Persistence in Profitability and in Innovative Activities.

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Abstract

The aim of the paper is to see whether there is a relationship between the strong inertia of firm profits and the persistence in innovation activities. In other words, the purpose is to investigate whether there is persistence in innovation and profitability considered jointly, at the firm level. The analysis is based on a balanced panel of 82 UK manufacturing firms observed continually throughout the period 1978 to 1991. We implement a non-parametric approach based on directly modelling the dynamics of the evolving cross-section distributions to analyse intra-distribution mobility and persistence of the firms' innovative activities and profitability. This alternative methodology uses discrete Markov chains to approximate and estimate a law of motion for the evolving distribution. Taking into account separately patents and profits distributions points out that, at the firm level, there is high persistence in both dimensions. The result suggests that the mobility in a firm's relative position is likely in the long run, while a strong inertia drives the dynamics in the short run. The analysis of the joint distributions gives a very similar picture: firms which are systematic innovators and earn profits above the average have a high probability to keep innovating and earning profits above the average, as well as firms which are occasional innovators and earn profit below the average have a high probability to remain in the initial situation. Finally, the mobility in a firm's relative position with respect to the average profitability appears not to be correlated with the firm's relative position in the innovation dimension in the short run. However, firm's relative position in the innovation dimension matters in the long run: the probability to earn profits above the average, in the long run, is higher if a firm starts as a systematic innovator than as an occasional innovator.

Keywords: persistence, innovation, patents, profitability, firms' growth.

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1. Introduction

Are firms which systematically innovate and enjoy profits above the average more likely to enjoy profits above the average than firms which are occasional innovators? The aim of the paper is to see whether there is a relationship between the strong inertia of firm profits and the persistence in innovation activities. In other words, the purpose is to investigate whether there is persistence in innovation and profits considered jointly, at the firm level.

An important, and still puzzling, stylised fact concerning the dynamics of firms growth is that firms display persistent differences with each other (Dosi et al., 1995). These differences (or asymmetries) pertain to significant differentials in productivity and costs (Nelson and Winter, 1982; Baily and Chakrabarty, 1985), in profitability (Mueller, 1990; Geroski et al.., 1993) and in innovative output (Griliches, 1986; Patel and Pavitt, 1991). What is particularly intriguing is the persistence of these asymmetries. Persistent asymmetries among firms involve interesting questions, such as what their sources are, why competitive interactions do not make them vanish, and, also, what their consequences are for industrial dynamics.

The attention has recently been focused on persistence in innovative activities. The existence of persistence in innovative activities is particularly relevant in order to discriminate among different patterns of technological change (i.e. technological change as a process of creative destruction versus creative accumulation) and among patterns of firm growth. Indeed, the existence of persistence would weaken those interpretations of the process of growth of firms (starting from simple Gibrat-type processes) where dynamics is essentially driven by small uncorrelated shocks. Recent empirical studies have shown that innovative activities are persistent at the firm level (Cefis, 1996; Malerba et al.,1997), or that, at least, there exists a group of “great innovators” (firms who apply for more than 5 patents every year) who are very persistent (Geroski et al., 1997).

Substantial research effort has been devoted to the examination of profit persistence. Recent literature has been addressing the following question: do industrial profits rates eventually converge to a common rate? Several empirical studies have shown that firms display persistent differences in profitability (Mueller, 1990; Geroski and Jacquemin, 1988; Droucopoulos and Lianos, 1993). That is, profits do not seem to converge to a common rate of return. Moreover, evidence seems to indicate that the adjustment of profits to their firm-specific "permanent" values is rather quick, although a significant variability is observed across different countries (see for example, Odagiri and Yamawaki, 1990; Schwalbach and Mahmood, 1990; Cubbin and Geroski, 1987). However, it is hard to say to what extent the observed persistence in profitability differentials reflects the persistence of differential "efficiency" levels which are not eroded away by the competitive process.

The aim of analysing whether there is persistence in the joint distributions of patents and profits is to provide empirical evidence on the relations between profits and innovation. Profits are generally modelled as a function of past innovations (for example Geroski et al., 1993) considering innovation as a shock which has an impact (large or small, permanent or transient) on the firm profitability. Investigating whether there is a relation between persistence in profits and persistence in innovation would suggest that the relation that needs to be studied is between the persistency in profits as a function of the persistency in innovations. That is, the attention is focused on treated either profits and innovation as processes, and in the case of innovation as a cumulative process.

We use data on a balanced panel of 82 UK manufacturing firms observed continually throughout the period 1978 to 1991. The 82 firms constitute a sub-sample of a random sample of 600 UK firms who have applied for a patent (at the European Patent Office) at least once during the period 1978-1991. Firm profitability is measured by operating profits scaled by firm total sales (operating profit margin), while the number of patent applications requested by each firm is used as a proxy of innovative activities carried out inside the firm. The data contains other variables controlling for the firm size, the industrial classification, the quoted status, and the independent status.

We implement a non-parametric approach (as in Quah, 1993) based on directly modelling the dynamics of the evolving cross-section distributions, based on what is called Random Fields. At each point in time there is a cross-section distribution of firm patents, which is the realisation of a random element in the space of distributions. The idea is to describe their evolution over time, which will allow us to analyse intra-distribution mobility and persistence of the firms' innovative activities and profitability. This alternative methodology uses discrete Markov chains to approximate and estimate a law of motion for the evolving distribution. The methodology exploits time-series and cross-section information more fully than standard cross-section regressions. The Transition Probability Matrices (TPMs) were estimated on empirical sample data for three different transition periods: : i) one year; ii) five years, to capture medium run dynamics; iii) ten years, to illustrate the long run dynamics. These TPMs offer useful information for analysing persistence since they measure the probability that a firm goes from a state to another state in one period. A state is identified by the number of patent applications filed each year. Once the Transition Probability Matrices of interest have been calculated from empirical data, a non-parametric approach is used to asses the accuracy of these estimates. This approach consists in applying the bootstrapping methodology to the transition matrices to find out the standard errors associated with transition probabilities.

The analysis is firstly performed on patents and profits distributions taken into account separately. The result shows that, at firm level, there is high persistence in both dimensions. Persistence decreases both in profits and innovation as the transition period lengthens. The result suggests that the mobility in a firm's relative position is likely in the long run, while a strong inertia drives the dynamics in the short run.

The analysis of the joint distributions gives a very similar picture: there is high persistence in a firm's relative position with respect to profits and innovation simultaneously considered. That is, firms which are systematic innovators and earn profits above the average have a high probability to keep innovating and earning profits above the average, as well as firms which are occasional innovators and earn profit below the average have a high probability to remain in the initial situation. The modification of a characteristic aspect of a firm (or, in other words, the change in technological and organisational capabilities) is a very gradual process: only in the long run, we can observe mobility in both dimensions.

Finally, the mobility in a firm's relative position with respect to the average profitability appears not to be correlated with the firm's relative position in the innovation dimension in the short run. The high persistence that characterises the firm profitability is not influenced by firm innovative characteristics. However, firm's relative position in the innovation dimension matters in the long run: the probability to earn profits above the average, in the long run, is higher if a firm starts as a systematic innovator than as an occasional innovator.

The paper is organised as follows: the second section describes the data. The subsequent section presents the methodology applied. In the fourth section, first, the analysis of persistence of patent distributions and profit distributions considered separately is presented, and, second, the results of the analysis of persistence performed on the joint distributions. Conclusion follows.

2. The data.

Our data consists of 82 UK firms, both quoted and non-quoted, observed continually throughout the period 1978 to 1991. These are a non-random, balanced sub-sample of the random sample of 600 manufacturing firms previously drawn from the population of the firms that, between 1978 and 1991, have applied for at least one patent to the European Patent Office. The 82 firms are the only firms out of the 600 for which accounts data over the entire period were available. Therefore, the main source of non-randomness arises from the fact that these firms are survivors who maintained a fairly clear identity over the period. The accounts data were taken from the DataStream on-line database, while the patents data are taken from the EPO-Cespri database.

The panel data is composed of a profits variable, an innovation variable and a few other dummy variables controlling for firm size, the industrial classification, the quoted status, and the independent status. Table 1 shows the composition of the sample across the different dimensions.

Patents are the proxy for innovative activities at firm level. Profits are measured as operating profit margins, defined as operating profits divided by total sales multiplied by 100. The operating profits are the net profits derived from normal activities of the firm after depreciation and before taxes, while total sales are the amount of goods and services to third parties, relating to the normal activities of the company. Dividing the operating profits by total sales, we obtain an indicator of profits that is scaled by firm size. We could choose operating profits per employee as proxy for profits, but the number of employees was not always available for each firm for each year.

Table 2.a shows the descriptive statistics of the variables. Some features stand out particularly clearly in the data. In the 82 firms sample, only 32,9% of the firms patent once, while in the random sample (the 600 UK manufacturing firms), 52,9% of the firms only patent once over the entire period. Indeed, on average, in the smaller sample, 72.5% of firms do not apply for a patent, 12.0% apply for one patent and 14.9% request even as much as one patent per year. These means are significantly[1] different from the average calculating on the large sample: 83.250% of firms do not apply for a patent, 10.143% apply for one patent and 6.236% request more than one patent per year. While the medians of the patents requested each year is 0 for both samples (see Table 2.b for the 600 firm sample), the means of patent variables are larger for the small sample and

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[1] For testing if the population means of the two groups are equal, when the variances are unknown and not equal, the following test is applied:

$$t = \frac{\bar{x} - \bar{y}}{\sqrt{s_x^2 / n_x + s_y^2 / n_y}}$$

where $\bar{x}$ and $\bar{y}$ are the sample means of the two groups, s represents the standard deviation, and n the number of observations. The result is distributed Student's t, with ν degrees of freedom, where ν is given by

$$\frac{\left(s_x^2 / n_x + s_y^2 / n_y\right)^2}{\frac{\left(s_x^2 / n_x\right)^2}{n_x - 1} + \frac{\left(s_y^2 / n_y\right)^2}{n_y - 1}}.$$

significantly different from the means calculated on the same variables for the large sample. The distribution of the total patents per firm has a mean of 60.134, a median of 3 patents and a standard deviation of 292.517 for the small sample, while the mean is equal to 14.20, the median 1 and the standard deviation 115.41. The patents distributions, for the small sample, are less skewed and the tails less thick than the patents distributions for the large sample.

On average, the firms in the small sample apply for more patents than the firms in the large sample. Firms in the small sample, that is, the survivors who maintained a fairly clear identity over the period, are characterised by a more intensive innovative activity: firms that survive are the ones that apply for more patents.

Not surprisingly, profit distributions are much less concentrated in the tails than patent distributions, even if the positive values of the kurtosis for all profit variables indicate that there are more firms in the tails with respect to a normal distribution with the same variance. Beside, profits distributions are always positively skewed except in the years of economic crises in UK: 1981, 1990, and 1991.

Finally, note that the mean of profits distributions is always larger than the median (except for the year 1991), but their values are very similar.

3. Methodology

The empirical hypothesis whether there is persistence in innovative activities might be tested using two different approaches. The first one is the standard autoregressive analysis where the autoregressive parameter can be interpreted as a measure of persistence. Given the shortness of patent time series, standard econometric methods do not give “good” estimates of the persistence parameter.

Another way of dealing with persistence is to consider the dynamic behaviour and the cross-section variation of the entire patent distribution. For that, it is necessary to develop an alternative econometric strategy, suggested by Quah (1993a, 1993b), which deals with the dynamics and cross-section dimensions, based on what is called Random

Fields. At each point in time there is a cross-section distribution of firm patents, which is simply the realisation of a random element in the space of distributions. The idea is to describe their evolution over time, which will allow us to analyse intra-distribution mobility and persistence of the firms' innovative activities.

In order to derive a law of motion for the cross-section distribution in a more formal structure, let F_t denote the joint distribution of patents across firms at time t; and let describe $\{F_t$: integer $t\}$'s evolution by:

$$\boldsymbol{F_{t+1} = P \cdot F_t} \qquad (i)$$

were P maps one distribution into another, and tracks where in F_{t+1} points in F_t end up. Operator P of (i) can be approximated by assuming a countable state space for firm patents and firm profits $S=\{s_1\ s_2\ ...\ s_r\}$. In this case P is simply a Transition Probability Matrix (TPM). P encodes the relevant information about mobility and persistence within the cross section distribution.

Therefore, assuming that Markov Chains are time-invariant and of first order, the one-step transition probability is defined by:

$$p_{ij} = P\left(X_{t+n} = j \middle| X_t = i \right)$$

with t = 1978, 1979,...,1991 and n = 1, 5, 10 years.

The Transition Probability Matrix $\boldsymbol{P}$ is the matrix with p_{ij} as elements measuring the probability of moving from state i to state j in one period.

To analyse persistence in patents distributions, the attention is placed on the transition of firms from the state in which they do not apply for a patent in a given year to the state in which they apply for at least one patent in the subsequent year. Subsequently, two states TPMs are estimated, where the first state is defined as having requested no patents at all in a year (what we called the "*occasional innovator*" state), while the second one represents having requested at least one patent (the "*systematic innovator*" state).

In order to investigate persistence in profits distributions, we need to discretize the continuous state space of the operating profit margin. Two states are defined by setting an upper boundary at the sample mean of the operating profit margins for each year from 1978 to 1991. In the resulting 2 $\times$ 2 matrix, the first state is defined as having registered an operating profit margin below the mean, while the second one represents having recorded operating profit margin above the mean. The two states transition probability matrices are estimated.

To examine persistence of the patent and profit joint distributions, we need to redefine the states of the matrix. Four states TPMs are estimated where the states are defined as follows:

a) occasional innovators (firms that do not apply for a patent) with profits below the mean of the profit distribution;

b) occasional innovators with profits above the mean;

c) systematic innovators (firms that apply for at least one patent) with profits below the mean;

d) systematic innovators with profits above the mean.

The results will be summarised and presented in the following way:

Four States Transition Probabilities of the joint distributions

Period (t + 1)

Period (t)	***Occasional*** *innovators with profits* ***below*** *the mean* **(LI; LP)***	***Occasional*** *innovators with profits* ***above*** *the mean* **(LI; HP)***	***Systematic*** *innovators with profits* ***below*** *the mean* **(HI; LP)**	***Systematic*** *innovators with profits* ***above*** *the mean* **(HI; HP)**
LI; LP	p_{11}	p_{12}	P_{13}	p_{14}
LI; HP	p_{21}	p_{22}	P_{23}	p_{24}
HI; LP	p_{31}	p_{32}	P_{33}	p_{34}

HI; LP	p_{41}	p_{42}	P_{43}	p_{44}

*Note: LI stands for Low Innovation; HI for High Innovation

LP for Low Profits, and HP for High Profits.

In this alternative methodological context, persistence could be defined as the probability of remaining in the state in which the firm initially is, where the state is defined on the basis of patents requested and/or profits earned in a given year by the firm.

Once TPMs have been obtained, the first order autoregressive parameter implied by each chain is calculated. This will be used as a synthetic measure of persistence.

Let s_t be a stochastic process approximated by a two states Markov chain with transition probabilities:

$$P\ \left[X_t = i \middle| X_{t-1} = j\right] = \begin{bmatrix} p & 1-p \\ 1-q & q \end{bmatrix}$$

the implied AR(1) process for s_t can be constructed as:

$$x_t = (1-q) + rx_{t-1} + v_t$$

where $r = p + q - 1$.

According to our definition, we are in front of persistence in innovative activities and/or in profits if the diagonal elements of the Transition Probability Matrix are both larger than 0.5, implying that r is greater than 0. Conversely, if p and q are both smaller than 0.5, $r < 0$, there is a tendency to revert from one state to the other in every period, and the innovative activities and/or profits could be characterised as non-persistent

TPMs are computed on three different period lengths: i) one year; ii) five years; iii) ten years. The five year period will permit to capture medium run dynamics of innovative activities while the ten year period will illustrate on the long run dynamics.

4. Persistence properties of the joint distributions.

Before considering the persistence properties of the joint distributions of patents and innovation, let us start examining the persistence properties of the distribution of profits and of innovations considered separately.

Table 3 shows the transition probabilities estimated on patent distributions considering only two states: the *occasional* innovator state (i.e. firms do not apply for a patent) and the *systematic* innovator state (i.e. firms apply for at least one patent). The two states TPMs show that there is a rather high persistence in innovative activities at the firm level that decrease slightly as the transition period lengthens. Indeed, the first order autoregressive parameter goes from 0.4617 for transitions over 1 year, to 0.3742 for transitions over 5 years, to 0.2179 for transitions over 10 years.

It is worth noting that the probability to go from the systematic innovator state to the occasional innovator state is always greater than the symmetric probabilities with respect to the diagonal. In other words, the probability to revert to the state in which firms do not apply for a patent is, for the three transition periods, greater than the probability to go from the occasional innovator state to the systematic innovator states. It appears that there is more mobility towards the occasional innovator state than towards the systematic innovator state.

Nevertheless, persistence measured by the elements on the main diagonal is high, especially if we compare the probabilities shown in Table 7.3 with those estimated for the random sample UK of 600 firms[2]. The higher persistence shown in Table 7.3 is probably due to the composition of the sample considered in this section. In the random sample there is evidence of heterogeneity especially across the industrial classification and the size classification. The sample analysed in this paper is not random and it is composed principally of quoted firms (94%) and large firms (83%). Previous analysis on the persistence in innovative activities (Cefis, 1996) has shown respectively that quoted firms are more persistent than non-quoted firms and that large firms are the most

[2] Results on the random sample can be found in E.Cefis. 1996, or on request.

persistent firms with respect to size classification. Moreover, 18% of the firms are in the chemical sector and 14% in the electrical and electronics sector, so 32% of the firms in the sample are in the sectors that are the most persistent among all sectors.

The two states TPMs estimated on operating profit margins (presented in Table 4) show that, for one year transition period, there is strong persistence in profit distributions, being both the elements of the main diagonal close to one. The almost perfect persistence shown by the estimates is not totally surprising: as we have already noted previously, many studies suggested that there is relevant persistence in firm performances across time. Nevertheless the persistence decreases rather rapidly as transition period lengthens: over a period of five or ten years there is a substantial mobility of firms with respect to profits.

Finally, note that between the two off-diagonal elements the element on the left of the diagonal is always greater, indicating that there is a tendency to revert to the state in which firms display profits below the mean. However, this tendency is very slight. The difference between the probabilities to revert to the state of profits below the average having started with profits above the average (0.1266, for one year transition period) and the probability to record profits above the average having started with profits below the average (0.1133) is very small for the one year transition period but becomes larger as time increases. The increasing distance between the two off-diagonal elements indicate that as time passes by the persistence that characterises the profits over the one year transition period decreases while there is a greater mobility towards the state with profits below the average.

Considering jointly patents and profits distributions, Table 7.5 shows the estimated TPMs for the three transition periods. In the short run (1 year transition period), the probabilities on the positively sloped diagonal are all greater than 0.5 indicating a high persistence in a firm's relative position. There is no evidence of "bimodality"[3], on the contrary, the probability to remain in the state of occasional innovators with profits above the average (0.7493) is the highest probability of the main diagonal. As the

[3] Here the term bimodality is used improperly. Bimodality here means only that the probabilities of the polar states in the main diagonal are the highest probabilities.

transition period lengthens, persistence decreases, but the distributions become slightly "bimodal". In other words, all probabilities on the main diagonal decrease, but the probabilities of the polar states (Low Innovation and Low Profits, and High Innovation and High Profits) decrease at a smaller rate than the others.

Considering the negatively sloped diagonal, note that all probabilities are very low. The negatively sloped diagonal is composed of probabilities to go from one state to another in which both the innovator status and the profitability status has to be the opposite of the starting state. For example, the probabilities at the extremes of the negative diagonal are the probability to become a systematic innovator with profits above the average starting as an occasional innovator with profits below the average, and, conversely, the probability to become an occasional innovator with low profits starting as a systematic innovator with profits above the average. Therefore, the low probabilities on the negative diagonal indicate that there is very little mobility in both dimensions (innovation and profits) simultaneously. As transition period lengthens, the probabilities on the negatively sloped diagonal increase indicating that a complete (with respect both to innovation and profits) change in a firm's relative position become more probable. The only exception is the probability to become a systematic innovator with profits above the average starting as an occasional innovator with profits below the average: as time passes by, this probability firstly increases (0.0292 for 5 year transition period, while it is 0.0161 for 1 year) and then returns to at the same level of the 1 year transition period (0.0144 for 10 years transition period). This latter probability could suggest that, even in the long-run, it is very difficult for a firm to acquire the technological and organisational capabilities to become a systematic innovator that earns profits above the average starting as an occasional innovator with profits below the average.

In order to see whether the mobility in a firm's relative position with respect to the average profitability is correlated with the firm's relative position in the innovation dimension, we have elaborated Tables 6.a and 6.b. Table 6.a shows the probabilities to go from a state with profits below the average to the states with profits above the average, for the three different transition periods. More precisely the Table 6.a provides the following probabilities:

1. the probability to go from the state of being an occasional innovator with profits below the mean to the states of profits above the mean independently of the innovator status (that is, both with low innovation and high innovation). The resulting probability is the sum of the probability of the first raw, second column, and of the first raw, fourth column (p_{12} and p_{14}; see the paragraph, in this Section, explaining the way to present the results).

2. the probability to go from the state of being a systematic innovator with profits below the mean to the states of profits above the mean independently of the innovator status (that is, both with low innovation and high innovation). The resulting probability is the sum of the probability of the third row, second column, and of the third raw, fourth column (p_{32} and p_{34}).

Similarly, Table 6.b shows the probabilities to go from a state of profits above the average to the states with profits below the average, for the three different transition periods. More precisely the Table 6.b provides the following probabilities:

1. the probability to go from the state of being an occasional innovator with profits above the mean to the states of profits below the mean independently of the innovator status (p_{21} and p_{23}).

2. the probability to go from the state of being a systematic innovator with profits above the mean to the states of profits below the mean independently of the innovator status (p_{32} and p_{34}).

For the 1 year transition period, the probability to go to the states with profits above the average starting as an occasional innovator with profits below the average (0.1037) is quite similar to the probability to go to the states with profits above the average starting as a systematic innovator with profits below the average (0.1386). This would suggest that the mobility in a firm's relative position with respect to the average profitability it is not correlated with the firm's relative position in the innovation dimension. However, it is worth noting that as time increases the difference between the two probabilities increases: for the 10 years transition period, the probability to go to the states with profits above the average starting as a systematic innovator with profits below the average (0.3784) is one and a half times the corresponding probability of starting as an occasional innovator (0.2590).

We obtain the same picture if we consider the probabilities to go from states with profits above the average to states with profits below the average. For the 1 year transition period the probability to go to states with profits below the average starting as an occasional innovator with profits above the average (0.1344) is quite similar to the corresponding probability starting as a systematic innovator (0.1068). Nevertheless, as the transition period lengthens, the first probability increases more rapidly than the second one and, for the 10 years transition period, the probability to go to states with profits below the average starting as an occasional innovator with profits above the average (0.4153) is twice the corresponding probability starting as a systematic innovator (0.2058).

From these calculations it emerges that a firm relative position in the innovation dimension matters for the mobility in the firm relative position with respect to the average profitability in the long run: the probability to achieve profits above the average, in the long run, is higher if a firm starts as a systematic innovator.

5. Conclusion

The persistence analysis is firstly performed on patents distributions and profits distributions separately. The transition probabilities estimated on patents data show that there is a rather high persistence in innovative activities that decreases slightly as the transition period lengthens. There is evidence of higher persistence in innovative activities in the non-random sample than in the random sample. This is due to the composition of the non-random sample: most of the firms are large, quoted and chemical or electrical firms which are proved to be the sub-groups more persistent in previous analyses.

Not surprisingly, the profits distributions show an almost perfect persistence that decreases rather rapidly as transition periods lengthens, implying a substantial mobility of firms with respect to the average profitability in the long run.

The transition probabilities estimated on joint distributions show that there is high persistence in a firm's relative position with respect to profits and innovation. That is, firms which are systematic innovators and earn profits above the average have a high probability to keep innovating and earning profits above the average, as well as firms which are occasional innovators and earn profit below the average have a high probability to remain in the initial situation. The modification of a characteristic aspect of a firm (that is, the change in technical and organisational characteristics) is a very gradual process that takes time: only in the long run, we can observe a mobility in both dimensions.

Finally, there is evidence that the mobility in a firm's relative position with respect to the average profitability is not correlated with the firm's relative position in the innovation dimension in the short run. However, firm's relative position in the innovation dimension matters in the long run: the probability to earn profits above the average, in the long run, is higher if a firm starts as a systematic innovator than if it starts as an occasional innovator.

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Table 1: Composition of the sample

Sub-group name	Number of firms
Non-quoted	5
Quoted	77
Independent	74
Subsidiary	8
Large firms (at least 1,000 employees)	68
Medium-large firms (from 500 to 999 empl.)	10
Medium firms (from 200 to 499 empl.)	4

Sectors	Number of firms
Metal manufacturing (22)	4
Non- metallic manufacturing (24)	5
Chemical (25 and 26)	15
Other metal goods (31)	5
Mechanical engineering (32)	10
Electrical & electronic machinery (34)	12
Motor vehicles & parts (35)	4
Other transport (36)	2
Instrument engineering (37)	2
Textiles (43)	6
Timber (46)	2
Paper & printing (47)	4
Rubber & plastics (48)	3
Other manufacturing (49)	1

Notes: The number in brackets represents the SIC code of the sector.

Table 2.a: Descriptive statistics (82 firms)

Variable	Mean	Median	Stand. Dev.	Skewn.	Kurtos.	Min.	Max.
OPM 78	9.442	8.932	4.256	1.411	3.480	3.130	27.702
OPM 79	8.930	8.772	4.649	0.744	3.112	-4.079	27.591
OPM 80	7.668	7.106	4.446	0.865	2.205	-2.993	24.955
OPM 81	6.263	6.257	5.001	-0.490	1.451	-9.124	18.718
OPM 82	6.876	5.807	4.907	0.438	1.008	-7.905	20.744
OPM 83	7.059	6.110	4.918	0.388	1.129	-6.694	20.244
OPM 84	7.652	6.841	5.126	0.543	2.719	-8.561	25.765
OPM 85	8.297	7.272	5.030	1.101	2.889	-3.359	26.101
OPM 86	9.211	8.462	5.649	1.825	6.180	-0.407	35.834
OPM 87	9.924	9.328	5.582	1.912	7.449	-1.162	38.139
OPM 88	10.628	9.797	5.284	1.626	5.250	-0.272	35.551
OPM 89	10.648	9.802	5.121	1.155	3.749	-2.202	33.035
OPM 90	9.619	9.343	6.479	-0.221	5.359	-16.995	34.198
OPM 91	7.734	7.952	7.483	-0.832	4.471	-21.135	32.411
PAT 78	0.866	0.000	6.222	8.812	78.876	0.000	56.000
PAT 79	2.854	0.000	16.358	8.115	68.910	0.000	143.000
PAT 80	3.488	0.000	20.952	8.220	70.439	0.000	184.000
PAT 81	3.512	0.000	19.356	7.677	62.339	0.000	165.000
PAT 82	4.244	0.000	21.550	6.979	51.413	0.000	174.000
PAT 83	3.256	0.000	16.283	7.417	58.760	0.000	137.000
PAT 84	4.049	0.000	19.561	6.827	49.199	0.000	156.000
PAT 85	3.890	0.000	17.570	6.525	45.819	0.000	138.000
PAT 86	4.610	0.000	20.842	6.313	42.328	0.000	159.000
PAT 87	5.659	0.000	27.121	6.176	39.113	0.000	197.000
PAT 88	5.671	0.000	26.527	6.002	36.166	0.000	180.000
PAT 89	6.756	0.000	31.907	5.987	35.733	0.000	204.000
PAT 90	6.756	0.000	31.754	6.063	36.476	0.000	204.000
PAT 91	4.524	0.000	23.185	6.144	37.268	0.000	154.000
PATSUM	60.134	3.000	292.517	6.575	44.863	1.000	2251.000

Note: OPM stands for Operating Profit Margins, PAT for Patents, and PATSUM is the variable that represents the total patents per firm.

Table 2.b: Descriptive statistics of the random sample (600 firms)

Variable	Mean	Stand. Dev.	Skewness	Kurtos.	Min.	Max.	Cases
PAT 78	0.18	2.48	20.41	447,848	0	56	600
PAT 79	0.52	6.27	20.86	467,200	0	143	600
PAT 80	0.69	8.02	21.14	478,129	0	184	600
PAT 81	0.70	7.43	19.73	423,844	0	165	600
PAT 82	0.91	8.29	18.00	353,789	0	174	600
PAT 83	0.86	6.53	17.02	337,607	0	137	600
PAT 84	1.03	7.88	15.61	282,077	0	156	600
PAT 85	1.05	7.26	14.32	242,376	0	138	600
PAT 86	1.17	8.63	13.96	225,571	0	159	600
PAT 87	1.38	10.98	14.23	227,131	0	197	600
PAT 88	1.48	11.10	13.06	189,530	0	180	600
PAT 89	1.63	12.86	13.98	213,795	0	204	600
PAT 90	1.51	12.58	14.72	232,900	0	204	600
PAT 91	1.02	9.14	14.99	239,669	0	154	600
PATSUM	14.20	115.41	15.98	283,420	1	2251	600

Table 3: Patent distributions

One Year Transitions

	No Patent	Patents
No Patents	0.8389 (*0.0121)*	0.1611 (*0.0121)*
Patents	0.3772 (*0.0550)*	0.6228 (*0.0550)*

Five Years Transitions

	No Patent	Patents
No Patents	0.7918 (*0.0220)*	0.2082 (*0.0220)*
Patents	0.4176 (*0.0649)*	0.5824 (*0.0649)*

Ten Years Transitions

	No Patent	Patents
No Patents	0.7251 (*0.0323)*	0.2749 (*0.0323)*
Patents	0.5072 (*0.0924)*	0.4928 (*0.0924)*

Table 4: Profit distributions

One Year Transitions

	Below Mean	Above Mean
Below Mean	0.8867 *(0.0156)*	0.1133 *(0.0156)*
Above Mean	0.1266 *(0.0221)*	0.8734 *(0.0221)*

Five Years Transitions

	Below Mean	Above Mean
Below Mean	0.7707 *(0.0350)*	0.2293 *(0.0350)*
Above Mean	0.2927 *(0.0511)*	0.7073 *(0.0511)*

Ten Years Transitions

	Below Mean	Above Mean
Below Mean	0.7159 *(0.0305)*	0.2841 *(0.0305)*
Above Mean	0.3684 *(0.0573)*	0.6316 *(0.0573)*

Table 5: Profit and Patent Joint Distributions

One Year Transitions

	LI; LP	LI; HP	HI; LP	HI; HP
LI; LP	0.7373 *(0.0121)*	0.0876 *(0.0096)*	0.1590 *(0.0070)*	0.0161 *(0.0018)*
LI; HP	0.1074 *(0.0465)*	0.7493 *(0.0380)*	0.0269 *(0.0119)*	0.1164 *(0.0217)*
HI; LP	0.3494 *(0.0616)*	0.0663 *(0.0281)*	0.5120 *(0.0686)*	0.0723 *(0.0383)*
HI; HP	0.0534 *(0.0226)*	0.2672 *(0.0213)*	0.0534 *(0.0257)*	0.6260 *(0.0715)*

Five Years Transitions

	LI; LP	LI; HP	HI; LP	HI; HP
LI; LP	0.5779 *(0.0222)*	0.1948 *(0.0155)*	0.1981 *(0.0129)*	0.0292 *(0.0051)*
LI; HP	0.2592 *(0.0441)*	0.5556 *(0.0337)*	0.0576 *(0.0244)*	0.1276 *(0.0301)*
HI; LP	0.3922 *(0.0748)*	0.1471 *(0.0555)*	0.3627 *(0.0828)*	0.0980 *(0.0492)*
HI; HP	0.1059 *(0.0646)*	0.1647 *(0.0089)*	0.1176 *(0.0763)*	0.6118 *(0.1120)*

Ten Years Transitions

	LI; LP	LI; HP	HI; LP	HI; HP
LI; LP	0.4964 *(0.0342)*	0.2446 *(0.0233)*	0.2446 *(0.0231)*	0.0144 *(0.0089)*
LI; HP	0.3050 *(0.0977)*	0.4153 *(0.0)*	0.1102 *(0.0884)*	0.1695 *(0.0270)*
HI; LP	0.3784 *(0.1251)*	0.1892 *(0.0497)*	0.2432 *(0.0644)*	0.1892 *(0.1054)*
HI; HP	0.1176 *(0.0652)*	0.2941 *(0.0988)*	0.0882 *(0.0540)*	0.5001 *(0.1821)*

Table 6.a: Probabilities to go from a state with profits below the mean to the states with profits above the mean.

Starting as:	occasional innovators	systematic innovators
1 year	0.1037 ($p_{12} + p_{14}$)	0.1386 ($p_{32} + p_{34}$)
5 years	0.2240	0.2451
10 years	0.2590	0.3784

Table 6.b: Probabilities to go from a state with profits above the mean to the states with profits below the mean.

Starting as:	occasional innovators	systematic innovators
1 year	0.1344 ($p_{21} + p_{23}$)	0.1068 ($p_{41} + p_{43}$)
5 years	0.3169	0.2235
10 years	0.4153	0.2058