Product Innovation and Small Business Growth: A Comparison of the Strategies of German, U.K. and Irish Companies

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ABSTRACT. Innovation in small firms is important both because of its direct contribution to the competitiveness of those companies but also because of the potential for the small firm sector to act as the initiator, catalyst and medium for wider technical change. In this paper data from the Product Development Survey, a new international survey of firms' product innovation activity and strategy, is used to examine the relationship between product innovation and growth in German, Irish and U.K. small firms. In each country the output of innovative small firms was found to grow significantly faster than that of non-innovators. In Germany, output growth was achieved by a product innovation strategy which sharply increased productivity but *reduced* employment. U.K. and Irish small firms adopted a more balanced approach with increases in both employment and productivity associated with innovative behaviour. Comparison of the organisation of product innovation indicated that German small firms adopted a less market-oriented, less risky, and more formally organised approach than their U.K. and Irish counterparts. The revealed characteristics of U.K. and Irish small firms suggested that they may be the most effective initiators and catalysts for wider technological change. The larger proportion of German small firms which were innovating, however, suggested that the German small firm sector may be the more effective technology transfer medium.

1. Introduction

Increasing competition in the European marketplace, resulting in part from the completion of the EU internal market, has raised the competitive pressure on small enterprises. In this environment, innovation and potentially the acquisition of novel technology, is an important if not crucial element of organisations' attempts to maintain or develop their market position. Innovation and technological development in small enterprises is not, however, important solely because of its direct benefits in terms of increased output or employment.[1] It has been argued that because of their special characteristics small firms play an important role as the initiators, catalysts and medium of wider technological change (Schumpeter, 1934). Because of their closeness to the market they may be the first to appreciate a market opportunity and develop a suitable technological response; or, because of their organisational and functional flexibility, they may be the first to adopt new technologies developed elsewhere. This, in turn, might encourage adoption by other organisations, the small enterprise acting as the diffusion medium.

The ability of small firms to fulfil their Schumpeterian role as the initiators or catalysts of technological change stems from their adaptability and flexibility (Wynarzyck et al., 1993), their closeness to the market, their internal consistency and in certain cases the willingness of the controlling entrepreneur to undertake risk (Rothwell and Zegveld, 1982). These potential advantages are offset, however, by diseconomies of scale and internal resource constraints (Rothwell and Dodgson, 1994), emphasising the potential importance of innovative firms' external linkages (Oakey, 1984; Beesley and Rothwell, 1986; Rothwell and Beesley, 1989). Measuring the net impact of the advantages and disadvantages of small firms vis-à-vis innovation raises questions about the definition of an innovation and measures of innovativeness (Kleinknecht and Bain, 1993). European surveys have tended to adopt an approach based on a single, technologically based

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definition of an 'innovation', often that advocated by the OECD. Firms are then asked to specify whether or not they have made any innovations fitting this definition within a specific time period. This allows the proportion of 'innovating' firms to be estimated but gives little indication of the significance of the innovations being made.[2]

Two main problems arise with this type of approach using a single, technologically based innovation definition. First, the results give little indication of the commercial or technological significance of the product change for the innovating company or other firms. Secondly, for small firms where much product innovation is likely to be incremental, the standard approach will underestimate the level of innovative activity. In the Product Development Survey, on which this paper is based, a hierarchy of five innovation indicators were used ranging from the introduction of entirely new products never produced previously to the introduction by the firm of *any* new or improved product. The latter, and least technologically demanding of these definitions, is intended to capture all product changes with any commercial significance. Applied to small firms, its use minimises any underestimation of the level of innovative activity by due to the imposition of arbitrary technological criteria. For both reasons this definition of innovativeness is used throughout the paper, ie. a small firm is said to be innovative if it introduced any new or improved product between 1991 and 1993.[3]

Implicit in this broadly defined notion of innovation is the idea that innovation is a business process rather than a technological process. This in turn emphasises the organisational aspects of innovation including the need for co-ordination and collective commitment. It also emphasises the importance of the context in which any innovation takes place. This includes both the macroeconomic situation within which firms were operating and any market or resource constraints they may face.

The remainder of the paper focuses on the product innovation strategies adopted by German, U.K. and Irish small firms. No explicit discussion of process choices is included, although it is likely that product and process changes are strongly linked for many small firms. The concentration on product rather than process development reflects the strategic situation of small firms; process developments may improve cost-effectiveness and/or product quality, but it is only by developing, or adopting new products that small firms can establish an independent market position. Section 2 of the paper examines the relationship between product innovation and turnover, productivity and employment growth. A clear distinction emerges between German firms which were following an innovation strategy oriented towards *productivity growth* and U.K. and Irish firms which were following a '*balanced growth*' strategy raising both productivity and employment. Section 3 focuses on some aspects of the innovation process, and examines the role of human resources, R&D and network linkages in the implementation of firms' strategies. Section 4 concludes with an assessment of the ability of German, U.K. and Irish firms to act as the initiators, catalysts and the medium through which wider technological development can take place.

2. Product innovation and small firm growth

Detailed information on business growth and the product innovation process is available from the Product Development Survey (PDS). This was a postal survey covering over 15,000 manufacturing enterprises in the U.K., Germany and Ireland and was conducted between November 1994 and April 1995 (Roper et al., 1996). In each country the sample was structured to allow size-band, regional and inter-industry comparisons. Overall response rates of 32.0 per cent in Ireland (533 responses), 25.1 per cent in Germany (1374 responses) and 20.6 per cent in the U.K. (1722 responses) were achieved. Prior to the analysis survey responses were weighted to allow for sample structuring and differential response. Weights for each industry/size-band cell were constructed by comparing sample responses and the 1993 target population of manufacturing firms in each country. The weights were subsequently modified to reflect differences in industrial structure between Germany, the U.K. and Ireland (see Roper et al., 1996). The resulting structurally adjusted statistics may be interpreted as an indication of what the level of innovation etc would have been in the U.K., if U.K. small firms had behaved like their German or Irish counterparts.[5]

To ensure a consistent pattern of responses to the PDS the main survey was preceded by pilot surveys in Germany and the U.K. and by face-to-face interviews in each area. A number of external or environmental factors, however, inevitably affect the comparability of the results of this type of study. In the PDS firms were asked primarily about their innovation activity during the 1991–93 period. In western Germany this was a period of sharply falling manufacturing output (–11.0 per cent) while U.K. manufacturing output was static (+0.8 per cent) and that in Ireland was growing strongly (+16.1 per cent). In eastern Germany, rapid output growth was taking place following the immediate post-unification crisis of 1990–91. These short-term differences in firms' market environment seem likely *a priori* to have depressed the level of innovation activity in Germany relative to the U.K. and Ireland. International comparisons of the relative *level* of product innovation activity from the PDS must therefore be treated with some caution. The PDS, however, also provides considerable insight into the organisation of the product innovation process. These findings – which typically reflect long-term or strategic decisions taken by firms – are likely to be less sensitive to short-term market fluctuations.

A second issue affecting the international comparability of the results from the PDS and other similar surveys is the influence of national – and to a lesser extent regional – policy on innovation behaviour. For example, it is well known that the German apprenticeship system (the 'Dual System') gives a much higher proportion of German young people a vocational qualification than in either the U.K. or Ireland (see, for example, Roper and Hofmann, 1993). Also, German R&D policy has for many years directed funding at collaborative projects and at promoting R&D employment and activity in small firms (Keck, 1993; Council on Competitiveness, 1995). Both factors would suggest that even without any behavioural difference between U.K., Irish and German firms innovation outcomes, and the organisation of innovation, might be expected to differ.

In an attempt to minimise (or clarify) the effect of both influences the PDS included a number of measures of 'innovativeness' and a range of organisational indicators. In terms of the level of innovativeness, the most straightforward is whether firms introduced a new or improved product during the 1991 to 1993 period. On this basis, and despite poor macro-economic conditions, the largest proportion of 'innovative' establishments in the sample was in Germany (71.4 per cent). This was significantly higher than that in both the U.K. (61.0 per cent) and Ireland (68.0 per cent; Table I). This significantly higher level of German product innovation activity is consistent with earlier work by the current author at the level of individual plants (Roper and Hofmann, 1993). It

TABLE I
Percentage of enterprises introducing new or improved products by plant size-band

	n	20–100 %	100–499 %	500 plus %	Total %
U.K.	1133	56.0**	82.9^^	93.2*^	61.0**
Republic of Ireland	404	64.5*^	79.8^^	88.0^*	68.0**
Germany	1184	66.0^*	81.4^^	94.7**	71.4**
Memo items: Western Germany	793	64.4	81.7	94.3	70.6

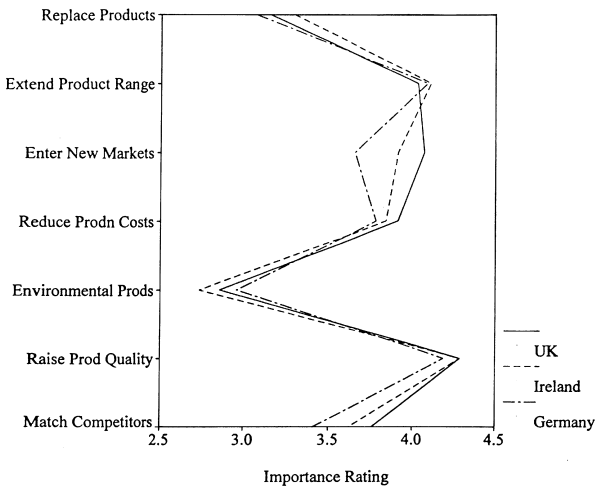
Notes:

1. Innovative firms were those introducing a new or improved product during the period 1991–93.
2. Sample observations are weighted to allow for sample structuring and differential response. Cell sizes are as follows (in ascending sizeband order); U.K., 654, 377, 102; Ireland, 254, 131, 19; Germany, 600, 455, 131.
3. Asterisk denotes rejection of the hypothesis that the proportion of innovative firms in any size-band is the same in the underlying national samples. This is based on a Pearson chi-square test ($\rho = 0.05$). The '^' character denotes non-rejection of the hypothesis. For the U.K. (Irish; German) figures the first superscript is relative to Germany (U.K.; Irish), the second to Ireland (German; U.K.).

Source: Product Development Survey.

also reflects national evidence of German firms' greater financial and manpower commitment to R&D and innovation (see, for example, STIAC, 1995). Also, like previous studies, the PDS suggests that the proportion of innovating firms in each size-band increases with establishment size (Table I). In this respect the U.K. stands out as having a significantly lower product innovation rate (56 per cent) among small firms (i.e. those with 20–100 employees) than Germany (66 per cent) and Ireland (65 per cent). No significant difference was evident between the proportion of innovating small firms in Germany and Ireland.

Despite the lower product innovation rate in the U.K., and differing economic and policy conditions, the PDS suggests a surprising uniformity of product innovation objectives (Figure 1). For small firms in each country the most important objectives were raising product quality and extending the product range. Producing environmentally friendly products was given the lowest priority in each area. The most significant difference in innovation objectives was in terms of firms' desire to diversify into new product markets.[6] U.K. and Irish firms gave this market objective a much higher ranking than German firms. This may simply reflect German firms' focus on their home market in difficult trading conditions or the already extensive market coverage of German firms. An alternative interpretation, however, and one that is consistent with other evidence presented below, is that U.K. and Irish small firms were adopting a more market oriented and pro-active attitude to product innovation than German firms.



Note: The importance ranking was on a 1 to 5 scale, where 1 was unimportant and 5 very important.
Source: Product Development Survey

Fig. 1. Innovation objectives of small German, Irish and British firms.

In this light it is interesting that the PDS suggests a strong positive association between innovation and turnover growth, but a less direct link between innovation and employment growth (Table II). From 1991–93, turnover growth in innovating small firms in Germany, the U.K. and Ireland was very much faster than that of non-innovating enterprises (Table II, part A). In western Germany, where manufacturing output was falling rapidly, the turnover of innovating firms fell by less than that of their non-innovating counterparts. The positive association between turnover growth and product innovation identified here reflects earlier studies (e.g. Woo et al., 1989; Solem and Steiner, 1989; Cambridge Small Business Research Centre, 1992; Wynarzyck, 1993; Siegel et al., 1993), however, a less straightforward association emerges between product innovation and employment growth. In Ireland and the U.K., where economic conditions were stable or buoyant, employment growth in innovating firms was more rapid than that in non-innovating companies (Table II, part B). In Germany, despite faster turnover growth, innovating firms were *reducing* their employment more rapidly than non-innovating firms.

The implications of this difference can be demonstrated most clearly by using the group of non-innovating firms in each area as an informal control group. Let turnover per employee be denoted as V, employment as E and turnover as T. Then the growth of turnover per employee and employment over the 1991–93 period may be partitioned as:

$$V_{93} = V_{91}(1 + \delta_i + \delta_s)$$

$$E_{93} = E_{91}(1 + \alpha_i + \alpha_s)$$

where subscript i denotes that element of growth associated with innovation and s denotes that element due to other secular factors. Assuming that the only difference between innovating and

TABLE II
Real turnover and employment growth of innovative and non-innovative small firms: 1991–93

	Innovators		Non-innovators	
	n	Growth 1991–93 % pa	n	Growth 1991–93 % pa
A. *Turnover Growth*				
U.K.	339	7.5**	271	5.7**
Ireland	167	15.7**	80	9.7**
Germany	365	4.3**	214	–2.9**
Memo items: Western Germany	191	–2.3	164	–4.0
B. *Employment growth*				
U.K.	339	3.7**	271	2.8**
Ireland	167	7.3**	80	4.3**
Germany	365	–7.2**	265	–3.6**
Memo items: Western Germany	191	–4.9	164	–3.4

Notes:
1. Innovative firms were those introducing a new or improved product during the period 1991–93.
2. Sample observations are weighted to allow for sample structuring, differential response and differences in industrial structure. See Roper et al. (1996) for details.
3. Asterisk denotes rejection of hypothesis that the national samples come from same population based on the Wilcoxon test ($\rho = 0.05$). The '^' character denotes non-rejection of the hypothesis. For the U.K. (Irish; German) figures the first superscript is relative to Germany (U.K.; Irish), the second to Ireland (German; U.K.).

Source: Product Development Survey.

non-innovating companies in the sample is the question of innovation, the secular element of turnover per employee and employment growth can be approximated by that of non-innovating companies. The change in turnover of innovating firms can then be expressed as:

$$T_{93} - T_{91} = V_{93}E_{93} - V_{91}E_{91}$$
$$= V_{91}(1 + \delta_i + \delta_s)E_{91}(1 + \alpha_i + \alpha_s) - V_{91}E_{91}$$

Or, after some rearrangement

$$\frac{(T_{93} - T_{91})}{(V_{91}E_{91})} = \delta_i(1 + \alpha_s) + \alpha_i(1 + \delta_s) + \delta_i\alpha_i + (\alpha_s + \delta_s + \sigma_s\delta_s)$$

The final term on the right hand side of this equation is a pure secular growth effect which will reflect national economic conditions. The other three terms reflect the impact of innovation. The first of these is a turnover per employee effect, the second is the employment effect and the third is an interaction term.[7] Table III gives the empirical results based on the growth statistics given in Table II. It is clear that in each area a positive turnover growth effect is associated with product innovation. In western Germany this effect is, however, dominated by a negative 'secular' growth effect. In the U.K. and Ireland, the positive turnover growth effect associated with innovation reinforces a positive secular effect. Decomposing that element of turnover growth associated with innovation indicates that in Ireland and the U.K. around half of the effect arises due to increased turnover per employee with the remainder resulting from increased employment. In western Germany, the situation is more complex, with innovation associated with a potential output increase of 3.2 per cent due to increases in turnover per employee. This is offset by a decrease in employment (equivalent to –1.5 per cent pa of turnover growth) which reduces the size of the turnover growth effect associated with innovation to 1.7 per cent pa.

The relatively large productivity (i.e. turnover/employee) effect associated with innovation by western German firms may represent a short-term response to difficult national conditions. Continuation of this type of '*productivity growth*' strategy, rather than the '*balanced growth*' strategy

TABLE III
Decomposition of revenue growth of inovative small firms

	Western Germany % pa	Ireland % pa	U.K. % pa
Effects associated with innovation	1.7	6.0	1.8
of which:			
Turnover/employee effect	3.2	2.8	0.8
Employment effect	–1.5	3.1	0.9
Interaction effect	–0.0	0.1	0.1
Secular growth effect	–4.0	9.7	5.7
Total Revenue Growth	–2.3	15.7	7.5

Note:
For non-innovating firms $E_{93} = E_{91}$ (1+ α_s). α_s can therefore be derived directly from Table II. Similarly, for innovating firms $E_{93} = E_{91}$ (1 + α_i + α_s). For turnover per employee for non-innovating firms:

$$\frac{V_{93}}{V_{91}} = (1 + \delta_s) = \frac{T_{93}/E_{93}}{T_{91}/E_{91}} = \frac{T_{93}}{T_{91}} \frac{1}{(1 + \alpha_s)}$$

Using Table III this allows δs to be defined. For innovating firms:

$$\frac{V_{93}}{V_{91}} = (1 + \delta_i + \delta_s) = \frac{T_{93}/E_{93}}{T_{91}/E_{91}} = \frac{T_{93}}{T_{91}} \frac{1}{(1 + \alpha_i + \alpha_s)}$$

Values are given below:

	α_s	α_i	δ_s	δ_i
Germany	–0.034	–0.015	–0.006	0.034
Ireland	0.043	0.030	0.052	0.026
U.K.	0.028	0.009	0.028	0.008

Source: Product Development Survey.

of innovative U.K. and Irish companies, has however potentially significant long-term implications for firms' international competitiveness. Consider a situation where firms in each area were (for the moment) manufacturing similar products, using identical technology, and had similar hourly labour costs. In this situation, and assuming similar market share growth, a successful 'productivity growth' innovation strategy would rapidly give western German firms a cost advantage relative to their U.K. and Irish counterparts. If, however, U.K. and Irish firms could increase output more rapidly than their German counterparts – as they did from 1991–93 – then even with a '*balanced growth*' strategy their productivity may increase sufficiently fast to offset German firms' productivity growth.

Introducing differentiated products, dissimilar production technologies and nationally distinct cost-structures into this scenario complicates the situation. In the past West German products have typically been found to be more complex, of higher quality and of higher unit value than those of similar U.K. and Irish firms (see, for example, Hitchens, Wagner and Birnie, 1990; Roper and Hofmann, 1993; O'Mahony and Wagner, 1994). If this was the case for innovative small firms it would tend to *reinforce* the (cost-based) competitive advantage which western German firms might derive from a 'productivity growth' strategy. Two important cost factors, however, will tend to *offset* western German firms' advantage. First, higher productivity in West German firms has been linked to higher labour quality and, more importantly in the current context, higher capital intensity (O'Mahony and Wagner, 1994). Secondly, West German firms have been shown to have significantly higher average labour costs (including social payments) than their U.K. and Irish counterparts (Roper and Hofmann, 1993).

Neither factor necessarily negates the competitive advantage that western German firms might derive from labour productivity increases. It is possible therefore that even with relatively rapid labour and/or capital cost increases in Germany, productivity growth might be sufficient to result in increased employment.

3. Implementing product innovation strategies

This section examines some aspects of the implementation of the *productivity growth* and *balanced growth* innovation strategies of western German, U.K. and Irish firms. For information, aggregate results for the whole of Germany are included in the tables. These results are not discussed in the text due to the potential for distortion introduced by the rapidly changing industrial organisation in eastern Germany. Attention focuses on three main issues; the qualificational breakdown and utilisation of firms' workforces; firms' R&D organisation and activity; and, the extent and nature of firms' network linkages.

Workforce qualifications and utilisation

In his recent review of the U.K.'s innovation performance Walker (1993) highlights poor education and training as one of the three main weaknesses of the U.K.'s innovation system.[8] Other studies have highlighted the productivity consequences of differences in educational standards between Ireland, the U.K. and Germany, particularly in intermediate vocational qualifications (see, for example, Roper and Hofmann, 1993; STIAC, 1995). It is therefore little surprise to find that significant differences existed between the qualifications of the western German, U.K. and Irish workforces (Table IV). German innovating firms had a significantly *lower* proportion of graduate employees than their U.K. and Irish counterparts, a significantly *higher* proportion of

TABLE IV
Qualification breakdown of staff in innovating and non-innovative small firms

	Graduates %	Technicians and Meister %	Apprentice or equivalent %	No vocational qualifics %	Total %
A. *Innovating Enterprises*					
U.K.	7.5**	12.8**	29.5**	50.2**	100.0
Ireland	9.4**	7.9**	28.5**	54.1**	100.0
Western Germany	5.7**	8.9**	51.0**	34.4**	100.0
Memo items: Germany	6.6	9.0	54.2	30.2	100.0
B. *Non-Innovating Enterprises*					
U.K.	5.4**	10.8*^	33.7**	50.1**	100.0
Ireland	6.9**	9.7^*	42.9*^	40.5*^	100.0
Western Germany	6.1**	8.3**	45.0^*	40.5^*	100.0
Memo items: Germany	6.8	8.4	46.7	38.1	100.0

Notes:
1. Innovative firms were those introducing a new or improved product during the period 1991–93.
2. Sample observations are weighted to allow for sample structuring, differential response and differences in industrial structure. See Roper et al. (1996) for details.
3. Asterisk denotes rejection of hypothesis that the national samples come from same population based on the Wilcoxon test ($\rho = 0.05$). The '^' character denotes non-rejection of the hypothesis. For the U.K. (Irish; German) figures the first superscript is relative to Germany (U.K.; Irish), the second to Ireland (German; U.K.).
4. Qualification breakdowns are approximate. In broad terms in the U.K. (Germany) graduates would include university and teaching qualifications (in Germany: university, teacher training, Fachhochschule); technician includes BTEC, HNC and HND certificates (Fachschule certificates and those with Meister or engineering technician certificates); apprenticeship or equivalent includes those with ONC or OND certificates (at least two years apprentice training or a Beruffachschule certificate).

Source: Product Development Survey.

employees with apprenticeship or other vocational qualifications and a significantly *lower* proportion of employees with no vocational qualifications (Table IV).

Contrasting innovating and non-innovating enterprises again suggests a difference between U.K. and Irish firms on the one hand and western German firms on the other. Innovating firms in the U.K. and Ireland had more graduate employees than their non-innovating counterparts (Table IV). Conversely, innovating western German companies in the sample had a *lower* level of graduate employment than non-innovators but a larger number of employees with technician or Meister qualifications. Past studies, based largely on U.K. evidence, have argued that graduate employment may have a particularly beneficial impact on firms' innovation capability due to established personal links with higher education institutions (Beesley and Rothwell, 1989). In other contexts, however, a number of studies have emphasised the importance for German firms productivity advantage of higher intermediate skill levels in Germany (see the references quoted in Roper and Hofmann, 1993).

The qualificational breakdown of a firm's workforce gives an indication of the character of the labour resource available to the firm's managers. The effective organisation and utilisation of that resource is another issue. Recent models of the innovation process have emphasised the network character of innovation, and the importance of feedbacks between functions (e.g. Rosenberg, 1982). In product innovation, particular importance is generally accorded to the inter-connections between those responsible for marketing and producing the product. Table V gives the proportion of innovative enterprises involving each functional group in different stages of the product development process. As previously, a significant difference emerges between the approach adopted by plants in western German and those in the U.K. and Ireland.[9] Throughout the product innovation process U.K. and Irish firms made significantly more use of design staff than their western German counterparts. Secondly, the initial stages of the innovation process were more heavily dominated by the involvement of marketing and sales staff in the U.K. and Ireland. For example, in the process of identifying new or improved products 84–87 per cent of U.K. and Irish companies involved marketing and sales staff compared to 54–58 per cent of western German firms.

The relatively high level of design and marketing involvement in product innovation in the U.K. and Irish companies suggests that these firms are undertaking product innovation largely in response to market demands or opportunities. Western German small firms, in keeping with the traditional technical emphasis of German management, seem more strongly oriented towards product innovation suggested by technological or manufacturing considerations. This type of innovation strategy, building on core technological and manufacturing competencies, is likely to be less risky and time-critical than a more market oriented approach. Later evidence on the networking behaviour of small firms provides supporting evidence as western German firms are found to place more emphasis on reducing the risk and cost of product innovation rather than on its speed of completion.

In-house R&D capability

Alongside workforce qualifications previous studies have also emphasised the link between firms' in-house R&D capability and their innovativeness (e.g. Northern Ireland Economic Council, 1993). In the PDS only 18–22 per cent of U.K. and Irish innovating small firms had a formal R&D department compared to 31 per cent of similar western German firms (Table VI). Conversely, over 73 per cent of innovating U.K. and Irish companies reported conducting some R&D in house compared to 60 per cent in Germany. In short, while R&D in small U.K. and Irish firms was more informally organised than that in western German firms a larger proportion of U.K. and Irish firms were actually undertaking some development work.

This profile is consistent with the type of government policies adopted in the U.K., western Germany and Ireland to encourage R&D and technological development in small firms. In Germany, long-term initiatives have been in place by both Federal and Lander governments to support the recruitment of dedicated R&D personnel and to encourage mutual co-operation

TABLE V
Percentage of firms involving functional groups of staff by stage of the product innovation process

	Design staff %	Engineers scientific and technical %	Marketing and sales staff %	Skilled production staff %
A. *U.K.*				
Identifying new products	35*^	31*^	84*^	44*^
Prototype Development	47**	39**	40**	66*^
Final design/development	50**	35*^	52*^	60*^
Production Engineering	23**	36^	10**	65^*
Developing Marketing Strategy	19**	17**	90**	13*^
B. *Ireland*				
Identifying New Products	37^*	27**	83^*	44^*
Prototype Development	48^*	30**	34**	63**
Final design/development	44**	26**	45^*	58^*
Production Engineering	19**	28**	13**	57**
Developing Marketing Strategy	17^*	11**	88^*	9^*
C. *Western Germany*				
Identifying New Products	13**	31**	58**	26**
Prototype Development	19**	34**	16**	59**
Final design/development	28**	33**	30**	47**
Production Engineering	0**	23**	7**	74**
Developing Marketing Strategy	1**	10**	95**	4**
Memo Items: Germany				
Identifying new products	13	34	60	27
Prototype development	17	36	17	58
Final design/development	27	36	32	47
Production engineering	0	27	8	68
Developing marketing strategy	1	12	92	5

Notes:
1. Innovative firms were those introducing a new or improved product during the period 1991–93.
2. Sample observations are weighted to allow for sample structuring, differential response and differences in industrial structure. See Roper et al. (1996) for details.
3. Asterisk denotes rejection of hypothesis that the national samples come from same population based on the Wilcoxon test ($\rho = 0.05$). The '^' character denotes non-rejection of the hypothesis. For the U.K. (Irish; German) figures the first superscript is relative to Germany (U.K.; Irish), the second to Ireland (German; U.K.).

Source: Product Development Survey.

between enterprises (Keck, 1993). Small businesses in particular have benefited from the existence of the Federation of Co-operative Research Associations and from the availability of long-term funding from the German banking system.[10] Also important is the relationship between small firms and government research institutes such as the Fraunhofer-Society with its focus on applied research. In the U.K. and Ireland support measures for technological co-ordination are less well developed.[11] Also, the concentration of public R&D resources in the U.K. on supporting basic or pre-competitive research is implicitly biased towards larger firms.[12] A notable exception to this general rule has been the public support available to small firms in the U.K.'s Assisted Areas and EU Objective 1 and Objective 2 regions. Typically in these areas a higher rate of support is available than in other parts of the U.K. In addition, financial support is usually available for a broader range of innovation activities than elsewhere in the U.K. including both pre-competitive and near-market product development or innovation. In Northern Ireland, for example, the Science and Technology Programme is designed to support pre-competitive R&D, while '*Compete*' is designed to support near-market product and process developments.[13]

TABLE VI
R&D activity in innovating and non-innovating small companies

	Innovators		Non-innovators	
	n	%	n	%
A. *Firms undertaking Some R&D (%)*				
U.K.	339	73.2*^	271	20.0**
Ireland	167	75.1^*	80	14.3^*
Western Germany	191	60.3**	164	14.4**
Memo items: Germany	365	62.8	214	15.1
B. *Firms with Formal R&D Dept (%)*				
U.K.	339	21.9**	271	2.2**
Ireland	167	18.2**	80	0.9**
Western Germany	191	30.6**	164	3.2**
Memo items: Germany	365	36.8	214	3.6

Notes: See Table V.
Source: Product Development Survey.

The informal, and perhaps therefore more flexible and responsive, nature of R&D in small U.K. and Irish companies is consistent with the idea that in the U.K. and Ireland product innovation is undertaken in response to often unpredictable market opportunities. In western Germany, the more formal organisation of R&D activity is consistent with a more planned and systematic approach which may stem from technological considerations. This in turn may reflect the German government's long-term policy to stimulate rapid technological diffusion throughout the economy (Council on Competitiveness, 1995).

Network factors

The positive role of close inter-firm linkages *in production* has a relatively long history from the discussion by Marshall of 'industrial districts' through to the recent descriptions of the Italian experience (e.g. Best, 1991). In this scenario, networks of local firms with different capabilities create economies external to the firm but internal to the district, generating a competitive edge for local firms (Ashcroft, Dunlop and Love, 1995). European understanding of the potential value of close inter-firm and other networks *in innovation*, however, has been slower to develop but has been stimulated by market pressures to compress product development cycles. Here, small firms with limited internal resources co-operate, either through mutual (ie joint venture) or market (i.e. sub-contract) mechanisms to exploit their own core expertise and generate competitive advantage.

A considerable amount of descriptive material exists on the long-term sub-contracting relationships which exist between Japanese firms (see references in Ashcroft, Dunlop and Love, 1995). Fewer studies have considered the degree of networking by small European firms. An interesting exception is Beesley and Rothwell (1986) which asked a small number of U.K. SMEs, which had made 'significant' innovations, about their external linkages. In their sample 39 per cent of firms contracted out some elements of R&D and 26 per cent participated in a collaborative R&D project. In the PDS firms were asked whether each stage of the product innovation process was carried out entirely in-house or whether external resources were utilised. A distinction was made between mutual (e.g. joint venture) agreements, market (ie sub-contract) arrangements and those linked to membership of a group of companies.

In each area around a quarter of innovative small companies were utilising external resources at some stage of the product development process (Table VII).[14] Differences in the proportion of enterprises with some form of network link were most evident during the final stages of the product innovation process. Western German firms were

TABLE VII
Percentage of firms using different types of network linkages in te product innovation process

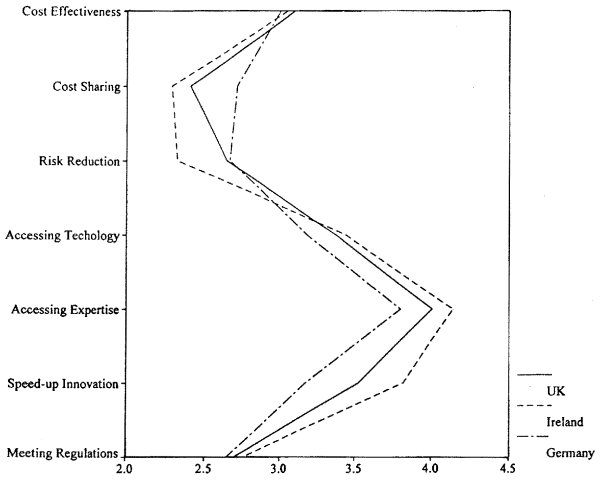
	Mutual %	Market %	Group %	Mixed %	None %
A. *U.K.*					
Identifying new products	5.2**	0.6^^	9.2**	6.6**	78.5*^
Prototype development	3.5**	5.6**	6.0*^	7.4**	77.5*^
Final design/development	5.2**	0.8**	6.8*^	5.4**	81.8**
Production engineering	6.1*^	1.5**	4.6*^	4.8**	82.9*^
Developing marketing strategy	4.5*^	3.0*^	10.8**	2.2*^	79.5*^
B. *Ireland*					
Identifying New Products	6.9**	0.4^^	7.5**	6.8**	78.4^^
Prototype Development	6.4**	3.4**	6.1^^	4.4**	79.8^*
Final design/development	10.0**	3.3**	6.0^*	3.3**	77.3**
Production Engineering	6.8^*	2.8**	5.6^^	1.2**	83.8^*
Developing Marketing Strategy	5.5^*	2.0^^	11.0**	5.0^*	79.5^*
C. *Germany*					
Identifying new products	19.9**	0.7^^	2.1**	0.7**	76.7^*
Prototype development	17.6**	1.9**	3.0^*	0.6**	76.9**
Final design/development	15.9**	0.7*^	1.9**	1.0**	80.5**
Production engineering	7.8**	0.1**	3.3^*	0.0**	88.8**
Developing marketing strategy	13.4**	1.3^*	4.2**	0.6**	80.4**
Memo Items: Western Germany					
Identifying new products	19.4	0.5	0.7	0.0	79.3
Prototype development	17.3	1.9	2.2	0.2	76.9
Final design/development	16.6	0.7	1.0	0.5	81.1
Production engineering	7.5	0.0	2.8	0.0	89.7
Developing marketing strategy	13.0	1.5	0.0	0.0	83.3

Notes: See Table V.
Source: Product Development Survey.

involved in a significantly lower level of external networking than the U.K. and Irish firms in both production engineering and the development of marketing strategies. Significant differences were also apparent in the mechanisms used to establish network links. In Germany extra-group links were almost exclusively through mutual mechanisms. In the U.K. and Ireland, however, market or sub-contract relationships were significantly more common particularly in the latter stages of the innovation process. For example in production engineering sub-contract or market mechanisms, either alone or in combination with some other approach, was used by 6.3 per cent of U.K. companies but only 0.1 per cent of western German firms (Table VII). This may again reflect the nature of support for R&D and technical development in German firms which has often been available only for collaborative projects (Keck, 1993). Perhaps more important, however, is the different motivation of companies in Germany and the U.K. and Ireland for establishing network linkages (Figure 2). For firms in western Germany risk reduction and cost-sharing were more important motivating factors for networking than for U.K. or Irish firms. U.K. and Irish firms gave a higher priority to using networking to accelerate the innovation process. This is consistent with the use of market mechanisms and the more market driven emphasis of U.K. and Irish product innovation noted earlier.

4. Conclusions

Despite broadly similar product innovation objectives the innovation strategies adopted by small manufacturing firms in western Germany the U.K. and Ireland have been shown to vary significantly. In the U.K. and Ireland, in the context of relatively benign macro-economic conditions, firms were



Note: The importance ranking was on a 1 to 5 scale, where 1 was unimportant and 5 very important.
Source: Product Development Survey

Fig. 2. Reasons for networking during the product innovation process: Small German, Irish and British firms.

pursuing a balanced growth strategy with productivity and employment increases associated with innovation. In Germany, in the context of declining manufacturing output from 1991–93, small firms were following a strategy oriented towards boosting turnover by improving productivity and shedding labour. Unfortunately from the evidence of the PDS is unclear exactly how small firms in western Germany were achieving this result. Three main (non-exclusive) possibilities exist. First, German small firms may have been focusing their innovative activity on reducing products' labour content and increasing physical labour productivity (see, for example Hitchens, Wagner and Birnie, 1990). Alternatively, German firms' product innovation may have been increasing the unit value of products while maintaining physical productivity levels (Roper and Hofmann, 1993). Thirdly, German small firms may have been using product innovation as a mechanism for increasing in-house productivity and reducing employment while sub-contracting lower value added functions to lower-cost areas.

Differing macro-economic conditions add to the difficulty of drawing long-term implications from one-off surveys of innovation activity such as the PDS. It is clear, however, that despite poor trading conditions in Western Germany from 1991–93, German small firms gained a larger productivity advantage from product innovation than their U.K. or Irish counterparts (Table III). Long-term continuation of this impressive performance would suggest a widening productivity and competitiveness gap between western German and U.K. and Irish small firms. This is not, however, consistent with the historical macro-economic evidence which suggests some narrowing of the productivity differential between the U.K. and German manufacturing firms over the last decade (O'Mahony, 1992).

While the differential growth and performance of small firms between national economies is likely to depend strongly on short-term environmental factors the organisation of product innovation activities is likely to be less cyclical. Evidence from the PDS on these 'process' aspects of product innovation in small firms can therefore be interpreted as characteristic of the product innovation activities of U.K., Irish and German small firms. In U.K. and Irish innovating small firms, for example, the initial stages of the product innovation process were dominated by design and marketing staff with a significantly less important role being played by engineering and production personnel. This suggests that in these areas product innovation was more strongly market driven than in western Germany. German small firms seem more concerned with less risky and more 'manageable' product innovation based on extending existing technological or production competencies. This is also evident from the networking objectives of small firms within the sample. In Germany, a major objective of networking was risk-reduction/cost-sharing leading to an emphasis on mutual or collaborative ventures. In the U.K. and Ireland, the major motivation for networking was to accelerate innovation with firms entering equally into collaborative and sub-contract relationships. In addition, R&D was more formally organised in German small firms than in the U.K. and Ireland. This again suggests a more managed or planned approach to product innovation on the part of the German companies rather than the less formal, more market-responsive pattern which might be said to characterise the activity in the U.K. and Ireland.

Although these distinctions between the organ-

isation and orientation of product innovation will be relatively insensitive to cyclical fluctuations they are likely to reflect long-term policy or cultural differences between firms' operating environments. In Germany, for example, although the preponderance of mutual network linkage reflects the espoused objectives of the sample companies, it is also consistent with the historical targeting of government assistance towards collaborative ventures. Similarly, the formality of organisation of R&D in German small firms may reflect businesses' objectives but may also be related to schemes to support the employment of R&D personnel in small firms (Keck, 1993). Whatever the reason, the more formal organisation of R&D suggests that the 'innovation' function is likely to be more strongly embedded in the structure and strategy of German small firms than in the U.K. and Ireland. Also, German firms' mutual network links are likely to be more cyclically robust, and perhaps more long-term, than the type of sub-contract relationships which characterise network linkages in the U.K. and Irish firms. The latter point reflects the observation by Walker (1993) noted earlier that a significant weakness of the U.K.'s innovation system was the lack of co-ordination between agents. His argument was predominantly related to the link between public and business organisations. The evidence presented here suggests that the point could equally well be made about business to business links.

Following these observations it is interesting to consider whether German, U.K. or Irish small firms are better able to fulfil the role suggested by Schumpeter (1934) as the initiators, catalysts or medium for wider technological development. In Germany, the PDS suggests that product innovation in small firms is more strongly oriented to productivity improvement than that in the U.K. and Ireland, and is perhaps less responsive to market demands or opportunities. Also, German firms' approach to the organisation of R&D and networking suggests that product innovation is likely to be more formally organised and more conservative or risk-averse than in U.K. or Irish companies. These characteristics suggest – on balance – that U.K. and Irish small firms may be more effective initiators or catalysts of wider technical change than their German counterparts. In terms of the diffusion of technical developments, however, the German small firm sector may be more effective than that in the U.K. or Ireland due to the greater proportion of firms which are making product innovations and to German firms' willingness to establish mutual network linkages.

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Notes

[1] A number of studies have identified a statistically significant and positive link between employment growth in small firms and the introduction of major changes in technology (e.g. Woo et al., 1989; Solem and Steiner, 1989; Cambridge Small Business Research Centre, 1992; Wynarzyck, 1993; Siegel et al., 1993; Barkham et al., 1996). Other studies have found no significant relationshp (e.g. Storey et al., 1989; Birley and Westhead, 1990; Kalleberg and Leicht, 1991; Kinsella, 1993).

[2] Alternative approaches based on patents, the identification of 'significant' innovations or product announcements (Acs and Audretsch, 1988 and 1993) are perhaps better at identifying the importance of specific innovations. However, both are particularly problematic with regard to small firms.

[3] For an extensive discussion of the relationship between this and the other indicators in the Product Development Survey see Roper et al. (1996).

[4] Throughout the paper Ireland refers to the Republic, western Germany refers to the former West Germany and eastern Germany to the former DDR.

[5] In the majority of cases the effect of the structural adjustment on the results was relatively small. Tables giving unadjusted values are available from the author.

[6] See Roper (1996) for a discussion of the impact of introducing new products in firms' existing and new product groups.

[7] The size of the effect associated wth innovation itself depends on the secular growth rate of the country concerned. This introduces a potential distortion due to differences in national economic circumstances. Recalculating Table III using an average secular growth rate suggests that this effect is insignificant.

[8] The other two being distortions due to heavy defence spending and, weak co-ordination between agents.

[9] Table s VII and VIII present results for all innovating small plants. More detailed examination suggests that there was little clear difference between the human resource strategies adopted by innovating enterprises in the upper and lower quartiles of the distribution of turnover growth rates.

[10] This covers some 50,000 small companies in Germany, around 90 per cent of all SMEs (Schiele, 1995).

[11] Walker argues that the short-termism which characterises policy initiatives in the U.K., allied with the instability of the U.K.'s political system, has led to an inability to create the institutional capability which would support a high national level of innovation.

[12] This is not to say that no assistance has been provided to small firms. Such measures as have been implemented have, however, only influenced a relatively small number of firms. Specific schemes have been introduced in the U.K. to promote collaboration between firms and HEI's (e.g. LINK, the General Industrial Collaboration Programme), between companies (e.g. the Advanced Technology Programme) and to promote product development in smaller firms (e.g. Support Products Under Research – SPUR). Smaller firms have also benefited from the SMART award scheme for outstanding development projects (Ashcroft, Dunlop and Love, 1994).

[13] In 1992–93, committed expenditure on Compete with £4.7m, compared to £6.4m on the Science and Technology Programme.

[14] This level of external linkage is lower than that identified by some other studies (e.g. Beesley and Rothwell, 1986; Oakey, 1984) although in the PDS firms in the upper quartile of the turnover growth rate distribution were more strongly networked than those in the lower quartile with the difference between paricularly marked for the U.K.

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