Is There Persistence in Innovative Activities?

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Abstract

This paper examines firm innovative persistence using patent applications of 577 UK manufacturing firms. Non-parametric techniques show the empirical distributions of patents are not Geometric nor Poisson. There exists a threshold effect represented by the first patent: the probability to go from zero to one patent is uniformly much lower than from *n* to *n+1 Patent*, with *n>0*. Transition Probability Matrices show little persistence in general, but strong persistence among "great" innovators that account for a large proportion of patents requested: innovative activities, at least which are captured by patents, are persistent. There is heterogeneity across industrial and size classification.

JEL: O31, D21

Keywords: innovation, patents, persistence, Transition Probability Matrices.

Contents

1. Descriptive Statistics

Table 1. Composition of the sample

Sub-group name	Number of firms
Unquoted	408
Quoted	169
Independent	188
Subsidiary	249

Sectors	Number of firms
Metal manufacturig (22)	13
Non- metallic manufacturing (24)	28
Chemical (25 and 26)	69
Other metal goods (31)	51
Mechanical engineering (32)	132
Office and data machinery (33)	18
Eletrical & electronic machinery (34)	100
Motor vehicles & parts (35)	9
Other transport (36)	18
Instrument engineering (37)	56
Food, drink & tobacco (41/42)	15
Textiles (43)	10
Leather goods (44)	1
Footwear & clothing (45)	3
Timber (46)	6
Paper & printing (47)	13
Rubber & plastics (48)	17
Other manufacturing (49)	12

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

Table 2. Descriptive Statistics

Variable	Mean	Stand. Dev.	Skewness	Kurtos.	Min.	Max.	Cases
PAT 78	0.18	2.48	20.41	447,848	0	56	577
PAT 79	0.52	6.27	20.86	467,200	0	143	577
PAT 80	0.69	8.02	21.14	478,129	0	184	577
PAT 81	0.70	7.43	19.73	423,844	0	165	577
PAT 82	0.91	8.29	18.00	353,789	0	174	577
PAT 83	0.86	6.53	17.02	337,607	0	137	577
PAT 84	1.03	7.88	15.61	282,077	0	156	577
PAT 85	1.05	7.26	14.32	242,376	0	138	577
PAT 86	1.17	8.63	13.96	225,571	0	159	577
PAT 87	1.38	10.98	14.23	227,131	0	197	577
PAT 88	1.48	11.10	13.06	189,530	0	180	577
PAT 89	1.63	12.86	13.98	213,795	0	204	577
PAT 90	1.51	12.58	14.72	232,900	0	204	577
PAT 91	1.02	9.14	14.99	239,669	0	154	577
PAT SUM	14.20	115.41	15.98	283,420	1	2251	577

2. The Poisson process

Let X(t) be the number of occurrence of the specified events in the time interval $[0, t)$ with $t \geq 0$ and $X(0)=0$.. Usually, the following postulates are made to define the Poisson process:

1. The probability $q_x(t)$ of exactly x events (in our case, the probability to apply for exactly x patents) occurring in the time interval $[\tau,\tau+t)$ depends only on the number x and on the length of the interval, but not on the time τ. Thus the random variables $X(\tau+t)$ - $X(\tau)$ and $X(t)$ are equidistributed. (Stationarity)
2. The number of events occurring on non-overlapping time intervals are mutually independent. Namely, for all t_i such that $t_0 < t_1 < ... < t_n$, the random variable $X(t_i) - X(t_{i-1}), i = 1, 2, ..., n,$ are independent. (Independence)
3. In a small time interval of length h the probability of one event occurring is $\lambda h+o(h)$ and that of multiple events occurring is $o(h)$, where λ is some fixed positive number and $o(h)$ means a positive quantity such that $o(h)/h \to 0$ as $h \to 0$. (Rareness).

Under the postulates above the form of $q_x(t)$ that is obtained is

$$q_x(t) = (\lambda.t)^x e^{-\lambda t} / x! \qquad x = 0, 1, 2, ..., \qquad (5.3)$$

which is nothing but the Poisson distribution with parameter λt, and hence $X(t)$ is called the Poisson process with intensity (or mean) λ (in our case λ represents the propensity, or better, the average capacity to patent).

The form of $q_x(t)$ is obtained by solving the following differential-difference equations:

$\frac{d}{dt} q_0(t) = -\lambda.q_0(t)$, and $\frac{d}{dt} q_x(t) = -\lambda.q_x(t) + \lambda.q_{x-1}(t)$, $x \geq 1$, with the initial conditions $q_0(0) = 1$ and $q_x(0) = 0$.

3. The Pearson χ^2 test.

The Pearson χ^2 is based on the idea of comparing the observed frequencies in a histogram with the theoretical frequencies given by the theoretical model that is tested. The null hypothesis is that the data of a variable *X* come from a specified model. On each patent distribution I test two different null hypothesis:

H_0: the data come from a geometric distribution, with parameter $0 < p \leq 1$ and probability density function (p.d.f.) $\Pr(X = x) = p(1-p)^x$, $x = 0, 1, 2, \ldots$.

H_0: the data come from a Poisson distribution, with parameter λ, and p.d.f. $\Pr(X = x) = \lambda.^x e^{-\lambda} / x!$, x = 0, 1, 2, ...

The test starts by grouping the *f* data in *k* classes. I choose to divide the data in 21 classes: the first class represents having requested 0 patent in a given year, the second having requested 1 patent, the third 2 patents, and so on, until the 21st class that represents having applied for at least 20 patents. Let us defined

- O_i the observed frequency of the class *i*, and

- $E_i = fq_i$ *(4.1)*

the expected frequency of class *i* according to the theoretical model, where q_i is the probability that the theoretical model we are testing assigned to the class *i*. As the classes cover all the possible value of the variable *X*, $\sum_i q_i = 1$.

The difference between the observed frequencies and the expected ones is given by:

$$D^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \quad (4.2)$$

D^2 is approximately distributed as a χ^2 when the model is correct. That is

$$D^2 \sim \chi^2(k - r - 1) \quad (4.3)$$

where *r* represents the umber of the parameters that we have estimated in order to calculate the probabilities *qi*. For the geometric distribution as well as for the Poisson distribution , the degrees of freedom are 19, since we have estimated one parameter in both cases.

The random sample $X = (x_i, \ldots, x_l)$, is composed of the number of patents (*x*) requested by a firm (*f* is the total number of the firms in the sample) in a given.

Table 3. The Pearson χ^2 test (year 1978)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	5.27	2.91
Large	2.9096E+20	1.8014E+7
Chemical	1.5882E+14	2.5091E+3
Mechanical Engineering	880.58	168.52
Electrical&Electronics	11.98	5.97
Instrumental engineering	na	na

Table 4. The Pearson χ^2 test (year 1979)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	6.5237E+4	408.28
Large	1.0430E+14	993.09
Chemical	9.8080E+7	152.16
Mechanical Engineering	1.1389E+5	470.41
Electrical&Electronics	1.6988E+6	4.8751E+3
Instrumental engineering	12.42	6.51

Table 5. The Pearson χ^2 test (year 1980)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	6.6502E+4	175.21
Large	2.2058E+12	432.79
Chemical	3.1793E+6	177.47
Mechanical Engineering	3.2630E+7	4.4842E+3
Electrical&Electronics	2.1420E+11	1.0186E+5
Instrumental engineering	1.4141E+3	96.06

Table 6. The Pearson χ^2 test (year 1981)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	1.2763E+7	1.2381E+3
Large	1.7748E+12	398.60
Chemical	4.8828E+6	159.83
Mechanical Engineering	1.5999E+9	2.8744E+4
Electrical&Electronics	1.3616E+7	925.17
Instrumental engineering	30.45	7.10

Table 7. The Pearson χ^2 test (year 1982)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	74.54	6.65
Large	1.6085E+10	233.28
Chemical	1.5640E+5	172.30
Mechanical Engineering	355.78	16.45
Electrical&Electronics	8.7345E+11	3.2789E+4
Instrumental engineering	1.1262E+3	33.24

Table 8. The Pearson χ^2 test (year 1984)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	3.1691E+3	47.12
Large	1.2222E+10	256.88
Chemical	4.0424E+5	172.06
Mechanical Engineering	1.1374E+5	455.92
Electrical&Electronics	7.0444E+12	3.6725E+4
Instrumental engineering	1.6084E+14	6.0092E+4

Table 9. The Pearson χ^2 test (year 1985)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	26.93	9.87
Large	2.3130E+10	285.46
Chemical	1.0595E+6	127.33
Mechanical Engineering	80.21	8.89
Electrical&Electronics	3.6039E+14	3.3327E+3
Instrumental engineering	668.34	3.1824E+3

Table 10. The Pearson χ^2 test (year 1986)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	1.3643E+6	640.38
Large	5.3565E+9	257.80
Chemical	1.9216E+5	164.02
Mechanical Engineering	1.05	0.29
Electrical&Electronics	1.1581E+13	734.56
Instrumental engineering	29.17	5.65

Table 11.The Pearson χ^2 test (year 1987)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	1.3643E+6	640.38
Large	1.6533E+8	283.36
Chemical	3.9650E+4	201.46
Mechanical Engineering	61.24	4.59
Electrical&Electronics	3.0024E+13	1.0711E+3
Instrumental engineering	1.6084E+14	9.2847E+4

Table 12. The Pearson χ^2 test (year 1988)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	6.4745E+6	789.35
Large	7.9336E+7	259.70
Chemical	4.1337E+4	185.40
Mechanical Engineering	602.78	26.96
Electrical&Electronics	8.9278E+11	340.42
Instrumental engineering	1.6084E+14	2.7403E+4

Table 13. The Pearson χ^2 test (year 1989)

Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	2.6386E+4	97.44
Large	9.7683E+6	260.87
Chemical	1.4481E+5	231.60
Mechanical Engineering	306.12	27.28
Electrical&Electronics	6.9883E+12	613.58
Instrumental engineering	2.6468E+15	7.0515E+4

Table 14. The Pearson χ^2 test (year 1990)

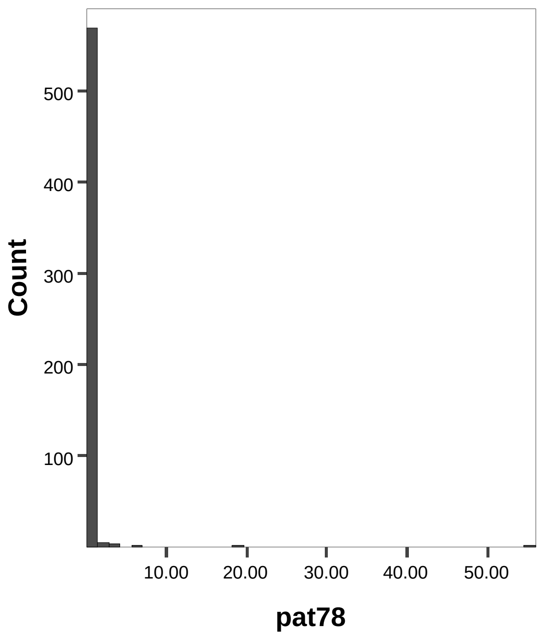
Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	2.3770E+8	737.16
Large	1.0429E+7	241.42
Chemical	8.7803E+4	183.35
Mechanical Engineering	174.10	14.36
Electrical&Electronics	1.8048E+14	1.8057E+3
Instrumental engineering	1.6084E+14	9.3628E+4

Table 15. The Pearson χ^2 test (year 1991)

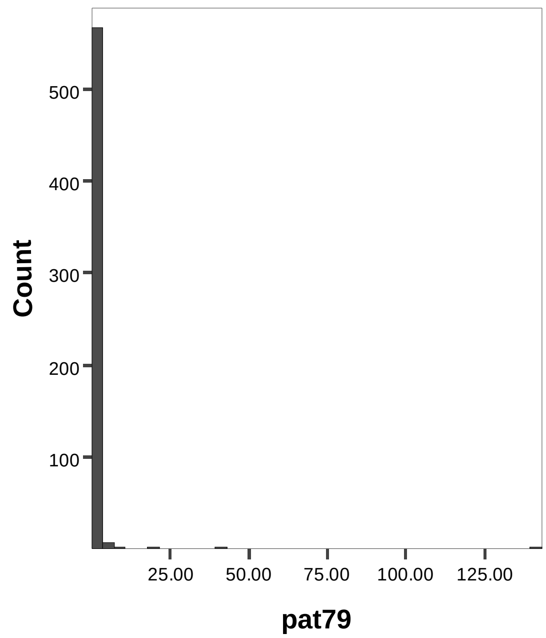
Sub-sample	H_0: Poisson distrib.	H_0: Geometric distrib.
Small firms	6.2506E+6	1.8758E+3
Large	2.0960E+9	256.53
Chemical	6.1754E+4	211.92
Mechanical Engineering	1.9857E+6	1.7734E+3
Electrical&Electronics	3.0422E+7	3.6665E+5
Instrumental engineering	4.6087E+12	3.0703E+4

4. Empirical distributions of patent data.

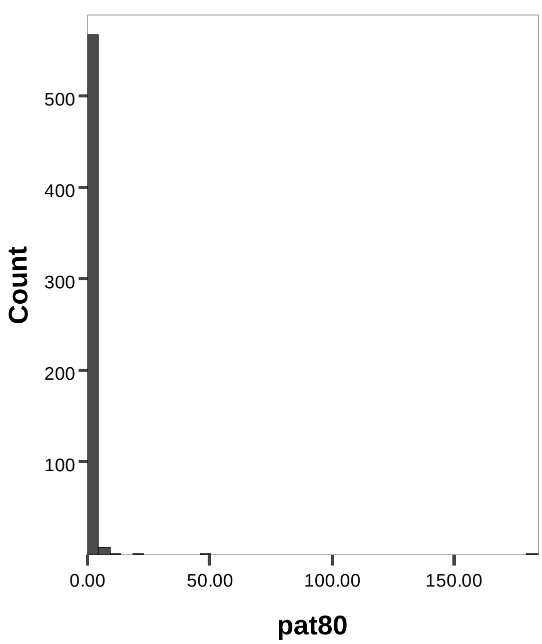
Histogram for the year 1978



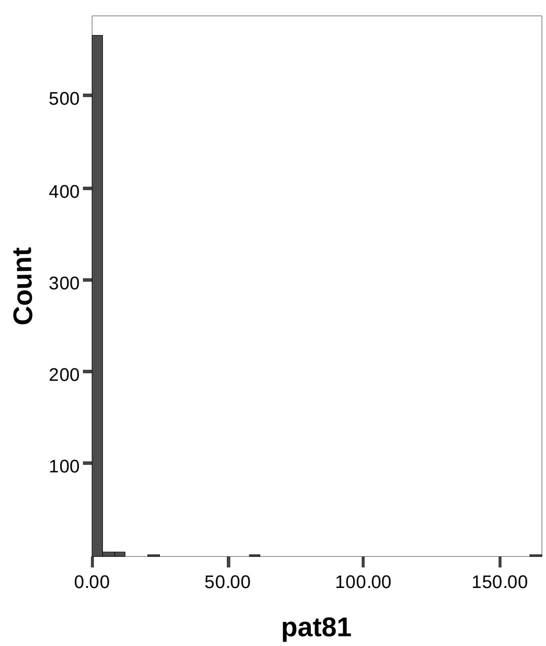
Histogram for the year 1979



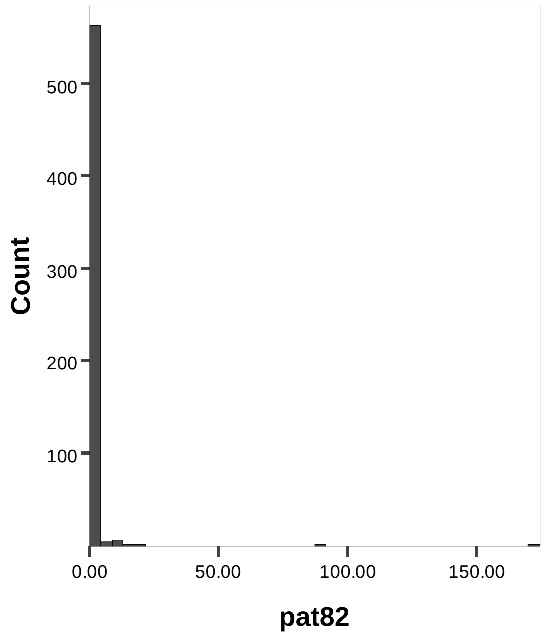
Histogram for the year 1980



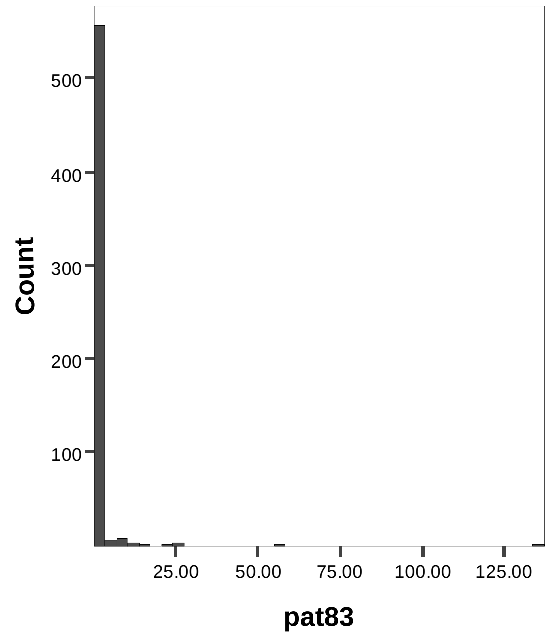
Histogram for the year 1981



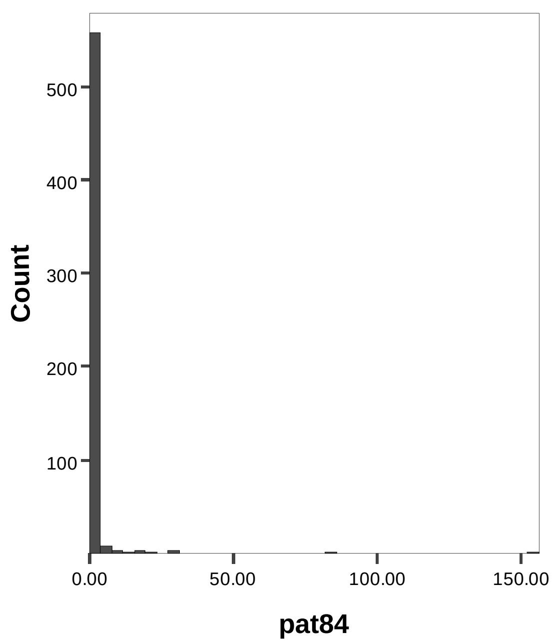
Histogram for the year 1982



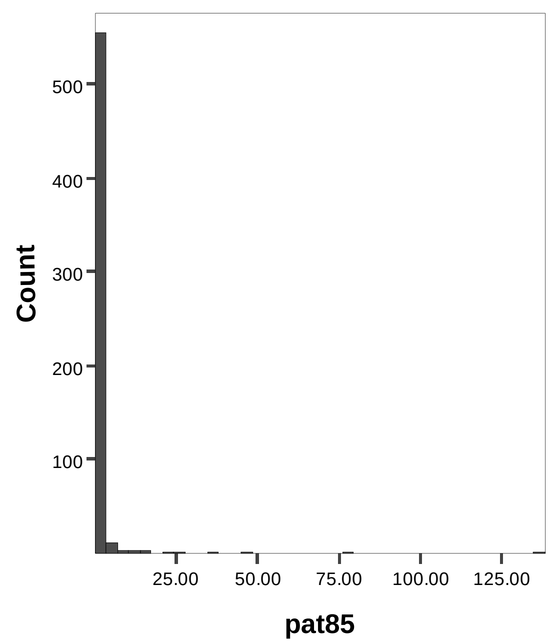
Histogram for the year 1983



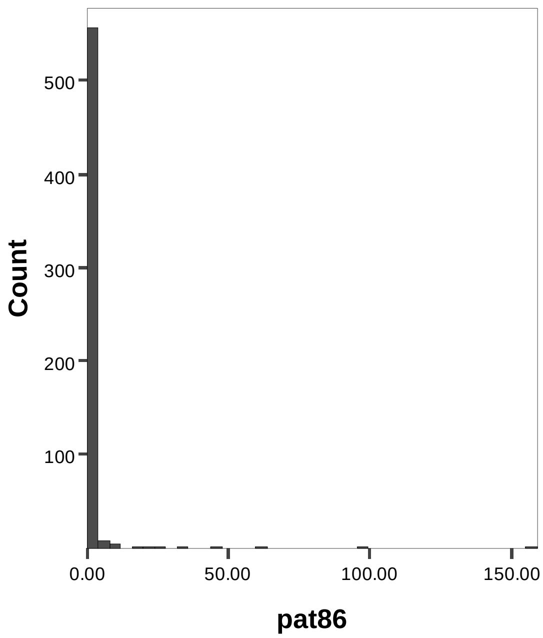
Histogram for the year 1984



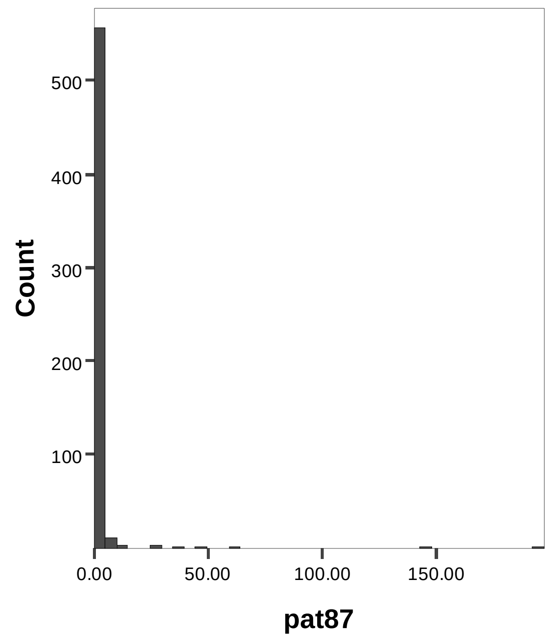
Histogram for the year 1985



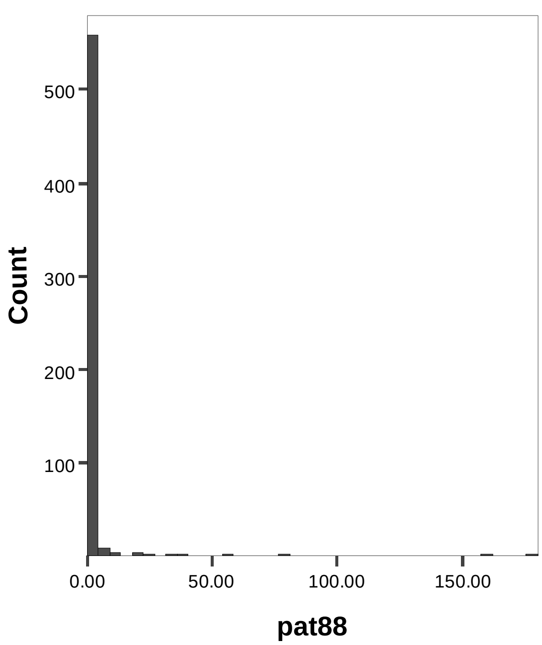
Histogram for the year 1986



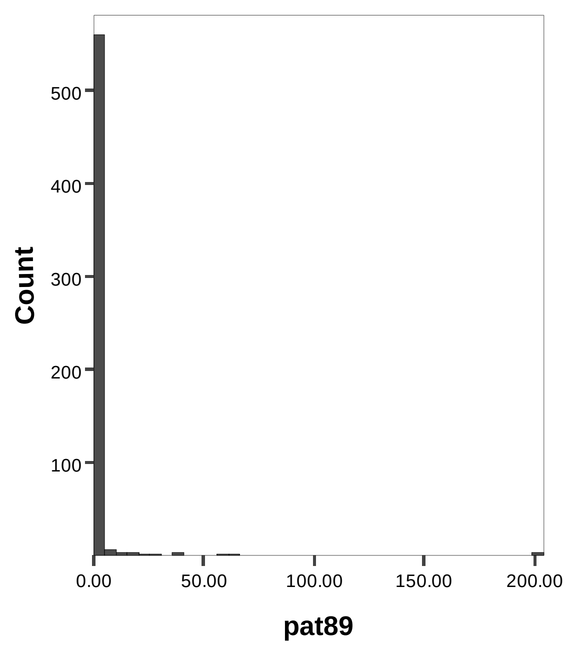
Histogram for the year 1987

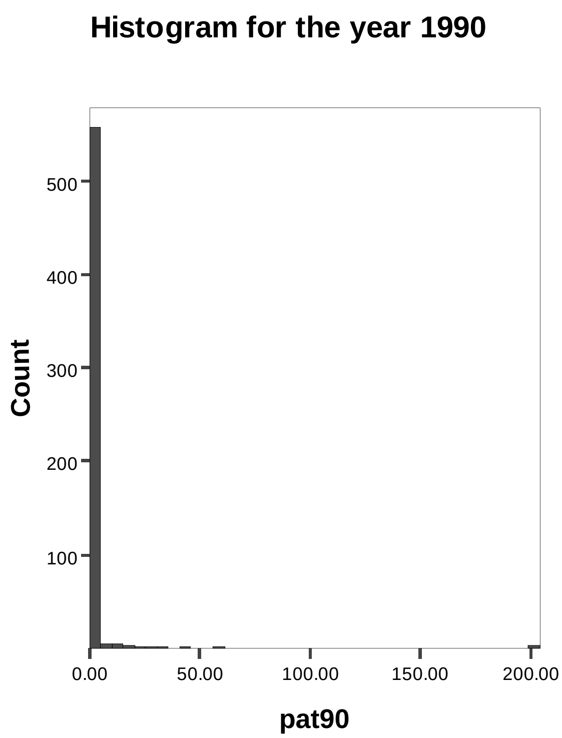


Histogram for the year 1988



Histogram for the year 1989




Histogram for the year 1990
Count
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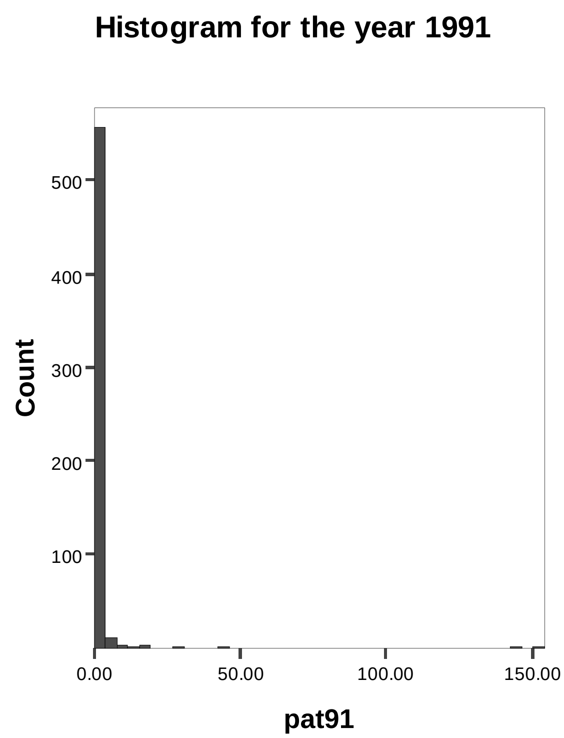
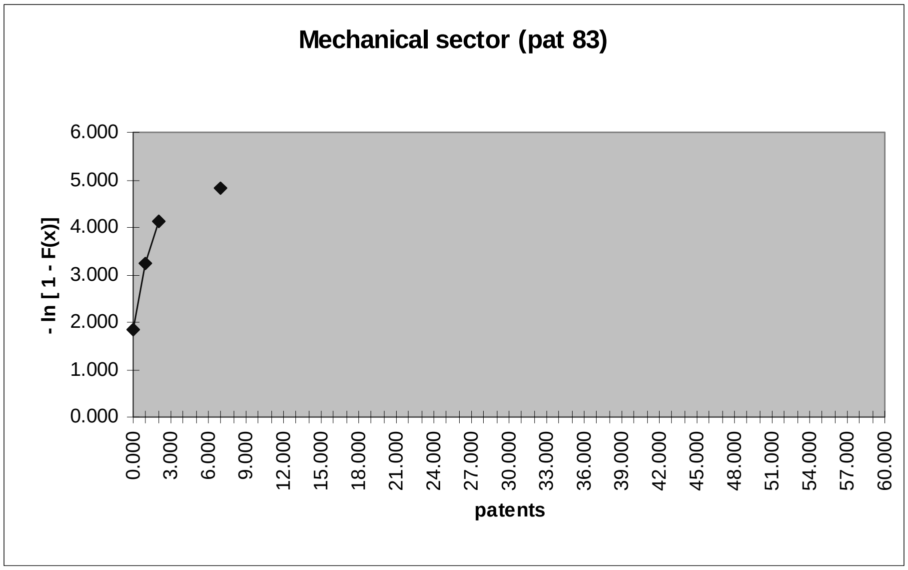
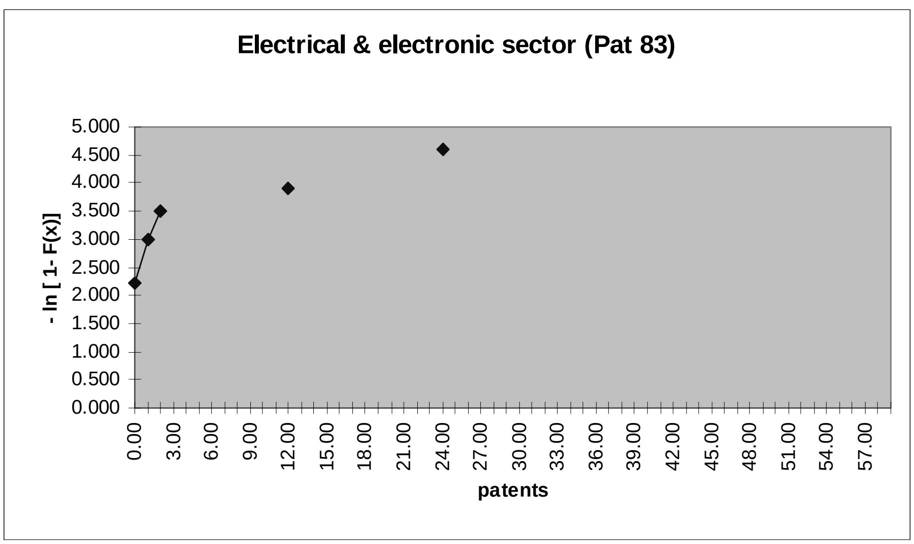
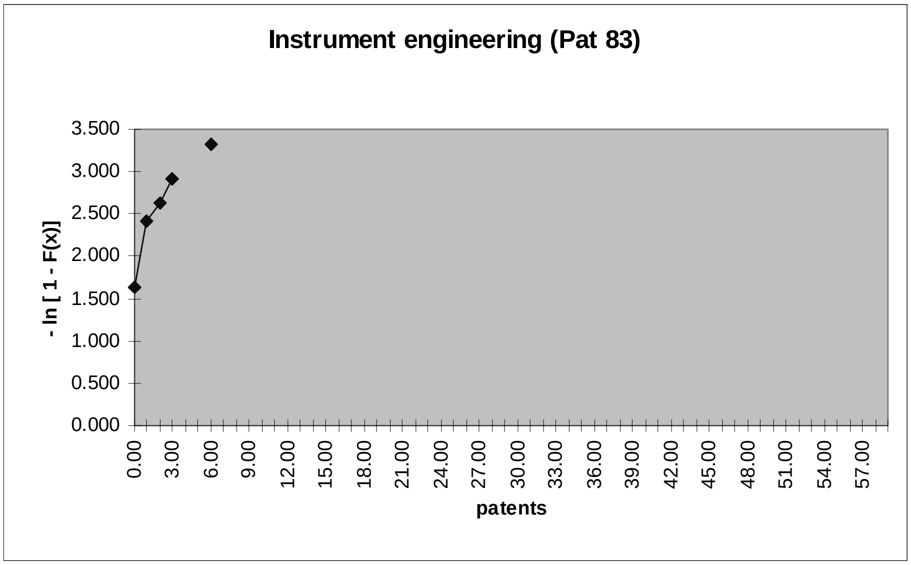
400
300
200
100
0.00
50.00
100.00
150.00
200.00
pat90


Histogram for the year 1991
Count
500
400
300
200
100
0.00
50.00
100.00
150.00
pat91

5. Q-Q Plots of the sub-samples






Instrument engineering (Pat 83)
- ln [1 - F(x)]
patents
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
33.00
36.00
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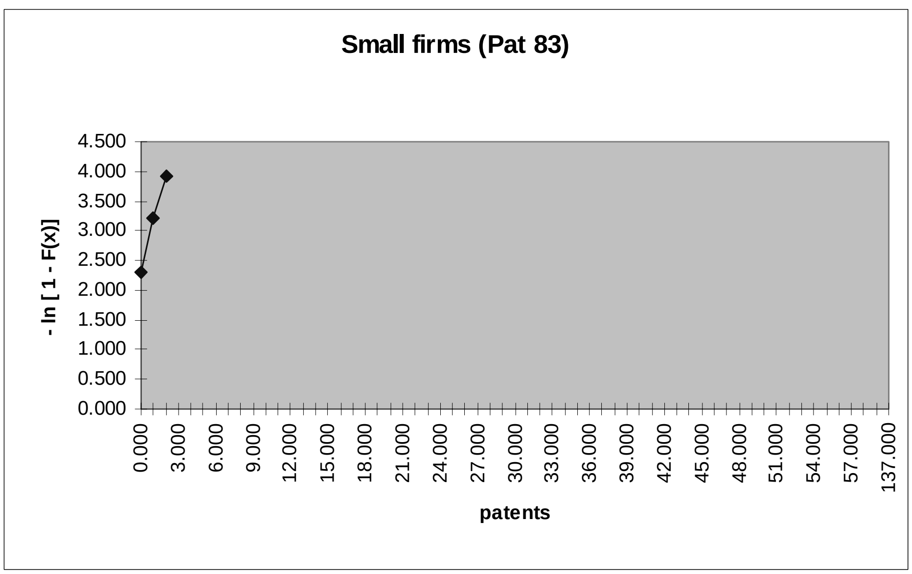
48.00
51.00
54.00
57.00


Small firms (Pat 83)
- ln [1 - F(x)]
patents
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
0.000
3.000
6.000
9.000
12.000
15.000
18.000
21.000
24.000
27.000
30.000
33.000
36.000
39.000
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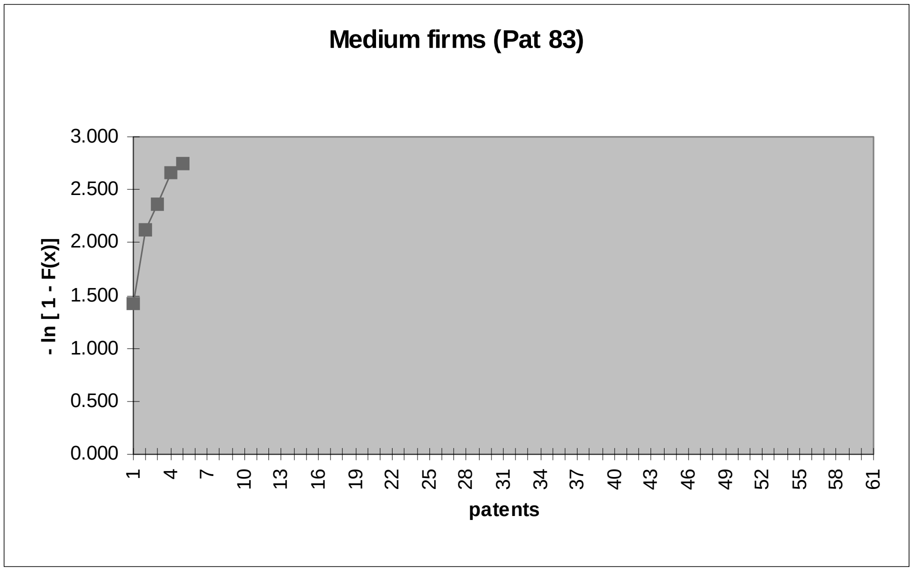
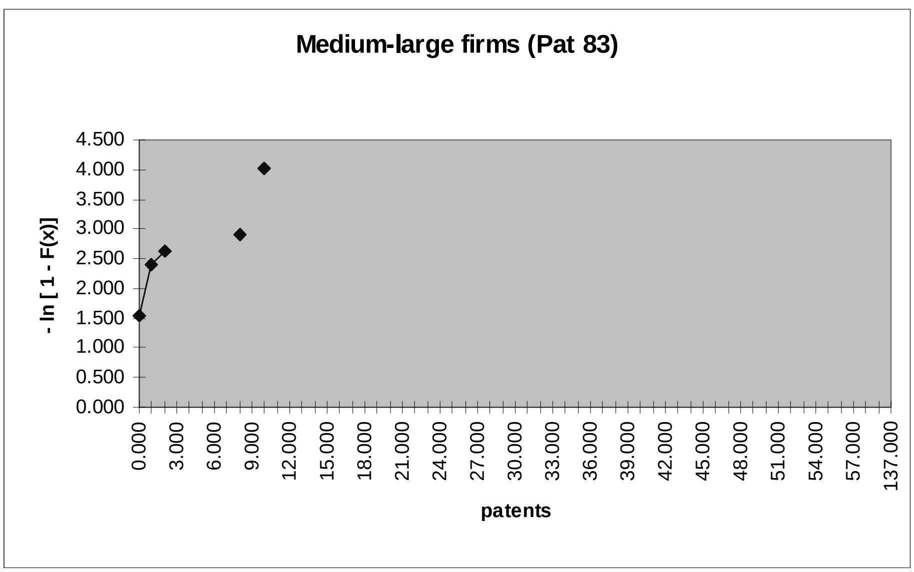
54.000
57.000
137.000


Medium firms (Pat 83)
3.000
2.500
2.000
1.500
1.000
0.500
0.000
- ln [1 - F(x)]
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
46
49
52
55
58
61
patents


Medium-large firms (Pat 83)
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
- ln [1 - F(x)]
0.000
3.000
6.000
9.000
12.000
15.000
18.000
21.000
24.000
27.000
30.000
33.000
36.000
39.000
42.000
45.000
48.000
51.000
54.000
57.000
137.000
patents

6. Transition Probability Matrices of the sub-samples

Table 16. Quoted Firms

A) Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.8632 *(0.0071)*	0.1368 *(0.0071)*
Patents	0.4624 *(0.0428)*	0.5376 *(0.0428)*

Five Year Transitions

	No Patent	Patents
No Patents	0.8103 *(0.0136)*	0.1897 *(0.136)*
Patents	0.5529 *(0.0502)*	0.4471 *(0.502)*

Ten Year Transitions

	No Patent	Patents
No Patents	0.7762 *(0.0222)*	0.2238 *(0.222)*
Patents	0.6526 *(0.0763)*	0.3474 *(0.763)*

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8632 *(0.0073)*	0.1033 *(0.0057)*	0.0318 *(0.0045)*	0.0017 *(0.0010)*
1 Patent	0.7149 *(0.0333)*	0.1860 *(0.0252)*	0.0702 *(0.0169)*	0.0289 *(0.0123)*
2-5 Patents	0.3279 *(0.0515)*	0.1885 *(0.0387)*	0.3689 *(0.0474)*	0.1148 *(0.0326)*
At least 6	0.0198 *(0.0162)*	0.0495 *(0.0242)*	0.1089 *(0.0400)*	0.8218 *(0.0596)*

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8103 *(0.0147)*	0.1303 *(0.0098)*	0.0521 *(0.0086)*	0.0073 *(0.0031)*
1 Patent	0.7533 *(0.0409)*	0.0867 *(0.0218)*	0.1067 *(0.0297)*	0.0533 *(0.0245)*
2-5 Patents	0.5125 *(0.0721)*	0.1375 *(0.0460)*	0.1625 *(0.0524)*	0.1875 *(0.0671)*
At least 6 Patents	0.1270 *(0.0678)*	0.0159 *(0.0159)*	0.1111 *(0.0604)*	0.7460 *(0.1045)*

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.7762 *(0.0217)*	0.1429 *(0.0156)*	0.0568 *(0.0121)*	0.0241 *(0.0091)*
1 Patent	0.8627 *(0.0508)*	0.0000 *(0.0000)*	0.1176 *(0.0471)*	0.0196 *(0.0197)*
2-5 Patents	0.5455 *(0.1337)*	0.0000 *(0.0000)*	0.0495 *(0.0423)*	0.4091 *(0.1253)*
At least 6 Patents	0.2727 *(0.1475)*	0.0455 *(0.0541)*	0.0909 *(0.0705)*	0.5909 *(0.1621)*

Table 17. Unquoted Firms

A) Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.8823 *(0.0034)*	0.1177 *(0.0034)*
Patents	0.6042 *(0.0314)*	0.3958 *(0.0314)*

Five Year Transitions

	No Patent	Patents
No Patents	0.8430 *(0.0068)*	0.1570 *(0.0068)*
Patents	0.6822 *(0.0376)*	0.3178 *(0.0376)*

Ten Year Transitions

	No Patent	Patents
No Patents	0.8272 *(0.0112)*	0.1728 *(0.0112)*
Patents	0.7402 *(0.0602)*	0.2598 *(0.0602)*

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8823 *(0.0034)*	0.0966 *(0.0030)*	0.0191 *(0.0022)*	0.0020 *(0.0007)*
1 Patent	0.7565 *(0.0218)*	0.1421 *(0.0160)*	0.0978 *(0.0199)*	0.0036 *(0.0027)*
2-5 Patents	0.4021 *(0.0433)*	0.2423 *(0.0275)*	0.2680 *(0.0407)*	0.0876 *(0.0222)*
At least 6	0.0267 *(0.0246)*	0.0267 *(0.0209)*	0.2133 *(0.0615)*	0.7333 *(0.0782)*

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8430 *(0.0069)*	0.1186 *(0.0048)*	0.0305 *(0.0034)*	0.0078 *(0.0024)*
1 Patent	0.8119 *(0.0263)*	0.0776 *(0.0141)*	0.0866 *(0.0161)*	0.0239 *(0.0117)*
2-5 Patents	0.5128 *(0.0587)*	0.1795 *(0.0352)*	0.2051 *(0.0484)*	0.1026 *(0.0418)*
At least 6	0.1190 *(0.0765)*	0.0714 *(0.0488)*	0.1667 *(0.0776)*	0.6429 *(0.1367)*

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8272 *(0.0115)*	0.1209 *(0.0085)*	0.0419 *(0.0062)*	0.0099 *(0.0036)*
1 Patent	0.8427 *(0.0469)*	0.0112 *(0.0111)*	0.0562 *(0.0253)*	0.0899 *(0.0392)*
2-5 Patents	0.6333 *(0.1062)*	0.0333 *(0.0323)*	0.2000 *(0.0751)*	0.1333 *(0.0649)*
At least 6	0.0000 *(0.0000)*	0.1250 *(0.1829)*	0.0000 *(0.0000)*	0.8750 *(0.1938)*

Table 18. Subsidiary Firms

A) Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.8684 *(0.0050)*	0.1316 *(0.0050)*
Patents	0.5258 *(0.0347)*	0.4742 *(0.0347)*

Five Year Transitions

	No Patent	Patents
No Patents	0.8190 *(0.0100)*	0.1810 *(0.0100)*
Patents	0.5978 *(0.0459)*	0.4022 *(0.0459)*

Ten Year Transitions

	No Patent	Patents
No Patents	0.7861 *(0.0172)*	0.2139 *(0.0172)*
Patents	0.6990 *(0.0661)*	0.3010 *(0.0661)*

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8684 *(0.0057)*	0.1002 *(0.0049)*	0.0284 *(0.0037)*	0.0030 *(0.0011)*
1 Patent	0.6925 *(0.0269)*	0.1773 *(0.0191)*	0.1247 *(0.0173)*	0.0055 *(0.0038)*
2-5 Patents	0.3736 *(0.0510)*	0.2356 *(0.0308)*	0.3103 *(0.0468)*	0.0805 *(0.0243)*
At least 6	0.0152 *(0.0201)*	0.0303 *(0.0267)*	0.2121 *(0.0723)*	0.7424 *(0.0899)*

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8190 *(0.0106)*	0.1235 *(0.0070)*	0.0469 *(0.0060)*	0.0106 *(0.0037)*
1 Patent	0.7304 *(0.0334)*	0.1130 *(0.0174)*	0.1304 *(0.0255)*	0.0261 *(0.0115)*
2-5 Patents	0.4796 *(0.0614)*	0.1939 *(0.0398)*	0.2143 *(0.0515)*	0.1122 *(0.0480)*
At least 6	0.0571 *(0.0629)*	0.0286 *(0.0363)*	0.2000 *(0.0961)*	0.7143 *(0.1396)*

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.6861 *(0.0171)*	0.1277 *(0.0120)*	0.0683 *(0.0102)*	0.0179 *(0.0058)*
1 Patent	0.8261 *(0.0500)*	0.0145 *(0.0144)*	0.0870 *(0.0344)*	0.0725 *(0.0307)*
2-5 Patents	0.5769 *(0.1203)*	0.0385 *(0.0386)*	0.2308 *(0.0868)*	0.1538 *(0.0752)*
At least 6	0.0000 *(0.0000)*	0.1250 *(0.1674)*	0.0000 *(0.0000)*	0.8750 *(0.1942)*

Table 19. Independent Firm

A) Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.8734 *(0.0056)*	0.1266 *(0.0056)*
Patents	0.4660 *(0.0420)*	0.5240 *(0.0420)*

Five Year Transitions

	No Patent	Patents
No Patents	0.8181 *(0.0121)*	0.1819 *(0.0121)*
Patents	0.5581 *(0.0541)*	0.4419 *(0.0541)*

Ten Year Transitions

	No Patent	Patents
No Patents	0.8003 *(0.0184)*	0.1997 *(0.0184)*
Patents	0.6154 *(0.0801)*	0.3846 *(0.0801)*

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8734 *(0.0061)*	0.0980 *(0.0046)*	0.0271 *(0.0038)*	0.0015 *(0.0009)*
1 Patent	0.7054 *(0.0337)*	0.1938 *(0.0257)*	0.0736 *(0.0161)*	0.0272 *(0.0128)*
2-5 Patents	0.3472 *(0.0543)*	0.1818 *(0.0354)*	0.3388 *(0.0500)*	0.1322 *(0.0330)*
At least 6	0.0189 *(0.0154)*	0.0471 *(0.0238)*	0.1132 *(0.0396)*	0.8208 *(0.0582)*

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8181 *(0.0125)*	0.1316 *(0.0086)*	0.0431 *(0.0067)*	0.0071 *(0.0028)*
1 Patent	0.7829 *(0.0423)*	0.0658 *(0.0183)*	0.0855 *(0.0248)*	0.0658 *(0.0295)*
2-5 Patents	0.4940 *(0.0697)*	0.1446 *(0.0448)*	0.1687 *(0.0486)*	0.1928 *(0.0645)*
At least 6	0.1212 *(0.0697)*	0.0303 *(0.0244)*	0.1061 *(0.0554)*	0.7424 *(0.1031)*

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8003 *(0.0184)*	0.1362 *(0.0133)*	0.0439 *(0.0102)*	0.0197 *(0.0076)*
1 Patent	0.8000 *(0.0850)*	0.0000 *(0.0000)*	0.1111 *(0.0581)*	0.0889 *(0.0684)*
2-5 Patents	0.5833 *(0.1299)*	0.0000 *(0.0000)*	0.0417 *(0.0385)*	0.3750 *(0.1177)*
At least 6	0.2727 *(0.1599)*	0.0455 *(0.0540)*	0.0909 *(0.0691)*	0.5909 *(0.1747)*

Table 20. Electrical & Electronic Machinery Industry

A) Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.8773 *(0.0075)*	0.1227 *(0.0075)*
Patents	0.5491 *(0.0600)*	0.4509 *(0.0600)*

Five Year Transitions

	No Patent	Patents
No Patents	0.8255 *(0.0128)*	0.1745 *(0.0128)*
Patents	0.6212 *(0.0759)*	0.3788 *(0.0759)*

Ten Year Transitions

	No Patent	Patents
No Patents	0.7922 *(0.0215)*	0.2078 *(0.0215)*
Patents	0.6923 *(0.1092)*	0.3077 *(0.01092)*

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8773 *(0.0080)*	0.0994 *(0.0066)*	0.0214 *(0.0043)*	0.0019 *(0.0014)*
1 Patent	0.7372 *(0.0378)*	0.1533 *(0.0291)*	0.0876 *(0.0241)*	0.0219 *(0.0167)*
2-5 Patents	0.3962 *(0.0754)*	0.2264 *(0.0566)*	0.3396 *(0.0702)*	0.0378 *(0.0276)*
At least 6	0.0294 *(0.1233)*	0.0588 *(0.0710)*	0.0589 *(0.0687)*	0.8529 *(0.1904)*

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8255 *(0.0135)*	0.1276 *(0.0091)*	0.0404 *(0.0094)*	0.0065 *(0.0036)*
1 Patent	0.7500 *(0.0636)*	0.0875 *(0.0283)*	0.1500 *(0.0501)*	0.0125 *(0.0121)*
2-5 Patents	0.6333 *(0.1104)*	0.1667 *(0.0708)*	0.1000 *(0.0549)*	0.1000 *(0.0731)*
At least 6	0.1364 *(0.2185)*	0.0455 *(0.0432)*	0.0000 *(0.0000)*	0.8182 *(0.2179)*

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.7922 *(0.0216)*	0.1440 *(0.0170)*	0.0526 *(0.0133)*	0.0111 *(0.0079)*
1 Patent	0.8148 *(0.0775)*	0.0370 *(0.0368)*	0.1111 *(0.0624)*	0.0370 *(0.0387)*
2-5 Patents	0.5000 *(0.3009)*	0.0000 *(0.0000)*	0.0000 *(0.0000)*	0.5000 *(0.2997)*
At least 6	0.3333 *(0.2760)*	0.1667 *(0.2346)*	0.0000 *(0.0000)*	0.5000 *(0.3055)*

Table 21. Instrument Engineering Industry

A) Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.8839 *(0.0086)*	0.1161 *(0.0086)*
Patents	0.5120 *(0.0663)*	0.4880 *(0.0663)*

Five Year Transitions

	No Patent	Patents
No Patents	0.8047 *(0.0233)*	0.1953 *(0.0233)*
Patents	0.7089 *(0.0709)*	0.2911 *(0.0709)*

Ten Year Transitions

	No Patent	Patents
No Patents	0.8095 *(0.0330)*	0.1905 *(0.0330)*
Patents	0.7857 *(0.1432)*	0.2143 *(0.1432)*

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8839 *(0.0094)*	0.0846 *(0.0093)*	0.0299 *(0.0074)*	0.0016 *(0.0016)*
1 Patent	0.7286 *(0.0579)*	0.2000 *(0.0427)*	0.0714 *(0.0346)*	0.0000 *(0.0000)*
2-5 Patents	0.3250 *(0.0769)*	0.1500 *(0.0699)*	0.3500 *(0.0643)*	0.1750 *(0.0587)*
At least 6	0.0000 *(0.0000)*	0.0000 *(0.0000)*	0.3333 *(0.1089)*	0.6667 *(0.1207)*

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8047 *(0.0234)*	0.1129 *(0.0152)*	0.0588 *(0.0161)*	0.0235 *(0.0116)*
1 Patent	0.8444 *(0.0452)*	0.0889 *(0.0352)*	0.0444 *(0.0313)*	0.0222 *(0.0224)*
2-5 Patents	0.5185 *(0.1323)*	0.0741 *(0.0504)*	0.1852 *(0.0797)*	0.2222 *(0.1254)*
At least 6	0.5714 *(0.2164)*	0.1429 *(0.1130)*	0.1429 *(0.1148)*	0.1429 *(0.2732)*

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.8095 *(0.0320)*	0.1095 *(0.0199)*	0.0476 *(0.0176)*	0.0333 *(0.0196)*
1 Patent	0.8750 *(0.1270)*	0.0000 *(0.0000)*	0.0000 *(0.0000)*	0.1250 *(0.1270)*
2-5 Patents	0.6667 *(0.2645)*	0.0000 *(0.0000)*	0.1667 *(0.1315)*	0.1667 *(0.1315)*
At least 6	NA	NA	NA	NA

7. The Great Innovators.

Table 22: Two-state Transition Probabilities

One Year Transitions

	No Patent	Patents
No Patents	0.7487	0.2513
Patents	0.0901	0.9099

Five Year Transitions

	No Patent	Patents
No Patents	0.4476	0.5524
Patents	0.1567	0.8433

Ten Year Transitions

	No Patent	Patents
No Patents	0.3371	0.6629
Patents	0.2113	0.7887

B) Four-state Transition Probabilities

One Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.7487	0.0963	0.0909	0.0642
1 Patent	0.2308	0.2500	0.3462	0.1731
2-5 Patents	0.1333	0.1333	0.4381	0.2952
At least 6 Patents	0.0227	0.0398	0.1534	0.7841

Five Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.4476	0.1329	0.1818	0.2378
1 Patent	0.2162	0.0541	0.2973	0.4324
2-5 Patents	0.1733	0.1467	0.3200	0.3600
At least 6 Patents	0.1238	0.0381	0.1333	0.7048

Ten Year Transitions

	No Patents	1 Patent	2-5 Patents	At least 6 Patents
No Patents	0.3371	0.1124	0.2247	0.3258
1 Patent	0.1875	0.0000	0.2500	0.5625
2-5 Patents	0.2400	0.0400	0.2000	0.5200
At least 6 Patents	0.2000	0.0667	0.0667	0.6667

8. Sensitivity analysis

The analysis in the paper has been conducted using various assumptions. In this section I study whether the results obtained are robust to changes in one of these assumptions. In particular, I will consider the possibility that the transition probabilities are not time invariant but display structural breaks within the 14 years of the sample.

I let the break date vary from 1982 to 1988 and compare the estimated TPMs for the two sub-samples with the one for the overall sample. Moreover, since in some cases the samples (along the time dimension) are too short I concentrate the attention primarily on one-year TPMs and examine five-years TPMs only when possible.

Several interesting features emerge from the exercise. First, the features of the TPMs are independent of the break date within the chosen interval.

This implies that (short-term) business cycle consideration have little importance for qualitative features of the results. Second, the features of the TPM for the two sub-samples are very similar to the ones for the overall sample, indicating substantial time homogeneity of the sample, although some heterogeneity appear along the cross section within each sub-sample.

In particular, the conditional probability of having requested for more than six patents, given that a firm had applied for six patents for the samples beginning in one of the years between 82-88 and ending in 91 is higher than for the sample beginning in 1978, while this last sample displays a much higher probability of reverting back to zero patent, no matter what class you started in. The Five Year TPMs provide an identical picture.

The differences between time sub-samples can be explained mainly by the fact that at the beginning of the sample period the European Patent Office was a new organisation offering a new product/service. Especially for the first 4-5 years the growth rate of patents application was very high because more firms began to patent following this procedure and because firms began to apply for more patents each year. Therefore, the mean of patent applications by firm increases, as well as its standard deviation. This is particularly true of "great" innovators which began to request more and more patents as time went by.

Table 23: Second Order Markov Chain

Two-state Transition Probabilities

Quoted

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8685	0.1315
$X_{t-1} = 0,\ X_{t-2} = 1$	0.6950	0.3050
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8021	0.1979
$X_{t-1} = 1,\ X_{t-2} = 1$	0.2521	0.7479

Non quoted

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8805	0.1195
$X_{t-1} = 0,\ X_{t-2} = 1$	0.7703	0.2297
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8513	0.1487
$X_{t-1} = 1,\ X_{t-2} = 1$	0.3232	0.6768

Subsidiary

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8693	0.1307
$X_{t-1} = 0,\ X_{t-2} = 1$	0.6978	0.3022
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8188	0.1812
$X_{t-1} = 1,\ X_{t-2} = 1$	0.3092	0.6908

Independent

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8753	0.1247
$X_{t-1} = 0,\ X_{t-2} = 1$	0.7137	0.2863
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8291	0.1709
$X_{t-1} = 1,\ X_{t-2} = 1$	0.2387	0.7613

Chemical Industry

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8872	0.1128
$X_{t-1} = 0,\ X_{t-2} = 1$	0.6757	0.3243
$X_{t-1} = 1,\ X_{t-2} = 0$	0.7778	0.2222
$X_{t-1} = 1,\ X_{t-2} = 1$	0.1990	0.8810

Mechanical Engineering Industry

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8803	0.1197
$X_{t-1} = 0,\ X_{t-2} = 1$	0.8176	0.1824
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8442	0.1558
$X_{t-1} = 1,\ X_{t-2} = 1$	0.3649	0.6351

Electrical & Electronic Machinery

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8726	0.1274
$X_{t-1} = 0,\ X_{t-2} = 1$	0.7087	0.2913
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8519	0.1481
$X_{t-1} = 1,\ X_{t-2} = 1$	0.3404	0.6596

Instrument Engineering Industry

	No Patents: X_t=0	Patents: X_t=1
$X_{t-1} = 0,\ X_{t-2} = 0$	0.8732	0.1268
$X_{t-1} = 0,\ X_{t-2} = 1$	0.6567	0.3433
$X_{t-1} = 1,\ X_{t-2} = 0$	0.8966	0.1034
$X_{t-1} = 1,\ X_{t-2} = 1$	0.3448	0.6552