Escaping the Doldrums of Non-Innovation: Path From Non-Innovator to Radical Innovator

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Non-innovators, incremental and radical innovators: tracing the role of process and organizational innovations in boosting product innovativeness

Process and organizational innovation as drivers of product innovation: paths from non-innovator to radical innovator

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Abstract

An important challenge for any firm is not only to become innovative, but also to strengthen the innovative capabilities over time, to at least remain innovative or even increase innovativeness. However, statistics repeatedly report that a significant share of firms across Europe are not able to break out of the non-innovative stage and hence jeopardize their own future competitiveness. This study investigates how the adoption and extent of use of specific organizational practices and production technologies discriminate between firms that are not innovative, innovative and radically innovative in new products. Based on survey data for manufacturing firms from five European countries, the article finds that to change from being non-innovative to incrementally innovative, firms benefit from adopting process technologies like e.g. rapid prototyping, whereas the further change from being incrementally innovative to become radically product-innovative requires implementation of organizational innovations like e.g. implementation of knowledge base systems and arrangements for flexible working hours. Interestingly, the process technologies do not statistically support this additional increase in innovative performance. The article discusses the paths towards increased product innovativeness, where our study highlights the importance of organizational innovation practices, leaving a limited role for process innovative technologies.

Keywords: Radical product innovation, incremental innovation, process innovation, organizational innovation, innovation performance.

INTRODUCTION: STAGNATING OR EVEN DECREASING INNOVATIVENESS IN EUROPE

Despite the strong voice by research as to the importance of innovation as a driver of the future competitiveness of firms and nations, the national statistics repeatedly report either stagnating or even decreasing innovativeness of firms (see e.g. Rammer & Schubert, 2018). Perhaps, the explanation is that *allocating scarce resources to uncertain innovation endeavours is a daunting task for many organizational decision makers* (Klingebiel & Rammer, 2014: 246). Across the EU-countries, only around 30% of the small and medium-sized enterprises (SME's) have innovated by introducing a new or significantly improved product or process in a three-year period (Hollanders & Es-Sadki, 2017). For the highest performing countries, like Germany and Belgium, the share is above 40% and for the lowest performing countries e.g. Latvia and Bulgaria the share is below 15% (Hollanders & Es-Sadki, 2017: 81). Common for all European countries, the share of product and process innovative firms to the total number of firms is below 50% and shows a declining trend over time. In fact, compared to 2010 (index 100), the index in 2016 is at 82 for product and process innovation (Hollanders & Es-Sadki, 2017: 19).

This raises the fundamental question, of how the innovative capabilities of firms can be strengthened. Firm innovativeness has been understood to occur in terms of product innovations, process innovations, or organizational innovations (Damanpour and Evan, 1984). We are particularly interested in product innovativeness, i.e. the firms' ability to introduce new products to the market, and whether and how process and organizational innovations can support, sustain and nurture product innovativeness. The second research question we are interested in is how firms can achieve the ability to not only introduce incremental new products, but also radical new products which are seen to create the basis for longer lasting competitive advantages. Grounded in the resource-based view (Barney 1991), we assume that firms able to introduce radical product innovations to the market will possess a distinct set of organizational practices and technological processes, and we are interested in how organizational practices and technological processes of radical product innovators differ from those of incremental innovators, and from those of non-innovators. Summarizing we pose the following research questions:

1) How are process and organizational innovation related to product innovations?
2) How is the set of realized process and organizational innovations of radical product innovators distinct from that of incremental and non-innovators?

We investigate these research questions based on data from small and medium-sized companies (SMEs) from the European Manufacturing Survey (EMS) of five European countries (n=1417), that allows us to consider different configurations out of 13 process innovations (technologies) and 15 organizational innovations, and their depth of implementation. In line with our hypothesis the results suggest that higher breadth and depth of process and organizational innovations explains higher levels of product innovativeness. Further analysis on the distinct sets of radical vs. incremental and non-innovators shows that process innovations are of limited relevance and only one particular set of technologies has explanatory power in advancing firm from non-innovators to incremental and radical innovators. In contrast, organizational innovations in human resource management and organization of work strongly distinguish the more radical innovators from incremental and non-innovators.

Defining the Innovation Forms

The starting point for defining different innovation forms must naturally be with Schumpeter (1934: 66) and the famous quote on the different forms of innovation:

(1) The introduction of a new good –that is one with which consumers are not yet familiar – or a new quality of a good. (2) The introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially. (3) The opening of a new market that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before. (4) The conquest of a new source of supply or raw materials or half - manufactured goods, again irrespective of whether this source already exists or whether it has first to be created. (5) The carrying out of the new organization of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position."

This quote clearly distinguishes the forms of innovation as product, process or new production method, market, material replacements, and organizational innovation. These forms have subsequently been discussed in more detail and prominently by Damanpour (1991). He defined innovation as a new product or service, a new production process technology, a new structure or administrative system, or a new plan or program pertaining to organizational members (Damanpour, 1991: 556). These forms are closely related to the categories by Schumpeter and call for a conceptualisation of innovation as a multi-faceted construct.

The most frequently studied type of innovation is *product innovation*. The product stands out as a source of revenue generator and is often (rightfully) equated with innovativeness. The prominence of the concept refers to the role of the product as the main contributor to performance whether related to financial or market performance. The product is commonly characterized based on the degree of novelty in the offering. Typically, a distinction between incremental and radical innovations is made (for an overview and discussion see e.g. Garcia and Calantone (2002)), although these two attributes are rather understood as opposite poles of a continuum than as categories. Definitions of radical innovations typically include the emergence or use of new knowledge whereas incremental innovations build on existing knowledge and competences (Hill & Rothaermel, 2003). The degree of product innovativeness has also been studied from the firm perspective (Danneels & Kleinschmidt, 2001), i.e. whether the innovation is new to the firm, new the market and whether it entails also major changes in the firm's organizational structure or even in the industry standards (Schultz, Salomo, & Talke, 2013). Intuitively, the innovative efforts towards radically new offerings rest on the assumption that consumers appreciate new features and are fascinated by the new opportunities that the product provides to increase the market performance, significantly.

A second innovative form is the *technical process innovation*, which refers to basic work activities or changed production methods and processes. Process innovativeness "refines and enhances existing procedures and techniques" (Kach, Busse, Azadegan, & Wagner, 2016: 912) and thereby influences the existing set-up and requires updating of resources used in the e.g. production setup. While product innovation constitutes a new offering, the process innovation reflects the "changes in the way firms create and deliver such products and services" (Piening & Salge, 2015: 82). While the development focus is internal (Crossan & Apaydin, 2010), the origin of the innovation is often external as the innovation is equated with adoption of technologies or machines that have been developed by others, e.g. the adoption of robots in a manufacturing process is an example. In this way, process innovation is an innovation type of its own because it represents the changes in internal processes achieved through adoption of innovations developed by other industries and embodied in capital equipment and intermediate inputs (Dosi, 1988; Kach et al., 2016).

Damanpour (1991) labels *organizational innovation* as administrative innovation and it is a means of ensuring that the organization is well-functioning and equipped with appropriate human resources adapted to the current and expected needs of the organisation allowing it to deliver its products and services successfully. According to the OECD (2005: 47) an organizational innovation is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations for instance knowledge management, but it can also be mechanisms to stimulate creativity. Scholars have also used the terminology of behavioural innovation (Avlonitis et al., 1994; Holahan et al., 2014; Mazzanti, Pini, & Tortia, 2006; Wang & Ahmed, 2004) including work styles and management methods such as job rotation or downsizing of hierarchies and is also seen as the core subject of change management.

Hypothesis Development: The interplay between types of innovation

Schumpeter (1934) already early on distinguished between several innovation types, but even so, research has yet to disentangle and investigate distinct dimensions of innovation and thereby respect the multi-dimensional nature of innovation (see for instance Hullova, Trott, & Simms, 2016). It is therefore surprising that very few studies investigate more than one or two types of innovation, e.g. an abundance of studies investigates new products (Brockman & Morgan, 2013; Holahan, Sullivan, & Markham, 2014; Knudsen, 2007) or process innovations as isolated types of innovation (Schlegelmilch, 2016). For a few exceptions considering more types of innovation simultaneously see e.g. Ballot, Fakhfakh, Galia, and Salter (2015), Camisón and Villar-López (2014), and Gunday, Ulosoy, Kilic, and Alpkan (2011). In this sense, earlier research has largely ignored that companies over time expectedly organize their innovation efforts towards different strategic aims, which may include one as more innovative types. This article follows the more recent studies by investigating the synchronically development of the three innovative types, namely product, process, and organizational innovation. Furthermore, our research centres on how the different types of innovation (process and organizational innovation) are related to the degree of novelty of product innovations. Thus far, the literature has mainly focused on distinct levels of novelty e.g. the antecedents of incremental innovation in firms (Knudsen, 2007) and drivers of radical innovation efforts separately (Kelley, O'Connor, Neck, & Peters, 2011; O'Connor & DeMartino, 2006; Slater, Mohr, & Sengupta, 2014). But these studies do not answer what distinct sets of process or organizational innovations firms can have to become incrementally innovative, and perhaps even to convert their innovative efforts into products or services that are radically new? This focus on the relationship between incremental and radical innovation has been an underdeveloped area (Crossan & Apaydin, 2010). The capability view of firms for strategy development suggests that in fostering innovativeness, firms can only dedicate specific capabilities and resources to innovative efforts once. Hence, when seeking innovativeness through product innovation, additional resources are needed for capability and knowledge creation and these may be obtained by investment, by re-organizing resources from existing activities, or third from benefits obtained as an effect of earlier process or organizational innovations. Different types of innovation (product, process and organizational) can therefore not be seen as independent from each other; they are interdependent both in terms of a financial trade-off and a capabilities development trade-off. Specifically, we investigate the extent and adoption of respectively new organizational practices and new production-related process innovations, and analyse how these contribute to discriminating between non-innovative, innovative, and radically innovative firms. In doing so, we go a step further and distinguish between breadth and depth of organizational and process innovations (e.g. Laursen and Salter, 2006). The reason for this is that not only the number of different processes (both organizational and technical) is related to a firm's innovation capability but also the depth of implementation of these processes, i.e. to which extent a firm is able to make use of the full potential of an implemented organizational innovation or technical process innovation.

Relationship between process and product innovation:

Scholars found that firms with a cost focus are more likely to be process innovators (Reichstein & Salter, 2006). Indeed, linking this result also with performance shows that firms do benefit financially from engaging in process innovation, but that beyond a certain threshold the marginal effect is decreasing (Piening & Salge, 2015). The performance effects of process innovation are by no means only financially visible: process innovations are also associated with quality improvements, cost and time savings, and better functionalities of the product (Hashi & Stojcic, 2013; Piening & Salge, 2015). Previous research has also shown that there is a statistical relationship between firms being process and product innovators at the same time (e.g. Camisón and Villar-López, 2014; Gunday et al. 2011). We therefore argue that the implementation of more (breadth) process innovations and a higher extent of use (depth) of these process innovations will be positively associated with a firm's product innovation activities and the ability to introduce incrementally and radically new products. Firms with more and higher use of technological process innovations have a wider repertoire of available choices to combine and will therefore be able to introduce not only better (incrementally new) products but will also be more likely to introduce products entirely new to the market. We therefore propose the following hypothesis:

Hypothesis 1a: Higher breadth and depth of technological process innovations positively discriminate between non-innovators and incremental innovators.

Hypothesis 1b: Higher breadth and depth of technological process innovations positively discriminate between incremental innovators and radical innovators.

Relationship between organizational and product innovation

Holahan et al. (2014) have studied the development practices during the NPD process for incremental and radical innovations respectively. Combined with a research stream that investigates radical innovations from a firm capability perspective (Kelley et al., 2011), it may be discussed how organizational structures can affect radical innovation capabilities (Green & Cluley, 2014; Hoonsopon & Ruenrom, 2012; O'Connor & DeMartino, 2006). Amongst others, these studies identify flexibility, top management support, and decentralization as supportive for radical innovations. Bharadwaj and Menon (2000) find that individual efforts and organizational mechanism to facilitate creativity are positively related to innovation. Furthermore, Bas, Mothe, and Nguyen-Thi (2015: 115) argue organizational innovation being a driver of both product and process innovation persistence respectively. Organizational innovations substantially shape the way work is being organized and carried out in companies. Organizational innovations that can spur innovation include the organization of work both in production facilities for example by stimulating continuing improvements in products and processes, but also in work flows that provide a nurturing ground for more radical innovations by for example encouraging knowledge sharing throughout the organization and its boundaries or stimulating creativity through intrapreneurship and team work. We therefore argue that organizational innovations are positively related to incremental and radical product innovation, and we propose the following hypothesis:

Hypothesis 2a: Higher breadth and depth of organizational process innovations positively discriminate between non-innovators and incremental innovators.

Hypothesis 2b: Higher breadth and depth of organizational process innovations positively discriminate between incremental innovators and radical innovators.

ANALYTICAL APPROACH, DATA AND RESEARCH DESIGN

The analytical approach is formulated in three steps. First, we analyse the overall extent of adoption (breadth) and the extent of use (depth) of the technologies and organizational practices. The technologies are indicators of process innovation and the organizational practices of organizational innovation. Second, we investigate categories of technologies and categories of organizational practices according to the type of use and their relationship with the degree of product innovation. Finally, we investigate the single technologies and practices and their ability to discriminate between the different levels of product innovation. In this way, we can systematically identify the main drivers of increased product innovativeness. The second and third step follow from the confirmative step of hypothesis testing (step 1). The second step inductively dives from the number of innovations into the types of innovations (at the categorical level) and further into an analysis of the role of the single process and organizational innovations. In this way, we achieve a comprehensive picture of the relationships between single organizational and process innovations in moving from a non-innovative to a radical product innovation.

	Analytical ambition	***Data analytical approach***
Confirmative	*H1a: Higher breadth and depth of technological process innovations positively discriminate between non-innovators and incremental innovators.*	Regression of breadth and depth of overall use of technologies and organizational practices
	H1b: Higher breadth and depth of technological process innovations positively discriminate between incremental innovators and radical innovators.	

	H2a: Higher breadth and depth of organizational process innovations positively discriminate between non-innovators and incremental innovators. *H 2b: Higher breadth and depth of organizational process innovations positively discriminate between incremental innovators and radical innovators*	
Inductive	Which categories of technologies and organizational practices discriminate between non-, incremental and radical product innovators?	Regression of categories of technologies and organizational practices
Explorative	Which concrete technologies and organizational practices distinguish between non-innovators and incremental innovators, and between incremental innovators and radical innovators?	Mean comparison of concrete technologies and practices across innovator groups

Table 1: Analytical approach

Study Design

The analyses are based on the multi-topic and multi-country European Manufacturing Survey (EMS). EMS is a European joint survey project carried out in 12 European countries. The current article is based on EMS data from Austria, Denmark, Finland, Sweden, and Switzerland that were collected in 2009 (April through June). The data on the introduction of new products to the market relates to the previous three years, 2006-2008. These five countries are selected because they are smaller countries with similar economic development, and therefore allow us to compare results across a larger sample. The population of firms was limited to manufacturing companies (NACE 15 to 37) with more than 20 employees.

The data collection procedures were in general similar as all responses were collected via surveys. Smaller variations in the procedures for collecting the responses refer to online vs. standard mail questionnaire. Online questionnaires were used in Finland, Denmark and Sweden, whereas Austria and Switzerland used postal questionnaires. In total, three reminders were sent to the respondents, approximately 14 days apart. The sample has been tested for representativeness using sector, region and size and no significant differences were identified indicating that the study is representative of the population of firms in the respective manufacturing industries of the presented countries. A total of 1543 cases are in the dataset (Table 2).

	Number of firms contacted	Number of valid cases	Return rate
Denmark	3341	328	9,8%
Sweden	1593	97	6,1%
Finland	1741	131	7,0%
Austria	3828	309	8,1%
Switzerland	5267	678	12,9%
Total		1543	

Table 2: Return rate by country

Variables

Structural variables. In the further analysis, we focus on SMEs and have consequently excluded cases with more than 499 employees from the analysis. Thus, the sample from which we calculate all further analysis is a reduced sample of 1417 cases. It is well-established from earlier research that larger firms are more innovative than smaller firms (Cohen & Klepper, 1996), and the challenge of being non-innovative is therefore more frequent for smaller firms.

The companies investigated are on average 47 years old (median 37 years, max. 241 years): 73% were founded before 1990, 17% were founded between 1990 and 2000, and 10% were established in or after the year 2000. Concerning the size of companies, we observe that on average the companies had 89 employees in 2008, 46.1% had less than 50 employees employed, 24.5% had 50 – 99 employees, 21.9% had 100 – 249 employees and 7.6% of the companies had 250 – 499 employees.

We performed an aggregation of the manufacturing sector according to technological intensity using the NACE Rev. 2 at 3-digit level for compiling aggregates related to high-technology, medium high-technology, medium low-technology and low-technology. Based on this, 7.2% of firms operated in high-technology industries, 47.9% can be classified as medium-high, 26.6% as medium-low, and 18.3% as low-technology companies. We integrated several control variables for our analysis: age of the firm (log corrected), size (log corrected), finished goods producer (producers of finished goods for consumers or businesses n=769 vs. suppliers or contract manufacturers n=507), the degree of technology intensity at the industry level (according to NACE codes), and five country dummy variables (Austria n=286, Switzerland n=646, Denmark n=268, Finland n=129, Sweden n=88). Finally, we included the degree of highly skilled employees (share of employees with PhD or graduate degree in %, min 0%, max. 70%, mean. 5.6%).

Dependent variable. The dependent variable for the degree of product innovation was computed on two CIS-type questions. The first asking the respondent whether the firm has introduced a product new to the firm in the period from 2006-2008. The second question asked the respondents whether the firm had introduced new products, not only new to the firm, but also new to the market in the same period. By combining these two questions, we computed a variable with 3 categories:

0 = no product innovation. 596 firms (42.5%) did not innovate at all.

1 = product innovation, new to the firm (we further label this type, incremental innovation). 381 firms (27.1%) innovated with incremental product innovation.

2 = product innovation, new to the market (we term this type, radical innovation). 427 firms (30.4%) introduced radically new products to the market.

We further ensure that the three categories are mutually exclusive, i.e. firms indicating that they were doing both incremental and radical innovation were assigned to the group of radical innovators. This variable thus is not a measure of innovation frequency (amount of innovations) but instead reflects the degree of product innovativeness.

Explanatory variables. The respondents checked those practices they had *actually adopted* from a list of 15 organizational practices (aggregated in five categories) and 13 technological processes (in four categories – see table 3). For each item, we asked both the year of adoption and the extent of used potential (high, medium, low). The technologies and organizational concepts have been selected by interviewing technology experts mainly at Fraunhofer Institute in Germany and researchers in Denmark. The criteria for including the technologies were that they would be broadly applicable (i.e. relevant to more than one industry) and that they would represent manufacturing needs. The main explanatory variables for process and organizational innovation are breadth (i.e. the number of practices or technologies adopted) and depth (the extent of use of the practices or technologies).

Descriptive Analyses: Adoption and Use of Technologies and Organizational Practices

To avoid overlap in the adoption of technologies and organizational practices with innovativeness (the dependent variable), we separated the variables by year of adoption and by year of development.

Specifically, the technologies and organizational practices were only included if they were implemented in 2005 or earlier (if adoption in 2006, the case was treated as non-adopter) and the dependent variable was focused on the period 2006-2008. In this way, we ensure that the adoption of organizational practices and technologies has taken place *before* the actual generation of product innovations. Furthermore, the measures as they are based on actual implementation, the year of implementation, and the extent of use (low, medium, high) are both more precise and these reflect actual behaviour and investments in technologies. This article argues that adoption of an organizational practice represents an organizational innovation and implementation of a new production technology (e.g. rapid prototyping) represents a process innovation. Table 3 lists the adoption rate and extent of use for each single technology and organizational practice (in % of the total sample).

		Percentages			
Type	**Technologies**	**not used**	**low**	**Medium**	**high**
Automation and linkage					
	Seamless integration of digital product design	65	5	15	15
	Industrial robots in manufacturing	74	4	11	11
	Integrated quality control (e.g. by laser, ultrasonic waves,)	80	2	9	9
	RFID-utilization in logistics	99	0	0.5	0.5
	Automated Warehouse Systems	90	0	4	6
Machining and production technologies					
	Laser as a tool	89	1	3	7
	Dry processing/minimum quantity lubrication system	94	2	2	2
	Bio- and gene-technology in manufacturing	99	0	0.5	0.5
New product development technologies					
	Rapid Prototyping	95	1	2	2
	Processing of novel materials (e.g. composite materials,)	91	2	4	3
	Virtual Reality, simulation in NPD	92	2	4	2
Digital factory					
	Digital exchange of operation scheduling data with suppliers	80	4	9	7
	Manufacturing execution system	81	2	7	10
	Organizational practices				
Organization of work					
	Team work in production	45	5	28	22
	Task integration	57	6	24	13
	Temporary cross-functional project teams	69	5	17	9
Organization of production					
	Customer/product-focused lines	72	2	11	15
	Internal zero-buffer principle	85	3	7	5
	Total cost of ownership	86	3	7	4
Quality Management					

Quality Circles	83	2	9	6
ISO 9000 quality management	55	4	20	21
Working hours, payment schemes				
Collective arrangement for flexible working hours	69	2	12	17
Wage systems with team performance incentives	87	2	7	4
Financial participation for all employment groups	76	5	12	7
Human resource management				
Regular individual appraisal interviews	45	7	32	16
Knowledge base systems	89	2	7	2
Personnel training programmes as a special function of HR	76	5	12	7
Possibility for employees to work at home	86	6	6	2

Table 3: Adoption and extent of use of technologies and organizational practices

Computation of breadth and depth of process and organizational innovation. The breadth (count variable) for the 13 technologies and the 15 organizational practices indicate that on average the companies adopted 1.7 technologies (min 0, max. 12, standard deviation 1.77) and 3.9 organizational practices (min. 0, max. 14, standard deviation 2.97). Hence, organizational innovation is on average more common than process innovation. For calculating the firms' depth in organizational practices and technological processes, we considered - similarly as in other studies (e.g. Laursen & Salter, 2006) – how competent each firm is in implementing and using each organizational practice and technology (0 = no use, 1 = low degree of use, 2 = medium, 3 = high degree of use). On average, firms reached a depth in technology use of 3.66 (min. 0, max. 26; possible max. 39, standard deviation 4.16) and in use of organizational practices of 8.26 (min. 0, max. 39; possible max. 45, standard deviation 6.9).

Analysis of the extent of organizational and technological process innovation for product innovativeness

The first analytical step is a confirmative test of the four hypotheses on the relationship between product, process and organizational innovation. Due to the categorical nature of the dependent variable, we use ordinal regression to estimate the impact of organizational and technological breadth and depth on the different degrees of product innovativeness. We tested for multi-collinearity, but it was not an issue since all VIF coefficients were below 1.5. For estimating the model, we used the PLUM (Polytomous Universal Model) procedure in SPSS.

Table 4: Ordinal regression – technological & organizational breadth and depth

Variables	*Estimates*	*S.E.*	*Wald*	*Sig.*	*Variables*	*Estimates*	*S.E.*	*Wald*	*Sig.*
Threshold					Threshold				
No innovation	1.492	.476	9.809	.002	No innovation	1.554	.476	10.651	.001
Incremental innovation	2.647	.481	30.219	.000	Incremental innovation	2.700	.482	31.444	.000
Technological breadth	.109	.040	7.553	.006	**Technological depth**	.034	.016	4.226	.040
Organizational breadth	.097	.024	16.244	.000	**Organizational depth**	.042	.010	17.208	.000
Degree of high-skilled employees	.033	.008	16.782	.000	Degree of high-skilled employees	.033	.008	16.956	.000
Age_log	.012	.070	.031	.860	Age_log	.014	.069	.043	.836
Size_log	.294	.078	14.178	.000	Size_log	.314	.078	16.194	.000
Finished goods	-.542	.130	17.511	.000	Finished goods	-.537	.129	17.221	.000
Nace Tech level (low tech)	.123	.274	.201	.654	Nace Tech level (low tech)	.141	.274	.265	.607
Nace Tech level (low-medium tech)	.276	.261	1.116	.291	Nace Tech level (low-medium tech)	.293	.261	1.263	.261
Nace Tech level (medium-high tech)	.147	.252	.343	.558	Nace Tech level (medium-high tech)	.187	.252	.554	.457
Nace Tech level (high tech)	0				Nace Tech level (high tech)	0[a]	.	.	.
Austria	-.050	.269	.034	.853	Austria	-.034	.269	.016	.901
Switzerland	-.215	.247	.762	.383	Switzerland	-.176	.246	.508	.476
Denmark	-.218	.263	.689	.407	Denmark	-.188	.263	.514	.473
Sweden	0[a]				Sweden	0[a]	.	.	.
Number of observations	1026				Number of observations	1025			
Cox and Snell R-square	0.129				Cox and Snell R-square	0.124			
Nagelkerke R-square	0.149				Nagelkerke R-square	0.141			
Pearson sig.	.412 n.s.				Pearson sig.	.409			
Test of parallel lines	.237 n.s.				Test of parallel lines	.310 n.s.			
Breadth organizational concepts^2	.008	.006	1.589	.207	Depth of technical concepts^2	.002	.002	.455	.500
Breadth technical concepts^2	.011	.015	.603	.437	Depth organizational concepts^2	.002	.001	2.773	.096

Reference category: radical innovation (on dep. variable), Nace Tech level (high tech) and Finland for country dummies (on independent categorical variables). Sweden: falls out of the estimation, because one of the control variables was excluded from the data collection in both Finland and Sweden.

The results of the first model (Table 4) indicate a good fit since the Pearson Goodness-of-Fit test (p= 0.412) yields a non-significant value and a non-significant test of parallel lines (p=0.237). The results show that both breadth in process and organizational innovation are significant factors in discriminating between the firms' capabilities in introducing radically new products to the market as contrasted to non-innovators or incremental innovators. Further the model shows that the three groups of innovators are distinct. Out of the control variables, size, the degree of high-skilled employees as well as finished goods producer are significant in discriminating between the firms' ability to introduce new and radically new products. There are no differences across the different groups of technology-level in the industry and across the five countries. The second ordinal regression model (Table 5) estimates the impact of depth, which is a measure of the firms' indicated extent of making use of a respectively adopted practice or technology. The second ordinal regression model too yields a non-significant Pearson value (p .409) and a non-significant value for the test of parallel lines (p .310). Again, the depths in both technological and organizational concepts adoption are significant predictors for firms' product innovativeness. As in the first model, size, the degree to which firms' have highly skilled employees and the fact that they are producers of finished goods allows us to discriminate between their ability to introduce new or radically new products.

Analysis of the Categories of Organizational and Process Innovations

In the second analytical step, the categories of process and organizational innovations are examined. Technologies are organised into 4 categories (automation technologies, machining and production technologies, and new product development technologies, and digital factory), while organizational practices are organised into 5 categories (organization of work, organization of production, quality management, working hours & payment schemes, HR management). These categories were formed by the experts, who in the compilation of practices also formed the relevant groups. The variables were derived by summing up the depth for each technology and practice belonging to the category. Important to notice is that at this stage, we only used the *depth* variables to form each of the categories.

Variables	*Estimate*	*S.E.*	*Wald*	*Sig.*
Threshold				
No innovation	1.685	.486	12.025	.001
Incremental innovation	2.826	.491	33.070	.000
Automation technologies (depth)	.034	.029	1.396	.237
Machining & prod. techn. (depth)	-.089	.061	2.109	.146
NPD technologies (depth)	.308	.064	23.454	.000
Digital factory (depth)	.071	.046	2.382	.123
Degree high-skilled employees	.034	.008	17.484	.000
Age_log	.049	.071	.468	.494
Size_log	.378	.079	23.089	.000
Finished goods	-.486	.131	13.745	.000
Nace Tech level (low)	.168	.277	.368	.544
Nace Tech level (low-med)	.221	.263	.705	.401
Nace Tech level (med-high)	.124	.254	.237	.626
Nace Tech level (high tech)	0a	.	.	.
Austria	-.001	.272	.000	.997
Switzerland	-.141	.249	.320	.572
Denmark	-.206	.266	.600	.438
Sweden	0a	.	.	.
Number of observations	1004			
Cox and Snell R-square	0.127			
Nagelkerke R-square	0.144			
Pearson sig.	.310 n.s.			
Test of parallel lines	.046			

Reference category: radical innovation (on dep. variable), Nace Tech level (high tech) and Finland for country dummies (on independent categorical variables).

Variables	*Estimates*	*S.E.*	*Wald*	*Sig.*
Threshold				
No innovation	1.814	.494	13.504	.000
Incremental innovation	2.965	.500	35.230	.000
Organiz. of work (depth)	.098	.029	11.640	.001
Organiz. of production (depth)	.065	.039	2.875	.090
Quality management (depth)	.023	.043	.278	.598
HRM (depth)	.100	.033	9.429	.002
Payment & working hours (depth)	-.033	.039	.693	.405
Degree high-skilled employees	.031	.008	13.793	.000
Age_log	.050	.073	.468	.494
Size_log	.295	.081	13.274	.000
Finished goods	-.585	.134	19.062	.000
Nace Tech level (low)	.277	.288	.921	.337
Nace Tech level (low-med)	.433	.274	2.493	.114
Nace Tech level (med-high)	.347	.265	1.719	.190
Nace Tech level (high)	0a	.	.	.
Austria	.073	.290	.063	.802
Switzerland	-.153	.266	.329	.566
Denmark	-.240	.283	.717	.397
Sweden	0a	.	.	.
Number of observations	968			
Cox and Snell R-square	0.14			
Nagelkerke R-square	0.159			
Pearson sig.	.373 n.s.			
Test of parallel lines	.376 n.s.			

Reference category: radical innovation (on dep. variable), Nace Tech level (high tech) and Finland for country dummies (on independent categorical variables).

Table 5: Ordinal regression – categories of technological processes and organizational practices

Tables 6 and 7 show the results for the ordinal regression with the four technology categories and the five organizational concept categories as the main predictors for the firms' product innovation ability. Among the three technological categories, only the adoption of NPD technologies distinguishes between non-, incremental and radical innovators. For the organizational concepts, we identified two categories as being significant in the regression: organization of work, and human resource management practices.

Analysis of the Individual Types of Organizational and Process Innovations

To detect significant differences among non-innovators, innovators and radical innovators related to the single practices and technologies, we further analysed the individual organizational practices and technologies in those categories that were significant in the ordinal regression. Again, for the analysis we used the depth variables of each technology and practice, as depth covers both the adoption (1/0) and the competence in use (x 1 – 3). Multivariate analysis of variances (MANOVA) was performed to compare the means of the three sub-groups along the implemented organizational practices and technology levels. Pillai's Trace test is highly significant (.000), therefore, the null hypothesis can be rejected according to which the means over the three sub-groups are equal. We list the differences out of the group comparisons between non-innovators and incremental innovators and between incremental and radical innovators in Table 8 (Levene's test was used to test for equality of variances, T-test for comparison of means).

Technologies. The category of *NPD technology* contains three technologies, namely rapid prototyping, processing of novel materials, and virtual reality and simulation for NPD. Incremental innovators differ from non-innovators with respect to the adoption of rapid prototyping and processing of novel material, but do not exhibit higher levels in the use of virtual reality technologies. In contrast, radical innovators differ from incremental innovators on exactly this technology, i.e. they do not use significantly more extensively rapid prototyping or novel materials, but try to simulate new products through virtual reality technologies. This is in line with other findings from the field which show that especially for radically new products, early prototyping and use of virtual reality tools can significantly reduce uncertainty, enhance speed to market and heighten chances of market success (Dahan & Hauser, 2002; Faullant, Krajger, & Schwarz, 2011). Further, remember that virtual reality is one of the least used technologies, where only 2% of the firms had a high use, and 92% did not implement the technology at all. There seems to be an unleashed potential for further use of this specific technology for incremental innovators to raise their innovativeness further. All other technologies do not separately form a way from incremental to radical innovation, whereas rapid prototyping and novel materials may form paths for non-innovators towards product innovativeness. In this way, they offer a first step towards product innovation.

Organizational practices. The *Organization of work* category contains three practices, team work in production, task integration, and temporary cross-functional teams. In the detailed analysis of mean comparisons, we found no significant differences between the groups for team work in production, i.e. non-innovators, incremental and radical innovators adopted this practice to about the same extent. The practice of task integration describes the planning, controlling or monitoring of tasks by machine operators. Here, incremental innovators show a significant higher degree of task integration than non-innovators, but it is not a distinguishing practice for radical innovators. Temporary cross-function project teams discriminate among all three innovator levels, with radical innovators making the most extensive use of cross-functional project teams. Also, this finding is in line with literature, where product innovation has been shown to benefit from cross-functional teams (McDonough, 2000; Sethi, Smith, & Park, 2001). The path from non-innovator to incremental innovator can therefore be supported by task integration and temporary cross-functional teams. Task integration was adopted by 43% of the firms and cross-functional teams by 31% of the firms. These are therefore some of the more frequently used practices. To stimulate further product innovativeness, the highest potential comes from cross-functional teams as these support both incremental and radical innovation.

Technology/Organizational practice Categories and single technologies/practices	Ordinal regression		T-test mean comparison: Non-innovators vs. incremental innovators		T-test mean comparison: Incremental innovators vs. radical innovators	
NPD technologies	***	(.000)				
Rapid prototyping			**	(.007)	n.s.	(.251)
Novel materials			**	(.003)	n.s.	(.182)
Virtual reality			n.s.	(.339)	**	(.004)
Organization of work	**	(.001)				
Team work in production			n.s.	(.137)	n.s.	(.398)
Task integration			***	(.000)	n.s.	(.416)
Temporary cross-functional teams			***	(.000)	*	(.024)
Human resource management	**	(.002)				
Regular individual appraisal interviews			**	(.003)	n.s.	(.150)
Personnel training programmes as special function in HR			+	(.057)	n.s.	(.105)
Possibility to work at home			n.s.	(.679)	**	(.007)
Knowledge base systems			n.s.	(.124)	**	(.001)
Automation technologies	n.s.	(.237)				
Machining & production technologies	n.s.	(.146)				
Digital factory technologies	n.s.	(.123)				
Organization of production	n.s.	(.090)				
Quality management	n.s.	(.598)				
Working hours and payment schemes	n.s.	(.405)				

Note: *** < 0.000, ** < 0.001, * < 0.05, + < 0.1 significant differences in means are for incremental innovators always higher than for non-innovators, and significant differences in means for radical innovators are always higher than for incremental innovators (the tables can be obtained from the authors upon request).

Table 6: Means comparison

Human resource management: This category includes four practices related to human resource management that target the competence development and motivation of the individual employee in an organization, namely regular individual appraisal interviews, personnel training programmes as special function in HR, the possibility to work at home, and knowledge base systems. In this category, we found two practices that are related to the ability of a firm to generate incremental product innovations: regular individual appraisal interviews, and personnel training programmes as special function in HR. To some degree they are also related to each other from a practical point of view: in appraisal interviews, typically the goals for the upcoming year will be negotiated, as well as the individual needs for competence development. By providing special personnel development programs, firms will be better able to meet theses competence development needs.

The other two practices in this category – possibility to work at home and knowledge base systems – discriminate between incremental and radical innovators. Thus, the possibility to work from home, gives employees additional autonomy to meet their goals. Literature on creativity at work highlights that autonomy will increase motivation and thereby also novelty (Amabile, 1997) although autonomy has also been shown to have detrimental effects on the likelihood of product innovation (Çokpekin & Knudsen, 2012). The results follow the perspectives presented by Amabile, as the possibility to work from home can be a path for firms to increase innovativeness from incremental to radical innovation. This practice is nevertheless also not used by very many firms as only 14% have adopted it – and only 2% use it to a high degree. Hence, this practice appears to present an opportunity for the innovative firms to further advance their innovative capabilities.

Finally, knowledge base systems present a way to systematically collect, monitor and manage different competencies and experiences relevant for e.g. innovation across the firm. Through these systems competencies become visible and accessible for other employees. Following Brusoni, Prencipe, and Pavitt (2001), we can infer that since radical innovation needs input from different systems and technologies, increased visibility and accessibility to knowledge is important. Only if firms know what they know, can they collect and capitalize on the needed competencies and knowledge for the innovation project. These systems therefore support the firms in strengthening the innovative efforts towards radical innovation. As seen with the previous practices supporting a path towards radical innovation, the practice has been adopted by only few firms – here 11% of the firms, and only 2% use knowledge base systems to a high degree.

Summarising these findings, the path from non-innovator to incremental innovator is supported by two NPD technologies and four of the organizational practices. It is worth noting that only one of the practices – *temporary* ***cross-functional teams*** – are beneficial for both the transformation from non-innovator to incremental innovator and further from incremental innovator to radical innovator. All other significant practices and technologies either support the first step or the second step.

THE PATH TOWARDS INNOVATIVENESS: DISCUSSION AND IMPLICATIONS

Even though, innovation is uncertain and the allocation of resources to such endeavors is daunting (Klingebiel & Rammer, 2014), this article has shown that there are ways to persevere for innovation. The descriptive analysis indicates that almost 50% of the firms in this sample are not-innovative, i.e. they have not introduced a new product on the market in a three-year period. Further, less than 30% have introduced new products that are new to the market and possess sufficient newness to directly oppose the competitors' products. This must call for the attention of both policy makers and managers of firms as the competitiveness of firms as well as the growth agenda of policy makers are both highly affected by the innovation efforts of firms. The article further responds to the recent call for research on firms combined innovation strategies (e.g. by Tavassoli & Karlsson, 2015) and the effect of such strategies on innovativeness. Convincingly, the article found that both organizational practices and implementation of new technologies support product innovativeness, but in different ways depending on whether the outcome is incremental or radical innovation. These results confirming hypotheses 1 (a and b) and 2 (a and b) are in line with previous studies (Camisón & Villar-López, 2014; Gunday et al., 2011). The curve-linear effects are not significant – indicating that the thresholds for organizational and process innovation have not yet been reached, and that in all companies studied further implementation in breadth and depth will be beneficial.

Contrary to what might be expected, the evidence does not support the pursuit of process innovation alone as sufficient to increase firms' product innovativeness. On the contrary, our results from the ordinal regression analysis point towards the necessity of implementing both technological and organizational innovation to raise product innovativeness, i.e. one cannot compensate for the other. This is an important finding, because it clearly corroborates our argument in the introductory section that the three types of innovation (product, process, and organizational) are interrelated and must be pursued complementarily. In contrast to Camison et al (2014) and Gundaz et al. (2011), who did not find a significant relationship between organizational and product innovation, our results show that organizational innovation has a far more central role in supporting product innovation. It is not an antecedent to technological process innovation, but a direct and important antecedent to product innovation. Any path to increase the innovative capabilities based on the pursuit of organizational and process innovation should accordingly bring both types into the decision.

With these results, we contribute to the literature that emphasizes the importance of resource orchestration through structuring and bundling of resources (Sirmon, Hitt, & Ireland, 2007) and the literature on resource allocation for innovation (Klingebiel & Rammer, 2014; Maritan & Lee, 2017b).

For firms with more radical innovation intents, Klingebiel and Rammer (2014) show that a broad project portfolio followed later by selectiveness is beneficial. Our results mirror these findings on the resource level, as we show that for radical product innovations a broader and more in-depth resources base of both technologies and organizational practices is necessary. We argue that more organizational practices and more technologies implemented both create an abundant resource base that, combined with strategic flexibility allows for multiple re-combinations of resources across the firm (Purchase, Kum, & Olaru, 2016). Such a broad base of resources may then form the necessary pre-conditions that allow starting a range of diverse, radical product innovation projects (Klingebiel and Rammer 2014).

The necessary combinations of processes that lead to development of innovative capabilities occur through managers' decisions of how to structure and bundle resources, but also on how to allocate especially human resources for new organizational practices. Our study adds to this research in demonstrating that investments in both organizational and technological processes are necessary to boost innovation – the positive correlation between organizational practices and technological processes indicates that there is not a trade-off, but instead a reinforcing and necessary concurrency in their realization.

The resources allocated to innovation are next to financial resources the human resources. When pursuing organizational and process innovation, the managerial consideration is that the type of innovation requires human resources. For organizational innovation, one can expect that more employees across the organization are affected by and involved in the implementation of the organizational practice. The finding that organizational practices primarily support the step from incremental to radical product innovation demonstrates in our view that organizational innovations help enhancing the strategic flexibility needed for redeploying capabilities (Li, Li, Wang, & Ma, 2017; Maritan & Lee, 2017a). The organizational practices are characterised by having a broader reach across employee groups and functions. For instance, the possibility to work from home, which may be given to any or all employees, and where the cross-functional teams may subsequently be the structure, which allows the firm to reconnect the work of the individuals. While the knowledge base systems will allow the firm to easier identify relevant and available human resources to redeploy to specific innovation projects of showing particular strategic potential (Maritan & Lee, 2017a).

Limitations and Perspectives for Future Research

Our study is a based on cross-sectional data. While we integrated a time lag in our analysis to ensure that the adoption of technologies and practices has occurred before the generation of the product innovation, we hold that the adoption figures on breadth and depth are momentary. We encourage future research to monitor through panel data how resource allocation and capability development in technologies and organizational practices within firms change over time (Maritan & Lee, 2017a) and to investigate how the dynamics affect their ability to generate incremental and radical product innovations.

While one can argue that the technologies and organizational practices we included are specific and change over time, we are more interested in the bigger picture of how the different innovation types are interrelated and lead to the generation of product innovations, as well as which conclusions can be drawn explaining the steps from non- to incremental and to radical product innovation. Future research could follow the research of Haned, Mothe, and Nguyen-Thi (2014) and Tavassoli and Karlsson (2015) by investigating the role of the single innovation types over time and identify the factors that may support long term innovativeness of firms.

Finally, our results do not point towards a significant role of automation technologies for product innovation. This may at first hand be surprising given the increasing interest in industry 4.0 and digitalisation. The lack of variation in the adoption of automation technologies may suggest that these technologies are needed but not to different degrees as they facilitate the production of the product itself rather than support specific aspects of the innovation process.

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