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Innovation Outputs in the Norwegian Economy: How Innovative are Small Firms?

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1. Introduction

This paper is a quantitative analysis of the pattern of innovation outputs in the Norwegian economy, looking at the extent to which SMEs are more or less innovative than larger firms. We show that this is not a simple question. It requires careful empirical analysis:, since the answers depend to a considerable extent on how one interprets the relevant indicators, and on how we categorise different size classes of companies.

The paper is based on an analysis of data from the Norwegian Innovation Survey of 1993. We explore innovativeness in terms of the development and sale of new products, looking at the role of different firm sizes, and at the sectoral distributions of innovative activity among small firms.

To anticipate the analysis below, we show that

- on a broad definition, larger firms (>100 employees) are generally more innovative than smaller firms (<100 employees)
- with a finer size classification, this applies only to firms with less than 60 employees; the 60-99 category is very much in line with larger firms
- however there is considerably more variation in innovative activity among smaller firms than among larger firms - innovation is very asymmetrically distributed in small firms, with much more apparent diversity, and with many non-innovative firms. This means that those SMEs which actually are innovative are often more innovative than larger firms.
- there is substantial variation in the innovation performance of small firms across industries, but there are no industries where small firms are particularly important in terms of generating new products; there are no clear 'SME branches' in the economy, and SMEs are important across the whole industrial spectrum.
- new product sales from SMEs are generally much higher in 'traditional' branches of the economy than in the so-called 'high-tech' sectors.

SMEs in the Norwegian economy

The Norwegian economy, and particularly the manufacturing sector, has traditionally had two distinguishing features: a predominance of industries engaged in processing of Norway's abundant raw materials, and a predominance of small firms. However since the late 1970s a new and in many ways dominating feature has emerged, namely the oil economy. This has led to significant structural change in the economy, mainly because an appreciating exchange rate has led to the decline of a number of labour-intensive industries, a change which has also had implications for the regional distribution of industry.

It has been widely recognised since the beginning of the oil economy that the only viable long-term adjustment both to the growth of the oil sector and to its ultimate decline must involve raising the technological level of the non-oil economy. Non-protected labour-intensive manufactures were doomed in Norway, and there has indeed been a sharp and continuing fall in manufacturing employment, especially in industries such as furniture, shoes and clothing. Given that large Norwegian firms were usually concentrated in stable or stagnant industries, this meant a need to promote and/or support the creation of new firms and measures for the support of the technological bases of such firms have been a long-standing feature of the Norwegian policy scene.

However there has been persistent debate as to how this objective of technological advance should be reached. Should it involve the active promotion of such high-tech sectors as IT? On the other hand, should it involve the technological improvement of low-tech but high-employment sectors such as food products? In Norway, as in many other countries, there are those who argue that policy should focus only on allegedly fast-growing high-tech sectors where innovation is concentrated. But how accurate is this, especially in terms of innovation by SMEs? This question ought to form an important framework for policy debate principally because the numbers of firms, and the levels of employment, are significantly higher in so-called low-tech or 'traditional' industries in Norway than in high-tech industries.

The Norwegian manufacturing sector is based on what are usually regarded as low-tech activities. With the exception of machinery - which in Norway has a close connection to maritime activities - the high-tech sectors are extremely small. ISIC 3825 ('Office machinery and equipment'), probably the most R&D-intensive sector outside pharmaceuticals, has an absolute total of 1100 employees, less than 300 of whom are in small (<100 employees) firms. Pharmaceuticals has about 2200 employees, with about a third in SMEs. Food products, on the other hand, has nearly 44,000 employees, of whom 80% work in small firms. Timber products has nearly 14000 employees, again with about 80% in small firms. For the overall health of the Norwegian economy, therefore, much depends on the innovation performance of these industries, and particularly on the performance of small firms within these branches. This paper looks empirically at such questions: first at the performance of small firms generally, and then at their performance across sectors.

Data and definitions

In this paper we use data from the Norwegian innovation survey of 1993 concerning innovation and innovation activities in small and medium sized enterprises in manufacturing.

For the purposes of this note, we will use both simple and more complex definitions of small and medium sized enterprises. At the simplest level, small and medium sized enterprises will here simply refer to firms with less than 100 employees; these will be compared to firms with 100 employees or more. However in addition to this we will also subdivide these two size categories further, using a classification with altogether six size categories.

We have a sample containing some 950 Norwegian manufacturing firms. In relation to the population of all Norwegian manufacturing firms, large firms are generally better represented than small firms. In what follows we will describe and analyse the sample we actually have. Later on we draw inferences to the population on the basis of the results from the sample and on the assumption that the firms in different categories in the sample are representative of the firms in the population in the same categories. But, to repeat, in what follows we limit our analysis to the firms in the sample and do not try to draw inferences concerning the population.

We focus both on innovative and non-innovative firms. That is, we limit our analysis to the firms for which we have both information on the size of different types of innovation costs and information on the share of the sales of the firm accounted for by products which are new to the firm, and also information on the share of the sales of the firm accounted for by products which are new not only to the firm in question, but also to the industry in which the firm operates. We include firms which give zero answers (to, say, the proportion of new products in sales) and exclude only firms which have not responded to these questions. This leaves us with a sample of 848 firms for the analyses that follow.

Of these 848 firms in our sample, 648 firms or 76.4 per cent of the firms have less than 100 employees, which leaves 200 firms or 23.6 per cent of the firms with 100 or more employees. In this sense, the small and medium sized firms thus dominate the sample. However, in terms of their shares of employment and of sales, the picture is reversed, as Table 1, below, shows.

Table 1. **Share of firms, employment and sales by firms with less than 100 and with 100 or more employees**.

number of employees	number of firms	share of firms, %	share of employ-ment, %	share of sales, %
less than 100	648	76.4	19.6	16.6
100 or more	200	23.6	80.4	83.4
Total	848	100	100	100

Thus, while the firms with less than 100 employees account for 76.4 per cent of the firms in the sample, they account for only 19.6 per cent of employment and 16.6 per cent of the production, as measured by sales, in the sample. Remember that in our sample the large firms are better represented than the small, so that in the population the shares of the small firms would be somewhat higher on all three items than the figures shown here for the sample.

2. Innovation activity in small vs large firms: an overview

How important are SMEs with respect to innovation in Norwegian manufacturing industry? Let us distinguish between two different aspects of innovation. The first aspect is innovation activities, the second is the result of these activities. Innovation activities are activities which aim at product or process innovations. The extent of such activities in a firm obviously tells us something about the extent of innovation in a firm. But it seems equally obvious that these kinds of activities may be more or less successful, and so we also would like to measure the results of such activities.

We concentrate here on the results of innovation activities. The measure we use is the share of the sales of the firm accounted for by products which are new to the firm. This is defined specifically as the share of the sales in 1992 which was accounted for by products which were new to the firm or were changed during the three year period 1990-1992. We have two different categories, or degrees, of product innovations. One covers less radical, incremental innovations, defined as products which underwent minor changes during 1990-1992. The other covers the more radical innovations, defined as products which were new to the firm or substantially altered during the same period.

The sum of the radical and the incremental innovations constitute all product innovations, whether radical or incremental. All product innovations, or all new products, are our point of departure. This category can be subdivided. In addition to the distinction already mentioned, between radical and incremental innovations, we also use another distinction between, on the one hand, products which are new to the firm but not to the industry in which the firm operates, and, on the other hand, products which are new also to the industry in which the firm operates.

In the following we will look at the share of the sales of each firm accounted for by (1) radical innovations, (2) incremental innovations, (3) new products of any kind, whether radical or incremental innovations, and (4) products which are new also to the industry in which the firm operates.

Let us first very simply distinguish between firms whose sales contain new products and firms whose sales do not contain new products in these different senses. Table 2 below, shows the number of firms in the two main size categories whose sales contain new products according to the above four definitions.

Table 2. **Number and percentage of firms whose sales contain new products, by firm size**.

		Number, and percentage, of firms with:			
number of employees	N	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 100	648	115 (17.7%)	109 (16.8%)	135 (20.8%)	86 (13.3%)
100 or more	200	938 (46.5%)	104 (52%)	114 (57%)	85 (42.5%)
Total	848	208 (24.5%)	213 (25.1%)	249 (29.4%)	171 (20.2%)

Clearly, a much larger share of the firms have product innovations among the larger firms than among the smaller ones. Thus, while among the firms with 100 employees or more, 57 per cent of the firms have some kind of product innovations, only 20.8 per cent of the firms with less than 100 employees do. For all definitions of product innovations, the difference between large and small firms are substantial in this respect.

This means that the firms with less than 100 employees make up a much smaller share of the firms with product innovations than of all firms. This is shown in Table 3, below.

Table 3. **Distribution of firms with product innovations, different definitions, across firm size categories (per cent)**.

	Share of	Share of the firms with:			
number of employees	all firms	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 100	76.4	55.3	51.2	54.2	50.3
100 or more	23.6	44.7	48.8	45.8	49.7
Total	100	100	100	100	100

To compare the relative ‘performance’ of each size category in terms of its share of the firms with innovations, let us, for each product innovation definition, divide the share of each size category of the firms with innovations with its share of all firms. This is done in Table 4, below.

Table 4. **Ratio of the size category's share of the firms with product innovations, different definitions, to share of all firms**.

		Ratio of share of the firms with innovation to share of all firms			
number of employees	All firms	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 100	1	0.72	0.67	0.71	0.66
100 or more	1	1.90	2.07	1.94	2.11
Total	1	1	1	1	1

We see that while the 100 or more employees size category generally has a share of the firms with product innovations which is twice its share of all firms, ranging from 1.90 to 2.11, the corresponding ratios for the less than 100 employees category range from 0.72 to 0.66. The less than 100 employees category perform better in terms of radical innovations than in terms of incremental innovations. This category also performs better in terms of all product innovations than in terms of products which are new also to the industry.

Let us now briefly look explicitly at the relationship between having radical innovations and having incremental innovations. Do firms which report radical innovations in general also report incremental innovations, or is there rather a general tendency for some firms to report radical innovations only and other firms to report incremental innovations only? This is shown in absolute numbers for all firms with product innovations in Table 5, below (this table is, of course, easily derived from Table 1, above).

Table 5. **Relationship between firms with radical innovations and firms with incremental innovations, absolute numbers. All firms with new products (N=249)**.

		radical innovations		
		no	yes	
incremental	no	0	36	36
innovations	yes	41	172	213
		41	208	249

Since we only include the firms with some kind of product innovation, there are, of course, no firms in the upper left cell in the table. At the margins we find the 249 firms with new products of any kind, the 208 with radical innovations and the 213

with incremental innovations. Of the 249 firms with product innovations a clear majority of 172, or almost 70 per cent, have both radical innovations and incremental innovations.

Let us now look at the relationship between firms which have radical innovations and firms which have incremental innovations for each size category separately. This is done in Tables 6 and 7, below, where we this time have expressed all frequencies as shares, in per cent, of all firms with product innovations in the size category (of course, these tables, too, are easily derived from Table 1, above).

Table 6. **Relationship between firms with radical innovations and firms with incremental innovations, per cent. Firms with new products, firms with less than 100 employees (N=135)**.

		radical innovations		
		no	yes	
incremental	no	0	19.3	19.3
innovations	yes	14.8	65.9	80.7
		14.8	85.2	100 (N=135)

Table 7. **Relationship between firms with radical innovations and firms with incremental innovations, per cent. Firms with new products, firms with 100 or more employees (N=114)**.

		radical innovations		
		no	yes	
incremental	no	0	8.8	8.8
innovations	yes	18.4	72.8	91.2
		18.4	81.6	100 (N=114)

Comparing the two tables, we find that of the firms in each size category which have product innovations, there is a larger share which have both radical innovations and incremental innovations among the large firms than among the small firms. Secondly, of the firms with one type of innovation only, there are more firms which have radical innovations only than incremental innovations only in the small firms category, while the opposite is true among the large firms, where twice as many firms have incremental innovations only as have radical innovations only.

We now turn to focus on the sales from new products, as distinct from focusing on a distinction between firms with and without product innovations. In Table 8, below, we show the share of the sales inside each size category accounted for by product innovations.

Table 8. **Share of sales, per cent, inside each size category accounted for by product innovations**.

Size categories		Share of all sales accounted for by:			
Number of employees	All sales	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 100	100	7.4	7.4	14.8	6.6
100 or more	100	8.6	12.0	20.6	8.4
Total	100	8.4	11.2	19.6	8.1

We see that according to all four definitions of product innovations, the share of the sales coming from product innovations is higher among the large firms than among the small firms. This is most pronounced in the incremental innovations case, while the radical innovations case is where the small firms come closest to the large. Notice that when we look at the shares of the sales accounted for by product innovations in the total and in each size category, the broad definition, new products of any kind, is simply the sum of radical innovations and incremental innovations, like it is for each individual firm.

The above shares mean that for all four definitions of product innovations, the firms with less than 100 employees have a smaller share of the sales from product innovations than they have of all sales. This is shown in Table 9, below.

Table 9. **Distribution of sales from product innovations, different definitions, across firm size categories (per cent)**.

	Share of	Share of the sales from:			
number of employees	all sales	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 100	16.6	14.5	11.0	12.5	13.5
100 or more	83.4	85.5	89.0	87.5	86.5
Total	100	100	100	100	100

These relative performances are also shown in Table 10 below, where we have divided the share of the sales from product innovations with the share of sales from all products.

Table 10. **Ratio of each size category's share of sales from product innovations to share of all sales, per cent**.

		Ratio of share of the sales from innovations to share of all sales			
number of employees	All sales	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 100	1	0.87	0.66	0.75	0.82
100 or more	1	1.02	1.07	1.05	1.04
Total	1	1	1	1	1

These ratios confirm that the small firms perform relatively best on radical innovations and relatively worst on incremental innovations. However, in all cases the ratio is less than 1, while, of necessity, it is more than 1 for the large firms.

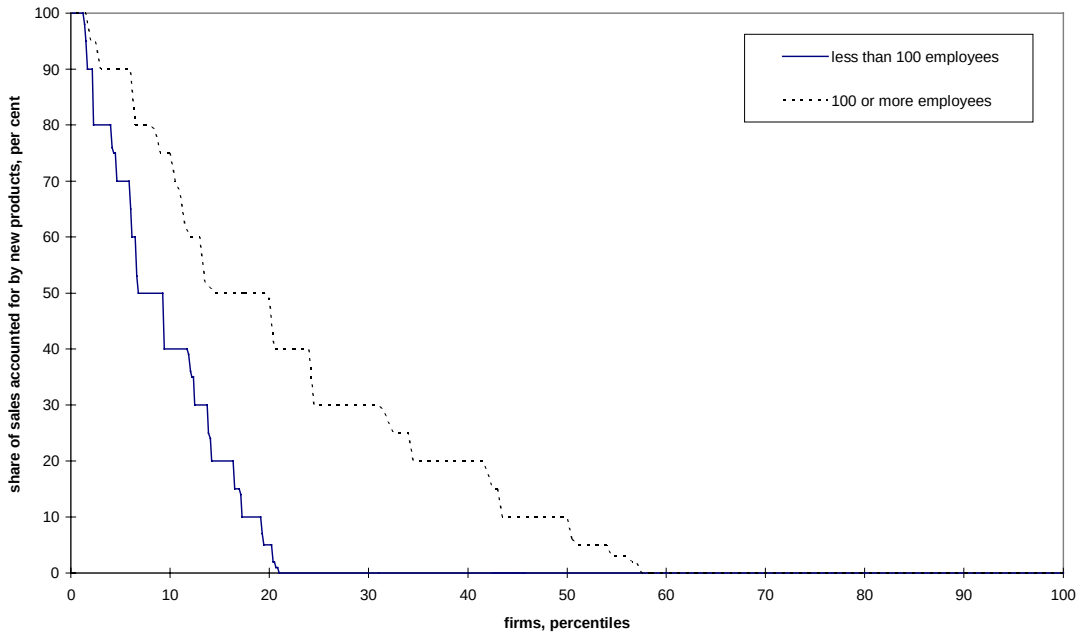
Thus, both in terms of number of firms and in terms of sales, the firms with less than 100 employees have a smaller share of firms with product innovations and of sales from product innovations, respectively, than of all firms and all sales, respectively. When we look at all firms in the sample, we find that in terms of number of firms the sample is dominated by firms with less than 100 employees, which account for 3/4 of all firms. The firms with less than 100 employees is still the largest group in terms of number of firms with product innovations, but here they are only slightly more numerous than the firms with 100 employees or more. In terms of all sales, however, the sample is to a large extent dominated by the large firm category, and this dominance is even more pronounced when it comes to sales from product innovations. On all four definitions, the firms with 100 employees or more account for more than 85 per cent of the sales from product innovations, the firms with less than 100 employees accounting for less than 15 per cent.

3. A first look at diversity: the distribution of innovative activity

When we have considered the share of sales accounted for by product innovations above, we have only looked at average share of sales accounted for by product innovations in each size category. Or, to be more precise, we have looked at the share of the sales accounted for by product innovations inside each size category as a whole, which means that we have been looking at the weighted averages inside each size category, where the weights are defined by the sales of each firm.

However, these (weighted) averages are averages of very unequal distributions, and these distributions, moreover, differ across size categories. This we have tried to show in Figure 1, below. The figure refers to share of sales accounted for by new products of any kind, i.e. the broad definition of product innovations. Inside each size category, the firms are ranked along the x-axis according the share of their sales accounted for by new products, while this share is shown on the y-axis. Moreover, along the x-axis, the number of firms is normalised so that the firms add up to 100 in each size category.

Figure 1. **Distribution of share of sales (per cent) accounted for by product innovations, broad definition, firms with less than 100 employees and firms with 100 employees or more**.



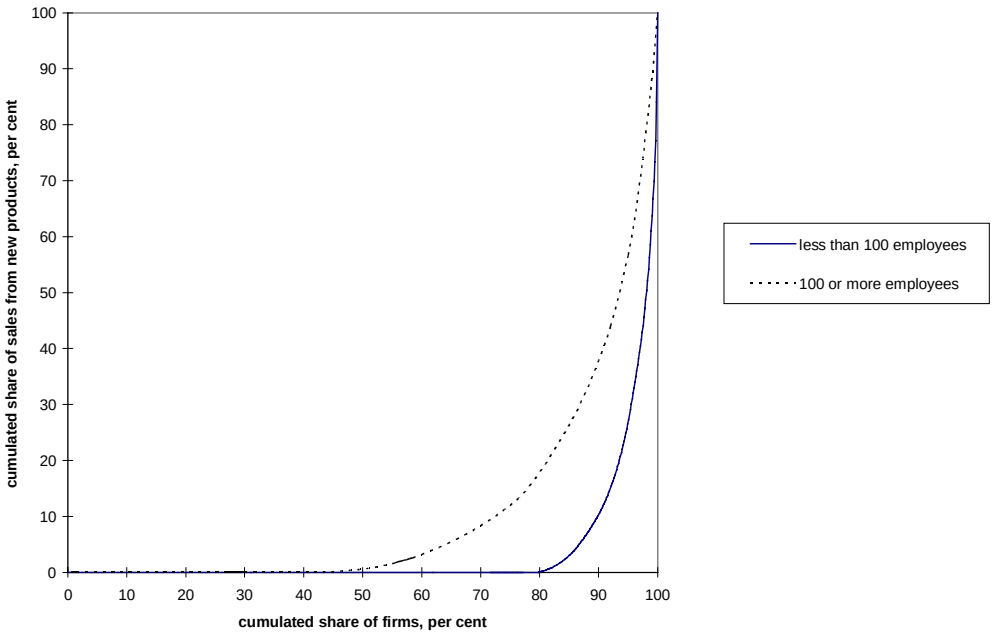
From Figure 1 we see that when the share of the sales accounted for by new products is 20.6 per cent among the large firms as a whole, while among the small firms the corresponding share is 14.6 per cent, these (weighted) averages in no way comes

about through the majority of firms in each size category having a share close to these respective averages. On the contrary, these distributions are very uneven. Among the large firms, only about 34 per cent of the firms have a share equal to or higher than 20.6 per cent (the weighted average in this category), while many have much higher shares and very many have zero. Similarly, among the small firms, only about 17 per cent of the firms have a share equal to or higher than 14.8 per cent (the weighted average among the small firms), while many have a much higher share and a vast majority of the firms have no new products at all.

Furthermore, that the large firms have a higher (weighted) average than the small firms does not mean that the highest performers among the large firms perform better than the highest performers among the small firms. We see that in both groups the top 1 per cent or so of the firms have a share of 100 per cent. But as we go down the rankings, the share drops much faster among the small firms than among the large firms. In fact, as we saw in Table 2, above, when we are through with 20.8 per cent of the small firms, this share is zero, while for the large firms we have to go through 57 per cent of the firms before we reach a share of zero. Thus, there is a much more unequal distribution of the share of sales accounted for by new products among the small firms than among the large. Among the small firms, a vast majority has no new products at all while a small share of the firms have very high shares of their sales accounted for by new products. Among the large firms, a far smaller share of the firms have no new products, while a much larger share of the firms have moderate shares of their sales accounted for by new products.

This more unequal distribution among the small firms than among the large firms is shown by the Lorentz curves depicted in Figure 2, below. There are two curves in this chart, one for the small firms and one for the large. Along the x-axis, the firms are ranked, in ascending order, according to their sales, in absolute numbers, of new products. The curves then depict the cumulated share of the firms along the x-axis and the cumulated share of sales from new products along the y-axis.

Figure 2. **Cumulated share of sales from new products, per cent (y-axis), cumulated share of firms, per cent (x-axis). Firms with less than 100 employees and firms with 100 employees or more**.



We see clearly that the distribution of the sales from new products is much more unequal among the small firms than among the large firms. Generally, the large firms curve runs much closer to the 45 degrees line than the small firms curve (except where both curves run along the x-axis). For instance, among the large firms the top 10 per cent of the firms account for about 62 per cent of the sales from new products, while among the small firms the top 10 per cent accounts for almost 90 per cent of new products.

4. A more detailed size breakdown

Six firm size categories

We will now look at the relationship between firm size and sales of new products using a more detailed classification of firms by size. We subdivide each of the two firm size categories from above into three classes, thus getting six firm size categories. These are firms with (1) less than 30 employees, (2) 30-59 employees, (3) 60-99 employees, (4) 100-199 employees, (5) 200-499 employees, and (6) 500 or more employees. In Table 11, below, the number of firms, the share of the firms and the share of sales in our sample accounted for by each size category.

Table 11. **Number of firms, share of firms and sales, by size category**.

number of employees	number of firms	share of firms, %	share of sales, %
less than 30	441	52.0	4.8
30-59	113	13.3	3.9
60-99	94	11.1	7.8
100-199	104	12.2	15.0
200-499	59	7.0	21.8
500 or more	37	4.4	46.6
Total	848	100	100

As we see, more than half of the firms have less than 30 employees. However, these firms account for less than 5 per cent of all sales in the sample. For the largest firms, those with 500 employees or more, almost exactly the opposite is the case. This category accounts for less than 5 per cent of the firms but close to 50 per cent of all sales.

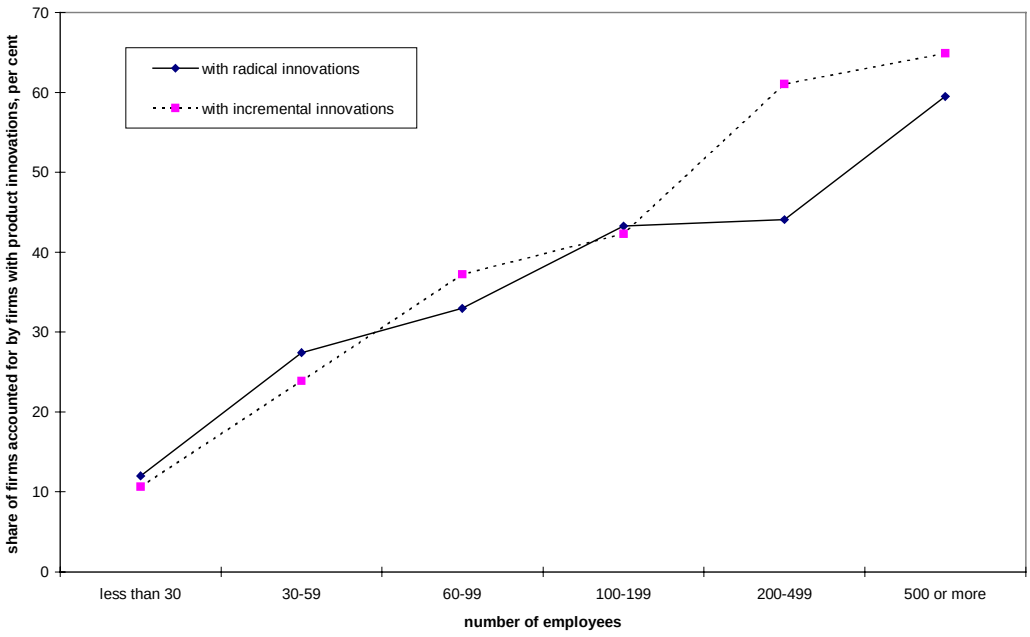
Let us first look at the share of firms inside each size category which have products innovations. This is shown, for all four definitions of product innovations, in Table 12, below.

Table 12. **Share of the firms (per cent) accounted for by firms with product innovations, different definitions, by size category (N=848)**.

		Share of all firms accounted for by firms with:			
number of employees	All firms	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 30	100	12.0	10.7	13.8	8.6
30-59	100	27.4	23.9	31.9	17.7
60-99	100	33.0	37.2	40.4	29.8
100-199	100	43.3	42.3	47.1	33.7
200-499	100	44.1	61.0	66.1	45.8
500 or more	100	59.5	64.9	70.3	62.2
Total	100	24.5	25.1	29.4	20.2

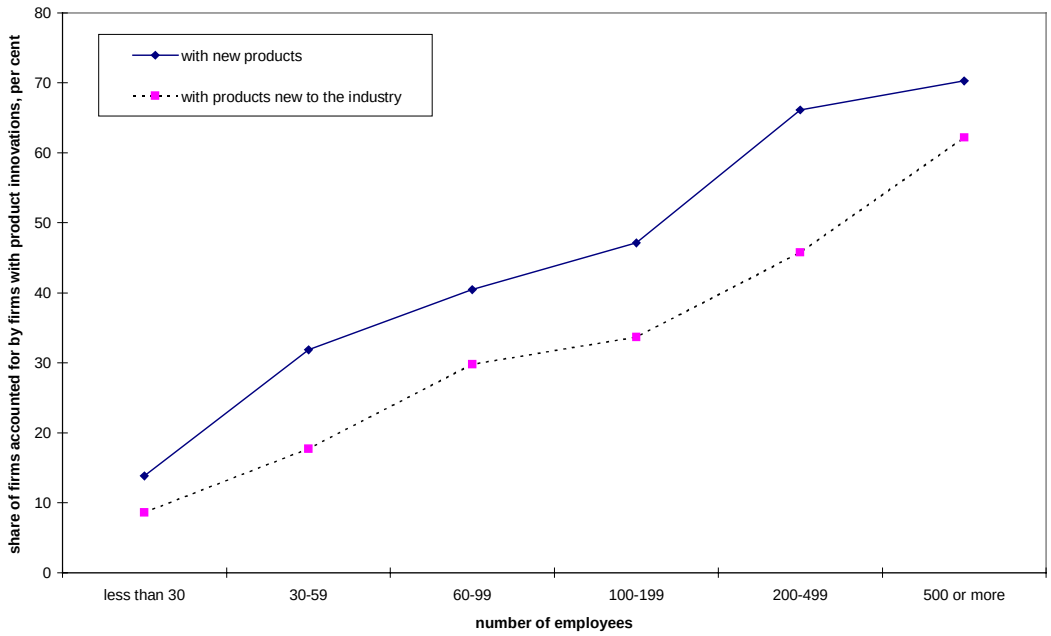
The share of firms inside each size category which have radical innovations and incremental innovations is also shown in Figure 3, below.

Figure 3. **Share of the firms inside each size category accounted for by firms with radical innovations and by firms with incremental innovations, per cent**.



Likewise, the share of firms inside each size category which have new products of any kind and which have products which are new also to the industry in which the firm operates is shown in Figure 4, below.

Figure 4. **Share of the firms inside each size category accounted for by firms with product innovations, wide definition, and by firms with products which are new to the industry, per cent**.



As emerges clearly from Table 12 and the two figures following it, for all four definitions the share of firms accounted for by firms with product innovations increases steadily and substantially as we increase firm size. According to the wide definition, while only 13.8 per cent of the firms with less than 30 employees have product innovations, the corresponding figure among the firms with 500 or more employees is 70.3 per cent. We may also note that there seems to be a tendency for the ratio between firms which have radical innovations and firms which have incremental innovations to fall with increasing firm size (see Figure 3).

Remember that further above we saw (Table 3) that when we divided the firms into only two size categories (less than 100 employees and 100 or more employees), there was a much higher share of the large firms than the small firms which had product innovations, regardless of definition. Here we thus find, by dividing these two broad size categories into more fine-grained categories, that the tendency for this share to increase with firm size seems very consistent and robust.

Now, there is, of course, a simple and straightforward substantive interpretation of this. It is that there is very large variation among small firms, so that even if a minority of them may be highly innovative, the large majority has neither the financial nor human nor social resources or capabilities to do any innovation at all.

However, there is also to some extent a plausible methodological interpretation of these results, which claims that the measure here used, the mere occurrence of a product innovation, is biased towards registering a higher innovativeness of large firms as opposed to small firms. Even in the case where the share of the firms which

had product innovations was the same among small and large firms, this measure would nevertheless show that a higher share among the large firms had product innovations than among the small firms.

This bias has to do with the time dimension of the measure. To see this, let us make a very schematic argument, based on highly stylised and simplified assumptions. First note again how the measure is constructed. It is asked how large share of the firm's sales in 1992 were accounted for by products which were introduced or changed during the three year period 1990-1992. The mere occurrence measure then becomes whether the firm in 1992 sold products which were new during this three year period.

Now, let us make the following stylised assumptions. Let us assume that there are two types of firms, small firms and large firms. Let us furthermore assume that the small firms engage in a very small number of activities and produce only a couple of products, while the large firms engage in a large number of activities and produce a large number of products. We then assume that the economy can be thought of as collection of a very large number of elementary production units, each producing one product or a couple of highly related products. Let us suppose that this means that we can think of the small firms as each consisting of one such unit, while the large firms each comprise a large number of such units. Now, given these assumptions, let us also assume that all these 'elementary units' are equally innovative, in the sense that they all introduce new products at the same rate, say, one new product every 15 years. This means that for any three year period, 20 per cent of the 'elementary units' introduce new products. Now, if these assumptions were true, and we were to ask the firms if they last year had sold any products which were new during the last three year period, only a small minority of the small firms, 20 per cent to be exact, would say yes, since each of the small firms only consists of one 'elementary unit'. For the large firms, however, the situation would be very different. Since each of the large firms would consist of many such units, the chances that at least one these units had introduced a new product in the preceding three year period would be very great. Consequently, a great majority of the large firms, indeed, given our assumptions virtually all of them, would answer yes to the question.

Of course, in many cases the above stylised assumptions are not true. In very many cases, the large firms do not produce any significantly larger number of products than a small firms, they do not to any significant degree have a more diversified production. It is simply the scale of production which is larger. To the extent that this is the case, the methodological interpretation is not true, and there is no bias of the sort this interpretation assumes. But in other cases large firms do have a substantially more diversified production than small firms, and to the extent that this is true, and to the extent that the three years we use in our measure is too short a time period to cover the full cycle of the renewal of products in innovating firms, the bias postulated by the methodological interpretation would be present.

In conclusion, both the substantive and the methodological interpretation are undoubtedly to some extent right, but we do not know to what extent. There no doubt is a certain bias in the measure of the sort indicated, but at the same time there is no reason to believe that this bias is large enough to explain the difference we have found in the share of firms which have product innovations between large and small firms.

5. Are SMEs really less innovative? A closer look at the size categories?

We will now turn to the share of the sales inside each size category accounted for by product innovations. This is shown, for all four definitions, in Table 13, below.

Table 13. **Share of sales, per cent, inside each size category accounted for by product innovations**.

Size categories		Share of all sales accounted for by:			
Number of employees	All sales	radical innovations	incremental innovations	new products of any kind	products new to the industry
less than 30	100	4.5	2.9	7.4	2.9
30-59	100	5.6	7.3	13.0	4.9
60-99	100	10.0	10.3	20.3	9.8
100-199	100	11.5	9.1	20.6	7.4
200-499	100	8.5	12.5	21.0	6.6
500 or more	100	7.8	12.7	20.4	9.6
Total	100	8.4	11.2	19.6	8.1

The share of the sales inside each size category which come from radical innovations and incremental innovations is also shown in Figure 5, below.

Figure 5. **Share of the sales inside each size category accounted for by radical innovations and by incremental innovations, per cent**.

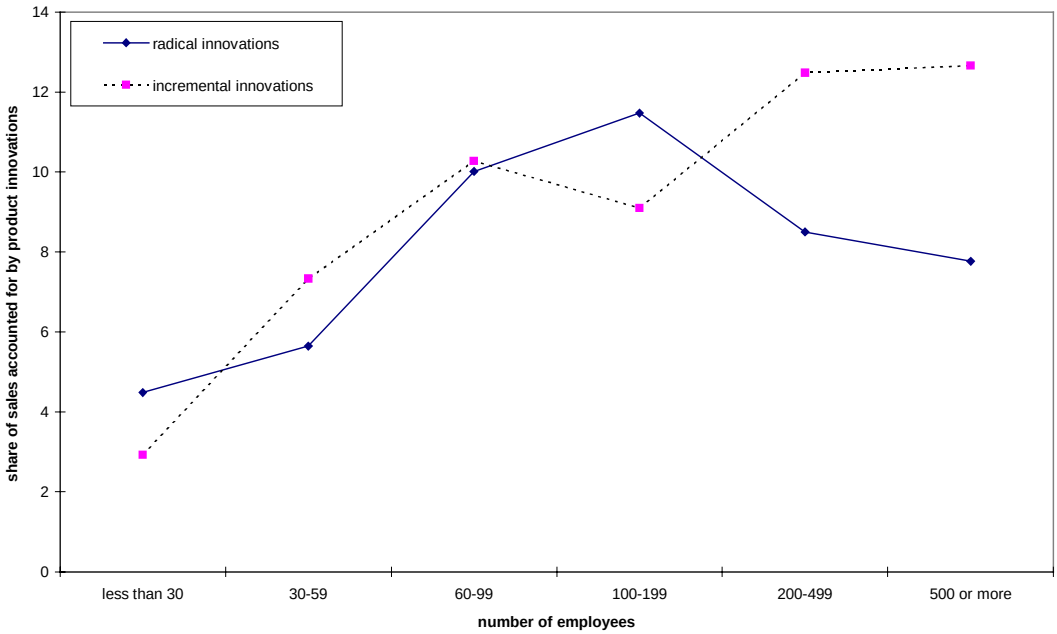
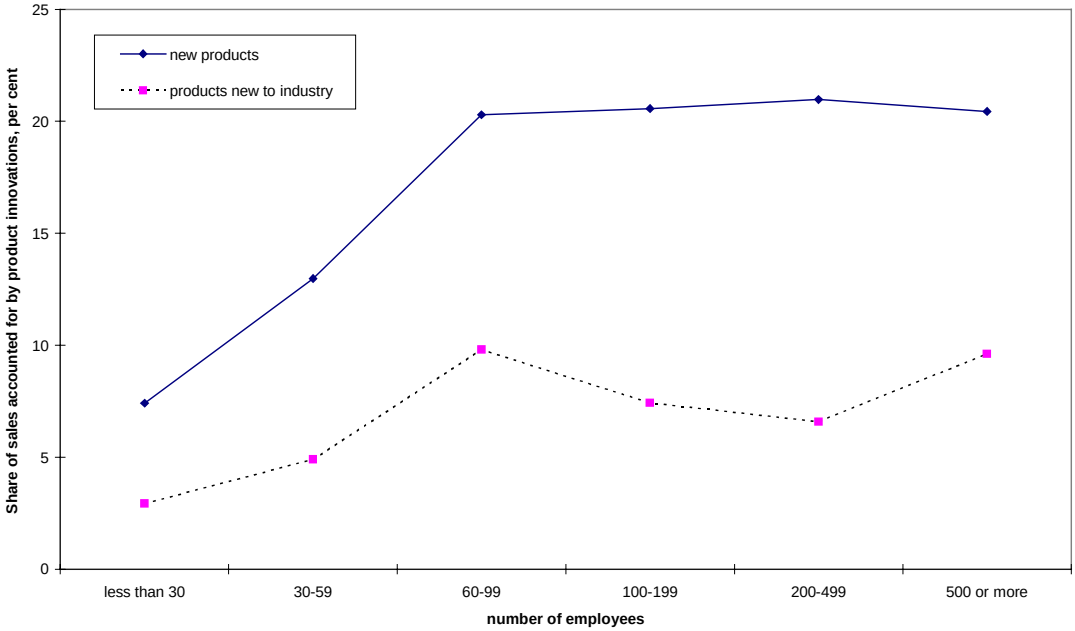


Figure 6, below, shows the share of the sales inside each size category accounted for by new products of any kind (wide definition) and by products new to the industry in which the firm operates.

Figure 6. **Share of the sales inside each size category accounted for by product innovations, wide definition, and by products which are new to the industry, per cent**.



Recall that when we operated with only two size categories above, less than 100 employees and 100 or more employees, we found that the large firms had a higher share of their sales accounted for by product innovations than the smaller. When we now use a finer classification with six size categories, we do not find the same kind of unambiguous relationship between firm size and innovative performance which we found in the case where we looked at the share of the firms accounted for by firms with product innovations, but a somewhat more irregular relationship.

What is still very clear is that the small firms invariably have smaller shares of their sales accounted for by product innovations than the rest of the firms. However, for this to be true, we have to define the small firms as those belonging to the two categories with firms less than 60 employees, not 100, as in the two category classification we used above. It is invariably the case that the less than 30 employees category and the 30-59 employees category have a substantially lower share of their sales accounted for by product innovations, and it is invariably the case that the less than 30 employees category has a substantially lower share than the 30-59 employees category.

But for the four firm size categories comprising the firms with 60 employees or more, we no longer find any clear relationship between firm size and share of sales accounted for by product innovations. In particular, by none of the four definitions the 60-99 employees category has a significantly lower share of the sales accounted for by product innovations than all the three categories comprising firms with 100 employees or more. For radical innovations the share rises until it reaches its highest in the 100-199 employees category, but the falls again, so that the 60-99 employees category has the second highest share. For incremental innovations the share rises with firm size all the way, apart from the 'anomaly' that the 100-199 employees category has a lower share than the 60-99 employees category. In sum, this means that for product innovations of any kind (the wide definition) the share rise until we reach the 60-99 category, but then is virtually equal for all the four categories comprising firms with 60 or more employees. For products new to the industry it is the 60-99 employees category which has the highest share, together with the 500 or more category (they are almost equal, 9.8 per cent against 9.6 per cent), with a lower share in the two categories in-between.

Thus, we still find that the small firms have a substantially lower share of their sales accounted for by product innovations than the larger firms, but for this to be true, the small firms would have to be defined as firms with less than 60 employees, not as firms with less than 100 employees, as in our dichotomous classification above. The firms with 60-99 employees in this respect have more in common with the larger firms than with the smaller firms.

We should note that in this case, where we look at the share of total sales inside each size category accounted for by product innovations, the methodological interpretation introduced in connection with the question of the share of the firms which have product innovations above does not apply. Since we here in effect treat each size category as one large firm, there will be no such bias as was postulated by the methodological interpretation. Referring to the stylised assumptions we made

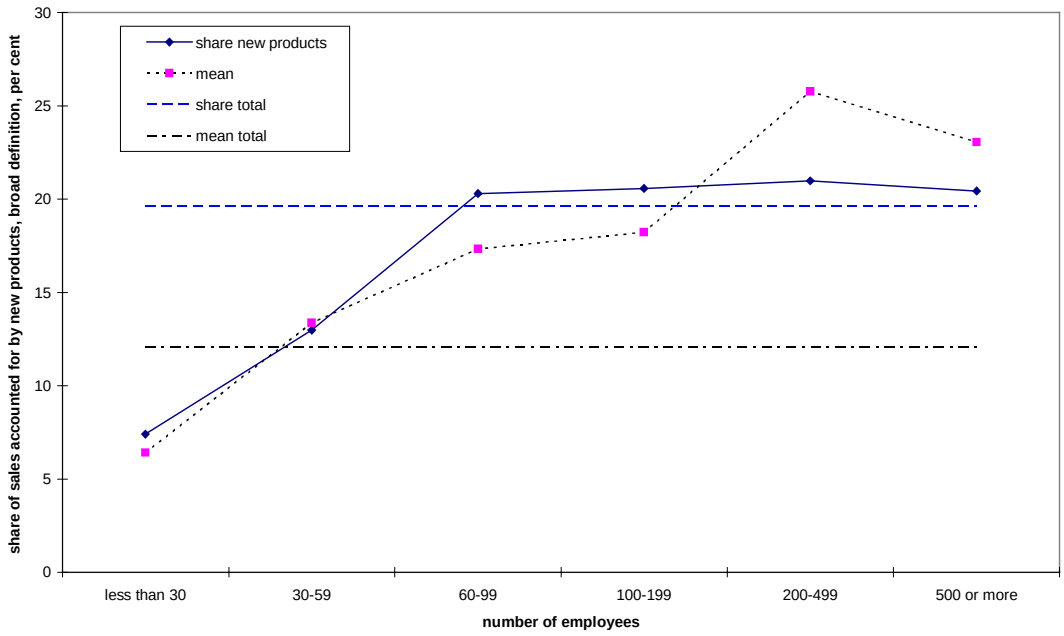
when making the methodological interpretation argument, if many (small) firms happen to be in a phase of their cycle where it is more than three years since they introduced a new product, this will be balanced by the fact that some (small) firms will happen to be in a phase where it is less than three years since they introduced a new product and where they will thus have a particularly high share of their sales accounted for by product innovations. (If the assumption is that the small firms make only one product each, a majority of firms with a share of sales accounted for by product innovations of zero will be balanced by the rest of the small firms having a share of 100 per cent.)

6. Variation inside the size categories

Let us now look briefly at the variation inside each size category in the share of the sales accounted for by product innovations. We will here use the coefficient of variation (standard deviation divided by the mean) as a measure of variation. This measure is in part based on the mean or, more precisely, the arithmetic mean of a distribution, whereas we above in using the share of the sales accounted for by new products in each category as a whole have used a weighted mean, where the weights are defined by the sales of each firm. Let us, therefore, first look briefly at the arithmetic mean, which we will simply refer to as the mean.

To give an idea of the difference between the mean and the weighted mean, we show in Figure 7, below, both the mean and the weighted mean of the share of sales inside each size category accounted for by product innovations of any kind, i.e. the wide definition of product innovations.

Figure 7. **Share of sales inside each size category accounted for by new products (weighted mean), per cent; (arithmetic) mean share of sales accounted for by new products by size category, per cent**.



Notice, first, that for the total, or all size categories combined, the weighted mean, or the share of all sales considered as a whole accounted for by new products, is much higher than the arithmetic mean. The point is that while the weighted mean of the total will lie close to the (weighted) mean of the large firms, the arithmetic mean of the total will lie close to the (arithmetic) mean of the small firms, and the mean (both weighted and arithmetic) is much higher among the large firms than among the small

firms. The reason for this is that the weights of the weighted mean are defined by the sales, and in terms of sales the large firms account for a much larger share of the total than the small firms, while in the arithmetic mean each firm counts for one, and in terms of numbers it is the small firms which account for a much larger share of the total than the large firms.

Thus, when there is a systematic relationship between firm size and a variable like the share of sales accounted for by new products, the mean and the weighted mean in effect express different things. If one wants to express the share of the sales of new products in total production as a whole, one should use the weighted mean. If one wants a measure which is more typical of the bulk of the firms, the (arithmetic) mean would be more appropriate. The same applies inside each size category.

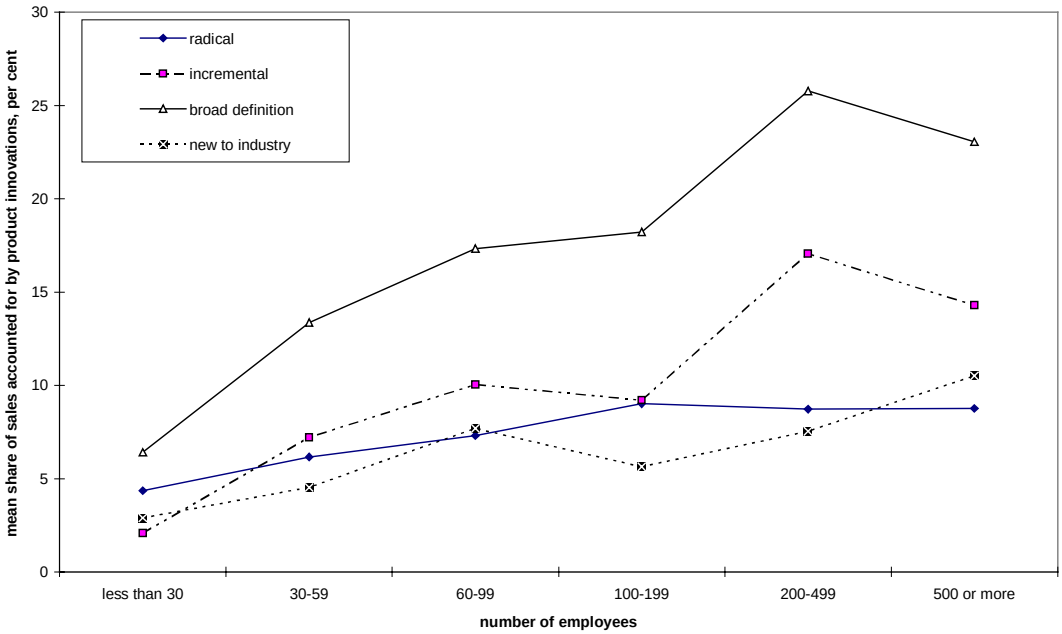
It is well known that the mean may be sensitive to extreme values by highly atypical units. In a sense, this danger can be even greater in the case of the weighted mean, if the unit or units with extreme values also should happen to be very large. In our case, this may especially affect the size category containing the largest firms, with 500 or more employees. If one or a couple of firms which are very large also should have values which are atypically high or atypically low, the weighted mean may give a misleading picture of what is typical of the firms of the size category.

Let us now briefly look at the difference between the mean and the weighted mean for each size category in Figure 7.

We see that the two categories at the large firm end of the scale, those containing firms with 200-499 employees and 500 or more employees, have a higher mean than weighted mean, while for the two categories in the middle, those containing firms with 60-99 employees and 100-199 employees, the opposite is the case. The result is that when we examine the mean of the share of sales accounted for by product innovations (wide definition), the relationship between firm size and share of new products in sales looks more like one which rises constantly, also for the size categories containing firms with 60 employees or more, than when we examined the weighted mean.

Let us now look at the mean share of sales accounted for by product innovations by size category for all four definitions of product innovations. This is shown in Figure 8, below.

Figure 8. **Mean share of sales accounted for by product innovations by size category, all definitions of product innovations**.

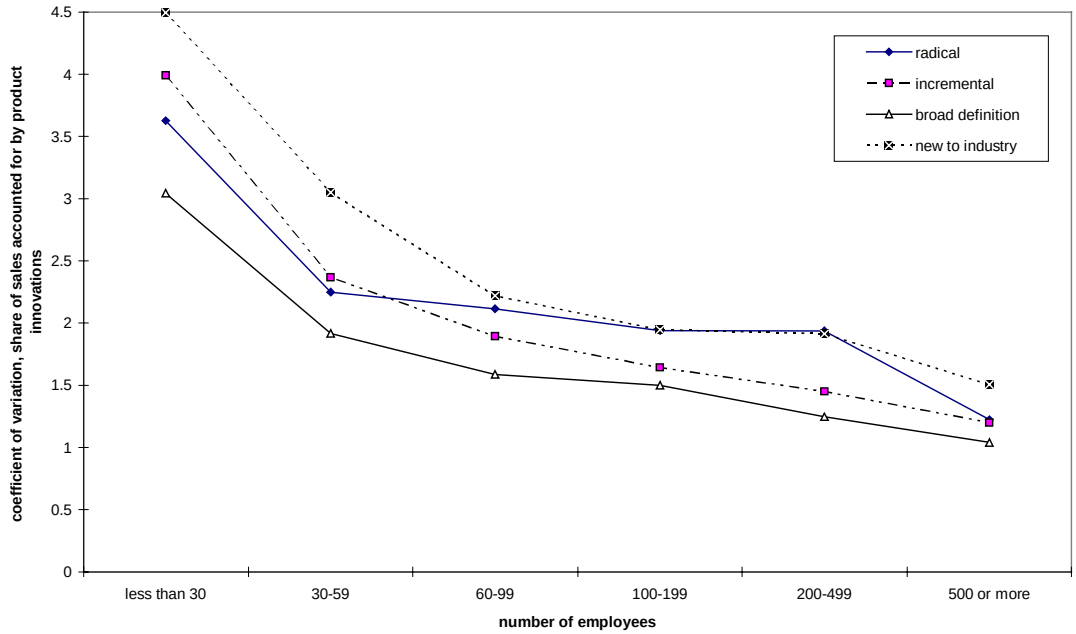


The picture we get when we look at the means is not very different from the one we got when we looked at the weighted means above. However, we should note that it is invariably the case, across all four definitions, that the 200-499 employees category and the 500 or more employees category have higher means than weighted means, while the 60-99 employees category has lower means than weighted means. This slightly modifies what we said when we discussed the weighted means above, but not much.

Now we can turn to the question of variation in share of sales accounted for by product innovations inside each size category, as measured by the coefficient of variation. The coefficient of variation is defined as the ratio of the standard deviation to the (arithmetic) mean. The standard deviation is a measure of to what extent the units are spread out far away from the mean and to what extent they lie close to the mean; the further they are spread out from the mean, the larger the standard deviation. By dividing the standard deviation by the mean, we normalise the standard deviation so that it is seen in proportion to the mean

In Figure 9, below, we show the coefficient of variation of the share of sales accounted for by product innovations for all size categories and all four definitions of product innovations.

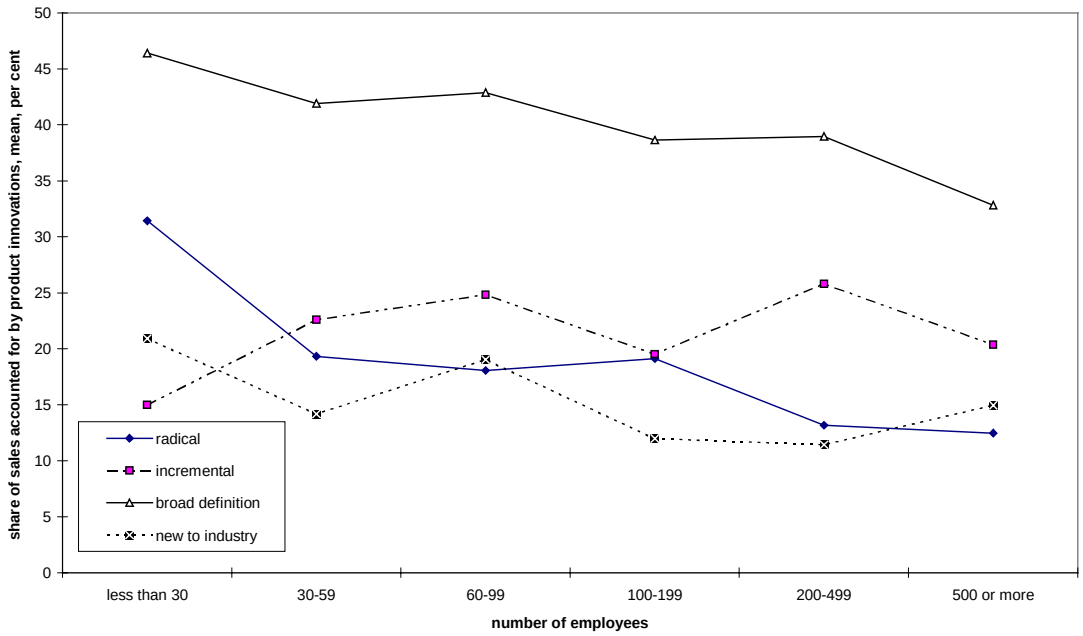
Figure 9. **Coefficient of variation of the share of sales accounted for by product innovations, by size category, all definitions of product innovations**.



As we see, the coefficient of variation invariably falls with increasing firm size, which confirms that the variation is much larger among the small firms than among the large firms. This is, of course, closely connected to the fact that the share the firms with no product innovations is much higher among the small firms than among the large firms.

That the variation is larger among the small firms than among the large we get additional confirmation of if we look at the mean share of sales accounted for by product innovations by size category among the firms with product innovations of some kind only. This is shown in Figure 10, below.

Figure 10. **Mean share of sales accounted for by product innovations by size category, all definitions of product innovations. Firms with product innovations of some kind only**.



Note that the firms included here in all four cases are firms with product innovations of any kind. This means that in the computation of the mean for product innovations of any kind (wide definition) no firms with a share of zero are included, while in the computation of the means for radical innovations, incremental innovations and products new to the industry firms with a share of zero are included, namely firms which have radical innovations but not incremental innovations and vice versa and firms which have new products but no products which are new also to the industry in which the firms operates.

When we consider only the firms with product innovations of some kind, we do not in any way find that the share of sales accounted for by product innovations increases with firm size. Rather, there is a tendency for the opposite relationships, at least for radical innovations and the wide definition, and also to a certain extent for products new to the industry. For all these three definitions, the smallest firms, i.e. those in the less than 30 employees category, have the highest share. For incremental innovations, there does not seem to be any relationship between firm size and share of product innovations in sales at all.

Thus, when we look at all firms we find that the smallest firms have by far the smallest share of sales accounted for by product innovations, but when we look at only the firms which have product innovations we find that the smallest firms have the largest share. It would seem that while only a small minority of the smallest firms have product innovations at all, the minority of them which do innovate are highly innovative.

However, we must make an important modification to what we just said, and this modification will apply to the extent that we accept the methodological interpretation of the difference in the share of firms which have product innovations between large and small firms which we discussed above, relating to the time aspect of our measure. To the extent that we accept this methodological interpretation in that case, we must also accept that in the case we are now discussing our measures are biased in the opposite direction. To see this easily, let us make the methodological interpretation argument in its most stylised form. We assume that the total productive activity may be regarded as taking place in a very large number of 'elementary production units' which each makes only one product. There are two kinds of firms: a very large number of small firms consisting of only one 'elementary unit' each, and a number of large firms consisting of many such units. We now assume that all these 'elementary units' are equally innovative in the sense that the one product they make is changed or replaced by a new product once every fifteen years. Since our measure registers the share of sales last year accounted for by products which were new or changed during the last three years, this means that in any one year 80 per cent of the 'elementary units' will happen to be in a phase of their cycle where they have not changed or replaced their product during the last three years. The remaining 20 per cent of the 'elementary units', on the other hand, will be in a phase where they have changed or replaced their product during the last three years, and they will consequently have 100 per cent of their sales accounted for by new products according to our definition. Thus, among the large firms, which consist of many such units, all the firms will have a share of their sales accounted for by product innovations of 20 per cent. Among the small firms, each consisting of only one 'elementary unit', 80 per cent of the firms will have no product innovations while 20 per cent of the firms will have a share of their sales accounted for by product innovations of 100 per cent. Thus, if we were measure the share of sales accounted for by product innovations in each size category including in the calculation only firms which report that they have product innovations, we would find that the large firms had an average share of 20 per cent and the small firms an average share of 100 per cent, whereas by assumption all production units were equally innovative.

Now, again, these assumptions are very stylised and extreme. But to the extent that they are approximated in the real economy, to the extent that large firms have a more diversified production than small firms and to the extent that three years is a too short time to cover the full cycle of renewal of products in innovating firms, there will be a bias in our measure, and in this case it will be in favour of the small firms.

But whether we calculate the share of sales accounted for by product innovations on the basis of the sales from all firms in each size category or only on the basis of the of the sales from the firms which report product innovations only, this does, of course, not affect the share of each size category of total sales from product innovations. In Table 14, below, we show these shares.

Table 14. **Distribution of sales from product innovations, different definitions, across firm size categories (per cent). Distribution of all sales and of all sales from firms with product innovations**.

	Share of	Share of the sales from:				Share of sales from
number of employees	all sales	radical innova-tions	incre-mental innova-tions	new products of any kind	products new to the industry	firms with new products
less than 30	4.8	2.6	1.3	1.8	1.7	1.4
30-59	3.9	2.6	2.6	2.6	2.4	2.3
60-99	7.8	9.3	7.1	8.1	9.4	5.7
100-199	15.0	20.4	12.1	15.7	13.7	11.9
200-499	21.8	22.0	24.3	23.3	17.7	22.0
500 or more	46.6	43.1	52.6	48.5	55.1	56.7
Total	100	100	100	100	100	100

Referring to the sale from product innovations of any kind (the wide definition), we see that the less than 30 employees category accounts for only 1.8 per cent of the total of these sales. If we want to relate the sales from product innovations to all sales from all firms in the size category, we should compare the 1.8 per cent share which the less than 30 employees category has of the sales from product innovations to the 4.8 per cent share which it has of all sales from all firms. Here it has a much smaller share of sales from new products than of all sales, which reflects that when we consider all firms, the smallest firms appear far less innovative than the rest of the firms. However, If we want to relate the sales from product innovations to only all sales from the firms with product innovations in the size category, we should compare the 1.8 per cent share which the less than 30 employees category has of the sales from product innovations to the 1.4 per cent share which it has of all sales from the firms with product innovations. (Notice that the relationship between share of sales from product innovations and share of all sales is connected to the weighted mean, not the arithmetic mean.) Here it has a larger share of sales from new products than of all sales, which reflects that when we consider only the firms with product innovations, the smallest firms appear more innovative than the rest of the firms.

Summing the shares in Table 14 we still find, of course, that the firms with less than 100 employees have only 12.5 per cent of all the sales from product innovations, the firms with 100 employees or more have the remaining overwhelming majority of 87.5 per cent.

7. Small firms' share of product innovations by industry

We now turn to an examination of the variation across industries in the share of sales from product innovations accounted for by small firms, To keep the analysis as simple as possible, we will only use two size categories, small and large firms. In spite of the fact that we found that the 60-99 employees category seemed in respect of the share of sales accounted for by new products to look more like the larger firms than the smaller firms, we will choose 100 employees as the dividing line between small and large firms. Also, still to keep things simple, we will only consider one of the definitions of product innovations, namely the wide definitions, which includes all products which are new to the firm in question, whether they are radical innovations or incremental innovations, and whether they also are new to the industry in which the firm operates or not.

First, let us give a brief overview of the industries, their relative importance in the sample and their innovative 'performance' according to our measure of product innovations. Thus, in Table 15, below, are listed the industries into which we have divided the total manufacturing sector, the number of firms in each industry in our sample, the share of total sales in the sample which each industry accounts for and the share of the sales in each industry accounted for by new products (product innovations, wide definition).

Table 15. **Number of firms in each industry, share of total sales accounted for by each industry, per cent, share of sales in each industry accounted for by new products, wide definition, per cent**.

	N	share of all sales	share of sales accounted for by new products
Food, beverage and tobacco	163	23.3	25.1
Textiles and clothing	46	1.1	12.0
Wood products	99	3.7	15.2
Pulp and paper	15	3.4	19.2
Graphical industry	105	6.1	0.9
Chemical products	33	10.0	20.0
Pharmaceuticals	4	2.7	13.9
Mineral products	37	2.5	13.3
Metals	24	14.6	8.0
Metal products	111	3.6	26.4
Machinery	71	13.8	18.3
Transport equipment	73	8.8	26.0
Electronics	23	3.0	62.3
Electrical machinery	28	3.0	28.5
Other manufacturing	16	0.5	13.0
Total	848	100	19.6

We divide the manufacturing sector into 15 industries. We see that of these by far the largest both in terms of number of firms and share of the sales in the sample is the food, beverage and tobacco industry. Some industries, like wood products, graphical industry and metal products, are large in terms of number of firms but not in terms of share of sales, reflecting the fact that the average size of the firms in these industries is small. For other industries, like chemical products and metals, it is the other way round. Machinery is fairly large both in terms of number of firms and share of sales. In terms of number of firms, pharmaceuticals is by far the smallest industry with only 4 firms, but it is not the smallest in terms of share of sales. In this respect, the residual category other manufacturing is the smallest industry with only 0.5 per cent of the sales.

Concerning the share of sales accounted for by new products, the by far highest share is found in the electronics industry. Next come electrical machinery, transport equipment and food, beverage and tobacco. The graphical industry has an extremely low share, and metals also come out far below the share in all sales of all industries combined. Next come textiles and clothing and other manufacturing. However, there are many difficulties with the interpretation of this measure as a measure of innovativeness, and we should be especially careful in our interpretations when we compare directly these shares across industries.

Let us now turn to the share of the sales from new products accounted for by small firms, i.e. firms with less than 100 employees, in each industry. This is shown in

Table 16, below, where the industries are also ranked according to this share, in descending order.

Table 16. **Share of sales from new products, wide definition, per cent, accounted for by firms with less than 100 employees, by industry**.

Other manufacturing	89.1
Graphical industry	30.5
Wood products	23.7
Metal products	23.6
Textiles and clothing	21.5
Food, beverage and tobacco	17.4
Chemical products	11.6
Mineral products	11.5
Electronics	9.9
Machinery	9.5
Pharmaceuticals	7.6
Metals	6.8
Electrical machinery	6.6
Transport equipment	5.4
Pulp and paper	0
Total	12.5

We see that this share is extremely high in other manufacturing, where almost 90 per cent of the sales from new products are accounted for by firms with less than 100 employees, but it is also clearly higher than average in graphical industry, wood products, metal products and textiles and clothing. It is zero in pulp and paper, and it is also very low in transport equipment, electrical machinery, metals and pharmaceuticals.

8. Cross-industry differences: a basic reference point

For the further examination, let us transform these shares, relating them to a reference point. For reference point we choose the share of all sales in all industries accounted for by firms with less than 100 employees, which is 16.6 per cent (see Table 1, above), and the transformation simply consists in subtracting this reference point share from the original shares. Table 17, below, gives these transformed shares.

Table 17. **Share of sales from new products, wide definition, accounted for by firms with less than 100 employees, by industry, less the share of all sales in all industries accounted for by firms with less than 100 employees (16.6 per cent), percentage points**.

Other manufacturing	72.5
Graphical industry	13.9
Wood products	7.1
Metal products	7.1
Textiles and clothing	5.0
Food, beverage and tobacco	0.8
Chemical products	-5.0
Mineral products	-5.0
Electronics	-6.7
Machinery	-7.1
Pharmaceuticals	-9.0
Metals	-9.8
Electrical machinery	-10.0
Transport equipment	-11.2
Pulp and paper	-16.6
Total	-4.1

Thus, the industries which have a higher share than this reference point will have a positive transformed score and the industries with a lower share will have a negative transformed score, the absolute size of the transformed score expressing the distance from the reference point.

Now, if an industry has a high share of the sales from new products accounted for by small firms, this may express two rather different things. On the one hand, a large part of all the sales in the industry may already come from small firms, so that even if the small firms are not any more innovative than the large firms, they will account for a large share of the sales from new products in the industry as well. On the other hand, the small firms in an industry may be more innovative (in terms of the share of sales accounted for by new products) than the large firms, so that even if they do not account for any particularly large share of the sales in the industry, they may

nevertheless account for a relatively large share of the sales from new products of the industry. Quite generally, these two effects may work in the same direction, or they may work in opposite directions.

Let us try to give a very simple quantitative expression of this idea. We start out with the share of the sales from new products accounted for by small firms in a given industry, and we want somehow to decompose this magnitude into two different components, one expressing the firm size structure of the industry, the other the 'innovative performance' of small firms relative to large firms. Now, first we transform the original share by relating it to a reference point, simply by subtracting from this share the share of all sales in all industries accounted for by small firms. The transformed score which we take as our point of departure thus becomes

share of sales from new products in industry accounted for by small firms - share of all sales in all industries accounted for by small firms

or, for short,

share new products in industry - share all sales all industries ,

remembering that all the time it is question of the shares accounted for by small firms (firms with less than 100 employees).

Now, let us introduce a third magnitude. For any industry we have the

share of all sales in industry accounted for by small firms or, for short, 'share all sales in industry'.

We thus start out from the expression

share new products in industry - share all sales all industries .

Now, since an expression is not changed if we add zero to it, and since

share all sales in industry - share all sales in industry = 0 ,

we have:

share new products in industry - share all sales all industries =
share new products in industry - share all sales all industries
+ share all sales in industry - share all sales in industry .

Rearranging this expression we get:

share new products in industry - share all sales all industries =
(share all sales in industry - share all sales all industries)
+ (share new products in industry - share all sales in industry) .

The first expression on the right hand side,

(share all sales in industry - share all sales all industries) ,

is a measure of the firm size structure of the industry. If this expression is positive, the industry in question has a higher share of its total sales accounted for by small firms than all industries combined, and a lower share if it is negative. The second expression,

(share new products in industry - share all sales in industry) ,

is an expression of the innovative performance of small firms compared to large firms in the industry in question. If this expression is positive, the less than 100 employees category has a higher share of its sales accounted for by new products than the 100 or more employees category, and a lower share if it is negative.

Thus, in a very rough manner we have here decomposed the share of the sales from new products in any given industry accounted for by small firms into a sum of two components, the first expressing the firm size structure of the industry and the second the innovative performance of small firms compared to large firms in the industry in question.

Let us now see how this decomposition works out for the individual industries. All the relevant information is contained in Table 19, below. First we have the magnitude which we are analysing, namely the share of the sales from new products in each industry accounted for by small firms. Then comes the share of all sales in each industry accounted for by small firms. Third comes the transformed expression of share of the sales from new products in each industry accounted for by small firms, which is simply this share minus the share of all sales in all industries accounted for by small firms (the total in the second column, 16.6 per cent). Fourth comes the component which expresses the firm size structure of each industry, which is the share of all sales in each industry accounted for by small firms minus the same share for all industries (the second column minus the share for the total in the same column). Lastly comes the component which expresses the innovative performance of small firms compared to large firms in each industry, which is the share of the sales from new products in each industry accounted for by small firms - the share of all sales in each industry accounted for by small firms (column 1 - column 2).

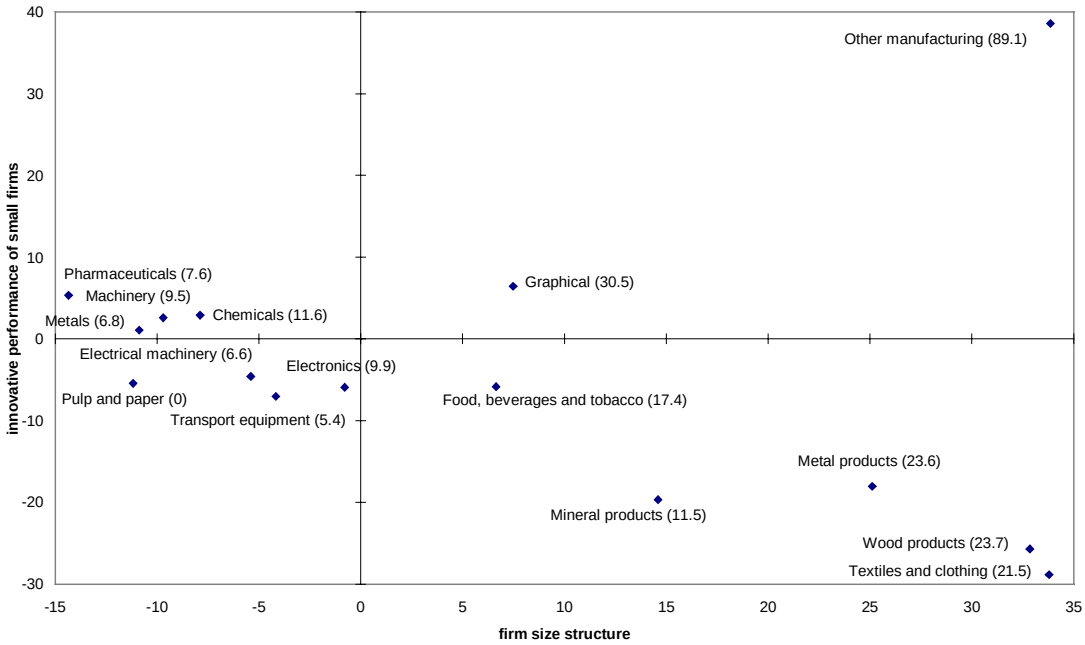
Table 18. **Share of sales from new products and share of all sales, per cent, accounted for by firms with less than 100 employees, by industry. Difference between (1) share of sales from new products in industry and share of all sales in all industries, percentage points, (2) share of all sales in industry and share of all sales in all industries, percentage points, and (3) share of sales from new products in industry and share of all sales in industry**.

	Firms with less than 100 employees		Differences		
	Share of sales from new products	Share of all sales	Share of sales from new products in industry - share of all sales in total	Share of all sales in industry - share of all sales in total (size structure of industry)	Share of sales from new products in industry - share of all sales in industry (innovative performance)
Food, beverage and tobacco	17.4	23.2	0.8	6.7	-5.9
Textiles and clothing	21.5	50.4	5.0	33.8	-28.8
Wood products	23.7	49.4	7.1	32.9	-25.7
Pulp and paper	0	5.4	-16.6	-11.2	-5.4
Graphical industry	30.5	24.1	13.9	7.5	6.5
Chemical products	11.6	8.7	-5.0	-7.9	2.9
Pharmaceuticals	7.6	2.2	-9.0	-14.3	5.3
Mineral products	11.5	31.2	-5.0	14.6	-19.6
Metals	6.8	5.7	-9.8	-10.9	1.1
Metal products	23.6	41.7	7.1	25.1	-18.0
Machinery	9.5	6.9	-7.1	-9.7	2.6
Transport equipment	5.4	12.4	-11.2	-4.2	-7.0
Electronics	9.9	15.8	-6.7	-0.8	-5.9
Electrical machinery	6.6	11.2	-10.0	-5.4	-4.6
Other manufacturing	89.1	50.5	72.5	33.9	38.6
Total	12.5	16.6	-4.1	0	-4.1

Notice that since the share of all sales in all industries accounted for by small firms is the reference point we have chosen, the size structure for the total is per definition 0. Anyway, this decomposition was devised with the intention of comparing different industries, so the figures for the total do not here have an interest in themselves, the total is simply the point of reference.

Figure 11, below, presents the results of the decomposition in Table 18 graphically. Along the vertical axis we find the innovative performance of small firms component, or the share of the sales from new products in the industry in question accounted for by small firms minus the share of all sales in the industry in question accounted for by small firms. Along the horizontal axis we find the firm size structure component, or the share of all sales in the industry in question accounted for by small firms minus the share of all sales in all industries accounted for by small firms. For each industry we have given the share of the sales from new products accounted for by small firms in parentheses.

Figure 11. **Decomposition of share of sales from new products in each industry accounted for by small firms (firms with less than 100 employees), expressed as difference from small firms' share of all sales in all industries, percentage points, into (1) the difference between small firms' share of all sales in industry and in all industries, percentage points (x-axis), and (2) the difference between small firms share of sales from new products in industry and all products in industry, percentage points (y-axis). In parentheses small firms' share of sales from new products in industry**.



Let us first look at the industries which have a higher than reference point share of the sales from new products accounted for by small firms. From Tables 16 and 17, above, we see that first comes 'other manufacturing', which has a share far above any of the other industries, and then comes graphical industry. These two industries are in fact the only ones which have a positive score on both components, i.e. they have a higher share of their sales accounted for by small firms than all industries combined and the small firms have on weighted average a higher share of their sales accounted for by new products than the large firms in these industries. Next comes three industries which are also well above the reference point when it comes to the share of the sales from new products accounted for by small firms, namely wood

products, metal products and textiles and clothing. These have a high share of their sales from new products accounted for by small firms because of a very high score on the size structure component, but they also have a large negative score on the innovative performance component. That is to say, they have a high share of their sales from new products accounted for by small firms solely because they have a high share of all their sales accounted for by small firms, while the small firms are much less innovative than the large firms in these industries. There is one more industry with a share of the sales from new products accounted for by small firms higher than the reference point, and that is food, beverages and tobacco. Also this industry has a positive score on the size structure component and a negative score on the performance component, but on both dimensions the absolute values are substantially smaller than for the three preceding industries.

Of the industries with a share of the sales from new products accounted for by small firms lower than the reference point, there is one more industry with a positive score on the size structure component and a negative score on the performance component, namely mineral products. The absolute scores are relatively high on both components, but in this case the absolute value of the negative performance component is larger than the absolute value of the positive size structure component.

Of the remaining eight industries with a share of the sales from new products accounted for by small firms lower than the reference point, four have a negative score on the size structure component and a positive score on the performance component, meaning that the small firms account for a relatively small share of total sales of the industry but are on weighted average more innovative than the large firms in terms of share of their sales accounted for by new products. These industries are chemicals, machinery, pharmaceuticals and metals. For all of them the absolute value of the positive performance component is lower than the absolute value of the negative size structure component.

Lastly, there are four industries with a negative score on both components. They are electronics, electrical machinery, transport equipment and pulp and paper.

Let us add a few comments to three of the industries, because they are a bit special. First, there is other manufacturing. Now, as we have seen, this is a very special industry in the sense that it is by far the one with the highest share of the sales from new products accounted for by small firms, where both the size structure component and the performance component contribute fairly equally to this result. However, the industry is special also in other ways. As we saw (Table 15, above), this residual category is a very small industry, in fact, in terms of its share of the sales in the sample it is the smallest of the fifteen industries with only 0.5 per cent of the sample sales. Also, it only contains 16 firms, and only 4 of these have 100 employees or more. Of the 16 firms, only 4 report that they have product innovations, of which 3 are small and 1 is large. Thus, the basis for computing the shares we are operating with here may in this case appear rather fragile. We should not attach too much importance to shares computed on the basis of so few firms.

Second, there is graphical industry, which is the industry with the second highest share of its sales from new products accounted for by small firms, and the only industry apart from other manufacturing which has a positive score on both

components. Now, graphical industry is large in terms of number of firms and it is not at all particularly small in terms of its share of total sample sales either (see Table 15, above). However, it is very special in that it has an extremely low share of its sales accounted for by new products, not comparable to any other industry. Against a share for all industries as a whole, it has a share of only 0.9 per cent. The second lowest share is 8.0 per cent (metals), while all the other industries have 12 per cent or more. In fact, while the industry accounts for some 6 per cent of all sales in the sample, it only accounts for 0.3 per cent of the sales from new products.

Third, there is pharmaceuticals. Here the small firms account for a far below reference point share of the industry sales from new products, but they account for a share of all sales in industry which is far lower than that again. Consequently, in pharmaceuticals the small firms have a higher share of the sales accounted for by new products than the large firms and so the industry has a positive score on the performance component. However, in this industry there are only 4 firms in our sample, 2 small and 2 large, all of which have product innovations. We should not attach much importance to shares computed on the basis of so few units.

Thus, in three of the industries where the small firms show the relatively best innovative performance, we should not attach much importance to the results because either the units are very few or the amount of sales from new products is very low.

These examples should make us aware of a more general point, namely that the impression of the relative innovative performance of the small firms across different industries we get from the kind of analysis made in Table 18 and Figure 11, above, may be modified if we also take into account the variation in importance of the different industries in terms of their share of total sales and total sales from new products.

Let us try to illuminate this from a slightly different angle. We will choose to focus on the share of the sales in each size category for all industries combined accounted for by new products. From Table 8, above, we see that this share is 14.8 per cent for the small firms and 20.6 per cent for the large firms. For all firms, i.e. small and large firms combined, it is 19.6 per cent. Thus, for all industries combined the small firms have a share of its sales accounted for by new products which is 4.8 percentage points below the share in the total. What we will try to do now is to somehow find an expression of how much each industry contributes to this difference of 4.8 percentage points between the share of the small firms and the share of all firms combined.

However, there is an important dimension which must be taken into account here, and that is the question of the difference between large and small firms in the distribution of their total sales across industries. Remember that we said we should be careful when we compare rates of sales accounted for by new products across industries, because the meaning in terms of innovativeness of having a product innovation may vary from one industry to another. Indeed, as we have seen, rates of sales accounted for by new products do in fact vary considerably across industries. Furthermore, we have also seen that the share of the sales accounted for by small firms is not the same in each industry, on the contrary, the industry firm size

structure varies substantially across industries (Table 18 and Figure 11, above). Now, it might very well be the case that part of the reason that the small firms have a smaller share of their sales accounted for by new products than all firms combined is that they, compared to all firms as a whole, have a disproportionately large share of their sales in industries where the share of sales accounted for by new products is low and accordingly a disproportionately low share of their sales in the industries where this share is high. In that case we would expect the share of sales accounted for by new products for all industries as a total to be smaller for the small firms category than for all firms, even if they were equally innovative (in terms of share of sales accounted for by new products) inside each individual industry.

Thus, we should in fact not compare the share of the sales accounted for by new products for all industries as a total with the corresponding share for all firms as a whole. Instead, we should compare it to a share which is adjusted for the difference in the distribution of sales across industries between small firms and all firms combined. Then we should try to find an expression of how much each industry contributes to this difference.

Let us first find the share of the sales accounted for by new products to compare with which is adjusted for the difference in the industry distribution of sales between small firms and all firms combined. Our point of departure will be that we will assume that the share of the sales of all firms of each industry accounted for by new products somehow is typical of the industry. If the small firms have a larger share than this they are more innovative than the typical and vice versa. Thus, as the reference point share to compare the actual share among the small firms with we choose the share of the sales accounted for by new products in all industries as a whole the small firms would have had if in each industry they had a share of their sales accounted for by new products which was equal to the typical share of the industry, i.e. equal to the actual share for all firms as a whole in each industry. This is simply equal to the weighted sum over all industries of the share of sales of all firms in each industry accounted for by new products, where the weights are defined by the distribution of total sales across industries among the small firms.

Notice that by this way of approach we abstract from the fact that if the share had been changed among the small firms in an industry, this would have changed, although to a lesser extent, the reference point share of all firms in the industry as well. Thus, in effect, we here argue as if the small firm category were so small in relation to all firms that a change in the share of sales accounted for by new products in this category would not affect the corresponding share of the total. Now, this is of course not the case, but this does not affect the logic of the argument or the nature of the results.

The computation of the share of sales accounted for by new products for all industries combined which the small firms would have had if they in each industry had the same share of sales accounted for by new products which all firms in the industry as a whole have, given the actual sales distribution across industries of small firms, is shown in Table 19, below.

Table 19. **Computation of reference share for share of sales accounted for by new products for all industries as a whole for firms with less than 100 employees. Sum over all industries (column 3) of product of share of sales accounted for by new products for all firms in each industry (column 1) and share of all sales from firms with less than 100 employees accounted for by each industry (column 2)**.

	(1)	(2)	(3) =(1)*(2) /100
	share of sales accounted for by new products, all firms	share of all sales by firms with less than 100 employees	reference share: small firms with share of total
Food, beverage and tobacco	25.1	32.7	8.2
Textiles and clothing	12.0	3.5	0.4
Wood products	15.2	11.0	1.7
Pulp and paper	19.2	1.1	0.2
Graphical industry	0.9	8.9	0.1
Chemical products	20.0	5.3	1.1
Pharmaceuticals	13.9	0.4	0.1
Mineral products	13.3	4.7	0.6
Metals	8.0	5.0	0.4
Metal products	26.4	9.0	2.4
Machinery	18.3	5.7	1.0
Transport equipment	26.0	6.6	1.7
Electronics	62.3	2.8	1.8
Electrical machinery	28.5	2.0	0.6
Other manufacturing	13.0	1.4	0.2
Total	19.6	100.0	20.4

The share which we are looking for is the total column 3. This is the sum over all industries of the product of the share in each industry of the sales of all firms in the industry accounted for by new products and the share of all sales from small firms accounted for by the industry. (In the same way we would find that the total of column 1 of 19.6 per cent, which is the share of sales accounted for by new products of all firms in all industries as a whole, can be expressed as the sum over all industries of the product of the share in each industry of the sales of all firms in the industry accounted for by new products and the share of all sales from all firms accounted for by the industry.)

We see that the industry structure adjusted reference share is 20.4 per cent. Given the distribution of sales across industries among the small firms, they would have had an

overall share of their sales accounted for by new products of 20.4 per cent if they in each industry had had a share of sales accounted for by new products equal to the corresponding share for all firms in the industry. This share of 20.4 per cent is actually higher than the corresponding share actually found among all firms. This means that none of the difference in the share of sales in all industries combined accounted for by new products between small firms and all firms can be explained by the difference in the distribution of sales across industries between small firms and all firms. From this difference in itself, we would actually have expected the small firms to have a higher share than all firms. Thus, of the difference in the shares of the sales accounted for by new products for all industries as a whole between small firms and all firms, more than this difference is accounted for by the small firms on weighted average having a lower share of their sales inside each industry accounted for by new products than all firms, while the difference in the distribution of total sales across industries works in the opposite direction.

We thus have the following decomposition. For all industries as a whole, the small firms have a share of their sales accounted for by new products of 14.8 per cent, while the corresponding share for all firms is 19.6 per cent. Accordingly, the small firms have a share which lies 4.8 percentage points below all firms. If the small firms, given their distribution of total sales across industries, had had a share equal to all firms inside each industry, they would have had a share of 20.4 per cent. This is 5.6 percentage points above the actual small firms share and 0.8 percentage points above all firms. Thus, of the 4.8 percentage points which the small firms are below all firms, the difference in the distribution of sales across industries accounts for 0.8 percentage points in the opposite direction, while 5.6 percentage points are accounted for by the small firms having on weighted average a lower share inside each industry. It is this difference of 5.6 percentage points which now becomes our point of departure. We want to find an expression of how much each industry contributes to this difference.

Having calculated above the share which the small firms would have had if in each industry they had had the same share as all firms, the calculation of the contribution of each industry to the actual small firms share's difference from this hypothetical share is straightforward. We choose to do this in the same way as we calculated the hypothetical reference share, only that instead of the share of sales in each industry accounted for by new products among all firms in the industry we substitute the difference between the share of sales in each industry accounted for by new products among the small firms in the industry and the share of sales in each industry accounted for by new products among all firms in the industry. Thus, to measure the contribution of each industry to the difference between the actual share of sales accounted for by new products in all industries as a whole among the small firms and the corresponding share the small firms would have had if in each industry they had a share equal to the share among all firms, for each industry we multiply the difference between the share of sales in the industry accounted for by new products among the small firms and the share of sales in the industry accounted for by new products among all firms by the industry's share of total sales from small firms. The sum of these products over all industries is equal to the difference between the actual share of sales accounted for by new products in all industries as a whole among the small firms and the corresponding share the small firms would have had if in each industry they had a share equal to the share among all firms.

The computations and the results are shown in Table 20, below.

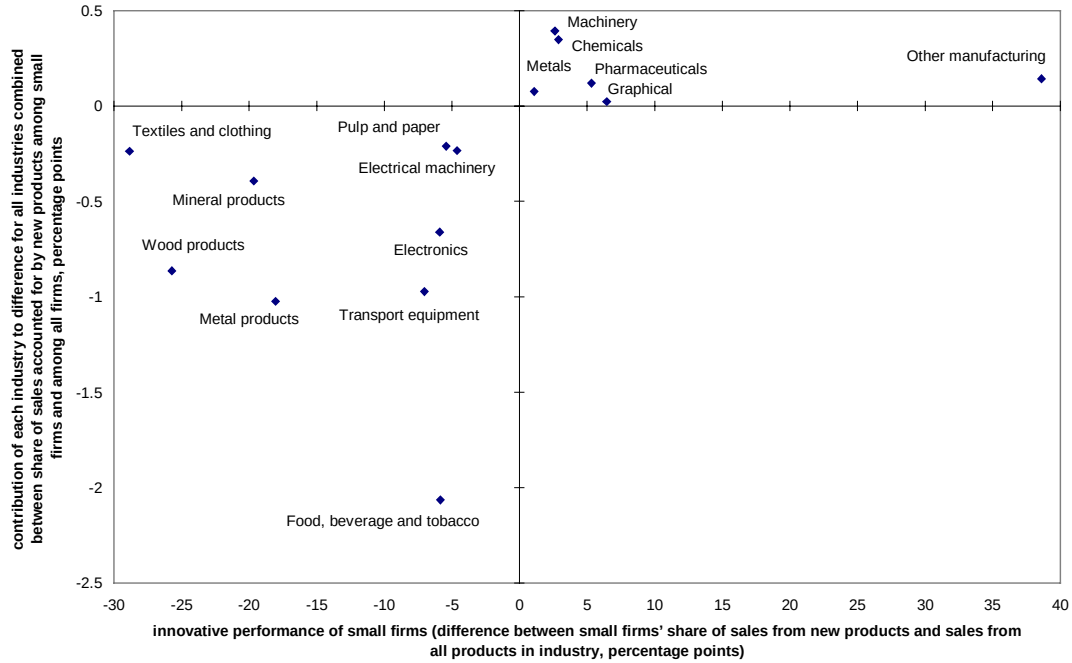
Table 20. **Contribution of each industry to difference between share of sales in all industries accounted for by new products among small firms and reference share adjusted for industry structure, column (5), = difference between share of sales accounted for by new products in each industry among small firms and among all firms, Column (3) = column (1) - column (2), multiplied by share of all sales from small firms accounted for by each industry, column (4). Differences in percentage points, all other figures per cent**.

	(1)	(2)	(3) =(1)-(2)	(4)	(5) =(3)*(4) /100
	share sales accounted for by new products, small firms	share sales accounted for by new products, all firms	differenc e share small firms - share all firms	share of all sales from firms with less than 100 employee s	contri- bution of each industry
Food, beverage and tobacco	18.8	25.1	-6.3	32.7	-2.1
Textiles and clothing	5.1	12.0	-6.8	3.5	-0.2
Wood products	7.3	15.2	-7.9	11.0	-0.9
Pulp and paper	0.0	19.2	-19.2	1.1	-0.2
Graphical industry	1.2	0.9	0.3	8.9	0.0
Chemical products	26.7	20.0	6.6	5.3	0.3
Pharmaceuticals	47.0	13.9	33.1	0.4	0.1
Mineral products	4.9	13.3	-8.4	4.7	-0.4
Metals	9.5	8.0	1.5	5.0	0.1
Metal products	15.0	26.4	-11.4	9.0	-1.0
Machinery	25.2	18.3	6.9	5.7	0.4
Transport equipment	11.3	26.0	-14.7	6.6	-1.0
Electronics	39.0	62.3	-23.3	2.8	-0.7
Electrical machinery	16.8	28.5	-11.7	2.0	-0.2
Other manufacturing	23.0	13.0	10.0	1.4	0.1
Total	14.8	19.6	-4.8	100.0	-5.6

We see that the contributions of all the industries do indeed add up to the 5.6 percentage points which is the difference between the actual share of sales accounted for by new products in all industries as a whole among the small firms and the corresponding share the small firms would have had if in each industry they had a share equal to the share among all firms.

In Figure 12, below, we give a graphical representation of these results, where the contribution of each industry to the difference between the share of sales in all industries as a whole accounted for by new products among the small firms and the corresponding share among all firms, adjusted for difference in distribution of sales across industries, is plotted along the y-axis, against the innovative performance of small firms component from Table 18 and Figure 11, above, along the x-axis.

Figure 12. **Contribution of each industry to difference for all industries combined between share of sales accounted for by new products among small firms, adjusted for distribution of sales from small firms by industry, and among all firms, percentage points (y-axis), difference between small firms' share of sales from new products and from all products in industry, percentage points (x-axis)**.



We see that the way these two dimensions are constructed, it is not possible to have a positive score on one dimension and a negative one on the other. If the small firms in an industry have a larger share of industry sales from new products than of industry sales from all products, it will also have to be the case that the small firms in the industry have a larger share of their sales accounted for by new products than all firms in the industry.

Apart from this, there is no clear relationship between the two dimensions. The first thing to note here is that the innovative performance of small firms component, represented along the x-axis, is not standardised, which means that a direct comparison of the industries in terms of the absolute value of this component is not necessarily meaningful.

For instance, compare textiles and clothing and pulp and paper along this dimension. From the inspection of the x-axis in Figure 12, it would appear that the small firms in textiles and clothing perform much worse than the small firms in pulp and paper. Now, for the textiles and clothing industry as a whole, the share of sales accounted for by new products is 12.0 per cent, while the corresponding share for the small firms in the industry is 5.1 per cent, which is less than half the share of all firms. This means that while the share of the small firms of all sales in the industry is 50.4 per cent, their share of the industry sales from new products is less than half of this, namely 21.5 per cent (Table 18, above). The difference between these two shares is 28.8 percentage points, which is the score of the industry along the innovative performance of small firms component. However, for the pulp and paper industry as a whole, the share of sales accounted for by new products is 19.2 per cent, while for the small firms in the industry the share is simply 0. But since the share of all sales in the industry accounted for by small firms is only 5.4 per cent, this is the maximum negative value that the small firms can have on the innovative performance component in this industry. Clearly, however, it seems reasonable to say that the small firms perform even worse in pulp and paper than in textiles and clothing. When comparing these two industries along the innovative performance of small firms component, we have to keep in mind that the small firms account for a very large share of the industry sales in textiles and clothing but a very small share of industry sales in pulp and paper.

Second, when we just compare the innovative performance of small firms to all firms inside an industry, we do not take account of how important the industry is in terms of its share of all sales from small firms. For instance, the small firms might perform very well compared to all firms in a couple of industries, but these industries might account for a rather minor share of all small firm production.

Third, there is the question of how to express the innovative performance of small firms compared to all firms in an industry (given that the measure of innovative performance simply is the share of sales accounted for by new products, as defined above). If this is done on a ratio basis, for instance by taking the ratio of the share of sales accounted for by new products among small firms in an industry to the corresponding share for all firms in the industry, then one does not take into account that the share of sales accounted for by new products varies substantially among industries. If there generally is very little sale from new products in relation to all sales in an industry (as in our material most typically in graphical industry), even a very high ratio of the small firm share to the all firms share will mean very little in terms of the percentage points differences between these shares, and it is these percentage points differences, combined with the weight of the industry in question in the total sales of the small firms, which are crucial when it comes to the contribution of the industry in question to the relative innovative performance of the small firms compared to all firms for all industries as a whole.

Thus, we see that the graphical industry, where the innovative performance of small firms compared to all firms is good, contributes almost nothing to the difference between the share of sales accounted for by new products among small firms for all industries as a whole and the corresponding share, adjusted for the difference in the distribution of sales across industries, among all firms. This is because the share of sales accounted for by new products in this industry is so extremely low. Likewise,

there is not much contribution from other manufacturing either, primarily because this (residual category) industry accounts for such a small share of the sales from small firms.

Of the industries which contribute in the positive direction, machinery and chemicals account for most, but none of them contribute very much (no more than 0.4 and 0.3 percentage points, respectively), none of them representing an especially large share of the sales from small firms (both around 5 per cent).

While six industries contribute in the positive direction, nine industries contribute in the negative direction, and they also each generally contribute more in absolute value than those which contribute positively. Five of the nine industries which contribute negatively contribute by more than 0.5 percentage points. All in all, then, the negative contributions by far outweigh the positive.

The industry which by far contributes most is food, beverage and tobacco, by more than 2 percentage points downwards. This primarily reflects its very large share of total sales from small firms (almost 1/3), combined with an innovative performance of small firms in the industry which lies a moderate distance below the performance of all firms in the industry.

Next to food, beverage and tobacco in terms of negative contribution come metal products and transport equipment, and then come wood products and electronics. For illustration, we may compare the two latter, which have roughly the same contribution. However, for wood products, the difference from all firms in performance is moderate, but the weight of the industry, its share of all sales from small firms, is large. For electronics, it is the other way round.

Above we said that there are many problems and uncertainties connected to our measure of innovativeness as the share of the sales accounted for by new products, and we said that in particular we should be careful when we compare such rates across industries. This would seem to imply that we should also be careful making comparisons across industries which are based on percentage points differences between such shares. On the other hand, we have compared such shares for all industries as a whole, which in effect means to add up such percentage points differences over all industries. Here we only show how much each industry contributes to this difference we find for the total, at the same time as we adjust for the difference in the distribution of sales across industries.

In spite of these reservations, we nevertheless conclude that we do not find any evidence of industries where small firms are very important in terms of product innovations, or more precisely, in terms of sales of new products as specified in our definition.

9. Conclusion

In this paper we have looked at product innovations in small and medium sized firms, comparing their performance in this respect with large firms. We have used a very simple measure of product innovations performance, namely the share of sales in the last year accounted for by products which were new or changed during the last three years. Four different definitions of product innovations based on this basic definition were used, where we distinguished between (1) radical innovations, (2) incremental innovations, (3) new products of any kind, and (4) products which were new also to the industry in which the firm operates.

Our basic definition of small and medium sized firms was very simply firms with less than 100 employees, which we contrasted to firms with 100 employees or more. We found that for all industries combined the small firms category as a whole had a lower share of its sales accounted for by new products than the large firms, and consequently a lower share of all sales from new products than of all sales from all products. This was true regardless of definition of product innovations, but the difference was more substantial for incremental innovations than for radical innovations.

When we used a finer size classification, with six size categories, the result that the small firms have a smaller share of their sales accounted for by new products than larger firms, was confirmed. However, the dividing line between the small firms and the rest in this respect seemed to lie at 60 employees rather than 100. The less than 30 employees and the 30-59 employees categories both had shares which were substantially below the other size categories, while the 60-99 employees category was more in line with the larger firm categories.

However, we also found that there is much more variation among the small firms than among the large firms in the share of sales accounted for by product innovations. Especially, the share of the firms which have no product innovations at all is much larger among the small firms than among the large firms. With a classification of firm size into six size categories, we found that the share of firms with no product innovations decreased sharply and steadily with firm size, falling from well over 90 per cent among the firms with less than 30 employees to 30 per cent among the firms with 500 or more employees. But while in the small firms categories a very large share of the firms had no product innovations, there was a small minority of the small firms which had a very high share of their sales accounted for by product innovations. In fact, when we excluded the firms with no product innovations and only looked at the firms which had product innovations, we found that it rather was the small firms which tended to have a larger share of their sales accounted for by new products than the large firms, although the relationship between firm size and our measure of sales from product innovations was not very impressive.

However, we also pointed to a bias in our measure both in the case of the share of firms which have product innovations and in the case of the share of sales accounted

for by product innovations when we exclude the firms without product innovations. We do not know how much this bias accounts for, but to the extent that it is present, it will favour the large firms in the case of the recording of the share of firms with product innovations to the same extent that it will favour the small firms in the case of the recording of the share of sales accounted for by new products when firms without product innovations have been excluded.

Lastly, we looked at the performance of small firms in terms of sales accounted for by new products by industry. Here we reverted to the dichotomy of small firms defined as firms with less than 100 employees and large firms defined as firms with 100 employees or more. Also, we only considered the wide definition of product innovations, i.e. the sum of radical innovations and incremental innovations. Although we did find substantial variation across industries in the innovative performance of small firms compared to large firms, but we did not find any industries where small firms were very much more important in terms of sales from new products than what we found for all industries as a whole.

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STEP group

STEP-gruppen ble etablert i 1991 for å forsyne beslutningstakere med forskning knyttet til alle sider ved innovasjon og teknologisk endring, med særlig vekt på forholdet mellom innovasjon, økonomisk vekst og de samfunnsmessige omgivelser. Basis for gruppens arbeid er erkjennelsen av at utviklingen innen vitenskap og teknologi er fundamental for økonomisk vekst. Det gjenstår likevel mange uløste problemer omkring hvordan prosessen med vitenskapelig og teknologisk endring forløper, og hvordan denne prosessen får samfunnsmessige og økonomiske konsekvenser. Forståelse av denne prosessen er av stor betydning for utformingen og iverksettelsen av forsknings-, teknologi- og innovasjonspolitikken. Forskningen i STEP-gruppen er derfor sentrert omkring historiske, økonomiske, sosiologiske og organisatoriske spørsmål som er relevante for de brede feltene innovasjonspolitikk og økonomisk vekst.

The STEP-group was established in 1991 to support policy-makers with research on all aspects of innovation and technological change, with particular emphasis on the relationships between innovation, economic growth and the social context. The basis of the group's work is the recognition that science, technology and innovation are fundamental to economic growth; yet there remain many unresolved problems about how the processes of scientific and technological change actually occur, and about how they have social and economic impacts. Resolving such problems is central to the formation and implementation of science, technology and innovation policy. The research of the STEP group centres on historical, economic, social and organisational issues relevant for broad fields of innovation policy and economic growth.