Staffing and organization of product innovation

4 Staffing and Organization of Product Innovation

The previous two chapters have shown how much innovation is taking place, and of what types. Next we need to explain how innovation takes place in small firms, what influences or constrains its development, and how regional differences fit into the picture. That is the task of the next three chapters.

The present chapter looks inside the firm, considering how far the availability and organization of *human resources* determines the progress made with innovation. The next chapter looks at the *market relationships* of firms (with customers, suppliers, sources of finance, and so on) and asks how these affect innovation. Widening the perspective still further, Chapter 6 considers the *characteristics of the regions* within which firms operate.

It seems obvious enough that a firm's ability to develop products depends on the ingenuity and skill of the people inside the firm. All the more so when, as Chapter 2 showed, a large part of development concerns wholly new products rather than gradual modifications. But there are many different ways in which the varied tasks of product development can be divided. In some cases, a single individual may find the basic idea for the product and carry out much of the development work. This conforms to a popular view of the inventor-entrepreneur. But in other cases, groups or teams of people may be involved, even in quite small firms, and if that is so then the staffing of this group is likely to be critical for success.

In addition, there may not be a clear line between product development and production, since an essential part of successful product development may be to bring the new or modified product 'on stream'. Hence the skills of engineers, technicians and operators on the shop floor may also be highly relevant. Indeed, even before the production phase of development, the existence of skilled and reliable personnel in jobs of all kinds may help to reduce the burdens of day-to-day management, and so free time for development work for the firm's directors or senior technical staff.

The view which we take of staffing and organization is, accordingly, a broad one. Availability or shortages of skill at any level in the organization may have important effects on product innovation.

Origination of product ideas or designs

The first stage in product innovation is to have an idea or design. But not all product innovation starts within the firm. Ideas and designs can be acquired from outside, from customers or suppliers, or by licensing or purchase. These 'market generated' innovations will be discussed in more detail in the next chapter. For the moment, all we need to establish is what proportion of the product innovations arise *inside* the firms in the British sample.

The simple answer is, approximately two in every three (63 per cent) of product innovations originated within the firm, wholly or partly. There was quite a marked difference between the East Midlands (55 per cent) and North East (74 per cent). Earlier chapters have established that product innovation was of a more intensive kind in the East Midlands, but obviously this was *not* the result of superior internal generation of product ideas. This point can be taken further by considering the origin of designs for microelectronic components or sub-systems used in new products; most of the new products with microelectronics came from the East Midlands firms. Only one third (32 per cent) of microelectronic designs came from within the innovating firm, the rest being acquired from outside. So the innovative skills of the East Midlands firms were in part those of harnessing and incorporating specialized technology from outside.

The 35 firms which had originated new product ideas or designs internally were asked the job titles of the individuals responsible, and also their qualifications. In four cases it was not clear who had initiated the new ideas. In 15 cases the originator was the managing director or owner, so the classic entrepreneurial model of innovation applied to not quite half of the relevant cases. (In two of these cases, also, the managing director was the joint rather than sole originator of the idea). Other directors or partners were responsible for new ideas in seven cases. Hence two out of three internally generated new products originated at Board level. Individuals at management level below the Board of Directors originated ideas in seven cases, and individuals below management level did so in six cases. It is interesting to note that ideas originated from sales or marketing management and staff, rather than from technical or production management and staff, in five of the 35 firms with internal origination of new products.

There was also a wide spread in terms of the qualifications of the originators of ideas. In 11 of the 31 cases where information was available, originators had a degree in science or technology, or a qualification of equivalent status such as a Higher National Certificate. At the other extreme, eight originators had no formal qualification. With one exception, these were managing directors or directors, who perhaps exemplified the British tradition of 'practical experience' (several quoted the number of years they had spent in the industry, as their qualification). There were also two originators with non-technological degrees, and others had membership of various professional institutes, or lower qualifications such as a craft certificate.

The overall picture, then, is of the main impetus for innovation coming from Board level, but with a spread of participation in a substantial minority of the firms. In addition, people offering many kinds of qualifications and experience can act as originators. The scope for a variety of individuals to become involved even in the earliest stages of product innovation appears to be quite wide.

'Research and Development'

Industrial research and development (R&D) spans the whole process from seeking improvements or innovations experimentally, to bringing an idea to the stage of production. In most industries, and probably in most small firms, *development* work (rather than longer-term *research*) predominates within R&D. Almost any idea for a new or improved

Entrepreneurs and their products: examples

Fabrication and Assembly Company (FAC) was formed by two people made redundant by an engineering company. One was the works manager, with a background in welding, and the other was the works study and planning engineer. Initial products were related to the markets served by their former employer (motorway balustrading), and welding technology remained of central importance in successor products.

Farm Machinery Manufacturer (FMM) was established by a dairy farmer and an electrical engineer. The engineer designed a system based on the product idea provided by the farmer, and this system was installed on the latter's own farm. When it proved successful, other local farmers wanted the system, and so the company was born. The engineer remained in charge of new product development and design.

Specialized Knitting Machines (SKM) was originally a sub-contracting subsidiary of a larger firm. The firm was purchased by the former managing director after being put into liquidation by the owners. He was a former tool maker who had worked his way into production management and then general management. He had also studied part-time and obtained a Diploma in Management Studies. The managing director was the main initiator and designer of the new products in this company.

Incinerator Company (IC) was run by three people, two of whom were father and son. One of these, originally a skilled operative who had gained considerable engineering experience, was the technical director and in charge of development and design. Another, who had previous marketing consultancy experience, had identified the opportunity for new types of incinerator in the course of his former work. He identified a possible collaborator in the USA, and obtained some of that company's incinerator designs when it went into liquidation.

product will have to go through a process of development in order to make it into something which can be produced and sold. It seems obvious that the amount of effort and resources put into R&D will strongly influence product innovation, but just how important is this? And in what way are resources and effort organized and brought to bear?

The questions posed in the survey distinguished between research and development 'activities' and the existence of a research and development 'department'. A company which has an R&D department can be presumed to take innovation very seriously indeed. Where a firm has no R&D department, but still regards itself as having R&D activities, this could reflect either of two possibilities. Its R&D activities might be occasional and on a very small scale, so that it would not be worth having anything so formal as a department. Or it might engage in a considerable amount of R&D work, but prefer to keep the organization fluid. Finally, if a firm has no R&D department and no R&D activities, it seems unlikely that it would place much emphasis upon product innovation. It might, however, still be able to make innovations in an *ad hoc* manner.

In total, just under one half (47 per cent) of the whole British sample saw themselves as being engaged in R&D activities. But only one in 10 (10 per cent) stated that they had an R&D department. As would be expected, then, the great majority of small firms engaging in R&D did so in an informal way.

Not all firms with R&D activity were concerned with product development, since a minority considered process improvements as their main aim. Nonetheless, *any* R&D activity, whether or not formally organized in a department, was very strongly linked to recent achievement of product innovation, as shown in Table 4.1. And there was a particularly strong link with product innovation involving microelectronic components.

Eight out of the 10 firms with R&D departments had product innovation with microelectronics, and the other two had produced new products of a conventional kind.

With one solitary exception, all the firms innovating with microelectronics either had R&D departments or engaged in R&D activities.

Most of the non-innovators had no R&D activities. However, just over one half of the innovation in conventional products (not involving microelectronics) came from firms which did not regard themselves as

Table 4.1 R&D and product innovation

		New products with microelectronics	New products without microelectronics	No new products
				column percentages
R&D department		36	6	0
R&D activities		59	42	19
Neither		5	52	81
Base for percentages		*22*	*34*	*42*
	base			*row percentages*
R&D department	*10*	80	20	0
R&D activities	*36*	36	42	22
Neither	*52*	2	33	65

taking part in R&D as such.

These findings confirm the conclusion of earlier chapters, that new products with microelectronics represent a particularly intensive kind of innovation. Even though most of the designs for microelectronic parts were supplied from outside, the overall development of products with microelectronics nearly always involved some recognized R&D activities, and quite often a formal R&D department.

Firms were also asked whether the staff taking part in R&D did so as their main task, or as one task among many. Eleven per cent of firms said that R&D was the main task for these staff, almost the same result as with R&D departments. But in only half the firms with R&D departments, was R&D the main task of the staff involved. And in half the firms where staff engaged in R&D as their main task, their activity was not regarded as that of a department.

Evidently, then, some R&D departments take on a range of other tasks, and some firms have staff intensively engaged in R&D without organizing them into departments. In terms of the outcomes achieved, there was no difference between R&D departments and groups working intensively on R&D. All the firms which had staff who devoted most of their time to R&D had recently introduced new products, and most of these were also involved in microelectronics.

It might be supposed that R&D was chiefly concentrated in the larger firms within the sample, but matters were not so simple as that. Firms with 50 or more employees were, indeed, more likely than the remainder to engage in R&D (65 per cent as compared to 40 per cent), but there was no difference between firms with less than 20 employees and those with 20-49 employees. And six of the 10 firms in the sample which had R&D departments, had less than 50 employees. Even formally organized R&D, therefore, is not a prerogative of larger firms.

Since the existence of recognized R&D activities was so strongly linked to product innovation, did it also help to account for the differences in innovation between the East Midlands and the North? Table 4.2 gives an answer in the affirmative. Eight out of 10 R&D departments were in the East Midlands, and the overall proportion with R&D activities was 58 per cent there, compared to 33 per cent in the North. The majority of East Midlands firms, one might say, took R&D seriously, while only a minority of Northern firms did so; this was reflected in the different intensities of product innovation in the two areas.

Table 4.2 R&D and region

column percentages

	East Midlands	North
R&D department	15	5
R&D activities	44	28
Neither	42	67
Base for percentages	*55*	*43*

Staffing of R&D

Since the existence of R&D departments or activities has such an important bearing on product innovation, it is worth knowing more about the numbers of staff involved. It seems likely that firms putting more people into R&D work will, other things being equal, more frequently introduce new products. This could be one of the main advantages of size in relation to product innovation.

Nearly all the firms which had R&D activities (including those with R&D departments) had *more than one person* involved. The most common number was two (14 out of 43 firms supplying figures), while the *median* was three people. There was also quite a considerable 'tail' of larger numbers, with a few of the firms even having more than 10 people engaged in R&D. The general picture, then, is of R&D being conducted by small groups of staff, but sometimes with larger numbers involved.

This picture does not change much if we focus on the smaller group of firms which either have R&D departments, or have staff with R&D as their main task. Three staff engaged in R&D was, for these firms, both the most common and the median result.

If the number of staff engaged in R&D makes a difference to chances of achieving product innovation, then those firms which have innovated would, on average, have more R&D staff than those without. Table 4.3 confirms this in detail.

Table 4.3 R&D and product innovation

column percentages

	New products with microelectronics	New products without microelectronics	No new products
Number in R&D:			
None	5	50	81
1	5	6	5
2	23	15	10
3	18	12	2
4-6	18	9	0
7-10	9	3	0
11 or more	18	3	2
(no info.)	5	3	2
Base for percentages	*22*	*34*	*42*

Nearly half the firms with an involvement in microelectronics had above-average sized groups, of four or more staff, on R&D tasks, but this proportion fell to 15 per cent in the case of product innovators without microelectronics.

Staffing of R & D: examples

Fabrication and Assembly Company (FAC) kept R & D under the control of the two original founders and owners. The activity was chiefly directed towards incremental improvements in both products and processes of manufacture. The two owners placed considerable stress on obtaining ideas from external sources, and development work was sub-contracted if it fell outside their experience. It was estimated that about three man months of their own time had been put into R & D in the year before the case study.

Farm Machinery Manufacturer (FMM) gave high priority to new products and had set up a formal R & D department, under the management of the electrical engineer who was the co-founder of the business. At its largest, the department had had eight full-time staff, but a contraction of the market had forced the company to reduce this to three (including the manager). One was a microprocessor software specialist, and was responsible for writing new programmes and for software interfacing of hardware. The other was a hardware engineer, concerned with the development of electronic test equipment for the products as well as with new products themselves. There were four other technically qualified employees, not directly involved in R & D.

Specialized Knitting Machines (SKM) believed that new products were of critical importance for its growth. The lead was taken in R & D by the owner/managing director, who spent about one quarter of his time on these activities, including detailed design work. He was helped by the two managers between whom the production responsibility was divided in this firm. Their support was chiefly in providing and evaluating ideas. Ideas were also actively sought externally. SKM had attempted to recruit a development engineer to support the owner, but had been unable to find a suitable person. This was regarded as a significant obstacle to growth.

Incinerator Company (IC) kept product development under one of the owners, as a part-time activity. He was assisted by a qualified engineer and a draughtsman, but these also had other responsibilities apart from development work. There were three other technically qualified members of staff, not involved in development work. The original design which permitted the firm to develop a successful new product was created as a spare-time activity while running a general engineering business. Design improvements continued to be carried out whenever spare time could be found.

Technical staff and skilled workers

We have now shown how crucial it is for product innovation to have staff designated to R&D. But how far does this in its turn depend upon the availability of a pool of technical staff (engineers or technicians) and of skilled production workers? For it is from such a pool of highly-skilled people that those involved in R&D will usually be drawn.

For the sample as a whole, the *median* proportion of engineers and technicians was 14 per cent, or almost one in seven of all employees. However, the spread was wide. Fifteen per cent of firms had *no engineers or technicians* whatever. And 20 per cent of firms had 50 per cent or more engineers or technicians. Although these results could be exaggerated by variations in firms' ideas of what is meant by an engineer or technician, there were clearly very large differences from one firm to another.

To our surprise, however, we found that the proportions of engineers and technicians did *not* vary much between firms with and without R&D activities. Those with R&D had 16 per cent as the median proportion, while those without R&D activities had 13 per cent; this difference could easily have arisen by chance, in view of the large variation in proportions of engineers and technicians from firm to firm. Similarly, the proportions (though in the expected direction) were not significantly different between product innovators (15 per cent) and non-innovators (10 per cent). Or again, the more innovative East Midlands firms had a slightly greater average proportion of higher level staff than did the Northern firms, but the difference was well within what could have arisen by chance.

It seems, therefore, that the critical factor, so far as higher level staff are concerned, is not how many of them there are, but how far they are deployed into R&D activities. Firms with similar availability of higher level staff make different choices about using them for R&D activities, and this is reflected in their different rates of product innovation.

But there is a further possibility to be considered. The availability of higher level staff for R&D may be facilitated by the support of skilled shop floor workers, or it may be limited by a lack of such workers. Firms may be forced to keep their higher level staff tied up in day-to-day production activities because of the low skill level of their production workers. We therefore examined the proportions of skilled workers on the shop floor.

The initial findings here were very similar to those for higher level staff, or indeed more negative. For example, firms with no product innovation had if anything higher proportions of skilled manual workers on the shop floor than did the remainder. However, as before the differences were non-significant. Closer investigation showed, however, that there might be complications masking the true importance of a skilled work-force. There were *higher* proportions of skilled workers in the *smallest* firms, and in firms in the North, and both of these had lower than average propensities to take part in R&D. *Within* each size group, and within each region, there was a tendency for the firms with greater availability of skills to be more active in R&D, although when the sample was split in this way, the groups were too small for statistically reliable comparisons to be obtained.

It must also be recalled, from the preceding chapter, that innovative firms tended to make more use of advanced production technology and of computer systems, especially those computer systems which support design and production planning. It is possible that these investments helped them to contain the numbers of higher level staff or skilled workers which they would otherwise have required. This is, however, a speculative interpretation, since we did not directly gather information about the relationship between human resources and process technology or computing.

Our initial conclusion from this analysis, then, is that the presence of higher level staff and of skilled manual workers is of relatively small importance compared with the decisions made by firms about how to use the human resources available to them, especially on R&D activities.

Shortages of engineers, technicians and skilled workers

The innovativeness of firms could be affected, not only by the human resources which they have, but also by those they want but cannot get. In addition, introducing new products may increase the need for new kinds or increased numbers of personnel, which may be difficult to satisfy.

The firms in the British sample were therefore asked if they had experienced any shortages of labour between 1980 and 1985. If so, they were also asked which kinds of labour were concerned.

Just over one half of the British firms said that they had experienced shortages, a finding which immediately suggests how significant this aspect may be. Firms were also asked if the shortages had affected their capacity either for product development or for process development. Three in five of the firms which had experienced shortages of personnel (30 per cent of the whole sample) felt that either their product or process development had been adversely affected. Moreover, if product development was affected, then so too, in most cases, was process development: 25 per cent of the sample felt that *both* product *and* process development had been retarded by personnel shortages.

The shortages much more frequently concerned *skilled manual workers* than *engineers or technicians*. In all, 36 per cent of the small firms had experienced shortages of skilled manual workers, and 19 per cent shortages of engineers or technicians. And, while it might have been thought that the more critical shortages for purposes of innovation would be those of the higher-level personnel, this was not in fact the case. Obstacles to product development were created by lack of engineers or technicians in 12 per cent of firms, but similar obstacles arose for 20 per cent of firms through lack of skilled manual workers. In the case of process development, similarly, nine per cent of firms were hindered by shortages of engineers or technicians, but 19 per cent by shortages of skilled manual workers.

The group of firms most likely to say that they had been short of engineers and technicians were those which *had* introduced new products with microelectronics components. In fact, they were more than twice as likely to be aware of such shortages as other firms; there was no difference here between the non-innovators and those innovating without microelectronics. In sharp contrast, shortages of manual workers were somewhat more highly concentrated among firms *without* product innovation. So, although shortages of higher level staff were less frequent, they occurred most in the firms which had been innovating most intensively. Conversely, the more widespread difficulties in getting skilled manual workers were spread more evenly and particularly affected the non-innovators (which were, perhaps, the firms relying most on skills of the traditional types). These findings are summarized in Table 4.4.

Table 4.4 Personnel shortages and product innovation

column percentages

	New products with microelectronics	New products without microelectronics	No new products
Shortages of engineers or technicians	36	12	14
Shortages of skilled manual workers	32	29	43
Base for percentages	*22*	*34*	*42*

It is mistaken to suppose, then, that shortages of personnel are generally associated with failure to innovate. As can be deduced from Table 4.4, two-thirds of the reported shortages of engineers and technicians, and just under one-half of the shortages of skilled workers, were in firms which had *succeeded* in introducing new products. Conversely, only one third of firms which had no product innovation, *both* reported a shortage of personnel *and* a resulting constraint on product development. It is only this group, representing 15 per cent of the whole sample, where it can be said in a simple way that labour shortages had prevented innovation.

This does not mean that the shortages of personnel in the remaining cases were unimportant. In these cases, the firms presumably began to run into the shortages *either* in the period when product development was under way, or after it had been achieved. This could happen perhaps because of the expansion or other new opportunities which innovation had created for the firms, leading them to seek new staff at an increased rate. The more innovative firms are, the greater their demands on the labour market, and the more likely they are to be hindered by shortages. And as they move into new technology as well as new products - microelectronics, in particular - their needs and their problems shift from the supply of traditional skills to finding higher level talents.

In addition, we naturally expect skill shortages to be more pronounced in areas where business is more successful and dynamic. Each firm in such a region is more likely to be making increasing demands for skills, and each is competing with a greater number of like-minded firms, by comparison with a relatively static or depressed area. This is precisely what we find in a comparison between the East Midlands and the North. East Midlands firms report twice the level of shortages for engineers and technicians, and three times the level of shortages for skilled manual workers. This is shown in Table 4.5.

Table 4.5 Personnel shortages and regions

column percentages

	East Midlands	North East
Shortages of engineers or technicians	24	12
Shortages of skilled manual workers	51	16
Base for percentages	*55*	*43*

Once again, therefore, we see that shortages of personnel are as much, or more, a consequence of innovation and growth as an obstacle in the path of small firms.

Comparisons with personnel shortages in West Germany

The German study did not investigate the existence or size of groups involved in development work. Because the German sample concerned firms of larger size (on average) than the British sample, and because product and process development were virtually universal there, it was assumed that R&D would be proceeding through organized groups of qualified and skilled personnel. It should also be borne in mind that, in general, industry in the FGR enjoys both a greater supply of personnel with higher engineering or technical qualifications, and of skilled production workers coming from a system of apprenticeship which is far more comprehensive than the arrangements in Britain.

These considerations, however, do not necessarily mean that the German firms have no troubles over personnel. As our examination of the British firms has suggested, those who pursue product innovation most intensively may stretch their human resources the most, and so be most likely to encounter shortages of supply. The German study in fact placed particular emphasis upon examining shortages of personnel, and in investigating how these related to product innovation.

The simplest, and most striking, point is that the German firms experienced *more* difficulties over recruiting the qualified personnel they needed, than did the British firms. No less than two firms in three within the German sample reported this problem, compared with around one half of the British sample. Since this cannot be the result of general deficiencies in the supply of qualified personnel to the labour market, there seem to be two possible explanations. It could be the result of generally more buoyant economic conditions in the FGR than in Britain over the 1980-85 period, leading to tighter job markets in the former. Or it could be a consequence of the higher levels of innovation in the German than in the British sample, making them more 'hungry' for qualified and skilled personnel. Or, of course, both influences could act in combination.

We cannot directly assess the influence of general economic conditions on the respective job markets, but it seems plausible to assume that this was playing some part. What the German survey does provide is further support for the view that innovation itself leads to a heightening of personnel shortages.

One of the clearest indications of this came, once more, from comparing those firms which were using microelectronics in their new products, with those which were not. Three quarters of the former had difficulties in getting qualified engineers, compared with less than one half in the case of firms without microelectronics. Similarly, 42 per cent of the firms using microelectronics experienced difficulties with the recruitment of technicians, compared to 22 per cent in the case of firms without microelectronics.

Equally impressive were the differences between the firms in the German sample which had introduced wholly new products, and the remainder. More than two thirds of the more radical innovators had difficulties in finding qualified engineers, whereas the proportion among the remainder was only 43 per cent.

It is notable that the shortages of engineers and technicians are far higher in the FGR than for comparable groups within the British sample. This perhaps again reflects the greater intensiveness of innovation among the German firms, but also no doubt a greater reliance on qualified personnel. Many of the British firms, developing in an environment where qualified engineers are scarce, have avoided this dependence - although doubtless at some cost to their competitiveness. Once again, it is progressive development which strains resources and highlights shortages.

The German firms were, in addition, far more likely to experience shortages of skilled workers or craftsmen. This applied to about three in four of the German sample, which is once more around twice as high as among the British firms. Moreover, in the more expansionary region of Baden-Wurttemberg (BW) the proportion was nine in 10, compared to seven in 10 in the relatively depressed region of Nordrhein-Westfalia (NRW).

This regional difference applied also to the other categories of qualified or skilled personnel: only to a minor degree in the case of engineers, but with particular acuteness in the case of technicians. In the NRW region, only 16 per cent of firms had difficulties in getting technicians, but this applied to around one half of the firms in the BW region. So the regional comparisons in the FGR yield results in the same direction as in Britain. It is in the more innovative and economically vital region that shortages of personnel are most frequently encountered.

Finally, the German firms were asked to rate the seriousness of the personnel shortages as restrictions on their ability to innovate. On average, they rated these shortages as a factor of medium seriousness, neither extremely limiting nor slight enough to be ignored. Interpreting freely, we might say that innovation proceeds despite shortages of personnel (which in part it produces), but that a better supply of qualified and skilled people could lead to still better results.

Conclusions

The way that skilled and qualified workers contribute to the development of small firms has been the subject of this chapter. The evidence which we have gathered is of a simple kind, but, we believe, represents a useful step forward from the previously prevailing lack of knowledge.

It is popularly assumed that small firms grow up around entrepreneurs who provide all the ideas and innovative skills. Our evidence only accorded with this picture to a small extent. Many of the firms in the British sample relied on developing ideas which they acquired from outside, and of those which originated their own product ideas, one third got them from employees below Board level. More important, the great majority of innovative firms used small *groups* of people who worked part of their time on R&D activities. Without such an *organized effort*, chances of developing new products, and especially new products with microelectronics technology, were greatly reduced.

Whether or not the small firms committed resources to R&D activities seemed not to depend upon how many engineers, technicians, or skilled workers they possessed - at least, if there was an influence, it was small enough to be of little practical importance. Hence the crucial point was how firms chose to deploy their resources of skill, rather than how big those resources were. Since the usual size of successful R&D groups was only two or three people, with R&D as a subsidiary rather than a main task, it seems reasonable that most small firms could manage something along these lines, if the motivation to innovate was strong enough. But as firms develop the use of microelectronics, the R&D groups tend to become larger, and the demands on human resources may become more difficult to satisfy.

The notion of personnel shortages (that is, shortages of qualified or skilled people) has provided the other main point of departure for this chapter. It is here that the British and German studies came closest together, and the results from the two countries were highly consistent. These results, especially when combined, gave quite a different picture from the simple and conventional assumption that high levels of shortage of personnel must indicate strong obstructions to innovation and growth.

The experience of personnel shortages was widespread, but it was focused to the highest degree upon those groups of small firms which were achieving the most innovation. The main group of firms *without* personnel shortages was in the non-innovating and rather static section of the British North. And nothing more clearly distinguished the British from the German firms than the low level of shortages of engineers and technicians in the former and the high level of shortages of these types in the latter. The explanation is obvious. High levels of product development create demands for more qualified staff to maintain the momentum, and not all of these can easily be satisfied. And firms which have grown up with a highly qualified and skilled work-force will expect more people of high quality as they attempt to innovate, diversify and expand.

These points are important for understanding the nature of personnel shortages. Small firms which encounter personnel shortages are seldom prevented from carrying out product innovation, but they may be slowed down in exploiting their innovation to the full or in pushing forward consistently. Firms adapt their development to the resources available in their environment.