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The profitability of innovating firms

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This article seeks to evaluate the effects on corporate profitability of producing a major innovation. We examine two types of effect: innovations can have a direct but transitory effect on profitability associated with the production of a new product or the use of a new process, and innovations can have an indirect effect on how firms generate profits because they signal the transformation of a firm's internal capabilities associated with the process of innovating. Positive direct effects on the order of £2.1 million spread over seven years are observed for a sample of 721 large, quoted U.K. firms. More fundamentally, large indirect effects are also observed, not least because innovating firms seem to be more able to benefit from spillovers and are relatively insensitive to adverse macroeconomic shocks. These indirect effects associated with the transformation of a firm's internal capabilities may be as much as three times larger than the direct effects of innovation.

1. Introduction

■ The question of whether private rates of return are too low to encourage enough innovation by firms has been a perennial concern of U.K. industrial policy makers, and numerous schemes have been (and continue to be) developed to help stimulate the generation and diffusion of innovations. In this article we propose to cast some light on this problem by measuring how the production of major innovations affects the profitability of innovation-producing firms (and their rivals).

Although the existence and size of the correlation between innovation and profitability is our main interest (and it is one that we share with a large and growing literature), we are also interested in asking two specific questions about that correlation. First: Is the relationship between profits and innovative *output* (i.e., the production of major innovations) similar

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to that which has been found between profits and research *inputs* (i.e., R&D expenditures) or patent counts (which typically are more highly correlated with research inputs than with measures of innovative output)?[1] The question is important because the relationship between research inputs and different measures of innovative output is complex and poorly understood. Indeed, there is much to be said in any case for focusing directly on the effects of new products and processes introduced into the market; after all, not all firms that introduce major innovations do R&D, and most patents protect relatively minor innovations. Our main conclusion on this issue is that innovative output measures generate quite different estimates of the size of spillovers than innovative input measures do.

Our second question is: Does the correlation between innovative output and profitability reflect transitory or permanent performance differences between innovating and noninnovating firms? This distinction is important because it corresponds to two quite different views about why innovation may be associated with superior performance: that it is the *product of the innovative process* which matters because new innovations favorably affect a firm's market position, or that it is the *process of innovation* which matters because it transforms a firm's internal capabilities. The first, and more commonly held, of these two views argues that the production of new products or processes strengthens a firm's competitive position vis-à-vis its rivals. As a consequence, its profits increase and remain high until rivals successfully imitate and begin to eat into the innovator's rents. An alternate and rather less common view asserts that the process of innovation transforms a firm, building up its core competencies in a variety of ways that make it quicker, more flexible, more adaptable, and more capable in dealing with market pressures than noninnovating firms. In this second view, innovation is itself often the consequence of a more fundamental transformation that occurs within an innovating firm. Evaluating the relative merits of these two views helps to make clear whether policies designed to stimulate innovation ought to concentrate on ameliorating discouraging features of the market environment in which product and process innovations are sold, or on strengthening the internal capabilities of firms.

At a statistical level, the difference between these two views of the effect of innovation turns on whether the returns to the production of innovations are transitory and associated with the production of a specific innovation (the product view) or whether they are permanent and associated with generic differences between innovators and noninnovators (the process view). To explore these two views about the effect of innovation on profitability, then, one needs to examine whether the profit differences between innovating and noninnovating firms that we observe are attributable to specific innovations produced at specific times, to some other (transitory) observable difference, or to a permanent and relatively fixed difference in the profitability of the two types of firm. Our main conclusion on this issue is that large fixed differences are observable only in recessions. That is, innovating firms appear to differ generically from noninnovators in ways that make them less sensitive to cyclical downturns.

Our plan is as follows. In Section 2, we shall briefly set out the empirical model, discuss the variables to be used, and outline the structure of testing. Our database contains 721 U.K. manufacturing firms observed over the period 1972–1983, of which 117 produced at least one innovation during that period. In Section 3 we present some estimates of the effects of innovations on price-cost margins and profits for the sample of 721 firms, discussing a number of further experiments designed to check the robustness of the conclusions and provide further information on the properties of the sample. Then, in Section 4 we focus

[1] For work on the returns to R&D or to patenting activity, see Shankerman and Pakes (1986), Pakes (1986), Shankerman (1991), Cockburn and Griliches (1988), the papers in Griliches (1984), the survey in Griliches (1990), and others. Mansfield et al. (1977), Bresnahan (1986), Trajtenberg (1989), and others look at the divergence between private and social rates of return.

on the sample of 117 innovating firms, looking for differences between them and the full population of 721 firms. Section 5 summarizes the main results of the analysis.

2. The experiment

■ The basic empirical model we use is designed to produce simple but robust measures of the effects of innovation on profitability. The main difficulty to be overcome is the formulation of a reasonably clean experimental setting in which to measure these effects, i.e., correcting for other factors that affect profitability, particularly those which might be associated with innovation. The literature suggests that innovation is likely to be affected by firm size, market structure, conditions of appropriability, the state of technological opportunity, and, perhaps, internal cash flow. Since many of these variables also affect profitability, we have built our empirical model up from conventional structure-performance foundations.[2] In particular, we model profit margins (ROR) as being determined by market shares (MS), industry concentration (CON), import intensity (IMP), and the interaction between shares and concentration ($MS*CON$). Since rents attributable to market shares or concentration are often siphoned off by labor, we also include a measure of unionization (UN) as a determinant of margins. We also allow for time dummies, for firm-specific fixed effects to correct for variations in technological opportunity and conditions of appropriability across firms, and for systematic time-varying effects associated with departures from and the subsequent return to equilibrium. Following Geroski and Jacquemin (1988), we capture these last effects using lagged margins (ROR_{t-1}).[3]

To capture the effects of innovation on profitability, we use two types of variables. Both are derived from a major study of innovations in the United Kingdom undertaken by the Science Policy Research Unit (SPRU) at the University of Sussex. This project identified technologically important and commercially significant innovations produced in particular years (over the period 1945–1983), locating both producers and users in specific three-digit (MLH, minimum list heading) industries and tracking down the ownership of each innovating unit (see Appendix A for further details). The main variable of interest for our purposes here is the number of innovations produced by each innovating unit or firm in any year (INN), and we allow it to have effects on profitability for up to six years. The other two innovation variables that we shall use are designed to capture any spillovers that occur within two-digit industries, and they are the number of innovations produced (IPI) and the number of innovations used (IUI) elsewhere in the two-digit industry in which the firm operates.

Thus, using i subscripts to identify firms and t subscripts for time, our estimating equation is

$$ROR_{it} = f_i + \alpha_0 * MS_{it} + \alpha_1 * CON_{it} + \alpha_2 * IMP_{it} + \alpha_3 * (MS_{it} * CON_{it}) + \alpha_4 * UN_{it}$$
$$+ \alpha_5 * ROR_{it-1} + \alpha_6 * IPI_{it} + \alpha_7 * IUI_{it} + \alpha_8 * T_t + \sum_{j=0}^{6} \lambda_j INN_{it-j} + \mu_{it}, \quad (1)$$

[2] For recent work on profitability that follows similar lines, see Kwoka and Ravenscraft (1986), Schmalensee (1987), Machin and Van Reenen (1993), and others. Surveys of the empirical work on the effects of market structure, firm size, conditions of appropriability, and technological opportunity on R&D, patenting, and innovation include Cohen and Levin (1989), Baldwin and Scott (1987), and Scherer and Ross (1990).

[3] One could interpret the lagged margins term as reflecting cash flow influences on innovative activity which feed through to innovation and thence to profitability within a year or so. Indeed, one might wish to endogenize the variables measuring current innovation rates to insure that any contemporaneous feedback from profits to innovations does not create bias. However, we believe that cash flow is much more relevant to decisions about the level of research inputs a firm chooses than to the timing of innovative output, and we are sure that feedbacks between profits and innovative output operate with very long lags (if at all).

where f_i is a firm-specific fixed effect, T_t is a time dummy common to all firms, and μ_{it} is assumed to be a normally distributed identically and independently distributed random variable. The short-run impact of innovation on margins is measured by λ_0; in the long run, each innovation has an effect on margins of $\sum_j \lambda_j/(1 - \alpha_5)$.

Appendix B provides a somewhat more precise description of the observables to be used in (1), together with estimates of the mean and standard deviation of each (over the period used in the estimation) for the sample of 721 firms (hereafter, "the population") and for the sample of 117 firms that innovated at least once during the period (hereafter, "the innovators"). Both these panels are unbalanced in that there are different numbers of observations per firm, mainly due to different dates of entry into the databank. The criterion for including a firm in our sample is that at least seven continuous time-series observations (out of a maximum of twelve) are available.[4]

In what follows, we shall (by and large) estimate (1) by differencing out the fixed effects, using an instrument for the lagged dependent variable (and, occasionally, some of the other variables). It is well known that in dynamic panel data models the usual transformations used to eliminate fixed effects (within-groups or first-differencing) induce bias in the estimated coefficient on the lagged dependent variable (see Nickell (1981)). A number of instrumental variable techniques have been proposed to circumvent this problem. Anderson and Hsaio (1982), for example, propose the use of $(t - 2)$-dated levels or differences of the dependent variable as valid instruments for a $(t - 1)$-dated lagged dependent variable in a first-differenced panel data model. Amemiya and McCurdy (1986) recommend stacking the instruments by year so as to make more instruments available. We use a dynamic panel data estimator recently proposed by Arellano and Bond (1991) (see also Holtz-Eakin, Newey, and Rosen (1988)) that makes full use of all possible orthogonality conditions to generate a more efficient estimator. The logic behind this estimator is quite straightforward, namely that the further advanced the panel, the more instruments available for use. For instance, suppose we have a ten-year panel and the model is estimated from year three to year ten. In year three we can (in the absence of serial correlation) use variables dated year one as valid instruments, while in year four we can use instruments dated year one and year two, and so on, until in year ten any instruments dated year eight or before are valid. Hence, we can generate more efficient estimates by calling on more instruments the further advanced our panel becomes. It is, of course, crucial that we have no serial correlation in the residuals, and we present appropriate tests of this below. We also present statistical tests of the overidentifying restrictions made available by the large instrument set.

3. Innovation and profitability

■ The first question we wish to ask is how large a difference the production of a major innovation makes to the innovation producer's profits. The first four columns of Table 1 show estimates of equation (1) under a number of different assumptions. The first three difference out the fixed effects and use instruments for the lagged dependent variable, while the fourth shows OLS estimates without fixed effects. Regression (i) allows only current innovations to affect margins, while (iii) includes six lags in the innovations variable. Regression (ii) is identical to (i) except that market share and its interaction are instrumented (see the notes to the table for more details). Initially we shall focus on regressions (i)–(iii).

[4] These 721 companies are manufacturing companies taken from the Datastream databank, and they are large quoted companies. In 1979, the total sales of our sample is 55.3% of total manufacturing sales as reported in the Census of Production. The exact balance of the panel is 10 firms with 7 records, 19 firms with 8, 40 firms with 9, 44 with 10, 69 with 11, and 539 with the maximum 12 time-series observations. We will report results using the balanced panel of 539 companies as a check for nonrandom attrition.

TABLE 1 Regression Estimates of Equation (1)

	(i) Estimate of (1)	(ii) *MS* Instrumented	(iii) Includes Lagged *INN*	(iv) OLS without Fixed Effects	(v) 117 Innovators	(vi) 604 Noninnovators
Constant	−.0093	−.0086	−.0088	−.0015	−.0101	−.0087
	(6.525)	(7.073)	(7.251)	(.426)	(12.683)	(6.328)
Innovations (*INN*)	.0029	.0036	.0036	.0031	.0033	—
	(2.817)	(5.078)	(5.115)	(3.002)	(9.492)	
Production spillovers/100 (*IPI*/100)	.0003	.0050	.0042	.0074	.0112	.0049
	(.307)	(.537)	(.453)	(1.783)	(2.268)	(.473)
Use spillovers/100 (*IUI*/100)	.0010	.0131	.0126	−.0039	.0359	.0159
	(.822)	(1.253)	(1.202)	(.386)	(3.158)	(1.472)
Unionization (*UN*)	.0046	.0091	.0106	.0037	.0195	.0058
	(.223)	(.531)	(.613)	(.801)	(.958)	(.353)
Market share (*MS*)	.1780	.3301*	.3823*	.0413	.0584*	.0862*
	(2.068)	(4.786)	(5.263)	(3.077)	(2.582)	(.945)
Concentration (*CON*)	.0185	.0294	.0280	.0060	.0142	.0202
	(1.166)	(2.193)	(2.071)	(2.054)	(.994)	(1.457)
Market share × concentration (*MS***CON*)	−.2873	−.3601*	−.4577*	−.0681	−.2315*	.2012*
	(1.808)	(3.255)	(3.679)	(2.590)	(5.408)	(1.310)
Import intensity (*IMP*)	.0188	.0060	.0041	−.0080	−.0294	.0037
	(1.022)	(.392)	(.266)	(2.201)	(1.880)	(.222)
Margins(−1) (*ROR*(−1))	.4978*	.4791*	.4835*	.8691	.3986*	.4831*
	(14.628)	(16.856)	(16.932)	(60.453)	(18.969)	(16.073)
Innovations(−1) (*INN*(−1))	—	−.0005	−.0026	−.0010	—	
			(.665)	(2.527)	(2.410)	
Innovations(−2) (*INN*(−2))	—	.0008	−.0004	−.0004	—	
			(.936)	(.341)	(.103)	
Innovations(−3) (*INN*(−3))	—	.0012	.0006	.0010	—	
			(1.327)	(.471)	(2.878)	
Innovations(−4) (*INN*(−4))	—	−.0007	−.0009	−.0001	—	
			(.705)	(.746)	(.319)	
Innovations(−5) (*INN*(−5))	—	.0024	.0021	.0022	—	
			(2.455)	(1.907)	(6.377)	
Innovations(−6) (*INN*(−6))	—	.0013	−.0001	.0004	—	
			(1.393)	(.097)	(1.364)	
Number of firms	721	721	721	721	117	604
Sample size	6086	6086	6086	6086	1005	5081
Serial correlation	−.795	−.841	−.812	−3.245	1.077	−1.757
Sargan (Degrees of freedom)	36.96 (25)	94.58 (77)	94.20 (77)	—	78.72 (77)	94.78 (77)

Notes: The dependent variable is the profit margin, *ROR*. Equations (i)–(iii) and (v)–(vi) are estimated in first-differences using Arenallo and Bond's (1991) instrumental variable estimator. A * superscript denotes an instrumented variable. In (i), the instruments used are *ROR*(−2) back to *ROR*(−4) in each time period. In (ii), (iii), (v), and (vi), *MS* and *MS***CON* are used in the same manner, together with dividends ($t-2$) and investment/sales ($t-2$). Absolute values of heteroskedastic-consistent t-ratios are given in parentheses below the estimated coefficients. All equations include eight time dummies. Sargan is a chi-square test of the overidentifying restrictions. For the first-differenced models in (i)–(iii) and (v)–(vi), the serial correlation test is an $N(0, 1)$ test for second-order serial correlation. In (iv), the levels model, it is an $N(0, 1)$ test for first-order serial correlation.

All three regressions reveal (surprising) positive but rather imprecisely estimated effects of unionization and import intensity, and positive, well-determined effects of market share and concentration on profit margins (see also Machin and Van Reenen (1993)). In fact, the size of the estimated effect of market share on margins is somewhat sensitive to the

assumption of exogeneity of market share. Using the estimates in (i), market shares are positively related to margins for all industries for which $CON < .6195$, while concentration is positively related to margins for all firms for which $MS < .0644$. Only 12% and 9% of the sample of 721 firms have average values of *CON* and *MS* above these limits. Using (iii), these limits are $CON < .8353$ and $MS < .0612$, and only 1% and 9% of the sample firms are above them. The coefficient on the lagged dependent variable is very precisely estimated in all three regressions, and suggests that the long-run effects associated with changes in the various exogenous variables are roughly twice the size of their short-run effects.

Both of the spillover variables, *IPI* and *IUI*, have very small positive effects on margins that are imprecisely estimated. That spillovers from the use and production of innovations are small is consistent with earlier work done on productivity growth in the United Kingdom using this innovations data (e.g., Geroski, 1991), but stands in contrast with other work on U.S. firms and industries that has uncovered spillover effects associated with R&D expenditures (e.g., Jaffe, 1986; Bernstein and Nadiri, 1988, 1989; Levin, 1988; Levin and Reiss, 1988; and others). There are several possible explanations for this difference in results, including institutional differences in knowledge transmission between the United States and the United Kingdom and the industry composition of different datasets. However, our view is that the main difference arises because the U.S. studies used data on research inputs to measure spillovers, while we have used data on research output. Since R&D is likely to measure disembodied knowledge (however imperfectly), while our innovation variables measure knowledge embodied in specific commercial products, the different results on spillovers suggest that knowledge in general (as generated by R&D programs) spills over between adjacent producers and users, but not knowledge embodied in the specific products of major innovations. That is, by the time knowledge has been embodied in a major innovation, it is likely to be too use-specific to spill over into many other applications.

The effect of innovations produced on an innovation-producing firm's margins is positive, significant, and quite robust to alterations in the vector of independent variables used. Using (i), the production of one additional innovation has a long-run effect of $.0036/(1 - .4791) = .0058$ on profit margins, raising them by some 6.1% relative to the mean. Using (ii), the long-run effect is estimated to be .0069. Regression (iii) allows for the effect of previous innovations produced on margins, generating a long-run effect of $(.0036 - .0005 + .0008 + .0012 - .0007 + .0024 + .0013)/(1 - .4835) = .0157$, which raises margins by some 16.5% relative to the mean. Since the extra six terms in (iii) cannot be eliminated without significantly reducing the fit (the Wald test is $\chi^2(6) = 14.03$ (p-value = 0.029)), our inclination is to prefer the estimates in (iii). To help get a handle on what these estimates mean, it is worth noting that in 1980 prices, the average total sales of the firms in the sample is £139 million, yielding an estimated increase in profits associated with the production of an innovation of just over £2.1 million over the seven years subsequent to its introduction.[5] The instantaneous increase in profits associated with innovation is about £500,000. Needless to say, the value of these (major) innovations to their producers far exceeds that of the average patent. Shankerman and Pakes (1986), for example, found the median value of U.K. patents that survived at least five years to be $1,861.

The effects of innovation on margins proved to be quite robust to a wide range of respecifications on (i). Dropping the other observables yielded long-run estimates of the order of .009, and much the same results emerged when only time or firm dummies were included in the regression. Dropping the lagged dependent variable raised the estimated coefficient on innovations by 50%, but it also induced serious serial correlation. Rerunning the regression shown in column (iii) using the level of industry R&D lagged two and three

[5] To check this calculation, we reran (i) using total profits as the dependent variable. The effect of innovation on profits was positive and yielded an estimated increment to long-run profits associated with one additional innovation of £1.79 million in 1980 prices.

periods as an instrument for current innovations yielded estimated coefficients (and t-statistics) on current and lagged innovation of .0042 (2.490), .0001 (.054), .0013 (.981), .0015 (1.338), −.0005 (.453), .0025 (2.302), and .0015 (1.420), suggesting that assuming innovations to be exogenous may lead to a slight understatement of their effect on profits. Experiments on a smaller sample of 539 firms (the balanced panel) also yielded results very similar to those in Table 1, allaying fears about sample selection bias arising from the possibility that noninnovators are less likely to survive. Including a capital/sales ratio in (i) and using a profits/capital stock ratio as the dependent variable both yielded estimates of profitability differences similar to those reported above.[6] These estimates of the effects of innovation on margins are also surprisingly insensitive to the estimation method used (although the effects of unionization, concentration, import intensity, and the lagged dependent variable are sensitive to estimation technique). For example, regression (iv) shows an OLS respecification of (1) in which the fixed effects are suppressed. This simplification does not much affect the estimates associated with innovations, although it does have extremely noticeable effects on the point estimates associated with market share and concentration. Using instruments proposed by Anderson and Hsiao (1981) (rather than the Arellano and Bond (1991) method) produced similar results to those shown in Table 1 in versions of (i)–(iii), but they were estimated with less precision.

The long-run effect of .0157 shown in regression (iii) in Table 1 is an average across all firms (or innovations) in the sample. Previous work tracing the effects of innovations sourced from different innovation-producing sectors on users' productivity growth has revealed major interindustry differences in the value of innovations, with those produced in engineering making a particularly substantial contribution (see Geroski (1991)). To examine whether the effects of innovation on profitability vary across industries, we ran regression (iii) on subsamples of firms located in various two-digit industry groups. Table 2 shows estimates of the long-run effects of innovation on producers' profit margins for each. As one might expect, there is a good deal of heterogeneity in the size of these effects across industry groups. What is somewhat unexpected, however, are the large positive effects in clothing and textiles, paper and printing, and bricks and glass, where relatively few innovations are produced, and the low effects in engineering and negative effects in chemicals, which are both high-innovation-producing sectors. Although the fact that larger effects on margins are recorded in sectors where less innovation occurs is (very roughly) consistent with the hypothesis of diminishing returns to innovation, a considerable degree of within-industry variance exists in these estimates. Further, the means shown on Table 2 are very sensitive to small reclassifications of firms to the different sectors. We conclude that there is a noticeable degree of heterogeneity in the effects of innovation on profits, but that it is not closely ordered by sector (at least at this broad level of classification).

4. Innovators and noninnovators

■ The second question we wish to ask is whether the differences in profitability between innovators and noninnovators are transitory or permanent; that is, are they associated with the introduction of specific innovations, or are they generic and based on differences in the underlying competitive abilities of innovators and noninnovators? The results reported in Section 3 were based on the product view of the effects of innovation, and our next step is to explore the process view. This rests on the premise that a firm is best thought of as a

[6] It is well known that accounting profits may diverge from economic profits if the valuation of capital is not handled correctly (although persistently high accounting profits mean that economic profits are also persistently high). We experimented with a transformation of the dependent variable suggested by Fisher (1987), which (under rather restrictive assumptions) overcomes this problem. The results so generated were almost identical to those reported in Table 2.

TABLE 2 Results by Industry Grouping

Industry	Long-run Innovation Effect	Number of Innovations 1972–1983	Number of Firms
All firms	.0076/(1 − .4835) = .0147	377	721
Chemicals	−.0024/(1 − .4911) = −.0048	63	43
Bricks and glass	.0059/(1 − .5527) = .0133	23	34
Metals and engineering, of which	.0040/(1 − .5251) = .0085	229	328
Mechanical engineering	.0215/(1 − .5352) = .0457	130	168
Others (electrical, instrument, vehicles, metals)	−.0016/(1 − .4753) = −.0029	99	160
Food, drink, and tobacco	−.0125/(1 − .0496) = −.0132	16	72
Clothing and textiles	.0431/(1 − .2328) = .0562	17	113
Paper and printing	.0126/(1 − .3540) = .0195	17	66
Miscellaneous	.0046/(1 − .1283) = .0053	12	65

Notes: Derived from specifications comparable to column (iii) of Table 1.

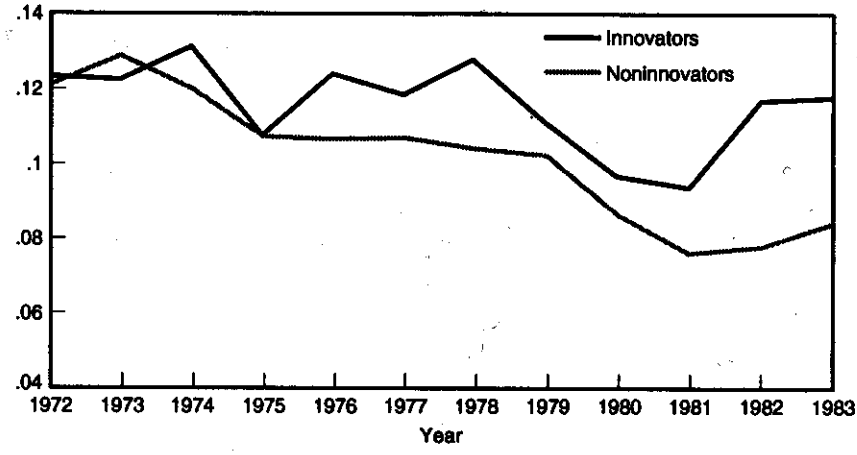
bundle of skills or distinctive capabilities: competitive advantage arises whenever a firm accumulates a set of skills that more than match those of its rivals. As many of the skills that give rise to competitive advantage are knowledge based, it follows that learning is likely to be a fundamental element of competitive strategy. Indeed, since knowledge is likely to be most useful only when it is firm specific, it follows that developing existing skills internal to the firm is likely to be as important as the purchasing of assets in the appropriate factor markets in building up competitive abilities. In this context, the process of innovating may matter because it helps to develop a firm's internal capabilities, enhancing its ability to learn about new technology, match technological possibilities with the characteristics of demand, and, as a consequence, sustain its market position in the face of changes in supply or demand conditions.[7]

Even a cursory inspection of the data reveals that there are more differences between innovators and noninnovators than the simple fact that the former produced one or more innovations during the period and the latter did not. In particular, an inspection of Appendix B reveals that innovators' market shares were nearly six times larger than those of noninnovators (the 1972–1983 average total sales of innovators was £460 million in 1980 prices; the average for noninnovators was £76 million). More interesting is the fact that the difference in profits between innovators and noninnovators is not fixed throughout the sample period, as Figure 1 shows. Although a clear difference in profitability is evident at the end of the period, no difference in margins between the two sets of firms is discernable in the first four years of the sample. This observation is particularly interesting because the number of innovations produced by firms in the sample declined throughout the period (see Figure 2). If the product view were the only explanation of how innovation affects profitability, one would expect to see larger profitability differentials between innovators and noninnovators at the beginning of the period, and not at the end. The early 1980s was a period of severe recession in the United Kingdom, and the fact that profitability differences seem to be largest then suggests that there may be generic differences between innovators and noninnovators that become particularly evident only in times of adversity.

[7] For similar arguments that stress the dual nature of R&D as a process that both produces innovative outputs and builds up internal capabilities, see Cohen and Levinthal (1989), Mowery and Rosenberg (1989), Pavitt (1991), Malerba (1992), and others.

FIGURE 1

AVERAGE PROFIT MARGINS IN U.K. MANUFACTURING FIRMS 1972–1983



To account for what is displayed in Figure 1, we estimated (1) separately for the sample of 117 innovators and for the sample of 604 noninnovators.[8] The split is supported statistically (p-value $< .001$), and regressions (v) and (vi) in Table 1 show estimates for the innovating and noninnovating subsamples that are comparable to (iii). Aside from an effect from the number of innovations produced, the major difference between the two samples lies in the coefficients associated with market share, the lagged profit margin, and the 1980 and 1981 time dummies (not reported). The estimates of the latter are significant and negative for noninnovators but insignificantly different from zero and positive for innovators. Even more interestingly, the coefficients on the spillover variables are larger and more significant in the innovators equation than in the noninnovators equation.[9] This is consistent with the view that the transmission of knowledge is not costless, that only firms with substantial in-house research capabilities are likely to be able to benefit from spillovers.

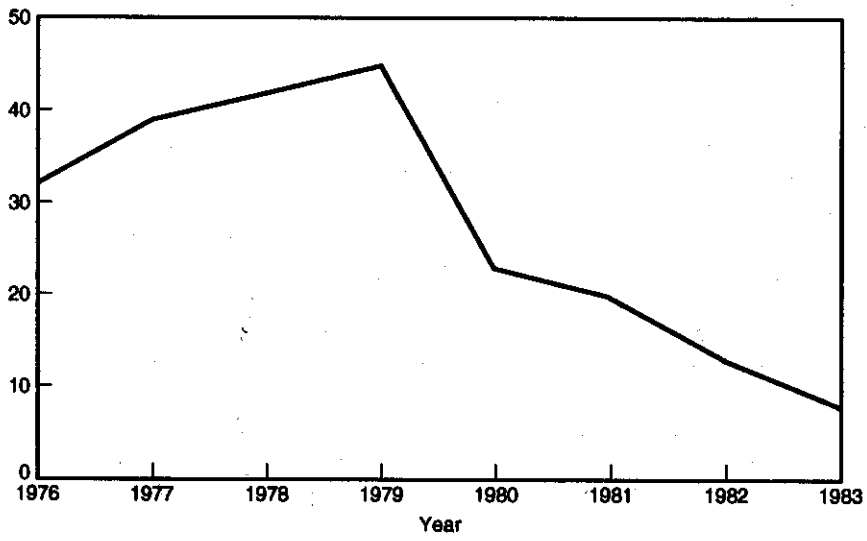
To interpret regressions (v) and (vi), write (1) as $ROR^I = X^I\beta^I + \mu^I$ when applied to the sample of innovators, and as $ROR^N = X^N\beta^N + \mu^N$ when applied to the sample of noninnovators. The predicted profitability differential can be written as $\hat{D} = \hat{\beta}^I(X^I - X^N) + X^N(\hat{\beta}^I - \hat{\beta}^N)$, where a hat denotes an estimated value. Thus, part of the difference between innovators and noninnovators (which, on average overall, is .012) comes from the fact that the latter produce no innovations and have smaller market shares (these may not be independent events), and part comes from the different coefficients on market shares, lagged profits, and the 1980 and 1981 time dummies (the contribution of the innovation variables is .0012, or 10% of the total differential). All these differences might be classified as "transitory" to distinguish them from "permanent" differences that are captured in the fixed effects. Interpreting (v) and (vi) in this way produces the rather strong conclusion that differences in the fixed effects are large and positive (the mean fixed effect for innovators was .048, while that for noninnovators was .030), while transitory effects are small and negative. However, the transitory effects are very noticeably cyclical

[8] Very similar results were obtained using a balanced panel of 539 firms that contained 98 innovators; see Geroski and Machin (1993).

[9] We also used a dummy variable (innovators = 1, noninnovators = 0) interacted with all the exogenous variables in (iii) in Table 1 to help identify which particular exogenous variables differed significantly between innovative and noninnovative firms. Although it proved to be very easy to reject the restriction that all 16 of the dummy-variable interacted terms could be excluded, the variables whose t-statistics were near conventional levels were the market share/concentration interaction, lagged margins, and all the time dummies.

FIGURE 2

TOTAL NUMBER OF INNOVATIONS PRODUCED BY FIRMS IN THE SAMPLE



in impact, suggesting that innovating firms were much more able to maintain margins in the recession of the early 1980s than were their noninnovating counterparts (the transitory predicted differential was .009 higher in 1980–1982 than it was on average over the earlier part of the period).[10] Most of this cyclical transitory effect is captured by the 1980 and 1981 time dummies, but it is also possible to observe a small contribution originating from the market share and innovation variables included in (1).[11]

Thus, profitability differences between innovators and noninnovators seem to reflect inherent generic differences between the two types of firm, but they are difficult to observe accurately because of the effects of a number of transitory cyclical factors. Identifying the source of generic differences is a good deal more difficult than measuring them, but it seems reasonable to believe that the differences in the fixed effects of innovators and noninnovators that we have observed are associated with innovative activity. In particular, regressing the estimated fixed effects on a number of observables suggests that they are higher for innovative firms, and for firms located in heavy-innovation-producing sectors (they are lower in heavy-innovation-using sectors). Denoting the estimated fixed effects as $\hat{\alpha}_i$, two typical regressions thrown up by this exercise are

$$\hat{\alpha}_i = \underset{(24.102)}{.030} + \underset{(5.624)}{.018}\ \overline{INOV}_i$$

$$\hat{\alpha}_i = \underset{(3.920)}{.034} + \underset{(6.000)}{.020}\ \overline{INOV}_i + \underset{(2.230)}{.003}\ (\overline{IPI}/10)_i - \underset{(2.625)}{.013}\ (\overline{IUI}/10)_i$$
$$+ \underset{(.658)}{.009}\ \overline{UN}_i - \underset{(2.363)}{.044}\ \overline{MS}_i - \underset{(.578)}{.005}\ \overline{CON}_i - \underset{(1.671)}{.017}\ \overline{IMP}_i,$$

[10] It is unlikely that this result arises because innovation-producing firms inhabit sectors that are not very cyclically sensitive, since most of the innovation producers are located in engineering and chemicals. However, it is worth stressing that our dataset contains only one recession, and the results reported in the text may be specific to the early 1980s.

[11] Geroski and Machin (1992) have also observed cyclically sensitive differences in the growth performance of innovators and noninnovators; in recessions, noninnovators grow noticeably slower than innovators.

where absolute t ratios are in parentheses, bars denote firm averages, $\overline{INOV}_i$ is a 0-1 dummy indicating whether firm i innovated between 1972 and 1983 or not. Including both $\overline{INN}$ and $\overline{INOV}$ yielded

$$\hat{\alpha}_i = \underset{(24.076)}{.030} + \underset{(4.618)}{.017}\ \overline{INOV}_i + \underset{(.479)}{.003}\ \overline{INN}_i,$$

suggesting that it is the fact that innovation occurs and not the total number of innovations that is associated with the fixed effects (which is why the OLS estimates of the effect of innovation in column (iv) of Table 1 are so similar to those in column (iii)). These results are, of course, consistent with the view that the different profit and innovation records of innovators and noninnovators arise from differences in some deep-seated "competitive ability" closely linked to the innovation process.

To put these results into perspective, we have made one final set of calculations. The product view of innovation looks for effects timed with the production of specific innovations, while the process view looks for effects associated with the transformation of a firm's internal capabilities. To assess the relative size of these two effects, we took a "typical" noninnovator (i.e., one whose exogenous traits were equal to the mean values of the exogenous variables used in (vi) for the subsample of noninnovators, and whose profits were given by the coefficients in (vi)) and transformed it by giving it the attributes of an innovator (i.e., supposing that its profits were determined by regression (v) in Table 1). The short-run gain in profits in the year 1975 was £.4 million (in 1980 prices), and pushing forward to 1983 gives a short-run gain of £4.087 million (evaluated at the innovator's mean values of all exogenous variables). Converting to long-run equivalents gives a gain of £7.135 million, some three times the size of the gain to the production of a specific innovation estimated earlier using regression (iii). That is, calculating the effects of innovation on profitability associated with the product of a specific innovation (i.e., those associated with the product view of innovation) considerably understates the total effects of innovation on profits. In the area of innovative activities, it may matter more what a firm does than what it produces.

5. Conclusions

■ In summary, we have uncovered two properties of the data that are worth highlighting. The first is that the number of innovations produced by a firm has a positive effect on its profitability, but the effect is, on average, only rather modest in size. It is, of course, possible that this kind of reward is commensurate with the efforts made by the firms themselves. To interpret this result properly, however, it is important to distinguish the returns to the production of innovations from the returns to their use. Relatively few of the innovations in this dataset were first used by the firm that produced them, and (largely anecdotal) evidence suggests that many were developed in close consultation with users. Other research using this data has revealed that these innovations have had a far greater impact on users' productivity growth than on producers' productivity (e.g., Geroski, 1991), and there is no reason not to think that this might also be true with profitability. It follows, then, that the relatively modest profits apparently realized by innovation producers may be only a fraction of the value created by innovative activity.[12] What is more (and what is more surprising),

[12] On the other hand, the fact that commercial success is one of the criteria used to select innovations into the SPRU dataset means that we are unlikely to uncover negative effects on profitability associated with them. As a consequence, the total returns to innovation activity (i.e., to producing successful and unsuccessful innovations) are likely to be lower than those reported in the text.

we observe relatively small (and very imprecisely estimated) spillovers associated with the innovations in our data. These apparently small spillovers stand in contrast with much larger spillovers estimated in the United States using data on R&D expenditures, and may reflect the fact that disembodied knowledge spills over more easily than knowledge embodied in specific new products.

The second interesting feature of the data is that although innovators seem to enjoy higher profit margins because of the specific innovations they introduce, substantial permanent differences in the profitability of innovating and noninnovating firms also exist that are not closely timed with the introduction of specific innovations. These permanent profitability differences probably reflect generic differences in "competitive ability" between innovators and noninnovators, and they seem to be associated in a very general way with the process of innovating. They also enable innovative firms to realize the benefits of spillovers more fully than noninnovative firms. Further, innovating firms enjoy higher margins because they have larger market shares than noninnovators, and because the margins associated with possessing a market share of a given size are higher for innovating firms. Both of these may reflect the indirect effects of the specific innovations introduced by these firms, or they may signal a more fully developed set of internal capabilities. Finally, the profit margins of innovating firms are somewhat less sensitive to cyclical downturns than are those of noninnovators, an observation that adherents of the process view of the effects of innovation are likely to regard as deeply sensible. Whatever it is that creates generic differences between innovators and noninnovators, the consequence is that the former are likely to be quicker, more flexible, more adaptable, and more capable in dealing with market pressures than the latter are. Since these are characteristics likely to have most value to their possessor in conditions of severe adversity (e.g., in harsh recessions), it is no surprise to observe that profitability differences between innovators and noninnovators are widest when the going gets rough.

Appendix A

■ **The SPRU innovations data.** The Science Policy Research Unit (SPRU) at the University of Sussex identified just over 4300 major innovations, defined as "the successful commercial introduction of new or improved products, processes or materials" introduced in Britain in 1945–1983. The innovations were judged on their technological merits by panels including over four hundred scientists, engineers, and academics over the course of the fifteen-year study. The firms who commercialized them were contacted, and information was gathered on the company itself, the date of introduction, and the industry where the innovation was first used (as well as on other things). The data on sector of first use is particularly important because many of the industries that produced an innovation were not the industries that first used it (see Robson, Townsend, and Pavitt (1988), who map the interindustry flow of the innovations in this dataset). Anecdotal evidence suggests that many firms developed innovations in close consultation with the firms who eventually used them.

The total number of innovations produced per year and appearing in the SPRU database increased irregularly over the period 1945–1980 and declined from 1980–1983. There appear to be discernible cycles of innovation that peak (roughly speaking) every five years or so. After 1971, there is at least one and perhaps two cycles, so that our data begin and end approximately at trough points. The innovations produced per year by the 721 firms in our sample display a pattern broadly similar to the full population of innovations in the SPRU database, but add up to less than 20% of the 1945–1983 total (small firms account for a disproportionately large share of the SPRU innovations; see Pavitt, Robson, and Townsend (1987)). The distribution of innovations by industry appears pretty stable over time, with the bulk of innovations concentrated in four two-digit industries: mechanical engineering, electrical engineering, vehicles, and chemicals. Almost all of the innovations in the dataset originated from the manufacturing sector, although nonmanufacturing industries were large users. Innovations produced by firms in our sample include the following: turbomolecular pumps, an aphicide for the control of pests, an epitropic fiber, Interferon, optical fibers for telecommunications, solar glass windows, the magnascan 560 color scanner, Tamoxifen, photochromic glasses, and copper/aluminium superplastic furniture.

The dataset is lodged at the ESRC Data Archive at the University of Essex, and it is described at length in Robson and Townsend (1984).

Appendix B **Variable definitions and descriptive statistics.**

Variable	Definition	All Firms (N = 721) Mean (standard deviation)	Innovative Firms (N = 117) Mean (standard deviation)	Data Source
Margins (*ROR*)	Net profits derived from normal trading activities before tax and interest payments divided by sales	.095 (.0634)	.1049 (.0561)	Datastream item 26, item 104
Innovations (*INN*)	Total number of innovations produced in all innovating units owned by the firm	.0449 (.3041)	.2716 (.7063)	SPRU innovations tape
Production spillovers (*IPI*)	Total number of innovations produced by all members of the two-digit industry	12.98 (15.23)	16.97 (15.96)	SPRU innovations tape
Use spillovers (*IUI*)	Total number of innovations used by all members of the two-digit industry	6.40 (5.88)	7.37 (5.781)	SPRU innovations tape
Unionization (*UN*)	Industry union density by two-digit industries	.6761 (.1168)	.7033 (.094)	Updated from Price and Bain (1983)
Market share (*MS*)	Total firm sales divided by three-digit industry total sales and work done	.0254 (.0682)	.0723 (.1190)	Datastream item 104, and ACOP, Table P1002a
Concentration (*CON*)	Five-firm three-digit industry concentration ratio by sales	.399 (.1776)	.4097 (.1675)	ACOP, Table P1002a
Import intensity (*IMP*)	Imports divided by home demand in each three-digit industry	.2506 (.1409)	.2625 (.1073)	Business Monitor, Table MQ12

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