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Innovation and Performance in British-based Manufacturing Industries

a Policy Analysis

Howard Cox and Marion Frenz

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Abstract

This paper analyses the relationship between business performance, R&D expenditures and innovation output. It utilises the second Community Innovation Survey (CIS2), a large-scale survey into firms' innovation activities conducted in the UK by the DTI. We matched up CIS2 with performance data as derived from the FAME database, using the four year period after the survey.

We find that many enterprises who claim to have produced innovation output, did not register any expenditures on formal R&D. Moreover, we find evidence that it is innovation output, the introduction of new or improved products and processes, which is correlated to productivity growth, not a high expenditure on R&D.

The UK's policy to support innovation via subsidising R&D expenditure may on the one hand fail to effectively target many firms who are successful innovators and on the other reward firms that engage in levels of R&D spending beyond the point where marginal social cost equals marginal social benefit. Our evidence strongly suggests that the key to supporting productivity growth in the economy as a whole is to develop policy initiatives that are able to facilitate product innovation directly.

Innovation and Performance in British-based Manufacturing Industries: Shaping the Policy Agenda

Howard Cox and Marion Frenz

Introduction

Over the course of the last decade, the putative link between innovation and enhanced economic performance has gained ascendancy as a key objective of economic policy. Harvard Business strategist Michael Porter, amongst others, has argued that higher standards of living within national economies can be truly sustained only if indigenous firms continually raise their productivity through innovation - a process which he refers to as “upgrading” (Porter, 1990). Such ideas have strongly influenced policy makers in the United Kingdom, and support for innovative activities has lately formed an important component of government policy (cf. Department of Trade and Industry/ Department for Education and Employment, 2001). In policy terms, one recent approach to boost innovation has been the measure announced by the Treasury to extend the system of tax credits to large firms who engage in R&D expenditure (Cookson and Kelly, 2001). Evidence suggests that the UK lags behind many of its key rivals in terms of R&D expenditure (HM Treasury Inland Revenue, 2001), but the efficacy of this policy initiative depends not merely on its role in boosting (as opposed to merely subsidising) the level of R&D activity (Bloom, Griffith and Van Reenen, 1999; Bloom, Griffith and Klemm, 2001), but also on the extent to which productivity-raising innovation depends upon R&D spending.

For many years, garnering evidence in support of the link between innovation and performance has been hampered by an absence of appropriate data. Expenditure on R&D by itself provides a measure of input only, which may or may not stimulate innovative outcomes. Moreover, it needs to be recognised that many enterprises who claim to have engaged in innovative activities do not register any expenditure on formal R&D. Thus a policy to support innovation via subsidising R&D expenditure may on the one hand fail to effectively target many firms who are successful innovators and on the other reward firms that engage in levels of R&D spending beyond the point where marginal social cost equals marginal social benefit.

Previous attempts to measure the output of innovation directly have tended to rely on patent registrations (e.g., Cantwell, 1995). Whilst this may represent a valid measure of innovative output, rather than input, it will certainly reflect a pattern of innovation that is industry-specific since much innovation - particularly new product launches - may be undertaken without accompanying patent registrations. Fortunately, during the 1990s the EU - through its statistical agency Eurostat - encouraged member states to undertake extensive surveys of operating enterprises, drawn from their population of manufacturing and service firms, in order to generate representative data on various indices of firm innovation. In the UK, the second of these Community Innovation Studies (CIS 2) provided a wealth of statistical evidence that can be used to study the economic impact of innovation in Britain during the second half of the 1990s (cf. Craggs & Jones, 1998). Recently, a third such survey has been undertaken by the Department of Trade and Industry, the results of which will be available in 2002.

Here we are seeking to use evidence drawn from the SIC survey to throw light on two aspects of innovation at the enterprise level. First, we wish to link claims of innovative activities by the enterprise surveyed with performance measures in an attempt to assess the fidelity of the purported link between innovation and enhanced economic performance. Second, we seek to consider the relationship between innovation *per se* and R&D expenditure to discern the extent to which the former occurs in the absence of the latter. The paper concludes by considering some of the implications of our findings for policy makers.

Innovation and firm performance

In the UK the CIS 2 survey was carried out through the Department of Trade and Industry (DTI). The survey was undertaken in 1997 and the reference period covered the years 1994 to 1996. Although the survey was applied to both manufacturing and service firms, the present study is based on the results derived from 1513 manufacturing enterprises that completed the questionnaire. Operating enterprises were asked to report whether during the reference period they had undertaken either a product innovation or a process-based innovation. They were also requested to provide information relating to R&D expenditure. In terms of innovation, 522 (35%) of enterprises claimed to have undertaken both product and process innovation during the reference period, 349 (23%) undertook only product innovation, 108 (7%) undertook only process innovation and the remaining 534 (35%) did not claim to have engaged in any kind of innovation. This subdivision has been used to classify the 1513 manufacturing enterprises in the study into four groups, namely highly innovative, product-innovators, process-innovators, and non-innovative enterprises.

In order to link the information from the CIS 2 survey with firm performance it was necessary to match the operating enterprise with its constituent firm. Firm-level performance data were obtained from the FAME database thus enabling firms to be designated within one of the four innovation categories. Valid performance data could be traced within FAME for a total of 967 of the enterprises who reported results in CIS 2 (64%). Clearly a drawback of this procedure is the possible misclassification of firms into innovation categories based on the use of enterprise level data. The danger is most acute where a subsidiary enterprise that belongs to an innovative firm undertakes no innovative activity itself. Where this occurs, the firm in question will be wrongly classified as non-innovative. Any positive impact resulting from innovation on that firm's performance will have the effect of biasing upwards the overall performance of the group of firms designated in this study as non-innovators. Notwithstanding this problem, it remains true that the group of firms designated in our study as non-innovators will necessarily contain all of the non-innovative firms. This is because there is no symmetrical problem of non-innovative firms being classified as innovators: enterprises that report undertaking innovative activities must, by definition, belong to innovative firms.

Two indices of performance were calculated from the FAME database. Firm productivity was measured as the ratio of sales to employees; firm profitability was calculated as the profit margin, i.e. pre-tax profits divided by turnover. Given that each of these indices will be industry-specific to a certain degree, firm performance was measured only relative to that of other firms within the same industry group (cf. Table 8 for industry groupings). Data were collected for each of the four financial years following the reference period (i.e. 1996/97 to 1999/2000). In each industry, for each of the four years, the productivity and profit margin of each firm was calculated in absolute terms and then normalised. This process of normalisation was done by setting the performance of the median firm in each industry at 100 and measuring the performance of other firms in the same industry relative to the median firm. Averaging these scores across the four year period provides an index of each firm's performance expressed in relation to the "average" (strictly speaking median) firm in each industry. Thus firms with a score above 100 have outperformed the (simple) majority of their rivals and those with a score below 100 have under-performed them.

In order to test the hypothesis that innovative firms will outperform non-innovative firms we assigned to each firm a binary score such that 0 = under-performing and 1 = outperforming. Using a logistic regression, the performance of the three categories of innovative firm were compared using the non-innovating firms as a benchmark. The results are presented in Table 1. The strongest results emerge from the productivity data, where the estimated coefficients are all positive as anticipated. Most significant is that the performance of product innovators (including those firms who engage in both product and process innovation) is shown to be superior (as a group) to the non-innovative firms. The chi-square statistic for this equation is significant at the 10% level. In relation to profitability, the results also provide some tentative support for the assumption that innovative firms outperform their non-innovative rivals, insofar as all coefficients are again of positive sign. However, the chi-squared statistic is not significant for this equation and it is therefore not possible to reject the basic hypothesis that innovation has no systematic affect on firm profitability.

Table 1: Logistic regression. Performance indices averaged over the years 96/97 to 99/00.

	Productivity	Profit margin
No innovation		
Process innovation	0.294	0.530**
Product innovation	0.437**	0.301*
Process and product innovation	0.331**	0.163
N (observations)	967	967
Model Chi-square (d.f.)	6.70 (3)*	5.13 (3)

*significance at 10%
**significance at 5%
***significance at 1%

Table 2 represents an attempt to test the robustness of these results by dropping the figures for the year 1996/97 and re-estimating the equation for the three years 1997/98 to 1999/2000 only. The outcome is essentially unchanged. The positive relationship between those firms who claim to have undertaken product innovation and the measure of productivity performance is actually strengthened with the model fit now significant at the 5% level and a strongly statistically significant coefficient linking the group of product innovators with above average levels of productivity performance. Again, the model fit linking innovation with profitability is not statistically significant, suggesting that any positive link between innovation and profitability is at best a complex one. Overall, the results of the logistic regression provide clear support for the basic assumption that innovative firms out perform non-innovative firms in the sense that product innovation is associated with higher levels of productivity during the ensuing three to four year period.

Table 2: Logistic regression. Performance indices averaged over the years 97/98 to 99/00.

	Productivity	Profit margin
No innovation		
Process innovation	0.241	0.463*
Product innovation	0.500***	0.347*
Process and product innovation	0.363**	0.301*
N (observations)	967	967
Model Chi-square (d.f.)	8.46 (3)**	5.66 (3)

*significant at 10%
**significant at 5%
***significant at 1%

Innovation and R&D

Given the preceding evidence that product innovation is associated with enhanced productivity, the policy issue that arises is the way in which these innovative activities of firms may best be supported. The effectiveness of a policy that provides tax benefits to firms who undertake R&D expenditure will depend critically upon the extent to which this spending contributes to product innovation within the economy as a whole. Data drawn from the sample of 1513 manufacturing enterprises in CIS 2 show that only 22 per cent of highly innovative firms did not report expenditure on R&D (see Table 3). However, 45 per cent of product-only innovators claim to have spent no money at all on R&D. This raises an important policy question: how can the activities of innovative enterprises who do not undertake formal R&D best be supported? In order to address this issue, it is helpful to pose two preliminary questions: (1) do the non-R&D spending innovators perform equally well in relation to productivity and, if so; (2) what is the industry profile of these firms and can innovation in these industries be best supported through other means?

Table 3: Innovation without R&D.

Sample size	Non-innovators	Process alone	Product alone	Product and process
N =1513	88%	63%	45%	22%
N = 967	83%	54%	36%	18%

Table 4 subdivides the sample of manufacturing enterprises by (i) whether or not they engaged in R&D expenditure and (ii) whether they claimed to have undertaken a product innovation. The results are reported both for the full sample of 1513 enterprises included in the CIS2 survey and the subgroup of 967 enterprises for which firm-level performance data could be traced in the FAME database. The table shows that 18 per cent of the full sample undertook product innovation without supporting expenditure on formal R&D, with a similar proportion (16 per cent) of the performance data sub-group of 967 enterprises also reporting this combination. Furthermore, over one hundred of the enterprises in the full sample (7 per cent) undertook R&D without claiming to have made a successful product innovation during the reference period 1994-96 (8 per cent of the performance data sub-group).

Table 4: Contingency table. Product innovation and R&D activity.

Full sample N = 1,513

		R&D activity yes	no	Total
Product innovation	yes	599 40%	272 18%	871 58%
	no	104 7%	538 36%	642 42%
Total		703 47%	810 54%	1513 100%

Reduced sample N = 967

		R&D activity yes	no	Total
Product innovation	yes	470 49%	152 16%	622 64%
	no	79 8%	266 28%	345 36%
Total		549 57%	418 43%	967 100%

Using the breakdown of the 967 enterprises for whom performance data are available, logistical regressions have been estimated to test the productivity performance of the innovating and R&D-spending firms against the performance of the remaining non-innovative enterprises (hereafter referred to as the nul-group). The results, reported in Table 5, show that the product innovators outperformed the nul-group regardless of whether they did or did not undertake R&D. In addition, the R&D-spending non-innovating group showed no statistically significant improved performance compared with the nul-group. The model fit was statistically significant at the 10 per cent level.

Tables 5: Logistic regression model 1.

	Productivity
No product innovation and no R&D expenditures	
Product innovation without R&D	0.470**
R&D expenditures without product innovation	0.396
Product innovation with R&D	0.378**
N (observations)	967
Model Chi-square (d.f.)	7.69 (3)*

*significant at 10%
**significant at 5%
***significant at 1%

One possible difficulty with these results lies in the link between productivity levels and enterprise size. A simple logistic regression linking firm size, as measured by the number of employees, to productivity performance shows a strongly significant relationship between the two variables (Table 6).

Table 6: Logistic regression. Productivity and firm size.

	Productivity
Number of employees 1996	$0.2\ 10^{-2}$ ***
N (observations)	967
Model Chi-square (d.f.)	12.350 (1)***

*significant at 10%
**significant at 5%
***significant at 1%

In Table 7 therefore, the logistic regression of Table 5 has been re-estimated using the number of employees as an additional variable. The results show a considerable improvement in the goodness of fit and a statistically significant coefficient attached to the size variable. The overall impact on the innovation variables, however, is quite limited. The group of firms who undertake product innovation with R&D experience a decline in the strength of the relationship with improved productivity which may reflect the relatively larger size of these enterprises. The performance coefficient for the non R&D-spending product innovators remain effectively unchanged, as does that of the R&D-spending non-innovators.

Table 7: Logistic regression model 2.

	Productivity
No product innovation and no R&D expenditures	
Product innovation without R&D	0.460**
R&D expenditures without product innovation	0.321
Product innovation with R&D	0.298*
Number of employees 1996	$0.2\ 10^{-2}$ **
N (observations)	967
Model Chi-square (d.f.)	18.28 (4)***

*significant at 10%
**significant at 5%
***significant at 1%

Conclusion and Policy Implications

The above results demonstrate the limitations of a policy approach to raising productivity purely through the support of R&D spending. Although such a policy will certainly enhance some aspects of innovation, it suffers from various shortcomings. A particularly vexed issue is the question of whether to adopt a volume approach, which provides credits in relation to the firm's total expenditure on R&D, or an incremental approach which is designed to reward only additional such spending. The Treasury's original inclination was towards the latter approach, as outlined in its consultative document (HM Treasury Inland Revenue, 2001), but this was subsequently reversed under pressure for a more straightforward system (Giles, 2001). However, the volume system that it now plans to introduce will have the effect of channelling greater resources towards those firms where R&D is already well entrenched, at the expense of firms who currently undertake limited programmes of R&D.

Our evidence strongly suggests that the key to supporting productivity growth in the economy as a whole is to develop policy initiatives that are able to facilitate product innovation directly. In order to do this it will be necessary to better understand the industry-specific forms and patterns of product innovation. The figures in Table 8 provide a step towards this goal. Two main observations are evident from these figures. On the one hand, the proportion of enterprises who report no expenditure on R&D is significantly lower amongst the high-tech industries, and hence R&D subsidies benefit these industries to a far greater extent than their low-tech counterparts (Cox, Frenz and Prevezer, forthcoming 2002). On the other hand, it is amongst the high-tech industries that the highest proportion of non-R&D-spending product innovators are to be found. In the communications industry, for example, 60% of the enterprises that did not report spending on R&D claimed to have engaged in product innovation. Of course, some of these enterprises may have drawn on R&D undertaken elsewhere in the firm to which they belong. However, even amongst single-enterprise high-tech companies 51 per cent of the firms who did no R&D still undertook product innovation.

Table 8: Product innovators without R&D expenditures.

	UK SIC	Proportion of firms in each sector without R&D activity	Rank	Proprotion of product innovators amongst the firms without R&D in each sector	Rank
High-tech					
Aircraft	353	59%	10	30%	16
Office, computing equipment	30	37%	21	56%	3
Pharmaceuticals	2423	35%	22	43%	7
Radio, TV, communication equipment	32	33%	25	60%	2
Medium-high-tech					
Scientific instruments	33	34%	23	33%	13
Motor vehicles	34	51%	15	43%	6
Electrical machinery	31	42%	20	40%	11
Chemicals	24ex2423	34%	24	54%	4
Other transports	35ex351+353	8%	27	100%	1
Non-electrical machinery	29	44%	19	40%	11
Medium-low-tech					
Rubber plastic	25	50%	16	26%	21
Shipbuilding	351	71%	5	17%	27
Basic metals	27	70%	6	40%	10
Non metalic mineral products	26	53%	14	30%	17
Fabricated metal products	28	70%	7	33%	14
Petroleum refineries	23	27%	26	25%	22
Recycling	37	68%	8	19%	26
Low-tech					
Wood	20	76%	3	42%	8
Paper	21	57%	12	19%	25
Publishing	22	86%	2	32%	15
Textiles	17	59%	11	26%	20
Clothes	18	86%	1	29%	18
Leather	19	47%	17	44%	5
Food and beverages	15	45%	18	25%	23
Furniture	36	63%	9	20%	24
Glass, electricity and water supply	40	71%	4	27%	19
Collection, purification and distribution of water	41	57%	13	42%	9

It is the low-tech firms, however, who are most disadvantaged by a policy approach to innovation that focuses on levels of R&D expenditure. Publishing and clothing are industries where the number of enterprises that undertake R&D is negligible, and yet almost one third of these enterprises claimed to have undertaken product development. Other industries, such as wood, leather and basic metals, display a similar combination of relatively low R&D spending and product innovation, with over 40% of the enterprises without R&D reporting product innovation activities. In some industries, market forces alone may suffice to stimulate a regime of on-going product innovation without the need for significant government support; publishing may well be a case in point. However, other low-tech industries such as wood, clothing, leather and metal products may warrant a much closer inspection in order to ascertain the nature of product innovation and whether appropriate incentives may be developed to promote these productivity enhancing activities.

It may be that boosting productivity in the low tech industries is best supported by facilitating co-operative schemes that enable firms to learn from one another. The 'Partners in Innovation' initiative promoted by the Department of the Environment, Transport and the Regions and the DTI, for example, helps to support schemes such as quality assurance in the construction industry (Anon, 1999). Another recent suggestion is to provide greater financial support for experts within the DTI. There are, it has been suggested, "thousands of talented people working within the DTI, many of whom have a real feel for the grass-roots needs of manufacturing industry. However, much of their good work is held back by lack of funding." (Anon, 2001). Facilitating productivity enhancement within Britain's industry may, in policy terms, be done more effectively by policies that directly support the actual processes of innovation rather than simply by providing tax credits for already large R&D budgets.

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