Small Business Economics (2005) 25: 49–64
DOI 10.1007/s11187-005-4257-9

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Perceived Environmental Uncertainty and Innovation in Small Firms

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ABSTRACT. Employing data, from a recent survey of Scottish and Northern English Small- and Medium-sized Enterprises (SMEs), the current paper provides new evidence of the extent to which perceptions of environmental uncertainty (dynamism, complexity and hostility), along a number of dimensions, discriminate between small firms engaged in various levels of product innovation. Drawing, broadly, upon an extended version of the classic Miles and Snow schema, novel innovators appear to be marked by perceptions of *uncertainty* in market and technological environments, but by perceptions of a relatively *certain* or benign competitive environment. Moreover, the paper observes some dissimilarities between manufacturing and service firms. For instance, higher levels of innovation in manufacturing firms are associated with higher perceptions of supplier uncertainty, whilst, higher levels of innovation in service firms are associated with higher perceptions of human resource uncertainty.

KEY WORDS: environmental uncertainty, innovation, small firms.

JEL: D81, L21, O32, M13.

1. Introduction

The persistence of uncertainty and innovation are central to contemporary conceptions of entrepreneurship (Brouwer, 2000). Indeed, the absence of uncertainties from the static efficiency models of neo-classical economics, largely explains the neglect of the entrepreneur in subsequent expositions of economic dynamics[1] (Herbert and Link, 1989). In these models, the role of the entrepreneur is limited to market entry in pursuit of known (at least, or at best, in the sense of a known probability distribution of) profit opportunities. By contrast, Austrian and Post-Keynesian economists emphasise the inevitability and pervasiveness of uncertainty and, accordingly, have recognised the pivotal role played by entrepreneurs. However, whilst these schools employ similar definitions of uncertainty, the influence accorded to uncertainty varies. That is, entrepreneurship is related to uncertainty in an ambivalent way. For instance, Schumpeter (1934), often lauded by the academic entrepreneurship community, did not view uncertainty as a necessary precondition for innovation and entrepreneurship. Rather, Schumpeter's entrepreneur creates uncertainty; wreaks 'gales of creative destruction'. In the language of economics, the entrepreneur acts in equilibrium to create disequilibrium (see Ricketts, 1994 pp. 61–65). For Keynes, 'when feeling uncertain, entrepreneurs are in an ''intermediate domain where one follows conventions, customs and rule of thumb''' (in Van Gelderen et al., 2000, p. 171). In the former instance, uncertainty is the outcome of entrepreneurship and innovation, in the latter, uncertainty is a disincentive to entrepreneurship and innovation. However, accepted wisdom now holds uncertainty as a first principle – that is, as a cause, rather than a consequence, of entrepreneurship and innovation.[2] In line with Kirzner (1973), the bounded rationality and knowledge imperfections of market participants (i.e. uncertainties in the relevant environment) create [indeterminate] opportunities for profit through the introduction of novelty: 'Since uncertainty is a fact of economic life, entrepreneurs are needed for arbitrage, to take

Final version accepted on November 2004

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risks and to innovate' (Van Gelderen et al., 2000, p. 169). At the very least, uncertainty is thought to bring about the conditions in which the entrepreneur (as innovator) may prosper.

2. The nature and measurement of uncertainty

Our understanding of environments, in the context of organisation studies, generally draws upon three dimensions; munificence, complexity and dynamism (Dess and Beard, 1984). These dimensions, in turn, relate to two common approaches to conceptualising environments – as either a source of information or as a stock of resources. In this vein, munificence is normally taken to signal a firm's dependence upon the environment for resources, whilst complexity and dynamism reflect the degree of uncertainty the firm faces. To this end, Milliken (1987) suggested that there are three types of uncertainty about environments. 'Effect uncertainty is an inability to predict the nature of the effect of a future state of the environment on the organisation. Response uncertainty is an inability to predict the likely consequences of a response choice. The third type, state uncertainty, is also referred to as perceived environmental uncertainty' (Buchko, 1994, p. 411). Here, as Edith Penrose noted, '...if one is concerned with the effect of uncertainty on the behaviour of the firm, one is concerned with 'subjective uncertainty' – with the state of mind of decision makers – and with subjective estimates of the risk of disappointment' (Penrose, 1995, p. 58). It is generally accepted that managers' perceptions of the environment are more important than the actual environment (Achrol et al., 1983 Duncan, 1972; Hambrick and Snow, 1977; Miller, 1988). If managers perceive an environment to be uncertain then they are liable to make decisions which are designed for uncertain environments. In other words, environments are neither certain nor uncertain in themselves, but thinking makes them so. In this way, although uncertainty will inevitably be a partial function of objective characteristics of the environment, this definition emphasises the importance of the perceptual process in the determination of environmental uncertainty. 'Perceptions of environmental uncertainty occur when executives are unable to predict future changes in components of the environment or possess an incomplete understanding of the relationship among components of the environment' (Buchko, 1994, p. 411). Here still, uncertainty is conceived of as a function of dynamism and complexity. The more complex and changing the environment, the higher the level of environmental uncertainty (Damanpour, 1996). However, more fundamentally, managerial perceptions of environmental uncertainty are determined by 'the predictability of conditions in the organizations environment' (Miles and Snow, 1978, p. 195; see also Miller and Friesen, 1978). The notion of predictability, as the converse of uncertainty, underpins both academic and popular conceptions of uncertainty and is apparent in the model developed here.

To this end Miles and Snow (1978) developed a measure of environmental uncertainty – the 'perceived environmental uncertainty scale' – which revolved around six subscales, corresponding to relative predictability in six key sectors of a firm's external environment: suppliers, competitors, customers, financial markets, government and regulatory agencies and trade unions. A similar scale had been developed by Duncan (1972) and, later, by Wernerfelt and Karani (1987) – though these last two compressed the economic environment variables (Table I).

The current study follows, most closely, the Miles and Snow (1978) model. However, given the falling level of unionisation over the last 25 years, and the focus upon small- and medium-sized firms, the impact of trade unions upon perceived environmental uncertainty is not considered here (Paggell and Krause, 1999). Moreover, all the sources of uncertainty identified (in Table I) are extra-organisational. Clearly, however, uncertainty may arise as a result of either complexity or dynamism in a more proximate or immediate environment – that of the individual or of the firm. Following the work of Jovanovic (1982), uncertainty is liable to be caused by the limited learning capabilities of the individual and the uncertainty associated with success or failure. Fundamentally, the Jovanovic model assumes that entrepreneurs starting a business are unsure about their managerial abilities and the consequent probability of success. Although entry may be made on an ambiguous notion of expected

TABLE I
Dimensions of perceived environmental uncertainty

Duncan (1972)	Miles and Snow (1978)	Wernerfelt and Karani (1987)
Actual users of your products	Customers	Demand
Competitors for your raw materials	Suppliers	Supply
Competitors for your customers	Competitors	Competition
Government regulations controlling your industry	Government and regulatory agencies	External
The public's attitudes towards your industry	Financial markets	
Trade unions	Trade unions	

post entry profitability, entrepreneurs only become aware of their true ability to manage in the given environment once their enterprise is established. Whilst explicitly concerned with business start-up, this source of uncertainty may reasonably be extended to 'new ventures' – such as a significant product innovation – within incumbent firms. Van Gelderen et al. (2000) style this type of uncertainty 'self confidence'. However, in a sample of established firms, its discrete measurement is likely to prove problematic and, moreover, one may safely assume that uncertainties at the personal level will be reflected in perceptions of environmental uncertainty at higher levels – that is, uncertainties regarding one's own abilities are likely to be both cause and effect of perceptions of complexity and dynamism in the environment in which one operates. Further moderation of the influence of this source of uncertainty is, in line with Jovanovic, attempted by inclusion of a firm age variable in the analysis reported below.

A more significant omission, at the level of the firm, relates to resource uncertainty. (see Van Gelderen et al., 2000). Whilst partially addressed by Duncan's (1972) model (under 'competitors for your raw material'), this dimension is likely to represent the firm's ability to enlist the necessary resources (i.e. skills, technology and finance), and the level of turbulence of the resources employed. Though linked to the concept of munificence (discussed above; see also Castrogiovanni, 1991), the essence of this measure also corresponds to the ability of the firm to recruit and *retain* the resources required to carry out firm strategies and is, in this sense, a measure of both environmental hostility, as the converse of munificence (Lumpkin and Dess, 2001), and dynamism.

Drawing together the strands of the above discussions allows one to develop a model of the sources of perceived environmental uncertainty encompassing three levels: the firm; the industry and market; and the supra-industrial, economic environment (Figure 1). (Note; that in contrast to Miles and Snow (1978), difficulties in accessing finance are considered a source of perceived resource uncertainty or hostility – though clearly this is a matter of preference).

3. Uncertainty and innovation

Russell and Russell (1992, p. 640) note that; 'One of the few sets of consistent findings in the innovation literature is that. . .innovation is positively correlated with environmental uncertainty (conceptualised in terms of complexity and dynamism)'. There are two obvious explanations for this finding. The first is that a high degree of innovation leads to perceptions of increased uncertainty among managers – i.e. innovation *causes* environmental uncertainty. By contrast, the alternative rationalisation holds that high levels of uncertainty generate more innovation

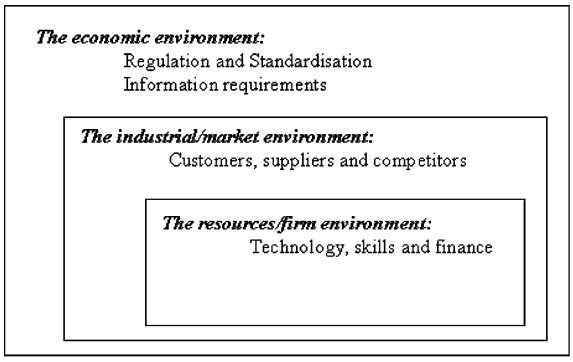

Figure 1. Levels of perceived environmental uncertainty.

through greater scope for opportunity seeking and adaptive behaviour. Despite the plausibility of the former, the latter explanation is generally accorded more popular credence. Though, here too, one may proffer a less heroic rationalisation – namely, that environmental uncertainty *requires* firms to change and adapt.

The innovation literature commonly suggests that firms are likely to pursue more proactive and more aggressive strategies as uncertainty increases (Özsomer et al., 1997). Increased environmental uncertainty creates the incentive for market segmentation strategies that require that the emphasis be placed upon innovation. That is, greater variability in the external environment is likely to compel incumbent firms to safeguard their market position through the introduction of new products or new processes. For instance, early studies suggested that over 50% of product and technological innovations, emerge in response to competitive, market or other environmental influences (Myers and Marquis, 1969, in Miller and Friesen, 1982). In essence, the more dynamic or complex the environment, the greater the compulsion to innovate and the more innovative firms are likely to be (Bhidé, 2000; Miller and Friesen, 1982;). When, for instance, customer tastes or expectations fluctuate or competitors introduce new products, the pressure on firms to innovate will be great and, accordingly, one may anticipate that the level of innovation will be high. Clearly, this is likely to be true for both entrepreneurial and conservative firms (Miller and Friesen, 1982).

Ultimately, however, and irrespective of differences in emphasis, the conclusion is much the same: '...that organizations residing in relatively uncertain environments may be expected to adopt a greater number of innovations than those residing in relatively certain environments' (Russell and Russell, 1992, p. 640).

However, whilst there is a relative consensus favouring a positive link between complex and dynamic environments and the propensity to innovate, the converse is true of perceived environmental hostility and innovation. That is, in a hostile environment the intensity of competition exerts significantly more pressure on firms, orienting them towards financial conservation (rather than innovation) strategies, and, accordingly, allowing less slack for experimentation (Lumpkin and Dess, 2001). In other words, '...given that hostile environments are often operationally defined as exhibiting tough price competition, one would expect competition on costs to be more prevalent than competition based on product differentiation' (Covin et al., 1999, pp. 184–185). That is, process improvements (aimed at improving productivity, reducing inventories or similar means of controlling costs) are likely to be more common than product innovations which require, often considerable, front-end, sunk and fixed costs – most especially within manufacturing firms. In contrast, one might anticipate that in benign environments, characterised by relatively high profit margins, low competitive intensity, and high customer loyalty, bases of competition other than price would dominate. Under benign conditions, 'Firms seek to distinguish themselves from competitors on the basis of differential products, allowing premium prices to be charged and maximum value to be extracted from their lucrative markets (Covin et al., 1999, p. 185) – though this by no means implies agreement in the literature (cf. Miller, 1988). Nonetheless, the operationalisation of the environmental variables, in the current study, has attempted to incorporate elements of both hostility and dynamism across the three levels, with a view to investigating the differential impact of relative hostility and dynamism.

More generally, this paper seeks to address one 'global' question:

To what extent, and along what dimensions, do higher levels of perceived environmental uncertainty and hostility mark innovators, relative to less innovative firms?

This question is driven by a desire to look beyond the [near] axiom that innovation is positively associated with environmental uncertainty, and to consider the various effects of levels of environment and types of uncertainty – in particular the comparative influence of dynamism and hostility. Moreover, the paper is concerned with the relative effect of perceptions of environmental hostility or dynamism on manufacturing and service firms. At the risk of over-simplifying, services frequently differ from tangible products in both the physical characteristics and the methods of production and delivery. Accordingly, one

might reasonably anticipate that manufacturing and service firms confront unique challenges in their innovation activities and, as a result, respond differently to comparable levels of uncertainty or, indeed, perceive of such 'objective' uncertainty differently (Brouthers et al., 2002). One obvious example of this distinction is in the level of resource commitments required and the associated exposure to market and macro-level uncertainties. Accordingly, and in line with Covin et al. (1999), by analysing manufacturing and services firms separately, one hopes that '...macro-industry effects are effectively controlled for in the research through the elimination of multiple and diverse macro-industry groups' (p. 190). Finally, the paper is concerned with the extent to which previous findings, linking environmental uncertainty and innovation, may be replicated within the small business sector. A sector in which levels of uncertainty are thought to be intrinsically higher (Storey and Sykes, 1996).

4. Data

The data presented here was collected as part of a wide-ranging 'Survey of Enterprise in Northern Britain.[3] This project drew heavily, in style and substance, upon the successful Cambridge studies (see CBR 1996, 1998, 2000; SBRC 1992). The rationale for undertaking the project emanated from concerns over coverage in these earlier (and ongoing) studies of UK Small- and Medium-sized Enterprises (SMEs). For instance, data from the 1997 Cambridge survey included only 146 Scottish firms. Notwithstanding this, the success of the work carried out at Cambridge provides a suitable exemplar from which to build. Accordingly, in common with the Cambridge studies a postal questionnaire was employed, which covered a number of issues, including; business advice, training, ICT and finance. This current paper is based, principally, upon the sections concerned with innovation and general business characteristics.

Again, in common with the Cambridge studies, the sample frame used in constructing the database was the Dun and Bradstreet UK Marketing Database (D&B). This database has its origins in the credit-rating business and, as such, it is likely that it over-represents expanding firms in search of finance. Moreover, the database is known to under-represent single person self-employed, sole proprietors and partnerships in comparison to the overall enterprise sector (Bullock et al., 1996). Accordingly, one obvious consequence of using this database is the likely under-representation of the smallest firms, relative to the UK business stock. However, studies of firm level innovation processes (such as the CIS), as a result of concerns over data adequacy, response-rates and issue relevance, invariably under-survey micro-firms. Whilst there is some evidence to counter these presuppositions (Cosh et al., 1998), custom and practice, and indeed commonsense, continues to underwrite their veracity. The principal consequence of this skew is likely to be an over-estimate of population levels of innovation, managerial sophistication, use of finance, and so on. However, when this caveat is borne in mind (i.e. that the survey did not seek to represent, in any isomorphic manner, the notional population), then the legitimacy of the subsequent analyses should not be compromised.

Consistent with the Cambridge studies, the sample design adopted a size-stratified approach (though our weightings and size bands differ, given the differing populations). We sought to obtain a manufacturing sample split in the ratio 30:60:10 across the employment bands 1–9, 10–99 and 100–499. For business services we sought a 75:20:5. The difference in ratios reflects the lower number of service firms in the larger size bands, both within the D&B database and the stock of firms. In addition to the size-stratification, the sample frame was split between manufacturing and business services on a 40:60 basis. Again, this over-represents manufacturing firms relative to the population. However, this weighting was deemed appropriate in light of Scottish and UK industrial policy objectives.[4]

The survey was conducted during April and May of 2001. Mailings were followed up with telephone prompts to initial non-respondents, though limited resources permitted only *ad hoc* re-mailing. This latter failing is likely to have, at least in part, contributed to the disappointing response rate: of the 5200 manufacturing firms surveyed, 597 provided useable responses (an 11.5% response rate); for service firms the figures

are 7472 and 748, respectively (a 10% response rate). On the whole, however, the sample appears reasonable reliable, statistically. For instance, from a notional SME (i.e. less than 500 FTEs) manufacturing population of approximately 15180 firms, the 597 responses represent a 3.9% sampling error at the 95% confidence level. For services, given an approximate SME population of 40555 firms (SIC (92) divisions 52.7, 64, 72–74, 92.1 and 93 only), the 750 responses represent a 3.5% sampling error at the 95% confidence level. In most survey research, error levels typically lie between 2% and 6% with 95% confidence limits (Oerlemans et al., 2001).

5. Analysis

5.1. *Innovation and uncertainty*

In addressing the question raised (i.e. the extent to which innovators are marked by higher degrees of perceived environmental uncertainty), multiple discriminant analysis was employed (using SPSS). The primary goal of discriminant analysis is to find the dimension or dimensions along which 'naturally' occurring [discrete] groups differ. Accordingly, one might also have employed multinomial (or polychotomous) logistic regression. However, the multinomial logit procedure implies an ordering of groups which, although intuitively comfortable in the current context, there is little *a priori* basis for supposing. However, irrespective of the choice of statistical method, and as one might have anticipated, the results of the discriminant and multinomial logistic analyses were broadly similar.[5] Nonetheless, for brevity and simplicity, only the discriminant analysis results are recorded here.

To this end, groupings (i.e. the dependent variable) were contrived based on level of product innovation, such that: novel product innovators are those who had introduced at least one product *new to the industry* during the period 1998–2001; incremental product innovators are those who had introduced at least one product *new to the firm only* during the same period; and, non-innovators are those who introduced *no new products*. In other words, the analysis is concerned with the ability of various predictor variables to discriminate between novel innovators, incremental innovators and non-innovators (of products) – though this is not to imply the existence of 'novelty' in a Schumpeterian sense. It is important to note that the concept of novelty, as recorded here, is fundamentally relative. The distinction drawn is one of degree rather than kind (and inevitably incorporates a degree of self-reporting construct bias). Nonetheless, one might reasonably anticipate qualitative differences to exist, in the main, between firms that introduce 'new to the industry' products, 'new to the firm only' products, and those not engaged in any new product development/introduction activities – not least in the level of risk, and uncertainty, faced.

Table II, details the variables used in the analysis. As noted, the objectives of the survey were wide-ranging. As such, the variables used do not mirror directly those employed in the Miles and Snow (1978) 'Perceived Environmental Uncertainty Scale', but rather, are intended to proxy the broad categories of environmental uncertainty and hostility identified in earlier work.[6] In addition to the environmental proxies, as the table indicates, firm age and size were used as moderating variables, since one may safely anticipate that older firms and larger firms, as a result of accumulated experience and greater resource, are less liable, *ceteris paribus*, to perceive higher degrees of environmental uncertainty. Finally, to the extent that the nature of innovation is thought to vary substantially and systematically between broad industrial sectors (Hoffmann et al., 1998),[7] the current analysis estimates functions for manufacturing and service firms separately.

Multicollinearity was investigated using correlation matrices (Tables III and IV) and, in both cases, no problems were suggested. As Tables III and IV indicate, only in the case of 'age' and 'size' (manufacturing) and 'skill index' and 'financial index' (both manufacturing and services) do the bivariate correlations exceed 0.3. Whilst the former finding is to be expected, the latter relationship is less intuitively straightforward. However, given that both 'skills index' and 'financial index' essentially measure the perceived strength of potential constraints to innovation, their correlation may not be so surprising. Nonetheless, the magnitudes of the correlation statistics do not suggest redundancy and the implications for multicollinearity are likely to be moderate.

TABLE II
Variables used in discriminant functions

Variables	Definition
Control variables	
Age	Age of firm in years
Firm size	Firm size in full-time-equivalent (FTEs) employees
Uncertainty in the economic environment	
Dynamic economy	Dummy variable representing dynamics in the economic environment, based upon changing information requirements and government regulations/legislation; highly dynamic environment = 1, otherwise = 0
Hostile economy	Dummy variable representing hostility of the economic environment, based upon the relative extent to which innovation was compelled by legislation, regulation and standardisation; hostile environment = 1, otherwise = 0
Market and industry uncertainties	
Competitors	Absolute number of serious competitors reported
Overseas competitors	Percentage of serious competitors based overseas
Larger competitors	Percentage of serious competitors larger than firm
Customer dependency	Dummy customer dependency variable; >49% of turnover from largest 5 customer = 1, otherwise = 0
Uncertain supply	Dummy variable representing changing composition of key suppliers and supplier search activities; high levels of turbulence and search = 1, otherwise = 0
Uncertain markets	Dummy variable representing changing composition of customers and market search activities; high levels of turbulence and search = 1, otherwise = 0
Internal resource uncertainties	
Technical index[a]	Scale representing changing levels of automation and technological accumulation (0–27); higher scores are associated with higher and changing levels of technological accumulation
Skill index[a]	Scale representing importance of human resource shortages as a barrier to innovation (0–25); higher scores are associated with higher perceptions of difficulties
Finance index[a]	Scale representing difficulties accessing finance as a barrier to innovation (0–15); higher scores are associated with higher perceptions of difficulties

[a]Tests of scale reliabilities report Cronbach's $\alpha > 0.7$ in all cases; whilst not strictly speaking continuous variables, studies suggest that ordinal scales that have 15 or more orderings may be treated as continuous.

Accordingly, the choice was made to include the variables in the subsequent analysis.

Turning to particulars; Tables V and VI record the results of a discriminant function analysis and group descriptive statistics, as described above, for manufacturing and service firms. As the data in Tables V and VI indicate, the functions are effective discriminators of innovator type.[8] However, in each instance, function one only appears to significantly discriminate between the three innovator groups contrived. Accordingly, only data relating to the first discriminant function are presented in each case.

Interpretation of the function relies largely upon consideration of the correlations between individual predictors variables and the respective functions (known as structure coefficients – in effect, factor loadings) – supported by the results of univariate ANOVAs for each variable. Whilst consensus is lacking with regards to the interpretation of loadings, a common 'rule of thumb' suggests that correlations in excess of 0.3 (i.e. 10% of variance) may be considered eligible for interpretation whilst lower ones may not (Tabachnik and Fidell, 2000). Accordingly, the discussion below adopts this convention. The tables also report the standardised canonical discriminant function coefficients. Discriminant function coefficients denote the unique (partial) contribution of each variable to the discriminant function(s), while the structure coefficients denote the simple correlations between the variables and the function(s). If one wants to assign substantive 'meaningful' labels to the discriminant functions (similar to the interpretation of factors in factor analysis), this involves interpretation of the structure coefficients. If, however, one wants to comment upon the unique contribution of each variable to the discrimination, then the discriminant function coefficients (akin to β weights in

TABLE III
Correlation matrix (manufacturing)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	.												
2. Firm size	0.379	.											
3. Dynamic economy	−0.027	0.035	.										
4. Hostile economy	−0.021	0.104	0.090	.									
5. Competitors	−0.020	0.003	−0.011	0.129	.								
6. Larger competitors	−0.132	−0.216	−0.017	−0.025	−0.064	.							
7. Overseas competitors	0.053	0.214	−0.001	0.041	−0.031	0.011	.						
8. Customer dependency	−0.029	0.048	0.039	0.011	0.101	0.092	0.056	.					
9. Uncertain supply	0.081	0.127	−0.016	0.143	−0.009	−0.010	0.118	0.040	.				
10. Uncertain markets	0.079	0.212	0.160	0.043	−0.055	−0.035	0.089	−0.053	0.210	.			
11. Technical index	−0.015	0.152	−0.002	0.031	−0.041	−0.006	0.136	0.067	0.022	0.160	.		
12. Skill index	0.013	−0.080	−0.048	−0.003	−0.068	0.024	0.061	−0.036	0.027	0.055	0.166	.	
13. Finance index	0.031	−0.066	0.016	0.049	−0.038	−0.051	0.056	−0.077	0.108	0.067	0.202	0.482	.

TABLE IV
Correlation matrix (services)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Age	.												
2. Firm size	0.213	.											
3. Dynamic economy	−0.011	0.024	.										
4. Hostile economy	0.022	0.034	0.055	.									
5. Competitors	−0.048	−0.007	0.028	0.002	.								
6. Larger competitors	−0.017	−0.139	0.049	0.008	−0.172	.							
7. Overseas competitors	0.036	0.141	−0.099	−0.044	−0.035	0.163	.						
8. Customer dependency	0.060	0.036	0.014	−0.024	0.083	−0.043	0.025	.					
9. Uncertain supply	−0.032	0.047	−0.011	−0.006	0.016	0.003	0.040	0.004	.				
10. Uncertain markets	−0.045	0.107	−0.041	−0.044	0.105	−0.021	0.110	0.057	0.217	.			
11. Technical index	0.000	0.197	−0.054	0.059	0.009	−0.065	0.032	0.002	0.056	0.043	.		
12. Skill index	0.017	0.071	−0.077	−0.037	0.008	0.040	0.060	0.076	0.033	0.067	0.200	.	
13. Finance index	−0.133	−0.065	−0.024	0.056	−0.024	0.031	0.072	−0.022	0.036	0.012	0.080	0.393	.

TABLE V
Manufacturing firms

Predictor Variables	Function 1 (only)		
	Correlations of predictors with discriminant functions	Standardised canonical discriminant functions coefficients	Univariate $F(2, 361)$
Age	0.292	0.059	1.870
Firm size	0.648	0.470	9.178[a]
Dynamic economy	0.301	0.293	2.103
Hostile economy	0.040	−0.145	1.344
Competitors	−0.201	−0.114	1.638
Larger competitors	−0.064	0.039	0.248
Overseas competitors	0.452	0.263	4.436[a]
Customer dependency	−0.084	−0.150	0.179
Uncertain supply	0.325	0.227	2.855[b]
Uncertain markets	0.511	0.230	6.237[a]
Technical index	0.465	0.330	4.863[a]
Skill index	0.246	0.329	1.491
Finance index	−0.025	−0.283	0.027
Canonical *R*	0.325		
Eigenvalue	0.118		
	Wilks lambda	χ^2	Df
Functions 1–2	0.867	50.867[a]	26
Function 2	0.969	11.329	12

Predictor variables	Group means and proportions		
	Novel innovators	Incremental innovators	Non-innovators
Age	37.75	34.13	28.16
Firm size	58.72	37.39	28.78
Dynamic economy	73.83%	64.65%	62.93%
Hostile economy	34.90%	44.44%	35.34%
Competitors	9.46	7.71	15.72
% Larger competitors	64.01%	62.79%	66.11%
% O/seas competitors	21.40%	16.90%	10.59%
Customer dependency	38.26%	41.41%	41.38%
Uncertain supply	30.02%	29.29%	18.10%
Uncertain markets	51.01%	46.46%	30.17%
Technical index	8.54	7.15	6.78
Skill index	10.69	10.54	9.82
Finance index	5.54	5.52	5.60
N	149	99	116

[a]significant at 1% level; [b]significant at 5% level; [c]significant at 10% level.

regression) are used. The current concern is largely with the former. However, given the intended roles of firm age and size as controls, some heed must also be taken of the respective weights.

Turning to specifics, one of the clearest findings concerns our control variables; that is, it is apparent that novel product innovators are larger than incremental innovators who, in turn, are larger than non-innovators. This finding holds for both manufacturing firms and service firms – and, in the case of manufacturing firms, firm size makes the largest unique contribution to the discrimination between groups. Given the absolute measure of innovation adopted, this is not entirely surprising. One may plausibly expect a different observation were one, instead, to adopt a relative measure of innovation, concerned with

TABLE VI
Service Firms

Predictor variables	Function 1 (only)		
	Correlations of predictors with discriminant functions	Standardised canonical discriminant functions coefficients	Univariate $F(2, 408)$
Age	0.237	0.175	2.343[c]
Firm size	0.502	0.324	3.074[b]
Dynamic economy	0.031	0.106	0.088
Hostile economy	0.048	0.058	0.090
Competitors	−0.270	−0.291	2.596[c]
Larger competitors	0.193	0.156	2.090
Overseas competitors	0.417	0.250	6.429[a]
Customer dependency	0.067	0.014	1.716
Uncertain supply	0.136	−0.026	1.195
Uncertain markets	0.613	0.574	12.568[a]
Technical index	0.360	0.213	4.508[a]
Skill index	0.450	0.309	7.542[a]
Finance index	0.193	0.062	1.160
Canonical R	0.367		
Eigenvalue	0.155		
	Wilks lambda	χ^2	df
Functions 1–2	0.836	71.832[a]	26
Function 2	0.965	14.111	12
Predictor variables	Group means and proportions		
	Novel innovators	Incremental innovators	Non-innovators
Age	23.89	19.74	18.31
Firm size	25.99	19.59	12.52
Dynamic economy	63.64%	64.96%	62.50%
Hostile economy	33.33%	32.48%	31.25%
Competitors	11.31	13.42	33.68
Larger competitors	74.92%	66.00%	67.96%
Overseas competitors	13.94%	6.86%	4.93%
Customer dependency	46.21%	34.19%	41.88%
Uncertain supply	25.76%	18.80%	20.00%
Uncertain markets	53.79%	44.44%	26.88%
Technical index	7.14	6.03	5.58
Skill index	11.41	11.27	9.64
Finance index	5.95	5.74	5.41
N	132	117	160

[a]significant at 1% level; [b]significant at 5% level; [c]significant at 10% level.

innovation intensities – e.g. number of new products per full-time-equivalent employee (Van Dijk et al., 1997). However, taking size as a proxy for resource availability, it is unequivocally the case that larger firms, taken as a whole, are more capable of successfully introducing significant innovations in products, than are their smaller counterparts. Less remarkably, the firm age variable does not appear to aid discrimination between innovators types.

With regards to the role of perceived environmental dynamism and hostility in discriminating between innovator type, and addressing manufacturing firms in the first instance: the market/industry dimension of uncertainty has the greatest apparent influence. That is, novel and incremental innovators report proportionately more overseas competitors than do non-innovators. There is, undoubtedly, an easy temptation to consider this indicative of a hostile competitive environment.

However, as Covin et al. (1999) note; '. . .market breadth – that is, geographical range of served markets – will likely correlate with competitive success in hostile environments' (p. 181). One might rephrase this as 'relative market breadth is likely to attenuate environmental hostility', or 'firms operating in diffuse geographic markets are less liable to perceive of high levels of environmental hostility'. In either case, operating in broad geographical markets should allow firms to contend for a greater proportion of total industry sales and for resources. Moreover, geographical market breadth may also insulate the firm against local hostilities. Apparent corroboration is intimated by the descriptive statistics relating to absolute number of serious competitors – though this finding is not significant. By contrast, a higher proportion of novel innovators perceive instability in suppliers and in customers, and are engaged in more frequent scanning for either new sources of supply or new markets (than do incremental innovators who, in turn, record higher levels than non-innovators). That is, increasing innovativeness appears to be associated with higher levels of perceived uncertainty relating to customers and suppliers. Moreover, with respect to internal resource uncertainties, the data suggest a positive association between level of innovativeness and increasing levels of automation or technology accumulation (i.e. dynamic uncertainties in process technology) – novel innovators report higher and more volatile levels of technology accumulation/automation, relative to incremental innovators, relative, in turn, to non-innovators.

Finally, whilst the factor loadings tentatively suggests that novel innovators are more likely to perceive increases in relevant government regulations and information requirements (i.e. dynamic economic environmental uncertainty) than their less and non-innovative peers, no support is offered by the related univariate ANOVA. Accordingly, one is bound to be more equivocal, or less certain, in this instance. Furthermore, the descriptive statistics point to greater perceptions of economic environmental hostility on the part of incremental innovators (than either novel or non-innovators) – to the extent that innovation is more likely to be compelled by either government regulation or quasi-government standardisation. However, as before, this finding is not significant in the discriminant analysis. Interestingly, though offered here as an aside only, these observations relating to the economic environment variables were found to be statistically significant when running the appropriate logistic regressions.

With respect to service firms, market and industry variables again seem to exert the greatest influence upon the discriminant functions. Specifically, univariate analysis suggests that both innovators types are liable to be in competition with fewer serious competitors than are non-innovators – i.e. lower perceived uncertainty relating to competition. Though, as before, interpretation of the factor loadings is less straightforward. That the proportion of competitors, which are larger than the firm, has no influence may be explained by the generally lower firm size within the service sector. However, and again as an aside, logistic regression analysis does suggest that 'novel' innovators were significantly more likely to report a higher proportion of larger competitors than either 'incremental' or non-innovators. Moreover, the data does indicate that, in common with manufacturers, the proportion of serious overseas competitors effectively discriminates between 'novel-innovators' and their peers. Again, I would argue, in line with Covin et al. (1999) and perhaps counter-intuitively, that this is indicative of a more benign environment.

With reference to uncertainties in customers and markets, a similar observation, to that noted for manufacturing firms, is also indicated for service firms; namely, that higher volatility in the customer base and more frequent market search activities appear to be associated with high levels of innovativeness. Unlike manufacturing firms, however, a parallel association was not found for changes in suppliers and supplier search activity. Again, this may be rationalised by the differing characteristics of manufacturing and service firms. Key suppliers to service firms are less likely to provide sub-assemblies and raw materials, which are incorporated in the end product, but rather provide supporting resources, which enable the more effective delivery of the end product/service. In this way, their influence upon the product innovativeness of individual firms may be less.

Differences between manufacturing and services firms may also explain the influence of

human resource related environmental hostility in discriminating between innovators types in service firms – a finding that was absent from the manufacturing analysis above. That is, the end product of a service firm (i.e. the delivery of the service) is largely embodied in the skills of the individual(s) who delivers it. Thus, innovation in products becomes more immediately dependent upon the efficacy of available human resources. Regardless, it appears that novel-innovators perceive a more hostile and uncertain environment in this respect (relative to incremental innovators relative, in turn, to non-innovators). In other words, perceptions of the difficulty in recruiting suitable human resources to enable innovation appear positively associated with higher levels of innovation. As with manufacturing firms, higher and changing levels of technology/automation (i.e. technological uncertainty) discriminate between novel innovators and other firms.

Finally, uncertainty, relating to either dynamism or hostility, in the economic environment appears to have limited influence upon the product innovativeness of service firms. This runs counter to the expectations of Brouthers et al. (2002) who note that, since 'Services are often locally produced because of their characteristic of inseparability...services are typically more exposed to macroeconomic uncertainty than manufacturing firms' (p. 498). In times of high economic environmental uncertainty, manufacturing firms may, for instance, import components or sub-assemblies and may inventory products to be sold at a later date. One might respond that the lower fixity of assets, and generally lower resource commitments, make service firms more mobile than their manufacturing peers. However, at least at the national level, this mobility is unlikely to be practiced. Rather, Brouther et al.'s (2002) concern is with the indirect effects of government on the environment (on variables such as inflation, exchange rates and so on) whilst the current concern is with the more direct effects of (changing) government and quasi-government action on firms' perceptions. The inability to distinguish the effects of the former is undoubtedly a weakness in the current study – though one would hope the latter represents a strength. Notwithstanding this, and accepting the operationalisation of the economic environment variables, one is bound simply to note that higher perceptions of an *increasingly* complex and demanding information and regulatory environment are not associated with the innovative activities of service firms.

One might be tempted to argue, and this undoubtedly reflects personal bias, that the greater perception of hostility in the economic environment, noted for incremental innovators in manufacturing, may reflect the disproportionate burden of regulation which this sector has to bear. This concern is further underscored by the higher unit cost of regulatory compliance (with few exceptions) that small firms, in general, face (Rothwell, 1983).

6. Concluding remarks

Employing new data, from a survey of 'Northern British' SMEs, the current paper sought to explore the extent to which innovation in products was associated with perceived environmental uncertainty. To this end, the data confirms earlier studies, and popular conceptions, with regards to uncertainties in markets or in process technologies. That is firms engaged in novel products innovation record a higher degree of flux in customer base and increased market search activities, and report higher levels of technological accumulation and, in general, less settled process technology. This finding holds for both manufacturing and service firms and, on the whole, accords well with our presuppositions. Yet, the extent to which perceptions of uncertainty, along these dimensions, are cause or consequence of innovation is impossible to unambiguously establish in cross-sectional research of this type (indeed, this issue is likely to prove intractable even in survey-based panel studies). Though, clearly, one may plausibly speculate along the lines discussed earlier. For instance, market uncertainties (as proxied here) may, on the one hand, create scope for new product introduction as a result of changing customer tastes and preferences, whilst, on the other hand, firms introducing 'novel' products are likely to be less certain of customer reactions and accordingly perceive a more uncertain market environment. Clearly the issue warrants further investigation; perhaps, where the emphasis is upon the collection of richer, longitudinal, firm- or project-

specific data. However, here we merely note the association.

Regardless of one's ability to unequivocally establish causality, these results may be interpreted as providing further substantiation for some generally accepted, though perhaps not as widely adopted, strategic injunctions. Namely: the importance of generic technologies and focused technology accumulation (i.e. technology strategy – see Rothwell, 1994); the value of market scanning and opportunity orientation; and, at least in the case of manufacturing firms, the merits of flexible supply (see below). These activities appear to be strongly associated with success in innovation.

In contrast to uncertainties in markets and process technology, novel innovation, in both manufacturing and service firms, appears to be negatively associated with uncertainties in competition – proxied by the absolute number, the size distribution and the geographic location of competitors. To rephrase, firms engaged in novel product innovation appear to perceive a less hostile, or more certain, competitive environment. This is not to suggest that firms in hostile environments will never be strategically oriented towards innovation – or those in benign environments adopt strategies based on lower costs. Rather, that 'the relative pervasiveness of these strategic orientations will differ among firms in hostile and benign environments' (Covin et al., 1999, p. 184). This distinction may, in turn, be heightened by relative industry maturity (Stopford and Baden-Fuller, 1994). That is, prior to the establishment of dominant design considerable product variety prevails and firms compete, not with each other, but 'against their own product inadequacies and market scepticism' (Utterback, 1994, p. 90). Once a dominant design has been established, the focus shifts from product to process innovation and to competition on costs. Unfortunately, the current dataset does not allow one to disentangle this issue and one merely notes the association between perceptions of a relatively benign competitive environment and innovativeness.[9]

Finally, the earlier discussion remarked upon two notable differences between manufacturing and service firms. Namely, that innovative manufacturers perceive a higher degree of supplier uncertainty than their less innovative peers (a distinction not found in service firms), and innovative service firms perceive a more hostile human resource environment (this time, not found in manufacturing firms). Irrespective of causal inferences (and, again, the findings lend themselves to both cause and effect interpretations), these dissimilarities may comfortably be rationalised by the divergent nature of supplier relationships and the extent to which individuals' skills are embodied, directly, in products or in service delivery. Nonetheless, the fundamental influence of sectoral issues and the danger of treating the business sector as some homogeneous mass are clear.

At various points in the paper, reference has been made to a number of weaknesses and omissions in study design and analysis. In closing, it may be useful to highlight a further three, which may give cause for concern: first, the development of innovation related dichotomies (or, in this case, a trichotomy) based upon successful new product introduction might be less appropriate. Our concern here is with the effect of perceptions of the environment upon decisions, not outcomes. Yet, the strategy followed in this paper, measures outcomes and infers decisions. It may be more appropriate to consider an innovation classification along the lines of: 'tried and succeeded', 'tried and failed' and 'not tried'. The effect of this weakness may be to understate observed differentials between innovators and genuine non-innovators. Second, the data reported here were not collected for a narrow, *ad hoc* purpose. Accordingly, there may be concerns over the distance of the individual proxies from the 'real' variables. However, by providing detail on variable construction (Appendix A), one would hope that the interpretation is transparent. Moreover, I am confident that the broad picture painted is reliable. Finally, the analysis would undoubtedly benefit from cross-validation. One might expect to obtain relatively high classification success, if one uses the same cases from which the classification functions were computed (i.e. the 'learning sample'). In order to get an idea of how well the current classification functions 'perform', one should classify (*a priori*) different cases, that is, cases that were not used to estimate the classification functions (i.e. a 'cross-validation sample'). The planned resurveying (see note 4) should facilitate this.

Acknowledgements

I am grateful to Marius Meeus and Leon Oerlemans for access to questions used in an earlier survey of Dutch manufacturing firms. I am also indebted to two anonymous reviewers and the guest editors for valuable comments. Nonetheless, the usual caveat applies.

Notes

[1] Alternatively, one may argue that, in neoclassical theory, uncertainties are present but are considered as unpredictable, incidental and temporary noise. However, since they are something which cannot be controlled, they cannot be of significance to decision making. I am grateful to a reviewer for raising this point.

[2] This implied unidirectional, causal step is a little misleading. Undoubtedly, whilst antecedent uncertainty provides the basis for entrepreneurial/innovative opportunity, subsequent entrepreneurial action, or innovation, is liable to create, at least temporarily, other forms of uncertainty in the markets in which entrepreneurs/innovators operate (which creates further opportunity, and so on).

[3] For the present purposes 'Northern Britain' encompasses Scotland and the Northern English counties of Northumberland, County Durham, Tyne and Wear, Teesside and Cumbria.

[4] Sectors not covered by the original project (such as construction, retail and tourism) will be addressed in a subsequent survey employing a shortened and tailored version of the original questionnaire. Thereafter, the intention is to resurvey biennially.

[5] In addition to the observations resulting from the discriminant analysis, multinomial logistic analysis suggested the following: (1) 'novel' manufacturing innovators were significantly more likely to perceive of a dynamic economic environment (than 'incremental' innovators than, in turn, non-innovators); (2) 'incremental' manufacturing innovators were significantly more likely to perceive of a hostile economic environment (than 'novel' innovators); (3) 'novel' service innovators were significantly more likely to report a higher proportion of larger competitors.

[6] The questions used to construct the variables are detailed in Appendix A.

[7] Although this is not to imply that service firms merely play a passive role [as users] in the process of technological development. Simply, that to lump service firms and manufacturing firms together, for the purposes of analysis, is to ignore the various dynamics in play.

[8] The functions for manufacturing and services firms, respectively, predict 49.5% and 49.4% of cases correctly (a 16% improvement on chance).

[9] Again, there are two competing causal interpretations: one the on hand, lower levels of competition provide 'space' for experimentation, whilst, on the other hand, one may argue that firms introducing products 'new to the industry' (i.e. novel, in the current context) are less liable to identify competitors for these products. Again, however, we may merely note the presence of an association.

Appendix A

The following details the questions used in the construction of the uncertainty variables.

Dynamic economy

Firms were asked to rank the following, on a five-point Likert scale, ranging from 'Greatly Decreased' to 'Greatly Increased':

- Government regulation/legislation affecting our business, have...
- The amount of information that the firm must be familiar with, has...

Hostile Economy

Firms were asked about the extent to which the following factors were important reasons for introducing new or improved products and/or processes (again on a five-point Likert scale, ranging from 'Not Important' to 'Crucial')

- To comply with legislation/regulation.
- As a result of standardisation (e.g. BS, ISO).

Uncertain Supply

Firms were asked about the extent to which:

- The composition of the group of key suppliers had changed in the last 3 years (on a three-point scale, ranging from 'Not Changed' to 'Greatly Changed').
- They consider searching for new suppliers (again, a three-point scale, ranging from 'Never' to 'Frequently').

Uncertain Markets

Firms were asked about the extent to which:

- The composition of the customer base had changed in the last 3 years (on a three-point scale, ranging from 'Not Changed' to 'Greatly Changed').
- Firms were asked about the frequency at which they make predictions about market developments (again, a three-point scale, ranging from 'Never' to 'Frequently').

Technical Index

Firms were asked about the extent to which the following processes were automated (both '3 years ago' and at the time of responding):

– Inventory/Stock control; Customer account management; Order processing; Organisational accounts; Personnel records management; Payroll; Product design; Project management; Supply Chain Management (EDE)

Skill Index

The firms were asked about the extent to which the following factors hindered their innovation activities, during the period covered by the study (on a five-point scale, ranging from 'Not Important' to 'Crucial'):

– Access to technological skills.
– Access to marketing skills.
– Access to management skills.
– Access to financial skills.
– Access to appropriate information/advice.

Finance Index

The firms were asked about the extent to which the following factors hindered their innovation activities, during the period covered by the study (on a five-point scale, ranging from 'Not Important' to 'Crucial'):

– Access to debt finance.
– Access to equity finance.
– Access to grants.

Additional variables were constructed on the basis of direct questions.

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