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Economic crisis and innovation: is destruction prevailing over accumulation?

by

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Abstract

The 2008 economic crisis has severely reduced the short-term willingness of firms to invest in innovation. But this reduction has not occurred uniformly and a few firms even increased their investment in spite of the adverse macroeconomic environment. This paper, based on the latest three waves of the UK Community Innovation Survey, compares drivers of innovation investment before and during the crisis. We find that the crisis led to a concentration of innovative activities among fast growing and already innovative firms. The companies in pursuit of more explorative strategies towards new product and market developments are those to cope better with the crisis.

Key words: Economic crisis, innovation investment, Community Innovation Survey
JEL classification: O12, O30, O52

1. Is the financial crisis bringing gales of creative destruction?

The 2008 financial crisis has severely reduced the short-term willingness of companies to invest in innovation (OECD, 2009; Paunov, 2011). While on the whole firms' investment in innovation declined during the economic downturn, a small but significant minority of firms are "swimming against the stream" and have increased their expenditures on innovation.[1] Who are these firms that have decided to respond to the crisis by innovating more rather than less? There are two possible scenarios.

(a) These firms are the most dynamic ones; those that cannot survive without changing their products and services. The competitive advantage of these firms resides in the generation and upgrading of new knowledge, and they innovate continuously, irrespectively of the business cycle.

(b) Or, alternatively, these firms are new innovators that were not necessarily involved in innovation before the crisis. These firms might be smaller in size or entirely new firms that take advantage of the crisis to contest the market shares of incumbent firms or to launch fresh markets.

Point (a) assumes that innovation and technical change are rooted in cumulative learning processes and path-dependent patterns that are woven into organizational routines. This brings persistence in innovative activities, and persistence, in turn, is led by well established firms (Dosi, 1982; Nelson and Winter, 1982; Antonelli, 1997). Point (b) is based on the assumption that economic turbulence makes it possible for new and small firms to emerge in a competitive market through innovation (Tushman and Anderson, 1986; Henderson and Clark, 1990; Simonetti, 1996; Freeman and Louca, 2001; Perez, 2002, 2009).

As most insights in the field of innovation, points (a) and (b) derive from the theorising of Joseph A. Schumpeter. Schumpeter and his followers suggested that economic cycles are the consequence of innovation, but also that innovative activities and innovative organisations are re-shaped by economic crises. In particular, we interpret the canonical debate between the two models elaborated by the young and the old Schumpeter in the following way.[2] During an upswing in the business cycle innovation is carried out in a cumulative fashion. Firms carry out innovation along established technological trajectories and develop into incumbents that accomplish innovation as a routine, also to prevent the entrance of newcomers (Schumpeter, 1942; Bell and Pavitt, 1993). Following Pavitt et al. (1999) and Malerba and Orsenigo (1995), we call this process *creative accumulation*. An economic turmoil, on the contrary, generates a shakeout in established industries and technological fields; new firms in new sectors play a relatively bigger role than incumbent firms in generating innovations. New firms are eager to exploit new technological opportunities also as a way to challenge incumbent corporations; as the young Schumpeter suggested, "it is not the owner of the stage-coaches who builds railways" (Schumpeter, 1911), p. 66. Following Schumpeter, we call this process *creative destruction*.[3]

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[1] For an analysis of the effect of the crisis at the country-level see (Filippetti and Archibugi, 2011).

[2] For an effective presentation of the innovation models presented by the young Schumpeter in his *Theory of Economic Development* (1911 (1934) and the old Schumpeter in *Capitalism, Socialism and Democracy* (1942), we draw on Freeman et al., (1982). Schumpeter's monumental analysis of business cycles (1939) was published in between these two works.

[3] The processes of creative destruction is widely described in Schumpeter's *Theory of Economics Development* (Schumpeter, 1911 (1934)), although the term itself was used for the first time in his *Capitalism, Socialism and Democracy* (Schumpeter, 1942). Paradoxically, the book which introduced the term "creative destruction" vindicated instead the importance of creative accumulation.

These, Schumpeter's insights have been largely enriched by the Neo-Schumpeterian stream of research. Following Nelson and Winter (1982) and Dosi (1982), it emerged that there are important differences across technological regimes and industrial sectors (Malerba and Orsenigo, 1995, 1997). The literature on the persistence of innovation, empirically supported by the analysis of patent data and innovation counts (Geroski et al., 1997; Cefis and Orsenigo, 2001) and innovation survey data (Peters, 2007; Roper and Hewitt-Dundas, 2008; Antonelli et al., 2010), somehow confirmed that there are several industries where the innovators of today were also innovators in the past. But on the whole this literature finds mixed evidence and shows that the cumulative and path-dependent nature of technical change is greater in those firms that (a) devote a substantial budget to R&D and innovation, (b) concentrate on product innovations, and (c) are large in terms of their size.

There are also a number of recent empirical studies that explore firms' innovative behaviour before and during economic recessions. Kanerva and Hollanders (2009), analysing Innobarometer data for Europe, find no association between firm size and decline in investment during 2008. Their results suggest that highly innovative firms continued to invest in innovation also during the downturn. Alvarez et al. (2010), in their analysis of Chilean manufacturing firms, explore firms' responses to the financial crisis of 1998. They find a positive association between firm size and organisational innovations, but no impact of financial constraints on innovation performance during the crisis. In contrast, Antonioli et al. (2010), find that, in their analysis of firms located in Italy's Emilia-Romagna, SMEs were more innovative compared with large firms during the recent crisis. In a firm-based study in eight Latin American countries, Paunov (2011) shows that the current crisis led many firms to stop ongoing innovation projects. The rising of financial constraint and the negative demand shock affected the decisions of firms to abandon innovation projects. Further, younger businesses supplying foreign multinationals or suffering export shocks were more likely to stop innovating. Filippetti and Archibugi (2011) explore firms' innovation investment in Europe and find that (a) the crisis brings about a reduction in the willingness of firms to increase innovation investment and (b) strong National Systems of Innovation help firms to retain their invest in innovation.

Thanks to a panel dataset we are able in this paper to explore firms' innovation behaviour before and during the crisis. While there is a general consensus on the fact that the most innovative firms are also more likely to persist in innovating, we would like to explore a counter argument. On the one hand, firms with a more agile/flexible structure might take better advantage of changing environments and new market opportunities; on the other hand, firms in more established industries might suspend or abandon ongoing innovation projects to reduce costs. In other words, the unique environment of the current economic crisis might challenge innovation in a cumulative fashion and lead to an environment more closely related to creative destruction. It is possible, and indeed likely, that the innovators during the crisis differ from those investing before the crisis. This paper seeks to shed light on this issue by examining the following question: *who are the innovators during the economic crisis compared to before the crisis?* Answering this question would provide important clues for policy makers.

We address this question by analysing a balanced panel of around 2,500 UK enterprises that responded to the last three waves of the UK version of the Community Innovation Survey (CIS), thus covering for each enterprise the period 2002-2008. The paper is structured as follows. Section 2 introduces our theoretical framework and

develops the hypotheses. Section 3 introduces the dataset and methodology. Section 4 presents the results that are discussed in the last section.

2. Is innovation the outcome of knowledge accumulation at the firm level or of the creative destruction in the economy?

The concepts of technological accumulation and creative destruction are at the core of Schumpeter's and Schumpeterian economics. The young Schumpeter looked at innovation as an event that could revolutionise economic life by brining into the fore new entrepreneurs, new companies and new industries. The mature Schumpeter, on the contrary, observed and described the activities of large, oligopolistic corporations, able to perform R&D and innovation as a routine activity by building on their previous competences.

On the ground of these insights, the Schumpeterian tradition has further investigated the relative importance of the two processes (Nelson and Winter, 1982; Patel and Pavitt, 1994; Breschi et al., 2000). Creative destruction is a regime of low cumulativeness and high technological opportunities, where entry and exit in technological areas is easy. Competition among companies is fierce and the role played by entrepreneurial spirits is crucial. Creative accumulation is a regime with high technological cumulativeness and low opportunities, leading to a stable environment in which the bulk of innovation is carried out by large and established firms incrementally. The resulting market structure has high entry barriers and oligopolistic competition.

Over the last decades this debate has been enriched by new theoretical developments and empirical research. The interest has shifted from a technological regime/industry-level to a micro-level. This is for two reasons. Firstly, there is increasing awareness that firm-level characteristics play a greater role in shaping innovation activity *within* technological areas and industries. Secondly, greater availability of micro-data, such as the CIS, has made it possible to investigate empirically firms' heterogeneity in innovation related behaviour. Explorative empirical studies have shown that there is a great deal of variety in the way firms innovate within industries and within countries (Srholec and Verspagen, 2008; Evangelista and Vezzani, 2010; Frenz and Lambert, 2010).

The focus of this paper is not on specific industries or technological regimes, but on how an exogenous shock, represented by the financial crisis, is affecting firm-level innovation investment. The remainder of this section develops a set of firm-level determinants of innovation investment in the context of the financial crisis. These determinants are examined in view of the changes at the macro-level – before and during the economic downturn – as we aim to understand if, and, if so, through what channels, the economic crisis led to variations/discontinuities at the aggregate level.

2.1 Creative destruction or firm level accumulation

Those who support the 'destruction/discontinuous hypothesis' argue that there are periods of turbulences associated with a change in the leading sectors and/or the emergence of new sectors, which bring about a decline of technological and profit opportunities in established industries (Perez, 2002, 2009). This, in turn, could lead to a change in the knowledge and technological base relevant for business innovation, and could disturb the hierarchy of innovators. This thesis has been supported by Simonetti (1996), Louca and Mendonca (1999) and Freeman and Louca (2001), who

suggest that a stream of new firms join incumbent firms during periods of discontinuities. This proposition is in line with studies showing that firms' organisational routines hamper the capacity of established firms to keep up with major discontinuities (Henderson and Clark, 1990; Leonard-Barton, 1992; Levinthal and March, 1993).

Other arguments support the relevance of cumulativeness of knowledge and innovation; firms that innovated repeatedly in the past are those more likely to continue to innovate also in the present and in the future. One explanation highlights the learning process underneath innovation, which leads to path-dependency (e.g. Pavitt et al., 1989; Antonelli, 1997; Pavitt, 2005). Some studies indicate that there is some degree of persistence among innovators (Cefis and Orsenigo, 2001; Peters, 2007) while others suggest that persistence is rather low (Geroski et al., 1997). This is also consistent with the fact that the number of large and incumbent firms remained relatively stable over several decades, as emphasised by Alfred Chandler (1977). Combining these facts with the empirical evidence that fewer firms invest in innovation during the crisis, we would expect that an economic downturn brings with it a greater concentration in innovation investment among fewer, highly innovative firms. Based on the latter arguments we test the following hypothesis:

Hypothesis 1. During a crisis innovation investment concentrates further in those firms that were already highly innovative before the crisis

If Hypothesis 1 is confirmed, it supports the idea that a crisis strengthens the patterns of accumulation at the firm-level. If Hypothesis 1 is contradicted, there will be some support for believing that a downturn encourages a process of creative destruction in the economy.

2.2 Firm-level characteristics and persistent innovation

The existing literature on persistence has identified the characteristics of innovating firms, but has not placed specific attention to economic cycles or to the size of the investment. The key findings of this literature relevant for our paper are that (a) persistence in innovation tends to be low (while persistence in non-innovation is high), and (b) persistence is strongest among 'great innovators' or firms that reach a specific threshold of innovation activities, identified, for example, by a large number of patents registered every year (e.g. Geroski et al., 1997; Cefis and Orsenigo, 2001).

Additionally, there is also evidence that persistence in R&D is strong (Antonelli et al., 2010; Latham and Le Bas, 2006), and that persistence in innovation outputs is more likely in terms of product innovations, while continuous process innovation is rare (Roper and Hewitt-Dundas, 2008). Further evidence, based on patent and survey data, also suggests that persistence in innovation occurs in the short-run, e.g. across two waves of innovation surveys, but that there is no evidence of persistence in the longer-run, i.e. across three or more waves of innovation surveys (Duguet and Monjon, 2004; Frenz and Prevezer, 2012). Raymond et al. (2010), in their analysis of four waves of the Dutch CIS, find persistence in high-tech industries but not among low-tech industries.

In order to further explore Hypothesis 1, we have tried to identify a category of highly innovating firms. "Great innovators", or those with a minimum threshold of innovation activities, are captured in Cefis (2003) as firms that have six or more patents. While Cefis's empirical work suggests that great innovators are more likely to innovate persistently, Roper and Hewitt-Dundas (2008) do not find higher

probabilities of innovation persistence among firms with high sales from innovation (their measure of comparatively greater innovativeness). We have singled out in our sample a category of "great innovators" that we define as all those firms that introduced "new-to-market product innovations". We would expect that these firms increase their share of innovation expenditure as a consequence of a crisis.

We combine the discussion on great innovators with another relevant strand of the literature on fast growing new entrants. There is theory and evidence that points towards the role of a relatively small group of new firms – perhaps those that from the outset of their establishment are comparatively large vis-à-vis less successful new firms – that survive (when survival rates are low) and that such firms sometimes turn into persistent innovators. In his study on industry demography, Audretsch (1997) observes that: (a) newly established firms are on average small with fewer than ten employees, and, thus, they are operating at suboptimal levels of output giving them a competitive disadvantage; and (b) if such new firms are successful in the market, they are very likely to rapidly expand and grow. We define new entrants as firms that were established after 1st of January 2000. On the ground of this, we develop the following:

Hypothesis 2. *Increased investment in innovation during the crisis is more strongly correlated with two groups of firms – (a) those previously classified as great innovators and (b) those classified as fast growing new entrants*

Most empirical studies find support for an impact on (continuous) innovation of internal R&D, firm size and internal financial resources (e.g. Duguet and Monjon, 2004; Antonelli et al., 2010). Specifically, because the current economic crisis has a financial origin, we want to explore if a lack of internal, financial resources hampered innovation during the crisis. In line with the empirical studies above, we expect that firms with strong internal resources are in a stronger position to continue investment in innovation.

But, continuing to invest does not necessarily mean *increasing* your investment. It is possible, and likely, that the majority of large and incumbent firms, those with greater internal resources, continue or increase innovating with respect to some of their ongoing projects, but still might pause, abandon or postpone other projects, leading to an overall drop in innovation investment during the crisis as, for example, suggested by Kitching et al. (2009). Our data do not allow detecting if the same company is investing in some innovative projects while divesting in others (i.e. if the firm is shifting or narrowing the focus of its innovative activity). But, as captured by Hypothesis 1, we expect some form of concentration in innovation investment among the great innovators. On average, we expect that firms with larger internal resources would be able to invest relatively more in innovation during the crisis compared with firms with smaller internal resources. And, we would expect this patter to be strong during the crisis compared with before it. This is leading to the following hypothesis:

Hypothesis 3. *Increase in investment in innovation before and during the crisis is positively associated with internal R&D, firm size and firm internal financial resources*

2.3 Innovation strategies during economic crises: a story of ambidexterity

The argument that during the crisis firms might continue some innovation projects, while discontinuing other projects, is linked to the so-called ambidexterity in innovation strategies, to which we now turn. In a recent article, Kitching et al. (2009) suggest that economic crises spur change in investment strategies as a managerial response to the changes in the macro-environment. And, because innovation is risky as well as costly, during a crisis many firms might focus more strongly on survival, and less on seeking out new opportunities. A probable strategy is a combination of 'retrenchment and investment' that involves seeking out new products or markets in certain areas, while engaging in cost cutting measures and activities aimed at increasing efficiency in other areas.

This trade-off between exploitation and exploration, or long-run and short-run strategies, was put forward by March (1991) who suggests that in order to survive firms need to maintain an appropriate balance between exploitation associated with cost cutting and exploration associated with new product or market development. Levinthal and March put it as follows: "the basic problem confronting an organization is to engage in sufficient exploitation to ensure its current viability and, at the same time, to devote enough energy to exploration to ensure its future viability" (1993, p. 105).

This balancing between exploitation and exploration is at the core of O'Really and Thusman's (2004) conceptualisation of the ambidextrous organisation. The importance of a simultaneous exploitation and exploration strategy is also implicit in the concept of dynamic capabilities initially developed by Gary Pisano and David Teece (Teece and Pisano, 1994; Teece et al., 1997), and it also builds on argument that the ability of established firms to survive technological discontinuities depends on their broader knowledge base and that firms "know more than they do", as suggested by Brusoni et al. (2001).

Lathman (2009), contrasting the strategies of smaller start-ups with those of established software firms during the 2001-2003 economic downturn, finds evidence that size and age (experience) matters with respect to strategic response and that smaller and younger firms more strongly lean towards seeking new investment opportunities, while established firms tend to emphasis more strongly cost reducing strategies. We therefore test the following hypothesis:

Hypothesis 4. Firms that follow mixed strategies of exploitation and exploration – ambidextrous firms – are more likely to increase investment in innovation, and this positive relationship is of greater strength or relevance during the crisis compared with before

3. Data and methodology

3.1 The UK Innovation Surveys

We analyse the activities of just under 2,500 enterprises that responded to the latest three waves of the UK version of the CIS, in other words we analyse a balanced panel with observations at three points in time (T=3). For details on the net sample, see Appendix 1 on data sources. The latest available reference year is the calendar year 2008, and this is when we measure our dependent variable: "change in innovation related expenditures during the crisis". We compare this with "change in investment before the crisis" measured for the calendar year 2006.

CIS type data are widely used in academic papers concerned with explaining firms' innovation activities and performances (e.g. Archibugi and Pianta, 1996; Smith, 2005; Mairesse and Mohen, 2008) and for the benchmarking of countries' innovation outputs (Archibugi et al., 2009; European Commission, 2011). The majority of CIS based studies make use of one cross-section or unbalanced panels. Using a balanced panel makes it possible to compare the characteristics of those firms that increase innovation investment at two points: before the crisis in 2006 and during the crisis in 2008.

The surveys have a set of disadvantages. While they offer breadth of information – in terms of the innovation related information/variables and coverage in terms of manufacturing and private services – the activities are self-reported. Responding enterprises might over-report their innovation activities. Further, the panel is biased towards large, established, and, because of this, also innovation active firms. Micro-firms, those with fewer than t employees, are not surveyed, neither are public services. Some of these shortcomings are mitigated by the fact that we do not seek to benchmark or report on levels of innovation performance in the UK before and during the crisis, but that we (a) look at changes in investment within the same firm over time and (b) compare the impact of different firm level characteristics on these changes.

3.2 The variables

Table 1 reports average innovation expenditures per employee and shows that there is a significant drop in innovation investment between the two periods. Innovation related investment, as defined by the surveys, includes in-house R&D expenditures, extramural R&D, other bought-in knowledge such as licensing, the acquisition of machinery and equipment, including computer hardware and software for innovation, expenditure on training and on the market launch of new products (goods and services).

Table 1 Average innovation expenditures per employee in the UK, 2006 and 2008.

Variables	N. of firms	Mean	Median	St. Dev.
Total innovation expenditure per employee in 2006 in £000s	2,479	2.44	0.25	10.82
Total innovation expenditure per employee in 2008 in £000s	2,485	2.04	0.06	9.63

Source: UK Community Innovation Survey (CIS).

UKIS2009, CIS6 for year 2008 and UKIS2007, CIS5 for year 2006. See Appendix for further details.
Note: Firms that participated in the CIS surveys 2004, 2006 and 2008 have been considered.

Average innovation investment per employee declined between 2006 and 2008 and became more concentrated among the higher investing firms (as shown by the larger difference between the mean and median in Table 1) in line with Hypothesis 1.

To test our hypotheses using regressions we require a measure of the *change* in innovation related investment during and before the crisis. This forms our two dependent variables. Values for innovation related investment are available in the balanced panel for the calendar years 2004, 2006 and 2008. We compute the change in 2008 compared with 2006 and use this as the change in innovation expenditure during the crisis. Before the crisis is the change in innovation investment in 2006

compared with 2004. The final variable used in the regressions is log transformed. Table 2 provides a full description of our variables – dependent, independent and control variables – and indicates their link with our hypotheses.

Table 2 Description of the variables and their link to research hypothesis

	Variable Name	*Description*	*Hypothesis*
1	Log change in innovation expenditure in 2006 and 2008	Log of innovation related investment compared to previous period	Dependent variable
2	Log total innovation expenditure in 2004 and 2006	Log of innovation expenditure in the previous period	Control variable
3	Great innovators in 2004	Dummy variable. Great innovators are enterprises that introduced new-to-the-market goods and services in 2004	Testing H1 and H2 - Great innovators increase innovation expenditure during the crisis
4	Newly established 2000	Dummy variable. Enterprises established between 2000 and 2004, value 1, others 0	Control variable
5	Growth of newly established firms in 2006 and 2008	Log of the change in turnover compared to previous period for new firms as defined in (4). This variable takes a value of zero for firms established before 2000	Testing H2 – Fast growing new enterprises increase innovation expenditure during the crisis
6	Internal R&D in 2004 and 2006	Dummy variable. Enterprises with internal R&D expenditure in the previous period, value 1, others 0	Testing H3 – Enterprises with internal R&D increase innovation expenditure during the crisis
7	Log employees in 2004 and 2006	Size of the firm according to the number of employees in the previous period	Testing H3 – Large enterprises increase innovation expenditure during the crisis
8	Availability of finance in 2004 and 2006	Dummy variable. Firms which gave in the previous period medium or high importance to the availability of finance as innovation obstacle, value 1, firms that gave no or low importance, value 0	Testing H3 – Enterprises with internal financial resources increase innovation expenditure during the crisis
9	Log sales per employee in 2004 and 2006	Log of sales per employee in the previous period	Testing H3 – Enterprises with higher sales per employee (as proxy of available internal resources) increase innovation expenditure during the crisis
10	Exploration in 2006 and 2008	Dummy variable. Firms in the upper two quartiles in the sum of the scores across four-point likert scales in the question: "how important were each of the following factors in your decision to innovate: (i) increase range of goods or services; (ii) entering new	Control variable

		markets or increased market share", value 1, others 0.	
11	Exploitation in 2006 and 2008	Dummy variable. Firms in the upper to quartiles in the sum of the scores across four-point likert scales in the question: " how important were each of the following factors in your decision to innovate: (i) improving quality of goods or services; (ii) improving flexibility for producing goods or services; (iii) increasing capacity for producing goods or services; (iv) reducing costs per unit produced	Control variable
12	Ambidexterity in 2006 and 2008	Dummy variable. A firm is in the upper quartiles with respect to both - exploration and exploitation (see 11 and 12), value 1, others 0	Testing H4 – Enterprises that follow mixed strategies of exploitation and exploration – ambidextrous enterprises, increase innovation expenditure during the crisis
13	IPRs in 2004 and 2006	Dummy variable. Firms that declared to use IPR protection in the previous period, value 1, others 0	Control variable
14	Skills in 2006 and 2008	Log of the proportion of employees that hold a degree at BA/BSc level or above.	Control variable
15	International markets in 2006 and 2008	Dummy variable. Enterprises that operate outside the UK, value 1, others 0	Control variable

Data source: UK Innovation Surveys 2005, 2007 and 2009, UK version of the CIS4, 5 and 6. See Appendix for further details.

In the regressions we include as our first independent variable a control for the level of innovation expenditure in the previous period, i.e. for the change in innovation expenditures in 2006, we include the level of expenditure in 2004, and for the change in 2008, we include the level of innovation expenditure in 2006. We take logs of the level of innovation expenditures in 2006 and 2008 to normalise the data.

To test our Hypotheses 1 and 2 we include a variable that selects our 'great innovators'. This variable is measured on a binary scale and selects all firms with sales from new-to-market products (goods and services) in 2004. The next variable, a control variable, selects all enterprises that were newly established between January 2000 and December 2004. The third independent variable is the product of the former variable 'newly established' and the change in turnover in 2006 and 2008 respectively. These variables are used to test if newly established and fast growing firms are more likely to increase investment during the crisis, as proposed by Hypothesis 2.

Among the variables looking at firm level heterogeneity, and designed to test Hypothesis 3, are: a dummy variable that takes values of one if an enterprises reported

in-house R&D, the log of the number of employees, a dummy that selects enterprises who reported as a constraint to innovation the (lack of) availability of finance and the log of turnover per employee. The latter is used as a proxy for the internal resources of firms. All these independent variables are captured with a time lead, i.e. they are measured in 2004 to predict change in innovation related investment in 2006, and are measured in 2006 to predict change in innovation related investment in 2008. Further, we include a control dummy that takes a value of one if the enterprise used IPRs and zero otherwise,

To examine Hypothesis 4 three variables are constructed. In order to identify the two strategies – exploration and exploitation – we use a set of CIS questions about the importance of different factors for the decision to innovation caputred on a four-point likert scale (3=high importance, 2=medium importance, 1=low importance, 0=not applicable). For exploration we sum across two factors/variables: to increase range of products; and to enter new markets or increase market share. For exploitation we use four questions: to improve quality of products; to improve production flexibility; to increase capacity for production; and to reduce costs per unit. The grouping of variables into consistent subsets indicative of exploration and exploitation is confirmatory factor analysis. We select the upper quantile (k=2) to identify firms with exploitation and exploration strategies. Further, we say that a firm is ambidextrous when both exploration and exploitation are high (i.e. the firm falls within the upper quantile on both variables). Similar constructs are developed in the literature (see, for example, He and Wong, 2004). The variables are not lagged as we are concerned with the dynamics of the exploitation/exploration activity during the crisis when compared with before the crisis.

Finally, we include the following classic control variables: (a) the share of employees that are educated to degree level; (b) whether or not an enterprise operated in international markets; and (c) 2-digit industry dummies. The results from the industry dummies are omitted from our presentations but can be made available upon request from the authors.

3.3 Methodology

We use regression methods to test our hypotheses. We report a Heckman model that corrects for a bias that arises because of an enterprise's decision to invest (or not) in innovation. The selection equation, investing or not in innovation, uses the following three explanatory variables, next to industry dummies which are also included: (a) an enterprise perceived no need to innovate due to market conditions, (b) due to previous innovations, (c) due to other factors constraining innovation. We compute robust standard errors. The results of the selection equations are not presented. Further, we compute truncated OLS regressions (OLS based on the firms investing in innovation using the same independent variables as feed into the ultimate Heckman equation) with robust standard errors. OLS coefficients are less prone to errors in variables. The results across the two estimation techniques are almost identical, reporting the same significance levels and effect sizes. They are not reported here, but can be made available upon request.

Our dependent variables – change in total innovation expenditure in 2006 and 2008 – are regressed against the set of independent variables and control variables that we introduced in Table 2 above. The structural independent variables lead by one period (i.e. a two year gap), when we are interested in the inter-temporal nature of the innovation behaviour of the firm. The time lags can also, at least to some extent, mitigate issues of endogeneity. With three time periods and a control for levels of

innovation investment in the previous period it is not possible to use panel techniques, such as fixed effects regressions.

We report the full model, as well as alternative models omitting specific variables one at a time (e.g. exploitation, exploration and ambidexterity are entered together, but we also compute two models, one using exploitation and exploration, and one using the ambidexterity variable). The summary statistics of our variables – mean and standard deviation – are presented in Table 3 with the zero-order correlations among variables reported in Appendix 2.

Table 3. Firms innovation behaviour in the UK, 2006 and 2008. Dependent and independent variables

	Before the crisis	N. of firms	Mean	Std. Dev.		***During the crisis***	N. of firms	Mean	Std. Dev.
	Dependent Variable					*Dependent Variable*			
1	Log change in innovation exp. 2006	2,485	0.20	2.58	1	Log change in innovation exp. 2008	2,485	-0.61	2.58
	Independent Variables					*Independent Variables*			
2	Log total innovation exp. 2004	2,485	2.73	2.63	2	Log total innovation exp. 2006	2,485	2.92	2.57
3	Great innovators 2004	2,485	0.13	0.34	3	Great innovators 2004	2,485	0.13	0.34
4	Newly established 2000	2,478	0.11	0.31	4	Newly established 2000	2,478	0.11	0.31
5	Growth of newly established firms in 2006	2,478	0.02	0.27	5	Growth of newly established firms in 2008	2,478	0.01	0.25
6	Internal R&D 2004	2,484	0.34	0.47	6	Internal R&D 2006	2,484	0.29	0.46
7	Log employees 2004	2,446	4.23	1.48	7	Log employees 2006	2,479	4.32	1.51
8	Availability of finance 2004	2,480	0.23	0.42	8	Availability of finance 2006	2,469	0.17	0.38
9	Log sales per emp. 2004	2,446	4.26	1.07	9	Log sales per emp. 2006	2,479	4.29	1.08
10	Exploration 2006	2,485	0.31	0.61	10	Exploration 2008	2,485	0.62	0.79
11	Exploitation 2006	2,485	0.34	0.67	11	Exploitation 2008	2,485	0.63	0.80
12	Ambidexterity 2006	2,485	0.05	0.21	12	Ambidexterity 2008	2,485	0.13	0.33
13	IPRs 2004	2,481	0.32	0.47	13	IPRs 2006	2,420	0.36	0.48
14	Skills 2006	2,061	1.74	1.49	14	Skills 2008	2,484	1.49	1.39
15	International markets 2006	2,482	0.39	0.49	15	International markets 2008	2,482	0.39	0.49

Source: as for Table 1.
Legend: For explanation of variables see Table 2.

4. Results

In this section we discuss our results in connection with Hypotheses 1, 2, 3 and 4. As reported before in Table 1, the crisis has a considerable impact on innovation investment. Innovation expenditure declined and is more concentrated. To test Hypothesis 1 we designed a variable selecting a group of 'great innovators' defined by positive new-to-market sales in goods or services. Our measure, as opposed to other measures used in the literature to identify great innovators such as 'patent intensity', is more likely to also capture strong innovators among smaller enterprises less likely to patent. Smaller firms play a role in some very innovative sectors such as biotech and ICTs. Additionally, and compared with patent data, this type of measure avoids differences in the patenting intensity across industries, and the bias of the manufacturing sector vis-à-vis the service sector. This is specifically relevant in an economy with a comparatively larger services sector. Thirteen percent of the enterprises in our dataset are classed as great innovators. Table 4 reports the characteristics of the great innovators compared with the remaining enterprises.

Table 4 Innovation expenditure of great innovators and other firms, 2006 and 2008

	Great innovators	All other firms	Total
No. of firms	324	2,161	2,485
Percent	13	87	100
Share of innovation exp. 2006	0.21	0.79	1
Share of innovation exp. 2008	0.37	0.63	1
Average innovation exp. 2006 in £000s	981	563	618
Average innovation exp. 2008 in £000s	1,599	413	568
Change in average innovation exp. 2006-2008	0.63	-0.27	-0.08

Source: As for Table 1.
Legend: Share of innovation expenditure of great innovators and of other firms.
Great innovators are firms that introduced new-to-the-market goods and services in 2004.

Before the crisis the group of great innovators account for 21 percent of total innovation expenditures, while this share increases to 37 percent during the crisis. This pattern is also reflected in the average innovation expenditure which between 2006 and 2008 is up from £981,000 to £1,599,000. By contrast, the average innovation expenditure of the remaining enterprises drops from £563,000 before the crisis to £413,000 during the crisis. These summary statistics reported in Table 4 are in line with the creative accumulation story picked up in Hypothesis 1. We now turn to the regressions results presented in Table 5 below to explore the full set of hypotheses.

Table 5 Innovation behaviour before and during the crisis. Regression results

1	Change in innov. exp. t	(1)	(2)	(3)	(4)	(5)	(6)
				Before the crisis (2006)			
2	Level of innov. exp. t-1	-0.92**	-0.92**	-0.92**	-0.92**	-0.92**	-0.91**
		(0.027)	(0.027)	(0.026)	(0.026)	(0.027)	(0.027)
3	Great Innovators 2004	0.02	0.03			0.01	0.14
		(0.132)	(0.132)			(0.133)	(0.139)
4	Newly established 2000	-0.24		-0.16		-0.25	-0.27+
		(0.152)		(0.147)		(0.152)	(0.161)
5	Fast grow. new firms t	0.31			0.23	0.32	0.36
		(0.287)			(0.261)	(0.289)	(0.304)
6	In-house R&D t-1	-0.13	-0.13	-0.13	-0.13	-0.13	-0.04
		(0.119)	(0.119)	(0.119)	(0.119)	(0.120)	(0.123)
7	Log employees t-1	0.51**	0.52**	0.51**	0.51**	0.51**	0.54**
		(0.043)	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)
8	Availability finance t-1	-0.15	-0.16	-0.16	-0.17	-0.15	-0.13
		(0.106)	(0.106)	(0.106)	(0.106)	(0.106)	(0.110)
9	Sales per employee t-1	0.40**	0.39**	0.39**	0.40**	0.40**	0.43**
		(0.061)	(0.059)	(0.060)	(0.061)	(0.061)	(0.064)
10	Explorative strategy t	0.32*	0.33*	0.33*	0.33*	0.27*	
		(0.140)	(0.140)	(0.141)	(0.140)	(0.128)	
11	Exploitative strategy t	0.62**	0.61**	0.62**	0.61**	0.62**	
		(0.116)	(0.116)	(0.116)	(0.116)	(0.116)	
12	Ambidexterity t	-0.26	-0.28	-0.27	-0.27		1.08**
		(0.198)	(0.197)	(0.198)	(0.197)		(0.152)
13	IPRs t-1	0.19+	0.18	0.19+	0.19+	0.19+	0.25*
		(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.114)
14	Skills t	0.24**	0.24**	0.24**	0.24**	0.24**	0.27**
		(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.037)
15	International market t	0.28*	0.29**	0.29*	0.29*	0.28*	0.31**
		(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.113)
	Industry dummies	Included	Included	Included	Included	Included	Included
	Constant	-1.24	-1.28	-1.20	-1.31	-1.22	-1.07
	N. of firms	2,112	2,117	2,112	2,112	2,112	2,112
	Censored observations	393	393	393	393	393	393
	Rho	-0.71**	-0.71**	-0.70**	-0.71**	-0.71**	-1.07**
	Chi-squared (d.f.)	1,657(31)**	1,674(29)**	1,651(29)**	1,650(29)**	1,719(30)**	1,577(29)**

Robust standard errors in parentheses. ** p<0.01, * p<0.05, + p<0.1. Source: As for Table 1. Legend: For explanations of independent variables see Table 2.

Table 5 Innovation behaviour before and during the crisis. Regression results cont.

1	Change in innov. exp. t	(7)	(8)	(9)	(10)	(11)	(12)
				During the crisis (2008)			
2	Level of innov. exp. t-1	-0.93**	-0.93**	-0.92**	-0.93**	-0.93**	-0.92**
		(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.032)
3	Great Innovators 2004	0.40**	0.40**			0.39**	0.54**
		(0.140)	(0.140)			(0.140)	(0.143)
4	Newly established 2000	-0.20		-0.16		-0.21	-0.28*
		(0.131)		(0.136)		(0.131)	(0.137)
5	Fast grow. new firms t	0.58**			0.58**	0.59**	0.62**
		(0.185)			(0.179)	(0.187)	(0.183)
6	In-house R&D t-1	0.51**	0.50**	0.55**	0.56**	0.50**	0.61**
		(0.125)	(0.125)	(0.124)	(0.124)	(0.125)	(0.129)
7	Log employees t-1	0.36**	0.35**	0.35**	0.35**	0.36**	0.39**
		(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.045)
8	Availability finance t-1	0.14	0.13	0.13	0.14	0.14	0.15
		(0.122)	(0.121)	(0.122)	(0.122)	(0.121)	(0.122)
9	Sales per employee t-1	0.29**	0.27**	0.27**	0.30**	0.29**	0.31**
		(0.062)	(0.061)	(0.061)	(0.062)	(0.062)	(0.067)
10	Explorative strategy t	0.59**	0.58**	0.61**	0.62**	0.54**	
		(0.115)	(0.115)	(0.115)	(0.115)	(0.115)	
11	Exploitative strategy t	0.39**	0.40**	0.39**	0.38**	0.34**	
		(0.118)	(0.118)	(0.118)	(0.118)	(0.114)	
12	Ambidexterity t	-0.33+	-0.35*	-0.32+	-0.32+		0.93**
		(0.177)	(0.177)	(0.178)	(0.177)		(0.148)
13	IPRs t-1	0.28*	0.29**	0.31**	0.31**	0.28*	0.29*
		(0.110)	(0.110)	(0.110)	(0.110)	(0.110)	(0.113)
14	Skills t	0.19**	0.19**	0.19**	0.19**	0.19**	0.22**
		(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.040)
15	International market t	0.11	0.13	0.16	0.14	0.12	0.17
		(0.113)	(0.114)	(0.114)	(0.114)	(0.113)	(0.117)
	Industry dummies	Included	Included	Included	Included	Included	Included
	Constant	-0.80	-0.73	-0.68	-0.84	-0.70	-0.12
	N. of firms	2,420	2,425	2,420	2,420	2,420	2,420
	Censored observations	391	391	391	391	391	391
	Rho	-0.18	-0.16	-0.17	-0.19	-0.22	-0.56**
	Chi-squared (d.f.)	1,141(31)**	1,137(29)**	1,122(29)**	1,127(29)**	1,131(30)**	982(29)**

Robust standard errors in parentheses. ** p<0.01, * p<0.05, + p<0.1. Source: As for Table 1. Legend: For explanations of independent variables see Table 2.

For Hypothesis 2 the relevant coefficients are those derived from the dummy variable 'great innovators' and the continuous variable 'fast growing new firms'.[4] Before the crisis, the coefficients for the variables great innovators and fast growing new firms are non-significant. In contrast, during the crisis the same coefficients are positive and significant ($p<0.01$). This supports Hypothesis 2 according to which during the crisis great innovators and fast growing new firms are more strongly correlated with increased innovation investment compared with before the crisis. We also test the behaviour of all new firms irrespectively of their turnover growth in 2006 and 2008. We find that in both during as well as before the crisis, the relevant coefficients – albeit insignificant – are negative.

We now turn to Hypothesis 3. The size of the firm – measured by the log of the number of employees – shows an interesting pattern. The coefficient is positive and significant both before and during the crisis. However, it seems to play a more important role *before* the crisis ($b=0.51$; $p<0.01$) when compared with during the crisis ($b= 0.36$; $p<0.01$). The second variable of interest, in-house R&D activity, produces results consistent with Hypothesis 3. The coefficient for in-house R&D is non-significant before the crisis, while it is positive and significant during the crisis. The non-significant coefficient before the crisis might be linked to the industry dummies included in all models and that might capture some element of R&D intensity. Or be linked to the fact that well over half of our sample contains enterprises whose main activities are in the services sector, the majority of which will not have traditional R&D activities (e.g. the large retails sector). The pattern that arises during the crisis suggests that internal R&D plays an important role during the crisis. This might be explained as follows: firms that commit to R&D in the form of personnel and labs are unlikely to change tact swiftly.

In order to explore the role of internal financial resources in affecting the innovation expenditure of the firm we consider two variables. The first – availability of finance – is related to the set of questions in the CIS questionnaire which addresses the obstacles to innovation activity. The second – sales per employee – is instead a measure of economic performance of the firm. While the former variable is not significant in the two periods, the pattern of the latter suggests a less important role of the availability of internal resources during the crisis when compared with before the crisis. With respect to the former variable, it is a well known fact that the constraints to innovate questions tend to produce endogenous results – with highly innovative firms assessing obstacles as strong – and less innovative firms self-reporting or perceiving obstacles as less strong.

The last hypothesis – Hypothesis 4 – picks up on the ambidexterity arguments discussed in Section 2. Interestingly, our results suggest that explorative strategies – positive and significant both before and during the crisis – have a larger size effect during the crisis ($b=0.59$; $p<0.01$ during the crisis compared with $b=0.32$; $p<0.05$ before the crisis). The reverse is the case for exploitation strategies that appear to matter more before the crisis (0.62; $p<0.01$) than during the crisis ($b=0.39$; $p<0.01$).

The results for ambidexterity are mixed. Ambidexterity is positively associated to higher increase in innovation investment before the crisis ($b=1.08$; $p<0.01$) and during the crisis ($b=0.93$; $p<0.01$), but only in the models that omit the variables for exploitation and exploration strategies (Columns 6 and 12 in Table 5). Ambidexterity is the interaction term between our variables exploitation and exploration introducing

[4] The variable 'fast growing new entrants' is captured by the product of the dummy variable 'newly established' and the change in turnover in 2006 and 2008 respectively. In other words, the variables give the rate of growth of the new firms in 2006 and 2008 and a value of zero for all established firms.

some element of multicolinearity. Nonetheless, the negative coefficient, that becomes marginally significant during the crisis (b=0.33; p<0.1, see Column 7 of Table 5) would imply some negative support for Hypothesis 4.

We computed the regressions presented in Table 5 also for two subsets of enterprises: services and manufacturing separately. Because the results on these two subsets are similar, and do not impact on the conclusions that we draw based on the results of the full sample, we omitted these results.

A last comment relates to the coefficients of our industry dummies. These are largely not significant. This can have two reasons. First, the enterprise/firm-level variables are more relevant in explaining change in innovation investment. Second, the industry dummies are too broad and do not usefully map against technological regimes at least with respect to some of sectors that we control for.

5. Discussion

The aim of this paper was to investigate whether the current economic downturn is significantly affecting the behaviour of innovating firms. During major recessions, the economic landscape is characterized by huge uncertainties about the direction of technological change, demand conditions, and new market opportunities. The first significant result at the aggregate level is that the crisis has substantially reduced innovation expenditure of the firm. On average, firms in our sample reduce innovation expenditure in 2008 by 8 percent compared to 2006. No doubt that the crisis has brought, at least in its initial stage, "destruction" in the amount of resources devoted to innovation. The second major aggregate result is that innovation expenditure started to be more concentrated: fewer firms are responsible for an increased share of innovation expenditure.

We used two well-established, ideal typical models – the creative destruction and creative accumulation – to frame our results. It has been assumed a clear-cut division according to which in regular times the model of creative accumulation would prevail while in times of crisis the model of creative destruction will affirm itself. We are well aware that a clear-cut division between the two models does not exist. Employing a panel dataset spanning the period 2004 to 2008 we were able to explore to what extent the innovators during the crisis are also those who were innovating before, or they are new innovators which are taking advantage of the peculiar environment of a major economic downturn. Our evidence strongly supports the case for creative accumulation. Those firms identified as the great innovators in 2004, are responsible for a larger share of innovation expenditure in 2008 compared to 2006. It should also be noted that the great innovators do not stand as increasing innovation before the crisis, in 2006. That is, being a great innovator does not predict increase in innovation investment before the crisis, but it does during the crisis. Put differently, the cumulative, or persistent, nature of innovation activity tends to be more prominent in times of crisis compared to during ordinary times.

But does it mean that the crisis is exacerbating the concentration of innovation in a few firms, thus leaving a few hopes for dynamic Schumpeterian entrepreneurs? In fact, alongside the great innovators there is another category of firms which is gaining momentum during the crisis by increasing innovation expenditure. They are the fast growing new firms. The latter are firms established between 2000 and 2004 coupled with a faster rate of turnover growth. As great innovators, this group of firms does not

show an above average behaviour in 2006 but it starts to increase expenditure during the crisis.

We then asked how the innovators look like during the crisis. Particularly, drawing from the research on innovation persistence we investigated those characteristics of the firm which make the firm more likely to keep on innovating, and we applied this framework to the context of the crisis. Similarly to previous studies, we find that size, economic performance, and an exploitation strategy predict increased innovation investment before the crisis. However, when we turn to what happened during the crisis we find interesting differences. Both size and economic performance play a less important role. By contrast, the presence of in-house R&D activity becomes a major predictor of increase in innovation expenditure during the crisis. As for the firm's strategy, pursuing an explorative strategy (including looking into new markets), becomes relatively more important. This evidence suggests that during the current crisis the sources of persistence in innovation are fundamentally two. In the first place, the existence of an R&D department suggests the firm has made a medium or long-term committed to innovation. Secondly, we show the important contribution of a strategy, and in particular of a strategy aimed at exploring new markets and new product developments.

Identifying the characteristics of the innovators during the turmoil, as we have tried to do here, can shed some light on how policy instruments interact with technological accumulation and creative destruction. There is little doubt that the old innovators are taking advantage of the turbulent environment to gain momentum. However, the picture is made more complicated by the presence of new entrants who have been growing fast. Our evidence is thus consistent with an innovation environment characterized by the presence of both Mark II types of innovators and Mark I types of innovators. This bears some implications for policy.

On the one hand, policies should support the good innovators, rewarding the winners. On the other hand, policies should also encourage the creation of new innovative firms. It is certainly not easy for policy makers to recognize which of the new firms are more likely to be successful and the fact that they are relatively young makes this task even harder. Our data suggests that size alone could not be enough to indicate if a firm will be successful. Other structural characteristics, such as the presence of an R&D department and its past economic performance, seem to play a more important role.

We conclude by pointing out some limitations of the study. The analysis presented here is limited by the data and the statistical models. First, the results are confined to the UK, and it will be important to see if they are confirmed for the rest of Europe, the United States as well as emerging countries. Second, data do not allow singling out the dynamics at the industry level. Finally, we could not look at the firms established *during* the crisis. Perhaps the Bill Gates, Steve Jobs and Mark Zuckerberg of the future are already at work. It would certainly not be the first time that innovation surprises us.

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Appendix 1 – Data sources

In the paper we have used the UK version of the Community Innovation Survey carried out by the Office for National Statistics on behalf of the UK Department for Business, Innovation and Skills – Science and Innovation Analysis unit (which was until 2009 part of the former Department for Innovation, Universities and Skills, and until 2007 part of the former Department of Trade and Industry). We have used three waves of the survey collected in 2005, 2007 and 2009, and that are the UK versions of CIS4, 5 and 6. The reference period of the surveys is (a) the three year period ending in the year before data collection or (b) for quantitative variables including innovation expenditures, turnover or employment figures the last calendar year before data collection, these are the years 2004, 2006 and 2008. Questionnaires for each CIS wave can be consulted on-line at http://www.bis.gov.uk/policies/science/science-innovation-analysis/cis.

Only firms that responded to the three periods have been considered, allowing us to consider panel data. The initial panel contained responses from 4,054 enterprises. These are reduced in our analysis to 2,420 and 2,112 enterprises during and before the crisis respectively. This drop in observations is due to missing values. In particular there are missing values in the turnover variables – 406 missing observations in 2004, 255 missing observations in 2006, and 535 missing observations in 2008 – and in the employment variables – 379 missing values in 2004, 257 missing values in 2006, and 528 missing values in 2008. There are also 720 missing observations in the innovation expenditure variable in CIS5. Because these missing values do not necessarily affect the same enterprise in all three waves, but can originate from different enterprises, this effect – reduction in the number of observations – is compounded.

For a detailed analysis of the survey, including the panel used in this paper, see the following references: Robson and Kenchatt (2010) and the UK Department for Business, Innovation and Skills (2010).

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Appendix 2 - Zero-order correlations among the variables

Before the crisis (t as per regression)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Change in innovation exp. 2006	1.00													
2 Log total innovation exp. 2004	-0.52	1.00												
3 Great innovators 2004	-0.09	0.28	1.00											
4 Newly established 2000	-0.04	-0.02	0.00	1.00										
5 Growth of newly established firms in 2006	0.02	-0.04	0.01	0.25	1.00									
6 Internal R&D 2004	-0.16	0.49	0.32	0.01	-0.05	1.00								
7 Log employees 2004	0.02	0.34	0.01	-0.07	-0.02	0.11	1.00							
8 IPRs 2004	-0.06	0.38	0.26	-0.03	-0.03	0.37	0.21	1.00						
9 Availability of finance 2004	-0.10	0.14	0.11	0.06	0.00	0.11	-0.02	0.19	1.00					
10 Log sales per emp. 2004	0.01	0.22	0.07	-0.12	-0.14	0.08	-0.01	0.14	-0.04	1.00				
11 Exploration 2006	0.09	0.33	0.27	-0.02	-0.02	0.34	0.11	0.27	0.07	0.08	1.00			
12 Exploitation 2006	0.10	0.34	0.25	-0.02	-0.02	0.32	0.13	0.26	0.08	0.09	0.88	1.00		
13 Ambidexterity 2006	0.02	0.19	0.17	0.02	-0.02	0.19	0.05	0.13	0.04	0.02	0.62	0.55	1.00	
14 Skills 2006	0.02	0.30	0.16	-0.01	0.02	0.25	0.18	0.27	0.08	0.20	0.24	0.23	0.10	1.00
15 International markets 2006	0.03	0.26	0.22	-0.05	-0.03	0.29	0.10	0.32	0.06	0.21	0.27	0.24	0.14	0.27

During the crisis (t as per regression)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Change in innovation exp. 2008	1.00													
2 Log total innovation exp. 2006	-0.50	1.00												
3 Great innovators 2004	0.05	0.20	1.00											
4 Newly established 2000	0.00	-0.07	0.00	1.00										
5 Growth of newly established firms in 2008	0.03	-0.03	0.01	0.14	1.00									
6 Internal R&D 2006	-0.09	0.49	0.30	-0.04	-0.02	1.00								
7 Log employees 2006	-0.10	0.38	0.01	-0.06	-0.02	0.12	1.00							
8 IPRs 2006	-0.07	0.40	0.23	-0.04	-0.01	0.37	0.20	1.00						
9 Availability of finance 2006	-0.03	0.17	0.09	0.00	-0.02	0.17	-0.01	0.22	1.00					
10 Log sales per emp. 2006	-0.05	0.24	0.07	-0.10	-0.14	0.10	-0.03	0.12	0.00	1.00				
11 Exploration 2008	0.13	0.34	0.28	-0.04	-0.03	0.37	0.11	0.26	0.14	0.09	1.00			
12 Exploitation 2008	0.11	0.34	0.24	-0.04	-0.02	0.36	0.13	0.24	0.13	0.09	0.87	1.00		
13 Ambidexterity 2008	0.06	0.26	0.23	0.00	-0.03	0.31	0.07	0.20	0.12	0.07	0.67	0.66	1.00	
14 Skills 2008	-0.01	0.33	0.15	-0.01	-0.01	0.28	0.19	0.26	0.09	0.20	0.25	0.24	0.17	1.00
15 International markets 2008	-0.01	0.30	0.22	-0.06	0.00	0.33	0.08	0.31	0.11	0.24	0.27	0.25	0.20	0.27