster groups is shown in Appendix 4.

One of clearest features of Table 4 is the distinctiveness of Cluster 5, "incremental product and process innovators". Cluster 5 has a significantly lower proportion of manufacturing firms (29%) than all other clusters. The differences in the proportion of manufacturing firms between the other groups is only marginal and not significant in any cases.[1] Cluster 5 firms are also the youngest on average and significantly so by comparison with firms in Clusters 1, 3 and 4. Cluster 5 firms are also the smallest on average. Finally, Cluster 5 firms are less likely on average to export than any other group.

The clear distinctiveness of Cluster 5 firms by comparison with the other groups across these variables confirms that, despite some similarity between firms in this group and those in Cluster 4 (as seen in Table 1), Cluster 5 contains a genuinely distinctive group of firms. The fact that Cluster 5 contains a uniquely high proportion of business service firms appears to be the key to understanding this group. It appears to provide part of the explanation for the apparent anomaly of the low proportion of firms in this group reporting either product or process innovations in the period 1986-91. As shown in Appendix 1, the question in the 1991 survey asked firms whether or not they had introduced any major innovations in several areas including "production processes", a category which would seem less applicable to business service firms than manufacturing firms as the former are not normally engaged in activities for which the word "production" is commonly used. Not surprisingly, a significantly lower proportion of business service firms reported "production process" innovations than did manufacturing firms (SBRC 1992). The reason why the picture regarding process innovations is different for this group in 1992-95 is that the relevant question in the 1995 questionnaire referred simply to "processes" rather than "production processes" (see Appendix 1), a wording which appears less likely to have discouraged business service firms from responding positively.

The fact that firms in this group report a significantly higher proportion of 1995 sales made up of "upgraded products" than firms in all other groups suggests that business service firms which are innovative but do not introduce novel innovations regard a significantly larger proportion of their sales as consisting of upgraded products by comparison with firms in other clusters. If correct, then this would help to account for the low proportion of firms in Cluster 5 which reported product innovations in the period 1986-91. In 1991, firms were asked whether or not they had introduced any major innovations in products or services in the last 5 years. If, as it appears, product/service innovation in this group tends to be incremental in nature, then one would not expect a high proportion of these firms to have reported "major innovations" in products or services.

Cluster 1 firms are distinctive in being larger on average than others and significantly so compared with all other groups except those in Cluster 3. They also have the highest proportion of firms which export and the highest proportion of firms with serious overseas competitors. Somewhat contrary to expectations, Cluster 1 firms are not the most likely to be in high technology industries, with only 16.2% in these industries. Instead, Cluster 2 firms are most likely to be in high technology industries (24.1%), followed by those in Clusters 4 (20.6%) and 5 (19.4%). Another distinctive feature of Cluster 2 firms is that on average they are the youngest and smallest of the novel innovating firms, i.e. those in Clusters 1, 2 and 3. Cluster 1 and 2 firms are roughly twice as likely as Cluster 3 firms to report serious overseas competitors and are also more likely than Cluster 3 firms to be exporters.

In summary then, it appears that the cluster analysis has identified groups which are distinctive not only with respect to the variables that were used in the cluster analysis, but also with respect to other variables which have been shown to be significant determinants of innovation. The next step is to evaluate the extent to which these groups rely on different types of input to their innovation activities.

4. Innovation Inputs in Different Types of SME Innovators

This section investigates the extent to which the importance of key inputs to innovation activity varies across different types of innovating firm as defined by the cluster analysis of innovation output. Two types of variable on innovation inputs are included in the univariate analysis. Firstly, there are variables which measure the capacity for technology development within the firm, as indicated both by the level of R&D activity and the level of technological skill. A primary indicator of whether or not the firm is engaged in R&D is whether or not they report staff engaged in R&D either full or part time in the financial year ending in 1995. Another binary variable, indicating whether or not a firm is engaged in R&D on a continuous as opposed to occasional basis provides a measure of the degree of formality in a firm's R&D activity. A firm engaged in R&D on a continuous basis, for example, is more likely than one which occasionally engages in R&D to have an established R&D department. R&D intensity is measured by the proportion of staff in full time R&D and the proportion of turnover in the financial year ending in 1995 spent on R&D. Both measures are useful as there may not be a perfect correlation between them due, for example, to variation across industries in the proportion of R&D costs due to capital expenditure and to inter-firm variation in the use of external R&D services.

Three variables provide an indication of the technological skills within the firm, namely the proportion of staff who are technicians or lower professionals, the proportion of staff who technologists, scientists or higher professionals and whether or not the firm entered into a formal or informal collaborative partnership in the period 1992-95. The first two measures are not without problems as indicators of technical skill. In addition to including occupations with formal technical qualifications such as technicians, technologists and scientists, both variables also include occupations which do not necessarily involve technical qualifications, namely lower and higher professionals which might include sales personnel, accountants as well as other managerial staff without technical qualifications. The reason for including the latter as an indicator of technological skill is that firms are only likely to enter into collaborative agreements if each participant believes that what they can contribute in terms of technical expertise can at least be matched by the other partners. It should be noted, however, that not all of such collaborative agreements exist for the purpose of technology development. Nevertheless, around two-thirds of the collaborating firms in this sample report that expanding the range of expertise or products offered to customers was an important reason for their collaboration (Kitson and Wilkinson 1996).

Archibugi et al. (1997) have demonstrated that amongst manufacturing firms in Italy, non-R&D innovation expenditures including design, tooling-up and trial production and investment in new equipment tend to be of greater importance to innovation than R&D expenditure, particularly amongst smaller firms. Unfortunately, the questions on these aspects of innovation spending in the CBR survey suffer from high item non-response and were excluded from this analysis.

Secondly, the analysis includes variables which measure whether or not relationships with external organisations are made use of in the process of developing new products or processes. These are all binary variables arising from questions asked in the 1991 survey. The 1995 survey did include a question which asked respondents to rate the importance of information from external organisations on a Lïkert scale. In theory, the latter should provide more precise and up to date information on the importance of information from the different external sources than the 1991 binary variables. However, respondents which reported neither a product nor a process innovation in the 1995 survey were instructed not to answer the question on the use of information from external sources. Thus, if the Lïkert scale variables had been included, all of non-innovating firms in the 1995 survey would have had to be excluded from the analysis. Even without the use of the Lïkert scale variables, missing values for one or more of the other variables on innovation inputs meant that 158 of the 600 firms which were included in the cluster analysis had to be excluded from the analysis of inputs, leaving a total of 442 firms that could be included.

Table 5 provides a univariate analysis of the importance of different innovation inputs across the clusters of innovator type. The table indicates significant differences in the importance of most of the innovation inputs across the categories of innovator type. A striking feature of the table is the distinctiveness of Cluster 6 firms. They are significantly less likely than firms in all other clusters to have any staff engaged in R&D and the probability of them having any staff engaged in R&D (18%) is four times lower than the average for the other groups of firm (71%). Cluster 6 firms are also significantly less likely than firms in all other groups to be engaged in R&D on a continuous basis; the probability (8%) is more than six times below the average for firms in the other clusters (50%). Moreover, firms in Cluster 6 are significantly less likely than firms in other groups to have entered into collaborative agreements, the probability (17%) being more than three times lower than for all firms (57%). In addition, Cluster 6 firms spend the lowest proportion, on average, of turnover on R&D (1.2%) as opposed to 3.4% for firms in Clusters 1-5. Finally, Cluster 6 firms tend to have a lower proportion of technically skilled staff than firms in other clusters. Within the clusters which report substantial innovation output, Cluster 5 firms are something of an exception, with a significantly lower incidence and intensity of R&D activity.

While the low incidence and intensity of R&D activity as well as the below average proportion of technically skilled staff amongst the Cluster 6 firms may not be entirely surprising, the results clearly indicate that firms which report substantial innovative output, i.e. those in Clusters 1-5, have a significantly greater capacity for technology development by comparison with Cluster 6 firms which report negligible innovation output. This finding challenges the view that small firm innovation can be characterised by a look in the suggestion box.

An interesting question is whether there are identifiable differences between firms which produce original or novel innovations and those which simply imitate innovations developed elsewhere. In other words, are there clear differences between Clusters 1-3 and Clusters 4 and 5? As noted above, Cluster 5 appears to be significantly less R&D intensive than other innovating firms. This leaves the question of whether or not there are significant differences between Clusters 1-3 and Cluster 4. Within Clusters 1-4, the group which appears to be the least R&D intensive by most measures is Cluster 3, rather than Cluster 4. Although firms in Cluster 3 are not generally less likely than other innovating firms to have staff engaged in R&D, they tend to have a considerably lower proportion of staff engaged full time in R&D as well as a significantly lower proportion of staff who are higher professionals by comparison with those in Clusters 1, 2, 4 as well as those in Cluster 5. It appears, therefore, that firms which focus exclusively on novel process innovations are not more R&D intensive than firms which introduce non-novel innovations. However, there is some evidence that firms introducing novel product innovations are associated with higher R&D intensity. Firms in Clusters 1 and 2 have a higher proportion of staff in full time R&D, spend a higher proportion of turnover on R&D and have a higher proportion of staff who are technologists, scientists or higher professionals by comparison with those in Cluster 4.

Turning now to the use of information from outside organisations for the purposes of innovation, it can be seen that the use of information from universities is largely a feature of innovating firms. Amongst firms in Clusters 1-4, 23% use information from universities in their innovative activity as opposed to 7% in Cluster 6. Despite containing innovative firms, Cluster 5 is again an anomaly with only 4% of firms in the group using information from universities. If, as seems likely, the use of information from universities is a distinguishing feature between innovative and non-innovative SMEs, then the suggestion that the links between universities and the SME sector as a whole have weakened over the last five years (see Moore 1996) should be a matter of concern to policymakers. Cluster 1 firms are significantly more likely than all others to rely on university links in their development of new products or processes with over 50% of firms in this cluster using information from universities. Unlike firms in any other cluster, those in Cluster 1 are more likely to use information from universities than from any other source in developing new products or processes. As Cluster 2 firms are less likely than Cluster 4 firms to make use of information from universities, the use of information from universities does not appear to be a specific characteristic of novel product innovation.

In all other clusters than Cluster 1, the most important source of information for innovation is suppliers or customers. Cluster 4 firms are the most likely of any group to rely on information from suppliers and customers with over 70% of firms in this group using information from these sources. In all other clusters, around 50% or fewer of firms use information from suppliers or customers. Another important source of information for all groups is trade or professional journals and once again, firms in Cluster 4 are the most likely to use information from this source.

5. Conclusion

The most outstanding feature of the pattern of inputs to innovation in the SME sector is the sharp contrast between firms in Cluster 6 which report negligible innovation output and those which report substantial innovation output, i.e. those in Clusters 1-5. By comparison with firms reporting negligible innovation output, those with substantial innovation output are significantly different in their use of innovation inputs; the latter are significantly more likely than the former to have any staff engaged in R&D, to be engaged in R&D on a continuous as opposed to occasional basis and to enter into collaborative agreements. While fewer than 20% of Cluster 6 firms report staff engaged in R&D, over 70% of firms in Clusters 1-5 have staff engaged in R&D activity. And while 50% of firms in Clusters 1-5 engage in R&D on a continuous basis, only 8% of Cluster 6 firms do so. Cluster 6 firms spend 1.2% of turnover on R&D on average by comparison with 3.4% for the other clusters. Firms in Clusters 1-5 tend also to have a higher proportion of staff who are technically skilled than those in Cluster 6. Finally, it appears that Cluster 6 firms are significantly less likely than innovative firms to make use of information from outside sources including universities as well as suppliers and customers for the purposes of innovation. While this may simply reflect the fact that Cluster 6 firms are less likely to be engaged in innovation activity at all and hence that they are not seeking information for innovation, it could also mean that attempts to innovate in these firms are less likely to succeed due to the fact that they do not consult widely enough amongst external organisations. These results all point towards the conclusion that the innovation output reported by firms in Clusters 1-5 is not simply the result of "a look in the suggestion box", but is rather the result of a considerable depth of costly innovative activity involving both internal and external searches for new technologies.

Amongst those SMEs which report substantial innovative output, there is considerable variation in the nature of innovative activity, both in terms of their characteristics and the inputs to and outputs from innovation. Cluster 5 is a distinctive group, containing a uniquely high proportion of business service firms. Innovation output in this group appears to be characterised by incremental innovation. Regarding inputs to innovation, Cluster 5 firms are less R&D intensive and are less likely to make use of information from outside organisations by comparison with all other clusters of innovating firm. There also appear to be important differences between novel innovator firms, i.e. those which report novel product innovations, novel process innovations or both, and the main group of non-novel innovators, namely Cluster 4. In terms of their innovative output, novel innovators tend to report a higher proportion of sales consisting of new products and a lower proportion of sales consisting of upgraded products, though these differences are not generally significant. In terms of the inputs to innovation, novel innovators are less likely to rely on information from suppliers and customers as well as from trade or professional journals for their innovation than non-novel innovators. Firms which introduce novel product innovations also tend to be more R&D intensive than non-novel innovators, spending a higher proportion of turnover on R&D and having a significantly higher proportion of staff who are technologists, scientists or higher professionals.

In terms of policy implications, it seems clear that policies which support the transfer of knowledge and skills to SMEs are likely to promote the incidence and extent of innovative activity in the sector. The Teaching Company Scheme, for example, which enables the employment of graduate engineers and scientists in SMEs is likely to have a positive impact on the capacity of SMEs to innovate. The evidence suggests that, by increasing the level of technical skill within a firm, this scheme would appear to have the potential to increase the probability either that the firm will innovate or that the firm will introduce a novel innovation. In addition, it is possible that the employment of people direct from university may promote the ongoing exchange of information and the transfer of technology between universities and firms which is also likely to promote SME innovation. In addition, measures that enable smaller firms to sustain adequate levels of R&D expenditure, such as those governing the rate of relief on capital expenditures for R&D (e.g. the Scientific Research Allowance) are likely to be important means to promote innovation in the SME sector. R&D appears to be a vital input to innovation not only in SMEs which introduce novel innovations. Even firms which do not report novel innovation are engaged in substantial R&D expenditure.

Notes

1. A more detailed analysis of the industrial classification of firms in the different clusters is shown in Appendix 4. It generally reinforces the view that most industries contain a wide variety of innovator types.

DIAGRAM AND TABLES

Diagram 1: Comparison of Innovation Types across Different Clustered Sets

Authors	Pavitt et al.		Archibugi et al.		Cesaratto et al.
innovator types	supplier dominated	→	producers of traditional consumer goods	→	cost oriented
					marketing oriented
			suppliers of traditional intermediate goods		investment based
	specialised equipment suppliers	→	specialised suppliers of intermediate goods and equipment		complex innovators
	scale-intensive	→	mass production assemblers		design based
	science based	→	R&D based		R&D based

Table 1: Descriptive Statistics of Clusters of Innovating and Non-Innovating Firms

Variable name	Mean value (and standard deviation) Cluster 1 (n=38) a	Cluster 2 (n=87) b	Cluster 3 (n=43) c	Cluster 4 (n=160) d	Cluster 5 (n=93) e	Cluster 6 (n=179) f	**All firms (n=600)**
product innovation 1986-91	0.89^{cef}	0.78^{ef}	0.58^{f}	0.89^{cef}	0.37	0.34	**0.60**
	(0.31)	(0.42)	(0.50)	(0.32)	(0.48)	(0.47)	**(0.49)**
process innovation 1986-91	0.63^{ef}	0.51^{ef}	0.67^{ef}	0.95^{abcef}	0.03	0.30^{e}	**0.51**
	(0.49)	(0.50)	(0.47)	(0.21)	(0.18)	(0.46)	**(0.50)**
product innovation 1992-95	1.0^{cdef}	1.0^{cdef}	0.40^{f}	0.79^{cef}	0.65^{cf}	0.08	**0.57**
	(0.0)	(0.0)	(0.49)	(0.41)	(0.48)	(0.28)	**(0.50)**
process innovation 1992-95	1.0^{bdef}	0.28^{f}	1.0^{bdef}	0.69^{bf}	0.62^{bf}	0.11	**0.49**
	(0.0)	(0.45)	(0.0)	(0.47)	(0.49)	(0.32)	**(0.50)**
product innovation 1992-95	0.95^{cdef}	0.82^{cdef}	0.09	0.11^{f}	0.03	0.0	**0.22**
(new to your industry)	(0.23)	(0.39)	(0.29)	(0.31)	(0.18)	(0.0)	**(0.41)**
product innovation 1992-95	0.97^{bcdef}	0.79^{cdef}	0.12	0.06	0.10^{f}	0.0	**0.22**
(new to all industries)	(0.16)	(0.41)	(0.32)	(0.23)	(0.30)	(0.0)	**(0.41)**
process innovation 1992-95	0.89^{bcdef}	0.0	0.72^{bdef}	0.03	0.02	0.0	**0.11**
(new to your industry)	(0.31)	(0.0)	(0.45)	(0.17)	(0.15)	(0.0)	**(0.31)**
process innovation 1992-95	0.82^{bcdef}	0.0	0.70^{bdef}	0.01	0.01	0.0	**0.12**
(new to all industries)	(0.39)	(0.0)	(0.46)	(0.11)	(0.10)	(0.0)	**(0.33)**
upgraded products as % 1995 sales	28.6^{f}	19.2^{f}	15.8^{f}	29.7^{bcf}	48.1^{abcdf}	4.9	**22.6**
	(21.1)	(20.5)	(13.7)	(25.8)	(28.9)	(8.7)	**(25.4)**
new products as % 1995 sales	23.5^{def}	18.8^{ef}	17.1^{f}	15.0^{f}	11.7^{f}	2.7	**12.0**
	(21.4)	(19.8)	(21.0)	(16.2)	(15.5)	(10.0)	**(17.2)**

The superscripted letters indicate a significant difference in the mean value for a particular variable between two clusters. Significance is measured at the 5% level in all cases and was calculated using the Bonferroni One Way ANOVA test. A superscripted "d" next to a mean value, for example, indicates that that mean value is significantly higher than the mean value in Cluster 4.

Cluster 1 "product and process originators", Cluster 2 "product originators", Cluster 3 "process originators", Cluster 4 "product and process imitators", Cluster 5 "incremental product and process imitators", Cluster 6 "occasional imitators"

Table 2: The "Between-Groups" Distances Between Clusters

	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Cluster 1	-/-/-/x/-/x/-/-	x/-/x/-/x/x/-/-	-/x/x/x/x/x/-/x	x/x/x/x/x/x/x/x	x/x/x/x/x/x/x/x
Cluster 2		-/-/x/x/x/x/-/-	-/x/x/x/x/-/x/-	x/x/x/x/x/-/x/x	x/x/x/x/x/-/x/x
Cluster 3			-/x/x/x/-/x/x/-	-/x/x/x/-/x/x/-	x/x/x/x/-/x/x/x
Cluster 4				x/x/x/-/-/-/x/-	x/x/x/x/x/-/x/x
Cluster 5					-/x/x/x/-/-/x/x

An "x" indicates a significant difference between two cluster groups with respect to a particular variable. A "-" indicates that the difference between two cluster groups with respect to a particular variable is not significant. Each cell shows the significance of differences between two cluster groups with respect to eight variables, in the same order as they are presented in Table 1. Two variables were excluded from Table 2, namely "Product innovation 1992-95 (new to all industries)" and "Process innovation 1992-95 (new to all industries)" as the differences with respect to these variables were almost identical to "Product innovation 1992-95 (new to your industry)" and "Process innovation 1992-95 (new to your industry)", respectively.

Cluster 1 "product and process originators", Cluster 2 "product originators", Cluster 3 "process originators", Cluster 4 "product and process imitators", Cluster 5 "incremental product and process imitators", Cluster 6 "occasional imitators"

Table 3: Proportion of Sample Across Clusters (%)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	**Total**
Proportion of all firms	6.3	14.5	7.2	26.7	15.5	29.8	**100**
Proportion of firms in Clusters 1,2,3,4,5	9.0	20.7	10.2	38.0	22.1	-	**100**

Cluster 1 "product and process originators", Cluster 2 "product originators", Cluster 3 "process originators", Cluster 4 "product and process imitators", Cluster 5 "incremental product and process imitators", Cluster 6 "occasional imitators"

Table 4: Univariate Analysis of the Characteristics of Innovator Types

	Mean value or percentage						
	Cluster 1 (n=32) a	Cluster 2 (n=80) b	Cluster 3 (n=41) c	Cluster 4 (n=144) d	Cluster 5 (n=84) e	Cluster 6 (n=145) f	**All firms (n=526)**
Average number of employees (1990)	120.8[bdef]	59.7	76.0	66.3	35.1	43.3	**61.5**
Average age	37.1[e]	27.4	36.9[e]	37.0[e]	18.3	29.9	**30.1**
% manufacturing (vs business services)	59.5[e]	57.5[e]	60.5[e]	65.6[e]	29.0	57.3[e]	**55.0**
% high technology industry (vs low tech)	16.2	24.1[f]	9.3	20.6[f]	19.4	8.4	**16.0**
% firms exporting (1991)	74.5[cef]	54.9[ef]	40.5	48.7[f]	30.3	30.7	**42.0**
% firms with serious overseas competitors	48.7[f]	43.4[f]	23.8	35.7[f]	28.4	15.6	**29.0**

The superscripted letters indicate a significant difference in the mean value for a particular variable between two clusters. Significance is measured at the 5% level in all cases and was calculated using the Bonferroni One Way ANOVA test. A superscripted "d" next to a mean value, for example, indicates that that mean value is significantly higher than the mean value in Cluster 4.

Cluster 1 "product and process originators", Cluster 2 "product originators", Cluster 3 "process originators", Cluster 4 "product and process imitators", Cluster 5 "incremental product and process imitators", Cluster 6 "occasional imitators"

Table 5: Univariate Analysis of Innovation Inputs Across Different Innovator Types

Survey year		Mean value Clusters 1 (n=30) a	2 (n=73) b	3 (n=35) c	4 (n=114) d	5 (n=72) e	6 (n=118) f	**All firms (n=442)**
1995	Firm engaged in continuous as opposed to occasional R&D	0.87^{bcdef}	0.51^{ef}	0.49^{f}	0.54^{ef}	0.29^{f}	0.08	**0.39**
1995	Any staff engaged in R&D either full or part time	0.97^{ef}	0.74^{ef}	0.83^{ef}	0.71^{ef}	0.51^{f}	0.18	**0.57**
1995	% staff in full time R&D	3.9	3.5	0.8	2.6	2.1	0.9	**2.2**
1995	% staff who are technicians or lower professionals (full time)	9.1	10.9	11.2	13.3	13.3	6.9	**10.7**
1995	% staff who are technologists, scientists or higher professionals (full time)	18.4^{c}	16.2^{cf}	2.9	10.3	13.8	7.1	**11.0**
1995	% of turnover in 1995 spent of R&D	4.0	4.3	2.1	3.8	2.2	1.2	**2.8**
1995	Firm entered formal or informal collaborative agreement	0.83^{ef}	0.59^{f}	0.53^{f}	0.56^{f}	0.47^{f}	0.17	**0.46**
1991	**Make use of following external sources of information for innovation:**							
1991	university/higher education	0.53^{bcdef}	0.16	0.17	0.21^{ef}	0.04	0.07	**0.16**
1991	private research institutions or consultants	0.47^{ef}	0.33^{f}	0.20	0.32^{f}	0.10	0.19	**0.25**
1991	government research establishments	0.07	0.15	0.09	0.11	0.03	0.08	**0.09**
1991	suppliers or customers	0.47	0.51	0.49	0.72^{ef}	0.38	0.39	**0.50**
1991	other firms	0.37	0.34^{f}	0.20	0.27	0.15	0.13	**0.23**
1991	trade or professional journals	0.47	0.44	0.34	0.56^{e}	0.31	0.39	**0.43**

The superscripted letters indicate a significant difference in the mean value for a particular variable between two clusters. Significance is measured at the 5% level in all cases and was calculated using the Bonferroni One Way ANOVA test. A superscripted "d" next to a mean value, for example, indicates that that mean value is significantly higher than the mean value in Cluster 5.

Cluster 1 "product and process originators", Cluster 2 "product originators", Cluster 3 "process originators", Cluster 4 "product and process imitators", Cluster 5 "incremental product and process imitators", Cluster 6 "occasional imitators"

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APPENDICES

APPENDIX 1: The Questionnaire Approach to Innovation

Innovation questions in the 1995 Survey

In this section we would like you to tell us about your innovative activity. We are interested in innovation in products and processes which are ***new to your firm.***

In answering the questions in this section, please count innovation as occurring when a new or changed product is introduced to the market (product innovation) or when a new or significantly improved production method is used commercially (process innovation), and when ***changes*** *in knowledge or skills, routines, competence, equipment, or engineering practices are required to make the new product or to introduce the new process.*

Please do ***not*** *count as product innovation, changes which are purely aesthetic (such as changes in colour or decoration), or which simply involve product differentiation (that is minor design or presentation changes which differentiate the product while leaving it technically unchanged in construction or performance).*

A1 Has your firm introduced any innovations in products (goods or services) or processes during the last three years which were new to your firm? *(Please tick only* ***one*** *box in* ***each*** *row)*

	Yes	No
Products		
Processes		

If you ticked No for <u>both</u> products <u>and</u> processes please skip A2-A6 and move onto question A7.

A2 If you introduced a product innovation, was it, to the best of your knowledge, already in use in other firms either in (a) your industry or (b) other industries? If you made more than one product innovation please answer with respect to your most important product innovation. *(Please tick only* ***one*** *box in* ***each*** *row)*

Product Innovation	Yes	No	Don't Know
(a) in use in your industry			
(b) in use in other industries			

A3 If you introduced a process innovation was it, to the best of your knowledge, already in use in other firms either in (a) your industry or (b) other industries? If you made more than one process innovation please answer with respect to your most important process innovation. *(Please tick only **one** box in **each** row)*

Process Innovation	Yes	No	Don't Know
(a) in use in your industry			
(b) in use in other industries			

A4 How were your firm's **total** sales in the last financial year distributed across the following types of products?

Products which were essentially technically unchanged in the last three years	%
Products whose technical characteristics have been enhanced or upgraded in the last three years	%
Newly-marketed products whose intended use, performance characteristics, technical construction, design, or use of materials and components was new or substantially changed in the last three years	%
Other products (Please specify):	%
Total sales last year	100%

Innovation question in the 1991 Survey

F1. Has your firm been successful in introducing any major innovations during the **last 5 years**? tick as appropriate

	Yes	No
In products or services		
In production processes		
In work practices, or workforce organisation		
In supply, storage or distribution systems		
In administration and office systems		

APPENDIX 2: Testing the Suitability of the Variables for the Pre-Clustering Principal Component Analysis

Explanation of variables used in the pre-clustering principal component analysis

Variable	Description	Values
PRCUSE31	process innovation 1992-95 (new to your industry)	1 yes, 0 no
PRCUSE32	process innovation 1992-95 (new to all industries)	1 yes, 0 no
PRDUSE31	product innovation 1992-95 (new to your industry)	1 yes, 0 no
PRDUSE32	product innovation 1992-95 (new to all industries)	1 yes, 0 no
PROC1C	process innovation 1986-91	1 yes, 0 no
PROD1C	product innovation 1986-91	1 yes, 0 no
PROC3	process innovation 1992-95	1 yes, 0 no
PROD3	product innovation 1992-95	1 yes, 0 no
SALPC32	upgraded products as % 1995 sales	%
SALPC33	new products as % 1995 sales	%

Kaiser-Meyer-Olkin Measure of Sampling Adequacy =.70659

Bartlett Test of Sphericity = 1365.8974, Significance = .00000

Anti-image Correlation Matrix:

	PRCUSE31	PRCUSE32	PRDUSE31	PRDUSE32	PROC1C	PROD1C	PROC3	PROD3	SALPC32	SALPC33
PRCUSE31	.65779									
PRCUSE32	-.53186	.63758								
PRDUSE31	-.22602	.09824	.71189							
PRDUSE32	.07045	-.25785	-.48290	.70672						
PROC1C	-.02062	.02465	.02377	.00600	.63599					
PROD1C	-.05005	.02106	-.09147	-.01634	-.39849	.71146				
PROC3	-.21030	-.17328	.06358	.05854	-.11959	.03204	.75391			
PROD3	.08041	.08572	-.22134	-.23944	-.09892	-.11823	-.18575	.77613		
SALPC32	.01275	.01519	.02751	.00651	.09535	-.15213	-.14882	-.16172	.67284	
SALPC33	-.03208	-.07452	-.06610	-.02026	.00669	-.06856	-.04435	-.15398	-.00703	.88793

Measures of Sampling Adequacy (MSA) are printed on the diagonal.

Factor Matrix:

	Factor 1	Factor 2	Factor 3	Factor 4
PRCUSE31	.59177	-.61075	.10417	-.12232
PRCUSE32	.55823	-.65927	.03896	-.08787
PRDUSE31	.69277	.16118	-.47345	-.08601
PRDUSE32	.68916	.09969	-.49902	-.05869
PROC1C	.39296	.35465	.53405	-.47711
PROD1C	.51683	.44299	.38103	-.23393
PROC3	.50743	-.33144	.43274	.24107
PROD3	.65533	.40533	-.13118	.19176
SALPC32	.29733	.20270	.28394	.77290
SALPC33	.47068	.04900	-.07719	.11061

Final Statistics:

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
PRCUSE31	.74902	*	1	3.03511	30.4	30.4
PRCUSE32	.75550	*	2	1.48322	14.8	45.2
PRDUSE31	.73747	*	3	1.20700	12.1	57.3
PRDUSE32	.73735	*	4	1.02037	10.2	67.5
PROC1C	.79304	*				
PROD1C	.66326	*				
PROC3	.61272	*				
PROD3	.64772	*				
SALPC32	.80748	*				
SALPC33	.24213	*				

APPENDIX 3: Results of Cluster Analysis Using 4 Factors Identified in Appendix 2

Final Cluster Centers

Cluster	FAC1_1	FAC2_1	FAC3_1	FAC4_1
1	1.6545	2.2389	.0089	-.2061
2	1.6851	-.7260	-.0151	-.3321
3	-.5932	2.2195	.1457	-.2737
4	-.3068	-.2074	.9909	.4969
5	-.2264	-.2335	-.8866	1.2430
6	-.6359	-.3489	-.4546	-.8191

Number of Cases in each Cluster

Cluster	Unweighted Cases	Weighted Cases
1	38.0	38.0
2	87.0	87.0
3	43.0	43.0
4	160.0	160.0
5	93.0	93.0
6	179.0	179.0
Missing	0	
Valid cases	600.0	600.0

APPENDIX 4: Innovator Types by Industry

Industry	Column percentages						
	Cluster 1 (n=37)	Cluster 2 (n=87)	Cluster 3 (n=43)	Cluster 4 (n=160)	Cluster 5 (n=93)	Cluster 6 (n=178)	**All firms (n=598)**
Metals	5.4	5.7	4.7	8.1	3.2	2.8	**5.0**
Chemicals	13.5	5.7	7.0	4.4	6.5	4.5	**5.7**
Mechanical engineering	27.0	18.4	16.3	20.0	10.8	17.4	**17.7**
Electrical engineering	8.1	11.5	4.7	9.4	3.2	2.8	**6.4**
Food processing	2.7	2.3	4.7	1.9	0.0	2.8	**2.2**
Textiles, clothing, footwear	0.0	5.7	11.6	5.0	2.2	9.0	**6.0**
Timber and furniture	0.0	2.3	4.7	6.9	1.1	6.7	**4.7**
Paper and pulp	2.7	5.7	7.0	10.0	2.2	11.2	**7.9**
All manufacturing	**59.5**	**57.5**	**60.5**	**65.6**	**29.0**	**57.3**	**55.0**
Management consulting & advertising	21.6	19.5	25.6	13.1	45.2	29.2	**25.3**
Technical and professional consulting	18.9	20.7	11.6	20.6	20.4	10.1	**16.7**
Other business services	0.0	2.3	2.3	0.6	5.4	3.4	**2.5**
All business services	**40.5**	**42.5**	**39.5**	**34.4**	**71.0**	**42.7**	**45.0**

Cluster 1 "product and process originators", Cluster 2 "product originators", Cluster 3 "process originators", Cluster 4 "product and process imitators", Cluster 5 "incremental product and process imitators", Cluster 6 "occasional imitators"