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ENTRY AND THE RATE OF INNOVATION

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I. INTRODUCTION

It is often said that competition is a dynamic process, and that it is the dynamics of the process which have a major effect on market performance. Our goal in this paper is to explore the spirit of this suggestion by examining the association between innovative activity and one observable manifestation of competitive market dynamics, namely entry.

There are a number of reasons why entry – and small firm activity more generally – is worth focusing on in connection with innovative activity. Chief amongst these is the recent policy interest that has been lavished on small firms in the name of rejuvenating industry and stimulating progressiveness. As is usual in these cases, elevating small firms up towards the top of the policy agenda has stimulated both a modest flow of careful research and a veritable flood of hyperbole. Numerous popular discussions have painted alluring pictures of a new industrial renaissance flowering from the seedbed of small firm activity, and the same five or six anecdotal case studies are regularly paraded in front of the argument by way of support. More scholarly examinations of the evidence have uncovered systematic evidence that loosely supports the spirit of some of these popular discussions. Small firms and entrants appear to make a fairly substantive contribution to the generation and diffusion of innovations, a contribution sufficiently large to dent the notion that there is necessarily a positive relationship between large firm size or market power on the one hand, and innovation on the other.[1]

Establishing that a correlation exists between entry or small firm activity and innovation is, however, only half the story. No less interesting and important is the further question of whether that correlation exists because entry stimulates innovation, or because new innovations open up market opportunities that small firms are either particularly quick or are unusually well suited to exploit. The question is an important one for several reasons. At a practical policy level, it is important to know whether aid given to encourage new business formation is feeding the causes or the consequences of innovative activity, whether support for small business is a (partial) substitute for or a (partial) complement to science and technology policy.

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More broadly, it is interesting to ask whether market structure determines the evolution of technology, or whether technological trajectories shape the structure of markets in systematic ways over time. Although most economists have been mainly interested in the causal links running from market structure to innovation, there are signs that the causal channel from technology to market structure is no less important. Blair, 1974, for example, has argued that many of the innovations introduced in the 20th century have been deconcentrating, and there is some evidence to suggest that innovative activity has had a modest negative effect on levels of industry concentration (e.g. see Geroski and Pomroy, 1989, and references cited therein). The question is of both practical and policy interest, not least because it may help to clarify whether the increasing concentration of markets is a response to some relentless technological imperative, or just an expression of managerial ambitions.

The plan of operation, then, is as follows. In Section II, we develop a model of entry and innovation that is general enough to describe both of the possible causal channels that may exist between the two variables. The model is applied to data on entry and innovation rates in the UK, 1974–1979, and the results of the causality tests are reported in Section III. Our conclusions are contained in Section IV.

II A DYNAMIC MODEL OF ENTRY AND INNOVATION

The immediate determinants of both entry and innovation, the 'condition of entry' and the 'condition of innovation' respectively, are a mix of permanent and transitory factors specific to each industry. The permanent factors are barriers to entry and technological opportunity respectively, while current market conditions register more transitory effects on entry and innovation.

Barriers to entry are structural factors that determine the ability of entrants to enter and compete successfully with incumbents, factors that include economies of scale, the degree of product differentiation and absolute cost barriers (e.g. Bain, 1956). Barriers are said to exist whenever incumbent firms are able to maintain prices persistently above costs for long periods of time without attracting entry. Most discussions of barriers restrict attention to structural factors which, while being industry specific, are also relatively constant over time and exogenous in the short and medium run. Barriers are not, however, the sole determinant of the condition of entry since the effect on entrants of a set of barriers of any given height or character depends on current market conditions and the strategic actions of incumbents. Economies of scale, for example, are a far less formidable barrier in growing markets than in shrinking ones, and their effect on entrants depends on the post-entry level of output that they expect incumbents to produce. Thus, while barriers to entry may be exogenous and constant in the short to medium run, the condition of entry – the specific problems faced by an entrant at any particular specific time -is likely to be only partially so.

Technological opportunity is the term usually used to describe the conditions that determine the number and kinds of inventions and innovations that it is feasible to produce given the existing knowledge base (e.g. Rosenberg, 1974). These conditions are exogenous to the decisions of firms, and they change only relatively slowly over time. However, while technological opportunity is the deep causal determinant of innovation, current market conditions and the strategic decisions of firms help to determine the precise timing of when innovations are actually introduced. Any particular technical breakthrough must always be embodied in a product before it can be offered to the market, and this means that both the timing of its appearance and its specific character are likely to be influenced by the actions of rivals and by the state of consumer demand. As it is a combination of deep structural factors and current market events, the condition of innovation is likely to be both less stable and less completely exogenous than is technological opportunity.

The major difficulty with using these observations to construct an operational model of entry and innovation is that changes in the conditions of entry and innovation (much less changes in entry barriers or technological opportunity) are difficult to observe. This problem has forced empirical workers to resort to rather incomplete sets of proxy variables. Some aspects of the conditions of entry and innovation are often reflected in easy-to-observe variables, and these have typically been used as a springboard to make wider inferences about the role of entry barriers and technological opportunity on entry and innovation rates. The hazards of this type of procedure are well known, and they are potentially severe enough to make one interested in examining alternatives. The approach that we shall explore here is to move away from trying to measure exogenous variables of interest, and to focus exclusively on the endogenous market variables that can be observed, entry and innovation rates.

The attraction of this course of action is that, in principle, such endogenous variables *fully* reflect the *complete* set of exogenous variables of interest. Indeed, they might usefully be thought of as the visible features – the observable indices – of changes in the deeper latent variables that constitute the conditions of entry and innovation in markets. Since it is not possible to directly observe the conditions of entry and innovation, it is not possible to measure the effects of either on entry and innovation. It is, however, possible to make some indirect inferences about these effects because unobserved changes in causes will be recorded in observed consequences. It follows, therefore, that one ought to be able to say something about the causal effects of the permanent and transitory components of the conditions of entry and innovation by looking at the causal relationships that exist between observable indices of them.

To make this argument more precise, it is useful to embody it in an explicit model.[2] Suppose that all the latent determinants of entry and innovation can be summarized by two orthogonal factors (i.e. sequences of serially uncorrelated shocks), a_t and b_t. A fairly general representation of the effects that these factors have on entry and innovation rates might be written as

$$
\begin{aligned}
E_t &= \sum_{\tau=0}^{\infty} \alpha_\tau a_{t-\tau} + \sum_{\tau=0}^{\infty} \lambda_\tau b_{t-\tau} \qquad (1)\\
I_t &= \sum_{\tau=0}^{\infty} \theta_\tau a_{t-\tau} + \sum_{\pi=0}^{\infty} \beta_\tau b_{t-\tau},
\end{aligned}
$$

where I_t denotes observed innovation rates and E_t denotes entry. With two factors and two observables, the model is underidentified and we normalise the units of measurement so that $\alpha_0 = \beta_0 = 1$ (λ_0 or θ_0 may also be set equal to zero without loss of generality). Since a_t and b_t are orthogonal, any correlation that is observed between entry and innovation rates is caused by non-zero values of the λ_τ and/or θ_τ. That is, if E_t and I_t are correlated, it can only be because the b_t have an effect on E_t, the a_t have an effect on I_t, or both.

The problem is that it is impossible to measure the λ_τ and θ_τ directly (much less to test whether they differ from zero) because the a_t and b_t are not observable. E_t and I_t are, however, observable, and they can be used to make inferences about the α_τ, λ_τ, θ_τ and β_τ. The basic insight is that E_t contains information on a_t (and a_{t-1} , a_{t-2}, ...), E_{t-1} on a_{t-1} (and a_{t-2}, a_{t-3}, ...), E_{t-2} on a_{t-2} (and a_{t-3}, a_{t-4}, ...) and so on. Each observable is, therefore, a signal of one or more of the unobservables. This relationship may be exploited (or, more precisely, inverted) to express a_t in terms of all of the values of E_t and I_t that it affects, and similarly with b_t. Substituting these relationships into (1) yields a reduced form expressed entirely in observables,

$$E_t = \sum_{\tau=1}^{\infty} \psi_\tau E_{t-\tau} + \sum_{\tau=0}^{\infty} \eta_t I_{t-\tau} \tag{2}$$

$$I_t = \sum_{\tau=1}^{\infty} \xi_\tau I_{t-\tau} + \sum_{\tau=0}^{\infty} \phi_\tau E_{t-\tau}$$

The reduced form parameters ψ_τ, η_t, ξ_τ and ϕ_τ bear a straightforward relationship to the structural parameters of interest, the α_τ, λ_τ, θ_τ and β_τ. Tedious but straightforward calculations reveal that

$$\alpha_\tau = \sum_{\tau=1}^{t} \psi_\tau \alpha_{t-\tau} + \sum_{\tau=0}^{t} \eta_\tau \theta_{t-\tau} \tag{3}$$

$$\lambda_\tau = \sum_{\tau=1}^{t} \eta_\tau \beta_{t-\tau} + \sum_{\tau=1}^{t} \psi_\tau \lambda_{t-\tau} \tag{4}$$

$$\theta_\tau = \sum_{\tau=1}^{t} \phi_\tau \alpha_{t-\tau} + \sum_{\tau=0}^{t} \xi_\tau \theta_{t-\tau} \tag{5}$$

$$\beta_\tau = \sum_{\tau=1}^{t} \xi_\tau \beta_{t-\tau} + \sum_{\tau=0}^{t} \phi_\tau \lambda_{t-\tau} \tag{6}$$

and $\theta_0 = \phi_0$, $\lambda_0 = \eta_0$. Thus, using (2) as a regression model, one can generate estimates of the ψ_τ, η_τ, ξ_τ and ϕ_τ which can be used in conjunction with (3)-(6) to produce estimates of the α_τ, λ_τ, θ_τ and β_τ in (1).

Our interest is in examining the causal links that exist between entry and innovative activity. Although the interpretation that one puts on unobservables is inevitably arbitrary, we shall nevertheless associate a_t with the 'condition of entry' and b_t with the 'condition of innovation'. Consider first the possibility that the conditions of entry do not have any effect on innovation; that is, that $\theta_\tau = 0, \tau \geqslant 0$. Equation (5) suggests that the $\theta_\tau = 0$ if and only if the $\phi_\tau = 0, \tau \geqslant 0$, since $\alpha_\tau \neq 0$. Hence, the hypothesis that the conditions of entry do not cause innovation corresponds to the restriction in (2) that the term $\Sigma\phi_\tau E_{t-\tau}$ be excludable.[3] Similarly, the hypothesis that the conditions of innovation have no effect on entry corresponds in (1) to the restriction that $\lambda_\tau = 0, \tau \geqslant 0$. Equation (4) shows that this will be the case if $\eta_\tau = 0, \tau \geqslant 0$, since $\beta_\tau \neq 0$. It follows that an appropriate test of the hypotheses that the condition of innovation has no effect on entry is whether one can accept the restriction that the terms $\Sigma \eta_\tau I_{t-\tau}$ can be excluded from (2). Notice that the acceptance of either of these restrictions converts (2) into a recursive system.

Although (2) is rich enough to enable one to test the hypotheses of interest, it is unduly restrictive in its current form. The one feature of both the condition of entry and the condition of innovation that is not reflected in (1) is the relative stability over time of entry barriers and technological opportunity. Although they are not directly observable, the effects of such permanent features of market structure can be measured using panel data. The key insight here is that any permanent component in, say, a_t will have an impact on E_t, E_{t+1}, and so on that is the same in each t. Thus, the permanent component in a_t will give rise to a permanent component in E_t that can be isolated from its time varying or transitory components using standard techniques. Much the same applies to the permanent component in b_t whose effect will register on I_t over and above the effects of any transitory components. It follows, then, that one may observe causal patterns between E_t and I_t that arise from transitory determinants that the two share in common, or because the permanent determinants of both E_t and I_t are similar.

The model that this last observation suggests is a simple generalization of (2), namely

$$E_{it} = \sum_{\tau=1}^{\infty} \psi_\tau E_{it-\tau} + \sum_{\tau=0}^{\infty} \eta_\tau I_{t-\tau} + A_i + \mu_{it} \qquad (7)$$

$$I_{it} = \sum_{\tau=1}^{\infty} \xi_\tau I_{it-\tau} + \sum_{\tau=0}^{\infty} \phi_\tau E_{it-\tau} + B_i + \gamma_{it}$$

where $i = 1,\ldots,N$ indexes industries and $t = 1,\ldots,T$ time periods. A_i and B_i are industry specific fixed effects assumed to be constant over time, and μ_{it} and γ_{it} are white noise residuals.[4] In effect, both A_i and B_i will extract an index of the stable features of the condition of entry (eg, entry barriers) and the condition of innovation (eg, technological opportunity) from the data. By contrast, the factors a_t and b_t only record the effects of transitory market conditions. The parameters ψ_τ, $\eta_{t,t}$ and ϕ_τ associated with them show the response of entry and innovation to systematic time varying components of the conditions of entry and innovation, components that reflect the transitory, day to day ebb and flow of market events plus any time variation in entry barriers or technological opportunity. Finally, the residuals μ_{it} and γ_{it} capture the impact of unpredictable, idiosyncratic factors on E_t and I_t.

III CORRELATIONS AND CAUSAL PATTERNS

The two observables that we shall work with are innovation rates and entry measured in four different ways. Our measure of innovation is a count of the number of major, commercially successful innovations produced in industry i at a time t. As one might imagine, the data is highly skewed across industries, and, to transform it into something more nearly normally distributed, we have elected to work with I_t defined as the log of unity plus the innovation count. All of our measures of entry and exit rates were computed by comparing adjacent tabulations of Census of Production, looking for enterprises new to the register or no longer in it. For the time being, we shall work with a net entry measure based on market penetration, the total sales of entrants in t less those of exitors in t expressed as a percentage of the total sales in the market at t. There are, however, a range of measures of entry that one can compute from this data, and an important part of the exercise will be to establish the robustness of the results to alterations in the definition of entry.[5]

The sample that we shall work with contains 79 three digit MLH (Minimum List Heading) industries, and, in the regressions that follow, we have pooled two cross sections – for 1978 and 1979 – together. The need to estimate the fixed effects in (7),

A_i and B_i, dictates the pooling of at least two cross sections, while the need to estimate potentially long distributed lags limits the pooling that can be done. As our entry data only goes back to 1974, we have opted to pool the minimum number of cross sections necessary to estimate the fixed effects.

Four broad features of the data are worth noting. The first is the rather modest impact (measured in terms of both sales and the number of new enterprises) that entrants make in most markets on average, and the fact that exit flows are typically larger than entry flows. Table 1 presents some basic descriptive statistics on the count of innovations and the four measures of entry which illustrate this clearly. There is, however, a considerable amount of inter-industry variation in the data and the second feature to note is that, truncation aside, values of entry are roughly normally distributed across industries, as is I_t, the log of unity plus the innovations count. Both gross entry measures and the innovations count variable are truncated at zero however, and have 34% (gross entry penetration and gross entry rate) and 67% (innovations count) of their values on the limit.

Of course, cross section variation is not the only variation worth noting in a panel data set, and the third interesting feature of the data is that cross-section variation is not, in fact, the predominant source of the total variation in the data. An analysis of variance of the innovations data pooled over the period 1975–1979 suggests that roughly 58% of the total variation in the innovations count data is 'between industry' variation. For the four entry measures shown on Table 1, the corresponding percentages are: 49%, 23%, 24% and 21% respectively. That there is a substantial degree of 'within industry' time series variation in the data raises the further question of how systematic it is. The fourth interesting feature of the data is that variations in innovative activity across industries over time are rather stable, but that variations in entry across industries over time are not. Thus, the correlation between variations in innovation across industries in t and those in t-1, t-2, t-3 and t-4 was always about 0.700; that between net entry penetration in t and in t-1,...,t-4 never exceeded 0.100.

Taken together, these four features of the data suggest the following characterization of entry and innovative activity. Inter-industry differences in innovation are slightly more pronounced than variations over time in the innovative activities of particular industries, not least because some industries simply do not innovate while

Table 1. Entry and Innovation*

		MEAN	*MAX*	*MIN*	*STD.DEV.*
Innovations	1979	1.316	26	0	3.688
Count	1978	0.975	9	0	1.948
Gross Entry	1979	0.0145	0.0680	0	0.0218
Penetration	1978	0.0186	0.1098	0	0.0170
Net Entry	1979	−0.0053	0.0519	−0.1295	0.0211
Penetration	1978	−0.0098	0.0889	−0.0765	0.0285
Gross Entry	1979	0.0205	0.1227	0	0.0253
Rate	1978	0.0342	0.0959	0	0.0190
Net Entry	1979	−0.0084	0.0720	−0.1363	0.0291
Rate	1978	−0.0064	0.0875	−0.1042	0.0303

*For 79 3-digit MLH industries in the UK. Entry penetration is defined as sales by entrants (net or gross of exit) as a percentage of domestic sales; entry rates are the number of entrants (net or gross of exit) as a percentage of the number of establishments in the industry.

others do so consistently. Current and near future innovating industries are relatively easy to spot on the basis of their near past innovation records. Inter-industry differences in entry, by contrast, are much less marked, and the substantial variation over time in the entry experience of any particular industry is relatively unsystematic and extremely difficult to predict. These observations, in turn, suggest that the condition of entry is likely to be very sensitive to a wide range of perhaps idiosyncratic market conditions. Entry barriers, the permanent and deep structural determinants of entry, seem likely to be less a deterrent to entry as a limitation on the post-entry market penetration of new firms and, perhaps, a main contributor to the relatively high exit rates observed in the data. The condition of innovation, by contrast, seems to be rather more stable, and the constraints on innovative activity imposed by technological opportunities seem to divide innovators from the rest fairly clearly.

Given the quite marked differences in the statistical properties of innovative activity and the various manifestations of entry, it seems rather unlikely that either of the two will prove to be a major causal determinant of the other. Partial correlations between values of either across industries in t and values of the other in t, t-1,...,t-4 are all positive but modest in size, never exceeding 0.215. Of course, partial correlations are likely to understate the cumulative effect of one variable on the other, and, in any case, they give no information on causal orderings. It is necessary, therefore, to probe somewhat more deeply using a statistical vehicle like (7), and Table 2 shows OLS estimates of a general and restricted version of (7). Equation (i) shows the results of regressing I_t on its own history (plus industry and time dummies), while (ii) is a more general version of (i) that includes entry. The five restrictions that transform (ii) into (i) are that the $\phi_\tau = 0$, $\tau = 0,....,5$. As can be seen, imposing these restrictions on (i) inflates the sum of squared residuals by about 9.3%. Applying a likelihood ratio test, the calculated $\chi^2(5)$ statistic is 14.1792, well above conventional 5% significance levels. Together, the two calculations suggest that it would be imprudent to accept the restrictions $\phi_\tau = 0$, however modest the estimated impact of the $E_{t-\tau}$ is. Equation (iii) shows the results of regressing E_t on its own history, and is a restriction of the more general model (iv) that corresponds to imposing $\eta_\tau = 0$, $\tau = 0,...,5$. These restrictions inflate the sum of squared residuals by a modest 4.6%, and the calculated $\chi^2(5)$ statistic is 7.206, well below conventional 5% significance levels. It follows that the restrictions $\eta_\tau = 0$ are not very costly. That the restrictions $\eta_\tau = 0$ are acceptable but $\phi_\tau = 0$ are not suggests that the fully interdependent two equation model (7) can be simplified to a recursive model in which E_t has an effect on I_t but I_t has no effect on E_t. That is, if one focuses only on the transitory determinants of entry and innovation, it appears that entry causes innovation, but that innovation does not cause entry.[6]

It turns out that this causal ordering is an extremely robust property of the data. Equations (i)-(iv) were replicated using all four of the measures of entry displayed in Table 1, and then, for each of the four entry measures, equations (i)-(iv) were rerun first with I_t defined as the count of innovations, then with E_t defined as the log of unity plus the entry measure, and then with both transformations. In eleven of the twelve cases, the results suggested that entry caused innovation but that innovation did not cause entry (using the levels of innovation counts and the level gross entry penetration suggested that no causal relations existed between I_t and E_t). The results also turn out to be robust to the estimation technique used. Repeating the exercises just described above using a probit estimator for the innovation equation continued to suggest that entry caused innovation, but not the reverse. Using a probit estimator for the two gross entry variables did, however, occasionally turn up weak evidence consistent with the hypothesis that innovation caused entry. We also experimented with sub samples defined by values of various exogenous variables. The most interesting partition divided industries into 'low' and 'high' concentration classes (defined by whether industry concentration was above or below the median concentration level in the sample), and tests suggested that the result that entry causes innovation could be observed only in 'high' concentration industries. No casual effects were apparent in the 'low' concentration group.

Thus, an examination of the transitory determinants of entry and innovation suggests that there are no grounds at all for thinking that innovation causes entry, but that there is some basis for arguing that entry causes innovation. This conclusion is, however, a little too simple and cannot be allowed to stand in an unqualified form. Both entry and innovation rates are also driven by relatively permanent features of market structure - technological opportunity and entry barriers. These two sets of factors are captured in (7) by the fixed effects, A_i and B_i, and the correlation that arises between innovation and entry through them is, in fact, strong and positivee[7]. Estimates of the fixed effects retrieved from equations (ii) and (iii) in Table 2 were found to be correlated with co-efficient 0.730. Regressing estimates of B_i on those of A_i yielded

$$\hat{B}^i = \underset{(5.69)}{0.7542} + \underset{(11.90)}{29.88\hat{A}^i} + \underset{(8.28)}{244.08\hat{A}_i^2} \qquad (8)$$

with $R^2 = 0.71$, where t statistics are given in the brackets beneath the estimated co-efficients.[8] The significance of the squared term in (8) suggests a particularly close

Table 2. OLS Estimates of (7)*

dependent variable	*(i)* I_t	*(ii)* I_t	*(iii)* E_t	*(iv)* E_t
I_t	–	–	–	−0.0111
				(2.745)
I_{t-1}	−1.066	−1.062	–	−0.0132
	(8.30)	(8.48)		(1.870)
I_{t-2}	−0.7116	−0.6142	–	−0.0095
	(4.96)	(4.96)		(1.590)
I_{t-3}	−0.1554	−0.0943	–	−0.0017
	(1.160)	(0.8241)	(0.2832)	
I_{t-4}	0.1814	0.1933	–	0.0004
	(1.262)	(1.334)		(0.0590)
E_t	–	−3.842	–	–
	(3.089)			
E_{t-1}	–	−2.440	−0.7367	−0.7348
	(1.509)	(12.70)	(13.19)	
E_{t-2}	–	−1.736	−0.6257	−0.6145
	(1.097)	(6.146)	(6.223)	
E_{t-3}	–	−2.493	−0.2587	−0.2767
	(1.174)	(2.484)	(2.668)	
E_{t-4}	–	−2.336	−0.0491	−0.0709
	(3.129)	(1.608)	(2.220)	
$\bar{R}^2$	0.7969	0.800	0.4850	0.4723
Log L 'H	13.56	20.65	478.348	481.951
SSR	7.7914	7.1227	0.02170	0.02073

*All equations include 79 industry specific industry dummies and one time dummy, and all estimates are heteroscedastic–consistent. $I_t \equiv$ log of unity plus the count of innovations and $E_t \equiv$ net entry penetration.

link between sectors with very rich technological opportunities (high B_i) and those with very low barriers (high A_i)[9]

Thus, there are two sources of correlation between entry and innovation rates, and, as it happens, the two partially offset each other. The correlation that arises because the permanent determinants of each are similar is positive, and suggests that entry barriers and technological opportunities are highly related across industries. Industries that are rich in technological opportunity appear to have lower entry barriers in general, and, therefore, high levels of entry and innovation activity simultaneously occur in these sectors. Transitory determinants, however, work the other way, and the correlation that arises between innovation and entry through the lagged values of the observables – a correlation that reflects the apparent causal influences of entry on innovation – is negative. Using (3) and the estimates in columns (ii) and (iii) in Table 2 to solve for the structural parameters in (1) reveals that[10]

$$\lambda_0 = \ldots \lambda_4 = 0 \tag{9}$$
$$\theta_0 = -3.842, \theta_1 = -2.202, \theta_2 = -1.2504, \theta_3 = -1.1576, \theta_4 = -1.1065$$

Thus, correcting for entry conditions and technological opportunities, increases in entry competition have a weak negative effect on innovativeness.

In short, there appears to be a strong interdependence between deep structural features of markets (like entry conditions and technological opportunity) that induces a positive correlation between entry and innovation, but that variations in entry rates have a modest (and declining) negative effect on innovation rates. Table 3 reports

Table 3. Simulations Using (ii) and (iii)

	Case 1		*Case 2*		*Case 3*		*Case 4*	
t	E_t	I_t	E_t	I_t	E_t	I_t	E_t	I_t
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.75000	0.01000	0.71158	0.01000	1.03858	0.00000	1.07700
6	0.00000	−0.04650	0.00263	−0.04021	0.00263	−0.06049	0.00000	−0.06677
7	0.00000	0.31848	0.00180	0.30573	0.00180	0.44459	0.00000	0.45734
8	0.00000	0.37086	0.00444	0.33305	0.00444	0.49475	0.00000	0.53256
9	0.00000	0.30129	0.00443	0.28070	0.00443	0.41207	0.00000	0.43266
10	0.00000	0.15321	0.00336	0.15965	0.00336	0.22645	0.00000	0.22001
11	0.00000	0.42069	0.00351	0.38348	0.00351	0.56690	0.00000	0.60412
12	0.00000	0.24862	0.00394	0.22731	0.00394	0.33555	0.00000	0.35650
13	0.00000	0.26039	0.00381	0.25282	0.00381	0.36635	0.00000	0.37392
14	0.00000	0.30422	0.00365	0.28366	0.00365	0.41630	0.00000	0.43687
15	0.00000	0.31768	0.00373	0.29143	0.00373	0.43002	0.00000	0.45645
16	0.00000	0.24080	0.00379	0.23002	0.00379	0.33500	0.00000	0.34579
17	0.00000	0.31211	0.00374	0.29288	0.00374	0.42985	0.00000	0.44818
18	0.00000	0.29298	0.00373	0.27096	0.00373	0.39870	0.00000	0.42071
19	0.00000	0.27747	0.00375	0.26094	0.00375	0.38191	0.00000	0.39845
20	0.00000	0.28458	0.00375	90.26778	0.00375	0.39186	0.00000	0.40866
TOTAL	**0.00000**	**4.8067**	**0.06406**	**4.5486**	**0.06406**	**6.60722**	**0.00000**	**6.9025**

Case 1: A = 0, B = 0.75; Case 2: A = 01, B = 0.75;
Case 3: A = 0.01, B = 0.77; Case 4: A = 0, B = 1.077.

some simulations designed to show these two offsetting forces at work. Case 1 shows a simulation of equations (ii) and (iii) from Table 2, setting $A_i = 0$, $B_i = 0.75$ for all i and $E_t = I_t = 0$, $t = 1,...,4$. Increasing A_i facilitates entry, as shown in case 2 where A_i increases to 0.01, and, for this reason, reduces the count of innovations through the transitory effects registered in (9). The reduction in innovation is about 5% in total over 15 periods. However, (8) suggests that A_i and B_i cannot be treated as independent parameters, and case 3 shows what happens when the increase in A_i is mirrored in an increase in B_i by an amount given by (8). Innovation rises considerably – by about 37% relative to case 1 and by about 45% relative to case 2. Finally, were B_i only to change, case 4 shows that innovation would be higher still. As before, the negative offset from the effects described in (9) lead to about a 5% decrease in innovativeness.

It follows from all this, then, that there exists a positive association between entry and innovation that is driven by the positive correlation between entry barriers and technological opportunity, and, further, that the positive association is more than strong enough to overwhelm a negative causal effect running from entry to innovation that is driven by more transitory market conditions.

IV CONCLUSIONS

In this paper, we have examined data on entry and innovative activities across a wide range of UK industries for the period of the late 1970's. The correlation between the two variables is positive, but, on the whole, rather modest, and it cannot be given a clear causal interpretation. Although there are noticeable negative effects running from entry to innovation (but none apparently that run in the other direction), these are more than dwarfed by the strong positive correlation that appears to exist between the deep structural determinants of entry and innovation. The joint incidence of high entry rates and high innovation rates appears to arise because industries where barriers to entry are low are apparently also industries where technological opportunities are particularly rich[11].

The reason for the weak correlation is easy to account for in purely statistical terms. Entry penetration and entry rates (gross and net) have a very high degree of within industry variation, much of which appears to be rather unsystematic. Innovation rates, by contrast, have a more marked and more stable between industry variation, and are more systematic in their variation both across industries and over time. The appropriate inference would seem to be that deep structural factors like technological opportunity play a much larger role in determining the condition of innovation than entry barriers do in determining the condition of entry. By contrast, current market conditions seem to play a larger role in determining entry rates than innovation rates, and the market conditions that matter for entry appear to be more idiosyncratic than those that matter for innovation.

These results carry a fairly strong policy implication for those concerned to maximize the contribution that new small firms make to economic performance. In particular, a simultaneous rise in entry or small firm activity and innovation rates probably should not be interpreted as necessarily suggesting that entry and small firm formation are likely to cause a renaissance in industrial innovativeness. Rather, it may be no more than a signal that industrial rejuvenation is occurring for other reasons. Small firm support schemes – however desirable they are on other grounds

– may, in this reading of the data, do little more than stimulate a symptom of innovative activity rather than a cause of it.

Notes

1. See Gort and Klepper, (1982), Gort and Kanakayama, (1982), Cohen et al, (1987), Geroski, (1990), Beesley and Hamilton, (1984), Pavitt et al, (1987), Acs and Audretsch, (1987, 1988), and, for surveys of the empirical literature on the Schumpeterian hypothesis, Scherer, (1980, Chapter 15), Kamien and Schwartz, (1982), and Baldwin and Scott, (1987).
2. What follows is known as a dynamic latent factor model; see, Geweke, (1977), and references cited therein. Applications of the model include Sargent and Sims, (1977), Pakes, (1985), Lach and Shankerman, (1989), Sullivan, (1988), Diebold and Nerlove, (1989), and others. For a general discussion of the uses and interpretation of factor analysis and latent variables models, see Aigner et al, (1984), and Judge et al, (1980, Chapter 13).
3. This is essentially a test of Granger causality (Granger, 1969) and, as such, is a test of whether the terms in E_{t-r} add anything to the linear predictor of I_t that uses information only on its own history (i.e., the I_{t-r}). Note that one cannot make any inferences about simultaneous causality using (2).
4. It is possible to put A_i, B_i, μ_{it} directly into the structural model (1), in which case the fixed effects and residuals that emerge in the reduced form (7) will be linear functions of A_i, B_i, μ_{it} and $_{it}$, the α_r, λ_r, θ_r, and β_r. There seems to be little purpose in trying to unscramble estimates of these primal variables (or of their stochastic properties) from their manifestations in the reduced form equations, although the reader is free to do so if s/he wishes.
5. The entry and exit data were drawn from a special compilation made by the Business Statistics Office. Market shares were defined as a percentage of total domestic production less exports plus imports. The innovations count was based on the number of significant technically and commercially successful innovations produced in each industry derived from a major study (involving 400 experts) by SPRU, University of Sussex, of 4378 major innovations in the UK, 1945–83; for details see Pavitt et al, (1987). Explicit attempts were made by the SPRU team to overcome a natural tendency to concentrate on the innovations of large firms in constructing their survey, and, although it is extremely unlikely, this may have imported a slight tendency to exaggerate the contribution of smaller firms.
6. These exercises were also repeated without including E_t in the I_t equation or I_t in the E_t equation in the general specification, but this had very little effect on the results. Note that the causality test should not include contemporaneous values of the putative causal variable on the right hand side, since it would enter regardless of causality if the two variables were correlated (i.e. the model permits no inferences to be made about simultaneous causality).
7. It is worth remarking that the fixed effects are estimated from two adjacent cross sections, a very short time period in which to get a fix on deep structural factors. Nevertheless, they play a substantial role in the estimated equations, affecting not only the degree of explanation achieved (suppressing them generally raised the sum of squared residuals by 200% or more) but also the sign pattern on the lagged variables. Estimates of (7) without fixed effects generally produced positive co-efficients on lagged dependent variables in both entry and innovation equations (although the negative cross effects between entry and innovation shown on Table 2 were largely robust to this change). The negative signs on lagged dependent variables arise because the fixed effects allow each industry to adjust entry of innovation to it's own long run 'target'. Since this target is generally higher in high entry or high innovation industries, then both entry and innovation rates are in fact positively correlated over time.
8. These estimates are heteroscedastic consistent. Much the same outcome emerged using estimates of the fixed effects retrieved from (i) and (iii) and (ii) and (iv). The fixed effects from (ii) and (iii) had means and standard deviations of (0.9988, 1.756) and (−0.006, 0.0416) respectively. The mean of I_t, the log of unity plus the count of innovations, was 0.420 and 0.425 in 1979 and 1978 respectively. The system (7) was also estimated using the restriction (8) and allowing the μ_{it} and $_{it}$ to be correlated, but the restrictions in (8) were much too strong to be data acceptable. It is also the case that the fixed effects could not be simplified to a single constant in either equation.
9. Steve Klepper has suggested (in private correspondence) that industries with greater technological opportunity provide more (and more varied) new, valuable information to potential and actual firms. If information cannot be (easily) sold, then new ideas that fall into the hands of potential entrants must be exploited via entry, leading to a higher entry rate in these sectors (ceteris paribus). That information flows facilitate innovative entry in sectors of rich technological opportunity is not inconsistent with the notion that entry barriers are lower in these sectors.

10. It also emerges that $\alpha_0 = 1, \alpha_1 = 0.2652, \alpha_2 = 0.1022, \alpha_3 = 0.0739$, and $\alpha_4 = 0.0686$; $\beta_0 = 1, \beta_2 = -0.062, \beta_2 = -0.0222, \beta_3 = -0.0201$ and $\beta_4 = 0.2398$.
11. This observation is quite consistent with the results presented by Gort and Klepper, 1982, who show that entry rates and innovation rates rise and fall together over the typical product life cycle. It is also not inconsistent with the important role played by small firms in generating the new innovations recorded in our data; see Pavitt et al, (1987).

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