

How much do innovation strategies differ across firms, industries and countries?

Martin Srholec

CAS Centre and TIK Centre (University of Oslo)

Bart Verspagen

ECIS (Eindhoven University of Technology) and
TIK Centre (University of Oslo)

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Diverse routes to success in innovation

- Not only how much innovation efforts to make, but also what kinds of innovation strategies to pursue
- Firm-level heterogeneity (Nelson and Winter 1982)
- Sectoral patterns (Pavitt 1984)
- National patterns (Lundvall 1992, Nelson 1993)
- The aim of the paper is to
 - quantify innovation strategies of firms
 - find out how much is innovation strategy of a firm influenced by the sectoral and national context

Overview of the dataset

- Micro data from the third Community Innovation Survey (CIS-3) provided by Eurostat
- Only successful innovators included
- A dataset of 13,035 innovating firms in industry and most sectors of market services in 13 European countries
- Belgium, Bulgaria, Czech Rep., Germany, Estonia, Spain, Greece, Lithuania, Latvia, Norway, Portugal, Romania, Slovakia
- Micro-aggregated weights that refer to the inverse of the so-called sampling fraction, corrected for non-response and for no longer existing enterprises

Hierarchical factor analysis

Firms choose from different options within the particular aspect of the innovation strategy and then combine them in the innovation process

Factor analysis in two steps:

- 1) Estimates separately on each set of the CIS questions
 - Different innovation activities
 - Effects of innovation
 - Sources of information for innovation
 - Methods of protection
 - Other important changes in the firm
 - Innovation co-operation
- 2) Factor scores obtained from these estimates enter the second stage, which reveals the different innovation strategies of firms

Factor analysis on variety of innovation activities

	(1) R&D	(2) Marketing	(3) External
Internal R&D	0.52	0.15	-0.12
Acquisition of extramural R&D	0.54	0.06	0.16
Acquisition of machinery and equipment	-0.10	0.03	0.41
Acquisition of other external knowledge	0.14	0.07	0.32
Training	0.13	0.55	0.31
Market introduction of innovations	0.13	0.76	0.01
Design and other	0.09	0.68	0.03

Note: Estimation weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 13,035; three factors with eigenvalue > 1 were detected, which explain 62.8% of total variance; extraction method: principal axis factoring; rotation: varimax with Kaiser normalization.

Factor analysis on effects of innovation

	(1) Product	(2) Process	(3) Other
Increased range of goods or services	0.75	0.04	0.02
Increased market or market share	0.77	0.11	0.06
Improved quality in goods or services	0.43	0.23	0.18
Improved production flexibility	0.17	0.71	0.13
Increased production capacity	0.10	0.79	0.15
Reduced labour costs per produced unit	0.08	0.75	0.19
Reduced materials per produced unit	0.13	0.61	0.35
Environmental, health and safety aspects	0.05	0.22	0.87
Met regulations or standards	0.13	0.21	0.60

Note: Estimation weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 13,035; three factors with eigenvalue > 1 were detected, which explain 69.1% of total variance; extraction method: principal axis factoring; rotation: varimax with Kaiser normalization.

Factor analysis on sources of information for innovation

	(1) Science	(3) Market	(2) Events
Within the enterprise	0.11	0.22	0.06
Suppliers	0.06	0.07	0.24
Clients or customers	0.05	0.86	0.08
Competitors or firms in the same industry	0.10	0.45	0.27
Universities and other higher education	0.79	0.15	0.15
Government or non-profit research institutes	0.64	0.12	0.14
Professional conferences, journals, etc.	0.29	0.16	0.53
Fairs and exhibitions	0.05	0.11	0.81

Note: Estimation weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 13,035; three factors with eigenvalue > 1 were detected, which explain 58.6% of total variance; extraction method: principal axis factoring; rotation: varimax with Kaiser normalization.

Factor analysis on methods of protection

	(1)	(2)
	Formal	Informal
Patents	0.54	0.16
Registration of design patterns	0.74	0.09
Trademarks	0.43	0.20
Copyright	0.22	0.25
Secrecy	0.19	0.73
Complexity of design	0.13	0.65
Lead-time advantage on competitors	0.22	0.74

Note: Estimation weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 13,035; two factors with eigenvalue > 1 were detected, which explain 55.5% of total variance; extraction method: principal axis factoring; rotation: varimax with Kaiser normalization.

Factor analysis on other important changes in the firm

	(1) Non-technological innovation
Strategy	0.65
Management	0.63
Organisation	0.61
Marketing	0.53
Aesthetic (or other subjective) changes	0.32

Note: Estimation weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 13,035; one factor with eigenvalue > 1 was detected, which explains 44.5% of total variance; extraction method: principal axis factoring; rotation: varimax with Kaiser normalization.

Factor analysis (2nd stage) on innovation strategies

	(1) Research- based	(2) User- driven	(3) Extensive	(4) Social responsibility
R&D	0.57	0.25	-0.03	0.04
Marketing	0.11	0.48	0.14	0.00
External inputs	0.07	0.05	0.62	0.14
Product effects	0.09	0.63	-0.02	0.10
Process effects	-0.01	0.05	0.14	0.26
Other effects	0.14	-0.05	-0.04	0.43
Information from science	0.51	0.04	0.04	0.19
Information from market	0.07	0.40	-0.02	0.02
Information from events	-0.04	0.21	0.08	0.36
Formal protection	0.25	0.31	-0.05	0.06
Informal protection	0.32	0.31	0.04	0.01
Non-technological innovation	0.12	0.34	0.13	0.17
Innovation co-operation	0.49	0.09	0.09	-0.06

Note: Estimation weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises; number of observations is 13,035; five factors with eigenvalue > 1 were detected, which explain 47.0% of total variance; extraction method: principal axis factoring; rotation: varimax with Kaiser normalization.

Overview of innovation strategies by industry

NACE, rev. 1.1.	Research-based	User-driven	Extensive	Social Responsibility	Number of observations
10, 11, 12, 13, 14	-0.14	-0.70	-0.14	0.14	143
15, 16	-0.20	-0.17	-0.08	0.19	1214
17, 18	-0.06	-0.13	-0.05	0.02	786
19	-0.22	-0.23	-0.11	0.01	167
20	-0.13	-0.23	-0.08	0.02	362
21, 22	-0.46	-0.21	0.18	0.12	570
23, 24	0.47	0.07	-0.24	0.21	731
25	-0.02	0.01	-0.12	0.06	488
26	0.20	-0.33	-0.16	0.12	484
27, 28	0.00	-0.02	-0.06	0.13	1,023
29	0.28	0.16	-0.13	0.03	903
30, 31	0.23	0.29	-0.05	0.03	456
32	0.31	0.16	0.07	0.02	244
33	0.46	0.47	0.05	-0.07	284
34, 35	0.32	0.04	-0.01	0.07	513
36, 37	-0.28	-0.03	-0.09	0.19	638
40, 41	0.15	-0.55	0.14	-0.06	228
51	-0.19	0.06	0.05	-0.06	987
60, 61, 62	-0.05	-0.43	0.13	0.03	285
63	-0.12	-0.13	0.25	-0.04	264
64	0.04	0.14	0.03	-0.22	145
65	-0.10	-0.07	0.05	-0.34	281
66	0.09	-0.01	0.20	-0.48	189
67	-0.24	0.15	0.04	-0.42	88
72, 73	0.29	0.35	-0.09	-0.24	1,030
74	0.15	0.13	0.20	-0.17	532

Note: Average weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises

Overview of innovation strategies by country

Country	Research-based	User-driven	Extensive	Social responsibility	Number of observations
Belgium	0.14	-0.12	-0.18	-0.09	705
Bulgaria	-0.19	-0.20	-0.20	0.04	724
Czech Rep.	0.05	0.02	-0.20	-0.07	943
Germany	0.03	0.18	0.07	-0.04	1,525
Estonia	0.09	-0.02	0.06	-0.08	650
Spain	-0.13	-0.23	-0.07	0.12	2,957
Greece	-0.16	-0.10	-0.04	0.11	349
Lithuania	0.33	-0.38	0.00	0.05	604
Latvia	0.12	-0.02	0.10	-0.05	404
Norway	0.35	-0.11	-0.30	-0.17	1,355
Portugal	-0.10	-0.43	0.05	0.09	729
Romania	-0.21	-0.11	-0.09	0.19	1,736
Slovakia	-0.02	-0.23	-0.03	0.04	354

Note: Average weighted by the inverse the sampling fraction, corrected for non-response and for no longer existing enterprises

A cross-classified mixed-effects model

$$\begin{aligned}\text{Level 1:} & \quad y_{ijk} = \beta_{0jk} + r_{ijk} \\ \text{Level 2:} & \quad \beta_{0jk} = \gamma_0 + u_{00j} + v_{00k}\end{aligned}$$

where y is the dependent variable (the factor score on innovation strategy), i is the firm, j is the industry, k is the country, β_{0jk} is the level-1 intercept in level-2 unit jk ; γ_0 is the mean value of the level-1 dependent variable, r_{ijk} is the unmodeled variability (error) for unit i , u_{00j} is the unmodeled variability (error) for unit j , and v_{00k} is the unmodeled variability (error) for unit k .

By substituting the level-2 equation into the level-1 equation we arrive to a reduced form of the model:

$$\text{Reduced:} \quad y_{ijk} = \gamma_0 + u_{00j} + v_{00k} + r_{ijk}$$

which is composed of a single fixed effect γ_0 and three random effects (r_{ijk} at level-1 and u_{00j} and v_{00k} at the higher levels).

Intraclass correlation coefficient (ICC)

$$ICC_j = \frac{\sigma_{u00}^2}{(\sigma_{u00}^2 + \sigma_{v00}^2 + \sigma_r^2)} = \frac{u_{00j}}{(u_{00j} + v_{00k} + r_{ijk})}$$

$$ICC_k = \frac{\sigma_{v00}^2}{(\sigma_{u00}^2 + \sigma_{v00}^2 + \sigma_r^2)} = \frac{v_{00k}}{(u_{00j} + v_{00k} + r_{ijk})}$$

where σ_r^2 is the variance of the of the firm-level errors r_{ijk} , σ_{u00}^2 refers to the variance of the industry-level errors u_{00j} and σ_{v00}^2 is the variance of the country-level errors v_{00k} , respectively.

Results of the mixed-effects model (26 industries and 13 countries)

	(1) Research- based	(2) User- driven	(3) Extensive	(4) Social responsibility
Intercept _{ijk} (γ_0)	0.191*** (0.069)	-0.101 (0.066)	-0.009 (0.041)	0.021 (0.042)
<u>Random effects:</u>				
Level-1 (r_{ijk})	0.573	0.470	0.440	0.348
Intercept _{ij} (u_{00j})	0.052	0.058	0.018	0.029
Intercept _{ik} (v_{00k})	0.036	0.027	0.013	0.008
Level-1 (i) firms	13,035	13,035	13,035	13,035
Level-2 (j) industries	26	26	26	26
Level-2 (k) countries	13	13	13	13
ICC _j	7.9	10.5	3.8	7.5
ICC _k	5.4	4.9	2.8	2.1

Note: *, **, *** denote significance at the 10, 5 and 1 percent levels.

Results of the mixed-effects model (13 industries and 13 countries)

	(1) Research- based	(2) User- driven	(3) Extensive	(4) Social responsibility
Intercept _{ijk} (γ_0)	0.173** (0.083)	-0.125** (0.061)	-0.030 (0.044)	0.055 (0.050)
<u>Random effects:</u>				
Level-1 (r_{ijk})	0.576	0.488	0.444	0.349
Intercept _{ij} (u_{00j})	0.052	0.022	0.012	0.024
Intercept _{ik} (v_{00k})	0.037	0.026	0.013	0.008
Level-1 (i) firms	13,035	13,035	13,035	13,035
Level-2 (j) industries	13	13	13	13
Level-2 (k) countries	13	13	13	13
ICC _j	7.8	4.1	2.6	6.3
ICC _k	5.6	4.9	2.8	2.1

Note: *, **, *** denote significance at the 10, 5 and 1 percent levels.

Conclusions

- Four innovation strategies: i) Research-based, ii) User-driven, iii) Extensive, and iv) Social responsibility
- Sectors and countries matter to a certain extent, but most of the variance (from 80 to 95%) is given by heterogeneity among firms
- Are there more relevant aggregation levels above the firm level (different/deeper industrial classification or regional level)?