Working Papers
Műhelytanulmányok

1093 Budapest, Fővám tér 8.
☎ (+36 1) 482-5424

The use of Community Innovation Survey to investigate the relationship between innovation and performance

Literature review

DEMETER Krisztina
krisztina.demeter@uni-corvinus.hu
Department of Supply Chain Management

183. sz. Műhelytanulmány
HU ISSN 1786-3031

2022. December

Corvinus University of Budapest
Fővám tér 8.
H-1093 Budapest
Hungary

Az innováció és a teljesítmény kapcsolatának vizsgálata a Community Innovation Survey (CIS) alapján

Absztrakt

A műhelytanulmány célja, hogy a CIS felmérés alapján áttekintést adjon az innováció és a teljesítmény kapcsolatáról, és ezzel további kutatásokat alapozzon meg. A tanulmányban először a CIS felmérést mutatjuk be. Utána szisztematikus irodalom áttekintés paramétereit írjuk le. Ezt a cikkek feldolgozása követi, betekintést nyújtva a cikkek kulcskérdéseibe, az innováció és a teljesítmény mérésére felhasznált változókba, a CIS felmérésen túl bevont adatok jellemzőibe, a módszertanba és az eredményekbe. A tanulmányt az elemzések alapján levont következtetések zárják.

Kulcsszavak: *innováció, teljesítmény, Community Innovation Survey, irodalom áttekintés*

The use of Community Innovation Survey to investigate the relationship between innovation and performance

Abstract

The purpose of this working paper is to provide an overview of the articles using the CIS surveys to investigate the relationship between innovation and performance, thus providing a foundation for subsequent research. In the study, first the CIS survey is introduced shortly. Then the parameters of the systematic literature research are described. This is followed by the processing of the articles, looking into the details of the research questions, the variables used to measure innovation and performance, the data utilized beyond the CIS survey, the methodology and the results. The study is completed by some conclusions.

Keywords: *innovation, performance, Community Innovation Survey, literature review*

Content

List of figures

List of tables

Introduction

The CIS survey, organized by Eurostat has been taking place since the mid-1990s. At first, the CIS was asked every four years in some EU countries, and since 2004, every two years in most countries of the European Union, and even some joined countries, like Norway or Iceland. Moreover, there are countries where the questionnaire is asked every year, supplemented with other questions.

The organizations responsible for the inquiry differ from country to country. In Hungary, the survey is organized by the Central Statistical Office. There are countries, where data collection is a joint effort of more than one organization.

Not only the responsible organization, but also the method of sampling varies. "Two countries (BG, MT) carry out the CIS as a census of all firms with 10 and more employees (target population). In all other countries the CIS is at least a combination of a census of large firms and random sampling among small firms. The size threshold above which all firms are covered ranges from 50 employees (BE, EE, SI, IS, NO, HR) to 500 employees (DE) and is 250 employees for the majority of countries" (Dachs et al., 2017). In Hungary the size limit is 100 employees. Nevertheless, the sectors are the same in all countries. Irrespective of the differences among countries, the collected data are significantly more than in average research samples. Furthermore, the sampling is carried out with stratified sampling, aiming for representativeness, which creates a good basis for researchers to analyse and achieve robust results.

The provision of data is highly supported in some countries. It is worth highlighting Spain, where the Technology Innovation Panel (PITEC – Panel de Innovación TEChnológica) not only provides Eurostat's questionnaire data but collects data every year and builds a panel from them for research (practically all the Spanish works rely on this database). Moreover, filling in the questionnaire is compulsory for firms over 200 employees, so the response rate is very high (Coad et al., 2016) In Italy the Micro-Manu dataset, an unbalanced panel of Italian manufacturing firms, is a result of collaboration between the Italian National Institute of Statistics (ISTAT, Regional office for Lombardy) and the Catholic University of the Sacred Hearth (Bartoloni & Baussola, 2018). In Germany, the Mannheim Innovation Panel was built by the Centre of European Economic Research with the cooperation of the German Ministry of Education and Research (Basit et al., 2018; Schmiedeberg, 2008).

The years of CIS surveys and the covered periods are collected in Table 1. Data, related questionnaires and country participation are available only since CIS3 on Eurostat website.

Table 1: CIS rounds and covered periods

Survey round	Covered period
CIS1 (1992)	1989-1991?
CIS2 (1996)	1993-1995?
CIS3 (2001)	1998-2000
CIS4	2002-2004
CIS 2006	2004-2006
CIS 2008	2006-2008
CIS 2010	2008-2010
CIS 2012	2010-2012
CIS 2014	2012-2014
CIS 2016	2014-2016
CIS 2018	2016-2018

Source: Eurostat and Wikipedia https://ec.europa.eu/eurostat/documents/203647/771732/Datasets-availability-table.pdf/8b046263-8535-4161-8b7c-b1df47fbeb3c?t=1643095819685; https://en.wikipedia.org/wiki/Community_Innovation_Survey

Data (scientific use files, SUF) are accessible in the Eurostat safe centre in Luxemburg or via accredited access points. Table 2 shows the participating countries in different CIS rounds.

*Table 2: Availability of microdata for countries in different rounds**

		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	CH	IS	NO	RS	UK
CIS 2018	SUF			x		x	x		x	x	x			x	x			x		x	x			x	x			x					
	Safe centre		x	x		x	x		x	x	x	x	x	x	x		x	x	x	x				x	x	x		x					
CIS 2016	SUF			x		x	x		x	x	x			x				x		x	x			x	x			x					
	Safe centre		x	x		x	x		x	x	x	x	x	x	x			x		x				x	x	x		x					
CIS 2014	SUF			x	x	x	x		x	x	x			x	x			x		x				x	x			x			x		
	Safe centre		x	x	x	x	x		x		x	x	x	x	x		x	x	x	x				x	x	x		x			x		
CIS 2012	SUF			x	x	x	x		x		x			x	x			x						x	x		x	x			x		
	Safe centre		x	x	x	x	x		x		x	x	x	x	x		x	x	x	x				x	x	x	x	x			x		
CIS 2010	SUF			x	x	x	x		x		x			x	x			x						x	x		x	x			x		
	Safe centre			x	x	x	x		x		x	x	x	x	x	x	x	x	x	x		x		x	x	x	x	x			x		
CIS 2008	SUF			x	x	x	x		x		x				x	x	x	x		x				x	x		x	x			x		
	Safe centre			x	x	x	x		x		x	x			x	x	x	x	x	x	x	x		x	x	x	x	x			x		
CIS 2006	SUF			x	x	x			x	x	x				x			x		x				x	x		x	x			x		
	Safe centre			x	x	x		x	x	x	x	x			x			x	x	x	x			x	x	x	x	x			x		
CIS 4	SUF		x	x		x	x		x	x	x				x		x	x		x				x	x		x	x			x		
	Safe centre			x		x		x	x	x	x	x	x		x		x	x	x	x				x	x	x	x	x		x	x		
CIS 3	SUF		x	x		x	x		x	x	x				x			x		x				x	x			x		x	x		
	Safe centre		x	x		x	x	x	x	x	x	x	x		x		x	x	x	x		x		x	x	x	x	x		x	x		

Source: https://ec.europa.eu/eurostat/documents/203647/771732/Datasets-availability-table.pdf/8b046263-8535-4161-8b7c-b1df47fbeb3c?t=1643095819685

About the literature review process

Since we have access to Hungarian CIS data from CIS4, therefore this literature review focuses only on the period between 2004-2021 February (when the queries in WoS were done). Using the WoS database the keywords of – “Community Innovation Survey” and (“company performance” or “firm performance” or “productivity”) were searched, limiting the results to Business and Management categories in English, excluding conference proceedings. Altogether 56 papers are collected. The date of search was 21.02.2021. The reason for including productivity as a key term was that during a preliminary search productivity as a performance measure frequently appeared.

After screening the papers five were excluded due to not using CIS data (1) or not related to performance (9), they usually used the existence of various innovation (such as product, process, marketing or organizational innovation) as a kind of performance measure. Although the remaining papers do not necessarily deal with the overall company performance, focusing more on innovation performance, they were kept in the analysis. So altogether 46 papers were analysed.

Basic characteristics of the collected papers

Publication place and time

The 46 articles were published in 26 different journals. The most frequent ones are, Research Policy (9 papers), Industry and Innovation (6 papers), and Industrial and Corporate Change (3 papers). Beyond these journals the papers are dispersed among many different outlets. Nevertheless, the big CIS samples provided the opportunity to publish in good journals as shown in Table 3.

Table 3: Place of publications

Journal	# papers	Quality (SJR 2021)
Research Policy	9	3.533 (Q1)
Industry and Innovation	6	1.039 (Q1)
Industrial and Corporate Change	3	1.735 (Q1)
European Journal of Innovation Management	2	1.023 (Q1)
International Journal of Innovation Management	2	0.480 (Q2)
Service Industries Journal	2	1.796 (Q1)
Small Business Economics	2	2.630 (Q1)
Technological Forecasting and Social Change	2	2.336 (Q1)
Technology Analysis and Strategic Management	2	0.731 (Q2)
Baltic Journal of Management	1	0.687 (Q2)
British Journal of Management	1	2.047 (Q1)
Business Systems Research Journal	1	0.265 (Q3)
Competitiveness Review	1	0.506 (Q2)
European Management Journal	1	1.477 (Q1)
Global Strategy Journal	1	2.865 (Q1)
Industrial Marketing Management	1	2.206 (Q1)
International Journal of the Economics of Business	1	0.469 (Q2)
International Review of Entrepreneurship	1	-
Journal of Business Research	1	2.316 (Q1)
Journal of Engineering and Technology Management	1	1.042 (Q1)
Journal of Technology Transfer	1	1.609 (Q1)
Management Decision	1	1.155 (Q1)
Review of Managerial Science	1	1.435 (Q1)
Science and Public Policy	1	0.714 (Q1)
Technovation	1	2.069 (Q1)

The use of CIS database for investigating the relationship between innovation and performance became more popular since 2012. But still, the number of papers is not very high, relative to the number of observations and the availability of data in many countries. The time of publications in our sample is shown in Figure 1.

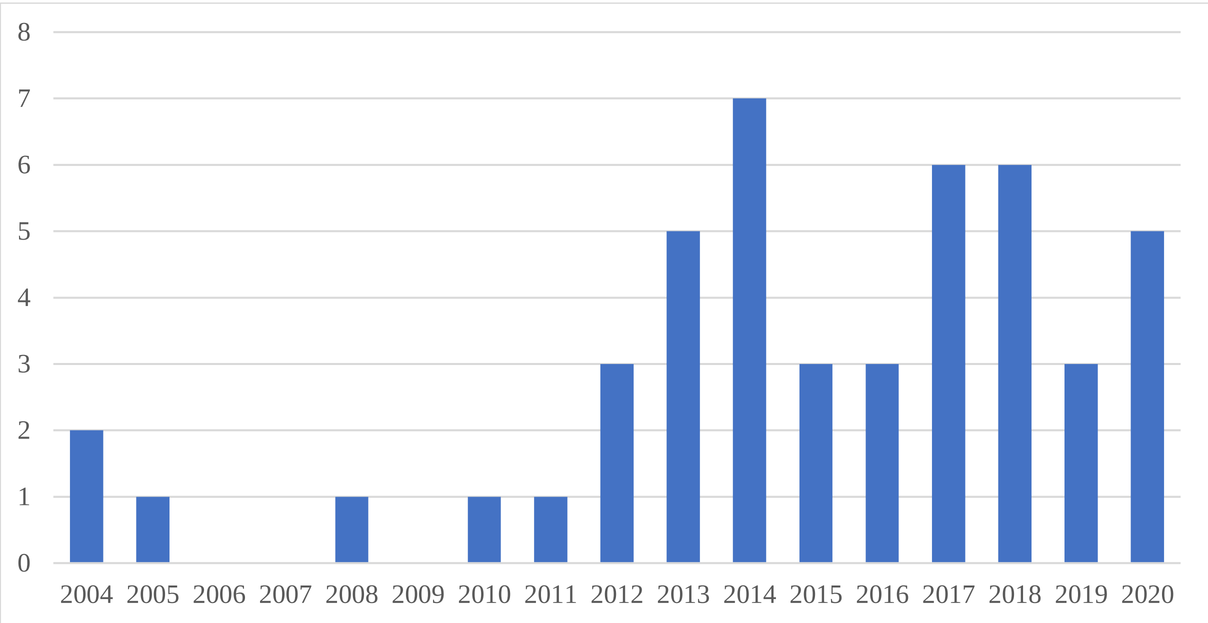

Figure 1: The timeline of publications

The data were the most used in Spain, which probably can be explained by the data cleaning and panel building service of the data collecting organization. We found 11 countries, where researchers used the country-level CIS data for analysis. It means that there are many countries, including Hungary, but many other countries from the Eastern bloc, like Romania, Bulgaria, Czech Republic or Slovakia, where the collected data have not been analysed for our topic. Some researchers collaborated with each other by doing the same analysis in their respective country and compared their results (see 2-3 country papers). And there are some researchers who got access to the whole European level micro database or just used the publicly available macro data.

Table 4: Countries examined in papers

Country	# papers	Papers
Belgium	1	Sarpong & Teirlinck, 2018
Estonia	1	Masso et al., 2013
Germany	4	Basit et al., 2018; Blind et al., 2017; Classen et al., 2014; Schmiedeberg, 2008
Ireland	2	Doran, 2012; Doran et al., 2019
Italy	4	Bartoloni & Baussola, 2018; Cainelli et al., 2004; Caldas et al., 2019; Catozzela & Vivarelli, 2014;
Netherlands	4	Belderbos et al., 2004; Estrada et al., 2016; Sabidussi et al., 2014; Woltjer et al., 2021
Norway	2	Aas & Pedersen, 2011; Sapprasert & Clausen, 2012
Portugal	1	Fernandes et al., 2019
Spain	7	Brem et al.; 2017; Coad et al., 2016; Duch-Brown et al., 2018; Hochleitner et al., 2017; Nylund et al., 2020; Segarra & Teruel, 2014; Urgal et al., 2013
UK	4	Ahn et al., 2018; Battisti &Stoneman, 2010; Crescenzi et al., 2015; Iona et al., 2013
Sweden	3	Lööf-Johansson, 2014; Tavassoli, 2015; Tavassoli & Bengtsson, 2018
2-3 countries	3	Fassio, 2015; Franco et al., 2014; Robin & Schubert, 2013
More than 3 countries	9	2017; Dachs et al., 2014; Evangelista &Vezzani, 2012; Falk, 2005; Ferreira et al., 2020; Greco et al., 2016; Greco et al., 2017; Hashi & Stojcic, 2013; Parrilli et al., 2020; Toshevska-Trpchevska et al., 2020

The investigated CIS rounds

There is a large diversity and also some confusion in using different datasets. Some papers mention a given CIS round but covers years that does not fit with them. Also, there are countries (like Spain, as mentioned before) where additional rounds have been made, and papers which cover more than one round but mention only the investigated years. All this makes identification a little bit difficult sometimes. Nevertheless, in Table 5 there is a list of papers, which made cross-sectional analysis, dealing with only one round.

Table 5: Papers with cross-sectional analysis

CIS round	**Papers**	**#**
CIS2	Cainelli et al., 2004;	1
CIS3	Catozzella & Vivarelli, 2014; Falk, 2005; Schmiedeberg, 2008	3
CIS4	Dachs & Peters, 2014; Evangelista &Vezzani, 2012; Fassio, 2015; Franco et al., 2014; Hashi & Stojcic, 2013; Iona et al., 2013; Lööf & Johansson, 2014; Tavassoli, 2015	8
CIS 2006	Aas & Pedersen, 2011; Classen er al., 2014; Crescenzi et al., 2015; Doran, 2006; Estrada et al., 2016; Urgal et al., 2013	6
CIS 2008	Greco et al., 2016; Greco et al., 2017	2
CIS 2010	Basit et al., 2018; Blind et al., 2017	2
CIS 2012	Caldas et al., 2019, Doran et al., 2019; Fernandes et al., 2019	3
CIS 2014	Parrilli, 2020; Toshevska-Trpchevska et al., 2020	2

There are 27 papers of the 46 (59%), which used only cross-sectional data. The most popular round for the analysis is CIS4. It is also quite visible from the table that there is a 5-8 years timelag between the collection of data and the publication date. Thinking about the Hungarian case, we got access to the CIS 2018 data in early 2022, and journals also have a 1-2 year lead time for publications. The remaining 19 papers cover multiple periods of the CIS. This is detailed in Table 6.

Table 6: Papers covering multiple periods

Paper	CIS2	CIS3	CIS4	CIS 2006	CIS 2008	CIS 2010	CIS 2012	CIS 2014	# CIS rounds	Panel
Ahn et al., 2018					x	x	x		3	x
Bartoloni & Baussola, 2018		x	x		x		x		4	x
Battisti & Stoneman, 2010		x	x						2	
Belderbos et al., 2004	x	x							2	
Brem et al., 2017					x	x	x		3	x
Coad et al., 2016				x	x	x	x		4	x
Dachs et al., 2017		x	x	x	x	x			5	x
Duch-Brown et al., 2018			x	x	x	x	x		5	x
Ferreira et al., 2020						x	x	x	3	
Hochleitner et al., 2017			x	x					2	
Masso et al., 2013		x	x	x					3	
Nylund et al., 2020						x	x		2	x
Robin & Schubert, 2013			x		x				2	
Sabidussi et al., 2014	x	x							2	
Sapprasert & Clausen, 2012		x	x						2	
Sarpong & Teirlinck, 2018					x	x			2	
Segarra & Teruel, 2014				x	x	x			3	x
Tavassoli & Bengtsson, 2018					x	x	x		3	x
Woltjer et al., 2021			x	x	x	x			4	
SUM	2	7	9	7	11	11	8	1		9

Important to note, as mentioned before. Nevertheless, taking into account only the official CIS rounds, there are two studies, which use five rounds, three with four rounds, six with three rounds, and eight with two rounds. Since the questionnaire change round by round, during five consecutive surveys only a few basic questions can be analysed. It might be the reason for the shorter covered time period. Among the studies almost half of them (9/19 = 47%) are based on panel data.

The use of additional data

Since CIS does not contain financial data, which are usually available at national statistical offices or similar bodies, many research supplemented CIS data with additional information. Table 7 gives insight into this issue.

Table 7: Papers using additional information beyond CIS data

Paper	*Additional source*	*Type of additional data*
Aas & Pedersen, 2011	Norwegian Register of Company Accounts	economic accounting data
Bartoloni & Baussola, 2018	Micro-Manu dataset	balance sheets and income statements
Belderbos et al., 2004	Production statistics database	output, employment, value added
Brem et al., 2017	PITEC	e.g. turnover, but not specified
Cainelli et al., 2004	System of Enterprise Accounts	economic indicators
Classen et al., 2014	Creditreform; Monopolkommission	credit rating, age of firm; industry concentration
Coad et al., 2016	PITEC	not specified
Crescenzi et al., 2015	AFD; Annual Respondents Database (firm level)	annual inquiry for FDI; firm level investments
Dachs & Peters, 2014	Eurostat	producer price index data
Duch-Brown et al., 2018	PITEC	total R&D including expenditure abroad
Falk, 2005	OECD Stan database	annual company reports
Lööf & Johansson, 2014		human/physical capital data, value added, total assets, ownership (1997-2006)
Masso et al., 2013	Bank of Estonia; Estonian Business Register	outward firm-level FDI; financial data
Sapprasert & Clausen, 2012		annual financial accounts (1999-2004)
Tavassoli, 2015	Statistics Sweden (SCB)	data on sales, physical capital, human capital, employment, export, import and corporate ownership structure
Tavassoli & Bengtsson, 2018	Statistics Sweden (SCB)	registered firm level data
Woltjer et al., 2021	Statistics Netherlands	non-public microdata

More than one third of the studies (17/46) used additional data. Many of them used financial data (balance sheets and income statements), but also other registered data like ownership, age of the company, employment, export-import data can be found among the type of data. Some of the studies relied on mezo (industry-level, like FDI or industry concentration) or macro data (like producer price index), as well. Many times, data sources are national statistical offices, but there are international bodies, like Eurostat or OECD, banks or the already mentioned Spanish PITEC, which integrates many data useful for innovation-related research.

Methodological characteristics

Looking at the big sample sizes, it is not surprising that the articles use sophisticated methodology. The most frequently used methodology is censored regression, which means that the dependent variable is not observed but censored in some way. For example, when examining the household expenditure on durable goods, there are many households not spending any money in the investigated period, because they did that before or plan to do later. Having zero there could mislead the results. This is the situation with innovation, as well.

Therefore, the idea is to modify the likelihood function so that it reflects the unequal sampling probability for each observation depending on whether the latent dependent variable fell above or below a determined threshold. After James Tobin it is also called Tobit model. The tobit model has several types. In innovation literature Type II tobit model is the most used. Type II tobit model allows the process of participation (selection) and the outcome of interest to be independent, conditional on observed data. It means that first, using several other data it is determined if an object probably innovate or not (selection). Then, using this probability the outcome (level) of this innovation is estimated, again adding several data characterising the innovation activity of the company (https://en.wikipedia.org/wiki/Tobit_model). In simple Tobit I models the two steps are made in one equation.

The Heckman selection model, frequently used in innovation studies, falls into this Type II tobit model. "Suppose that a researcher wants to estimate the determinants of wage offers but has access to wage observations for only those who work. Since people who work are selected non-randomly from the population, estimating the determinants of wages from the subpopulation who work may introduce bias." The Heckman correction takes place in two stages. First, with a probit regression, calculates the probability of work, and in the second stage self-selection is corrected by incorporating a transformation of these predicted probabilities as an additional explanatory variable (for details see https://en.wikipedia.org/wiki/Heckman_correction).

And now we arrived at the CDM model (Crépon et al., 1998). The model was developed by Bruno Crépon, Emmanuel Duguet and Jacques Mairesse. It consists of three main blocks. The first block builds on the decision equation and the intensity equation grasping the R&D intensity of the firm (this block is a Heckman correction, described before). The second block is the innovation equation, connecting R&D intensity to innovation output. The last block is the productivity equation, which relates innovation activity (innovation output) to productivity. We can also say that the model grasps the innovation input (decision + investment), the innovation output (knowledge production) and firm productivity (Hashi & Stojcic, 2013; Duch-Brown et al., 2018).

Censored models have several forms in the studies, we can find logit and probit models, as well, depending on the characteristics of the dependent variable, with random or fixed effect, etc. The number of other analyses, like factor or cluster, SEM analysis are quite rare, and sometimes only used to prepare the data for further regression analysis. Also, using panel analysis is less frequent.

Table 8: Methodological characteristics of papers

Methodology	Papers
Simple/preparatory methods	
Comparison tests (pairwise, Mann-Whitney-Wilcoxon)	Aas & Pedersen, 2011; Cainelli et al., 2004
Correlation analysis	Battisti & Stoneman, 2010; Catozella & Vivarelli, 2014; Falk, 2005
Cluster analysis	Ahn et al., 2018; Battisti & Stoneman, 2010
Factor analysis	Battisti & Stoneman, 2010; Franco et al., 2014; Franco et al, 2014
Propensity score matching/estimation	Basit et al., 2018; Parrilli et al., 2020
Regressions	
linear probit regression	Basit et al., 2018; Crescenzi et al., 2015; Greco et al., 2016
linear logit regression	Fernandes et al., 2019; Greco et al., 2016
multiple logit regressions	Schmiedeberg, 2008;
ordered logistic regression	Hochleitner et al., 2017
OLS regression	Cainelli et al., 2004; Doran, 2012; Evangelista & Vezzani, 2012; Franco et al, 2014; Urgal et al., 2013; Woltjer et al., 2021
OLS regression with IV	Dachs & Peters, 2014
Semiparametric estimation, IV, OLS	Iona et al., 2013
GLS regression	Nylund et al., 2020
Multiple linear regression	Caldas et al., 2019; Fernandes et al., 2019
Hierarchical linear regression	Ahn et al., 2018;
Pseudo-poison ML	Sarpong & Teirlinck, 2018
Granger causality test*	Belderbos et al., 2004
Tobit I	Estrada et al., 2016; Greco et al., 2016; Sabidussi et al., 2014; Tavassoli, 2015;
Tobit II (Heckman two-step)	Sapprasert & Clausen, 2012
Tobit II (Heckman model) +OLS	Blind et al., 2017; Catozella & Vivarelli, 2014; Fassio, 2015; Robin & Schubert, 2013
Double-censored Tobit	Greco et al., 2017
Heckman model + quantile regression	Segarra & Teruel, 2014
CDM	Classen et al., 2014; Doran et al., 2019; Duch-Brown et al., 2018; Ferreira et al., 2020; Hashi & Stojcic, 2013; Masso et al., 2013; Toshevska-Trpchevska et al., 2020
Panel analysis	
Random effects	Bartoloni & Baussola; Brem et al., 2017
Mixed effects (fixed + random)	Tavassoli & Begtsson, 2018
Pooled Instrumental estimators	Dachs et al., 2017
Dynamic GMM model	Lööf & Johansson, 2014
Panel quantile regression	Coad et al., 2016

*A variable X that evolves over time *Granger-causes* another evolving variable Y if predictions of the value of Y based on its own past values and on the past values of X are better than predictions of Y based only on Y's own past values.

The investigated topics

First, let us focus on the contingencies of innovation, by highlighting the type of businesses (industry, size or other characteristics). Details are summarized in Table 9.

Table 9: The contingencies of innovation

Context	Papers
all firms (no restriction)	Bartoloni & Baussola, 2018; Battisti & Stoneman, 2010; Belderbos et al., 2004; Blind et al., 2017; Brem et al., 2017; Caldas et al., 2019; Coad et al., 2016; Crescenzi et al., 2015; Dachs et al., 2017; Dachs & Peters, 2014; Doran, 2012; Evangelista & Vezzani, 2012; Fernandes et al., 2019; Ferreira et al., 2020; Franco et al., 2014; Greco et al., 2016; 2017; Hashi & Stojcic, 2013; Iona et al., 2013; Lööf & Johansson, 2014; Masso et al., 2013; Nylund et al., 2020; Robin & Schubert, 2013; Sapprasert & Clausen, 2012; Segarra & Teruel, 2014; Tavassoli, 2015; Tavassoli & Bengtsson, 2018; Toshevska-Trpchevska et al., 2020
firms with technological innovation	Urgal et al., 2013
manufacturing firms	Ahn et al., 2018; Sabidussi et al., 2014; Woltjer et al., 2021
innovating manufacturing firms	Catozzella & Vivarelli, 2014; Estrada et al., 2016; Schmiedelberg, 2008
mid-low tech sector	Fassio, 2015
ICT firms	Duch-Brown et al., 2018
service firms	Basit et al., 2018; Cainelli et al., 2004
service vs. manufacturing firms	Aas & Pedersen, 2011; Teixeura & Bezerra, 2016
SMEs	Classen et al., 2014; Doran et al., 2019
innovating SMEs	Hochleitner et al., 2017; Sarpong & Teirlinck, 2018
not available	Falk, 2005; Parrilli et al., 2020

Most of the studies (28/46 = 46%) did not make any restriction on the company characteristics, using all the available data in the given context. Some studies take only the manufacturing (8) or service companies (2) or compared the two (2). There are studies, which focused only on innovating firms (altogether 6), let them be from the manufacturing sector (3) or SMEs (2). Company size, more specifically, SMEs are also relatively frequently investigated (4).

Probably the most interesting part of the analysis to look at the topics investigated by the papers. Certainly, it is impossible to build a mutually exclusive list of topics as papers deal with diverse and interrelated topics. In this overview we focus on innovation. Results are shown in Table 10.

Table 10: Topics investigated in the paper

Investigated relationships	**Papers**
Innovation performance as final measure	
innovation → innovation performance	Battisti & Stoneman, 2010; Doran et al., 2019; Tavassoli, 2015; Tavassoli & Bengtsson, 2018
innovation types → innovation performance	Catozella & Vivarelli, 2014
innovation activities → innovation performance	Schmiedeber, 2008
innovation failure → innovation performance	Ferreira et al., 2020
MNE investment → innovation performance	Crescenzi et al., 2015
collaboration → innovation performance	Estrada et al., 2016; Sarpong & Teirlinck, 2018
coopetition → innovation → innovation performance	Fernandes et al., 2019
cooperation → innovation → innovation performance	Parrilli et al., 2020; Robin & Schuber, 2013
external sourcing strategies → innovation performance	Sabidussi et al., 2014
open innovation → innovation performance	Greco et al., 2017; Hochleitner et al., 2017
knowledge resources → innovation performance	Urgal et al., 2013

absorptive capacity → innovation performance	Franco et al., 2014
regulation → innovation costs	Blind et al., 2017
Firm level performance as final measure	
service innovation → financial performance	Aas & Pedersen, 2011;
openness → financial performance	Ahn et al., 2018
persistent innovation → firm performance	Bartoloni & Baussola, 2018;
subsidies → marketing + organizational innovation → firm performance	Basit et al., 2018
R&D cooperation → firm performance	Belderbos et al., 2004
open innovation → firm performance	Brem et al., 2017; Nylund et al., 2020
innovation types → firm performance	Doran, 2012
R&D persistency → firm performance	Lööf & Johansson, 2014
FDI → innovation → firm performance	Masso et al., 2013
organizational innovation → firm performance	Sapprasert & Clausen, 2012
resources → innovation → firm performance	Cainelly et al., 2004
industry innovation spending → firm innovation → firm performance	Caldas et al. 2019
innovation input → innovation output → firm performance	Classen et al., 2014; Duch-Brown et al., 2018; Fassio, 2015; Hashi & Stojcic, 2013; Toshevska-Trpchevska, 2020;
innovation → firm growth	Coad et al., 2016; Evangelista & Vezzani, 2012; Iona et al., 2013
R&D investment → firm growth	Segarra & Teruel, 2014
innovation → employment growth	Dachs et al., 2017; Dachs & Peters, 2014; Woltjer et al., 2021
organizational innovation → productivity growth	Falk, 2005

Looking at the results the papers are relatively balanced between considering innovation performance (19 papers) vs. firm performance (26) as a final measure. Within firm performance the majority of papers considers actual financial (2) or more general level firm performance (16), but there are some papers looking at firm (4), employment (3) or productivity growth (1).

From future research perspective it is important to see what kind of performance measures previous research use for both innovation performance and firm performance. These are detailed in Table 11 and 12.

Table 11: Measures of innovation performance

Measures	Papers
copyright application	Basit et al. (2018)
patent	Schmiedeberg (2008)
effect of the introduction of product and processes in increasing value added; turnover from innovation; the share of firm's total sales due to sales of new products	Battisti & Stoneman (2010); Brem et al. (2017); Catozella & Vivarelli (2014); Estrada et al. (2016); Fernandes et al. (2019); Ferreira et al. (2020); Franco et al. (2014); Greco et al. (2016); Hashi & Stojcic (2013); Parrilli et al. (2020); Robin & Schubert (2013); Sabidussi et al. (2014); Sarpong & Teirlinck (2018); Schmiedeberg (2008); Tavassoli (2015); Tavassoli & Bengtsson (2018); Toshevska-Trpchevska et al. (2020)
impact of innovation upon turnover	Battisti & Stoneman (2010)
growth in productivity in innovative (new to the market) sales	Belderbos et al. (2004)

innovation costs	Blind et al., 2017
ongoing or finished product innovation	Crescenzi et al. (2015)
ongoing or finished process innovation	Crescenzi et al. (2015)
(introduction of) product innovation	Catozella & Vivarelli (2014); Classen et al. (2014); Doran et al. (2019); Duch-Brown et al. (2018); Fassio (2015); Fernandes et al. (2019); Franco et al. (2014); Masso et al. (2013); Parrilli et al. (2020); Robin & Schubert (2013)
(introduction of) process innovation	Catozella & Vivarelli (2014); Classen et al. (2014); Doran et al. (2019); Duch-Brown et al. (2018); Fassio (2015); Fernandes et al. (2019); Masso et al. (2013); Parrilli et al. (2020); Robin & Schubert (2013); Tsinopoulos et al. (2018)
organizational innovation	Crescenzi et al. (2015); Duch-Brown et al. (2018); Parrilli et al. (2020)
marketing innovation	Crescenzi et al. (2015); Duch-Brown et al. (2018); Fernandes et al. (2019); Parrilli et al. (2020)
strategic innovation	Crescenzi et al. (2015)
proxi for form's potential absorptive capacity	Franco et al. (2014)
collaboration intensity	Greco et al. (2017)
open innovation efficiency	Greco et al. (2017)
unit cost reduction, cost reduction in materials, production flexibility increase, production capacity increase	Robin & Schubert (2013)
the impact of innovation activities on products, processes and sustainability (9 effects)	Urgal et al. (2013)

The most typical measure of innovation performance (used in 17 papers) is the turnover from innovation, which is called sometimes differently with the same meaning. The next is the introduction of product (10) and/or process innovation (10), but marketing (4) and organizational innovation (3) are also considered in several studies. Other measures are less frequently used, some of them referring to R&D (like patents or copyrights), others use more complex measures to grasp innovation performance.

Table 12: Measures of firm performance

Measures	Papers
operating result	Aas & Pedersen (2011)
operating result growth	Aas & Pedersen (2011)
profitability (operating result/total assets)	Aas & Pedersen (2011)
return on sales	Bartoloni & Baussola (2018)
profitability growth	Aas & Pedersen (2011)
productivity (sales/employee)	Aas & Pedersen (2011); Cainelli et al. (2004); Coad et al. (2016); Doran (2012); Doran et al. (2019); Duch-Brown et al. (2018); Hashi & Stojcic (2013); Lööf & Johansson (2014); Masso et al. (2013); Toshevska-Trpchevska et al. (2020)
productivity (sales/employee) for innovation modes (complex/intermediate, simple)	Duch-Brown et al. (2018)

labour productivity (value added/employee)	Bartoloni & Baussola (2018); Masso et al. (2013)
labour productivity growth (net value added)	Belderbos et al. (2004); Classen et al. (2014); Falk (2005)
productivity growth	Aas & Pedersen (2011)
turnover (log)	Brem et al. (2017); Fassio (2015); Nylund et al. (2020)
turnover growth, sales growth	Ahn et al. (2018); Cainelli et al. (2004); Coad et al. (2016); Evangelista & Vezzani (2012); Iona et al. (2013); Segarra & Teruel (2014)
ratio of shareholders' funds to total debts	Bartoloni & Baussola (2018)
capital/labour	Bartoloni & Baussola (2018)
employment growth	Cainelli et al. (2004), Coad et al. (2016); Dachs et al. (2017); Dachs & Peters (2014); Evangelista & Vezzani (2012); Segarra & Teruel (2014)
firm turnover growth/industry turnover growth	Caldas et al. (2019)
outcomes from innovating product services (quality, product range, market share)	Hochleitner et al. (2017)
effects of organizational innovation (factor score of six effects)	Sapprasert & Clausen (2012)
labour productivity by innovation, sales by innovation	Woltjer et al. (2021)

Regarding firm performance, labour productivity is the most frequently used measurement, sometimes simply as sales/employment (10 papers), sometimes as net value added/employment (3 studies). Static and dynamic (growth) variables are also used.

Future research opportunities

Analyzing the 46 papers there are some issues worth mentioning for future research.

Regarding the geographical distribution of papers, there are very few papers dealing with innovation in the Central and Eastern European region. We found only one paper focusing on Estonia (Masso et al., 2013) and another two comparing various regions within Europe (Hashi & Stojcic, 2013; Toshevska-Trpchevska et al., 2020). Quite clearly, the level of innovation and governmental policies and supporting systems are different in this region from the more developed part of Europe, which urge further studies to exploit data from Central and Eastern Europe.

There is a wide variety of data used to complement CIS data, including data from banks, statistical offices, company registers. These data are usually used to measure the economic performance of companies, but also to identify ownership or investments. Other surveys, however, are rarely combined with CIS data, beyond a more frequent (yearly) rounds or some additional questions added at national level. Combining CIS with other European level data sources, such as the ICT survey, or transaction data between companies could open new avenues for research topics. such as what exact ICT technologies are behind technology innovations, what relationships can be discovered between innovation and digital technologies, how innovation and digitalization spread along the company networks, etc.

While cooperation, R&D, open innovation, hindering factors of innovation are widely researched, the motivation behind innovation and its impact of performance is much less so.

The reason partly can be, that these intentions are not measured heavily in previous rounds of CIS. Although there were already some strategic variables in the 2016 round of CIS, and there are much more in 2018, using these kinds of data to see the motivations behind innovation is still rare, not only in the CIS papers, by the way, but also in general.

Methodologically, the papers usually rely on censored regression models. Some of the papers rely on panel data, especially Spanish ones. Building panels and looking into longitudinal patterns still provide opportunities. Innovation is naturally a topic which requires a longer timeframe to see its antecedents or results. Also, other data methodologies, like cluster analysis, multidimensional scaling, factor analysis can result in further insight into the topic.

Measuring performance is limited to a small number of variables. In order to see the firm level performance additional databases are needed. That might be a reason why many papers rely only on innovation performance, which can be measured using CIS data. Nevertheless, even studies using additional data stuck to typical measurements, like productivity or turnover, although there could be a more complex set of measures to use and relate to innovations.

References

Crépon, B., Duguet, E. and Mairesse, J. (1998) 'Research, Innovation and Productivity: An Econometric Analysis at The Firm Level', Economics of Innovation and New Technology, 7: 115–58.

The list of sample papers

Aas, TH; Pedersen, PE (2011): The impact of service innovation on firm- level financial performance, SERVICE INDUSTRIES JOURNAL, 31(13), 2071-2090, DOI:10.1080/02642069.2010.503883

Ahn, JM; Mortara, L; Minshall, T (2018): Dynamic capabilities and economic crises: has openness enhanced a firm's performance in an economic downturn?, INDUSTRIAL AND CORPORATE CHANGE, 27(1), 49-63, DOI:10.1093/icc/dtx048

Bartoloni, E; Baussola, M (2018): Driving business performance: innovation complementarities and persistence patterns, INDUSTRY AND INNOVATION, 25(5), 505-525, DOI:10.1080/13662716.2017.1327843

Basit, SA; Kuhn, T; Ahmed, M (2018): The Effect of Government Subsidy on Non-Technological Innovation and Firm Performance in the Service Sector: Evidence from Germany, BUSINESS SYSTEMS RESEARCH JOURNAL, 9(1), 118-137, DOI:10.2478/bsrj-2018-0010

Battisti, G; Stoneman, P (2010): How Innovative are UK Firms? Evidence from the Fourth UK Community Innovation Survey on Synergies between Technological and Organizational Innovations, BRITISH JOURNAL OF MANAGEMENT, 21(1), 187-206, DOI:10.1111/j.1467-8551.2009.00629.x

Belderbos, R; Carree, M; Lokshin, B (2004): Cooperative R&D and firm performance, RESEARCH POLICY, 33(10), 1477-1492, DOI:10.1016/j.respol.2004.07.003

Blind, K; Petersen, SS; Riillo, CAF (2017): The impact of standards and regulation on innovation in uncertain markets, RESEARCH POLICY, 46(1), 249-264, DOI:10.1016/j.respol.2016.11.003

Brem, A; Nylund, PA; Hitchen, EL (2017): Open innovation and intellectual property rights How do SMEs benefit from patents, industrial designs, trademarks and copyrights?, MANAGEMENT DECISION, 55(6), 1285-1306, DOI:10.1108/MD-04-2016-0223

Cainelli, G; Evangelista, R; Savona, M (2004): The impact of innovation on economic performance in services, SERVICE INDUSTRIES JOURNAL, 24(1), 116-130, DOI:10.1080/0264206041233l301162

Caldas, LFD; Paula, FD; de Macedo-Soares, TDLV (2019): Industry innovation spending and openness to collaboration as levers for firm performance, EUROPEAN JOURNAL OF INNOVATION MANAGEMENT, 22(4), 617-638, DOI:10.1108/EJIM-04-2018-0075

Catozzella, A; Vivarelli, M (2014): The Catalysing Role of In-House R&D in Fostering Complementarity Among Innovative Inputs, INDUSTRY AND INNOVATION, 21(3), 179-196, DOI:10.1080/13662716.2014.910890

Classen, N; Carree, M; Van Gils, A; Peters, B (2014): Innovation in family and non-family SMEs: an exploratory analysis, SMALL BUSINESS ECONOMICS, 42(3), 595-609, DOI:10.1007/s11187-013-9490-z

Coad, A; Segarra, A; Teruel, M (2016): Innovation and firm growth: Does firm age play a role?, RESEARCH POLICY, 45(2), 387-400, DOI:10.1016/j.respol.2015.10.015

Crescenzi, R; Gagliardi, L; Iammarino, S (2015): Foreign multinationals and domestic innovation: Intra-industry effects and firm heterogeneity, RESEARCH POLICY, 44(3), 596-609, DOI:10.1016/j.respol.2014.12.009

Dachs, B; Hud, M; Koehler, C; Peters, B (2017): Innovation, creative destruction and structural change: firm-level evidence from European countries, INDUSTRY AND INNOVATION, 24(4), 346-381, DOI:10.1080/13662716.2016.1261695

Dachs, B; Peters, B (2014): Innovation, employment growth, and foreign ownership of firms A European perspective, RESEARCH POLICY, 43(1), 214-232, DOI:10.1016/j.respol.2013.08.001

Doran, J (2012): Are differing forms of innovation complements or substitutes?, EUROPEAN JOURNAL OF INNOVATION MANAGEMENT, 15(3), 351-+, DOI:10.1108/14601061211243675

Doran, J; McCarthy, N; O'Connor, M (2019): The importance of internal knowledge generation and external knowledge sourcing for sme innovation and performance: evidence from Ireland, INTERNATIONAL JOURNAL OF INNOVATION MANAGEMENT, 23(7), -, DOI:10.1142/S1363919619500695

Duch-Brown, N; de Panizza, A; Rohman, IK (2018): Innovation and productivity in a science-and-technology intensive sector: Information industries in Spain, SCIENCE AND PUBLIC POLICY, 45(2), 175-190, DOI:10.1093/scipol/scx072

Estrada, I; Faems, D; de Faria, P (2016): Coopetition and product innovation performance: The role of internal knowledge sharing mechanisms and formal knowledge protection mechanisms, INDUSTRIAL MARKETING MANAGEMENT, 53(), 56-65, DOI:10.1016/j.indmarman.2015.11.013

Evangelista, R; Vezzani, A (2012): The impact of technological and organizational innovations on employment in European firms, INDUSTRIAL AND CORPORATE CHANGE, 21(4), 871-899, DOI:10.1093/icc/dtr069

Falk, M (2005): ICT-linked firm reorganisation and productivity gains, TECHNOVATION, 25(11), 1229-1250, DOI:10.1016/j.technovation.2004.07.004

Fassio, C (2015): How Similar is Innovation in German, Italian and Spanish Medium-Technology Sectors? Implications for the Sectoral Systems of Innovation and Distance-to-the-Frontier Perspectives, INDUSTRY AND INNOVATION, 22(2), 102-125, DOI:10.1080/13662716.2015.1033160

Fernandes, CI; Ferreira, JJ; Veiga, PM; Marques, C (2019): The effects of coopetition on the innovation activities and firm performance Some empirical evidence, COMPETITIVENESS REVIEW, 29(5), 622-645, DOI:10.1108/CR-12-2018-0080

Ferreira, JJM; Fernandes, CI; Ferreira, FAF (2020): Wearing failure as a path to innovation, JOURNAL OF BUSINESS RESEARCH, 120(), 195-202, DOI:10.1016/j.jbusres.2020.08.006

Franco, C; Marzucchi, A; Montresor, S (2014): Absorptive Capacity, Proximity in Cooperation and Integration Mechanisms. Empirical Evidence from CIS Data, INDUSTRY AND INNOVATION, 21(4), 332-357, DOI:10.1080/13662716.2014.942083

Greco, M; Grimaldi, M; Cricelli, L (2016): An analysis of the open innovation effect on firm performance, EUROPEAN MANAGEMENT JOURNAL, 34(5), 501-516, DOI:10.1016/j.emj.2016.02.008

Greco, M; Grimaldi, M; Cricelli, L (2017): Hitting the nail on the head: Exploring the relationship between public subsidies and open innovation efficiency, TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE, 118(), 213-225, DOI:10.1016/j.techfore.2017.02.022

Hashi, I; Stojcic, N (2013): The impact of innovation activities on firm performance using a multi-stage model: Evidence from the Community Innovation Survey 4, RESEARCH POLICY, 42(2), 353-366, DOI:10.1016/j.respol.2012.09.011

Hochleitner, FP; Arbussa, A; Coenders, G (2017): Inbound open innovation in SMEs: indicators, non-financial outcomes and entry-timing, TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT, 29(2), 204-218, DOI:10.1080/09537325.2016.1211264

Iona, A; Leonida, L; Navarra, P (2013): Business group affiliation, innovation, internationalization, and performance: a semiparametric analysis, GLOBAL STRATEGY JOURNAL, 3(3), 244-261, DOI:10.1111/j.2042-5805.2013.01060.x

Loof, H; Johansson, B (2014): R&D Strategy, Metropolitan Externalities and Productivity: Evidence from Sweden, INDUSTRY AND INNOVATION, 21(2), 141-154, DOI:10.1080/13662716.2014.896600

Masso, J; Roolaht, T; Varblane, U (2013): Foreign direct investment and innovation in Estonia, BALTIC JOURNAL OF MANAGEMENT, 8(2), 231-248, DOI:10.1108/17465261311310036

Nylund, PA; Ferras-Hernandez, X; Brem, A (2020): Automating profitably together: Is there an impact of open innovation and automation on firm turnover?, REVIEW OF MANAGERIAL SCIENCE, 14(1), 269-285, DOI:10.1007/s11846-018-0294-z

Parrilli, MD; Balavac, M; Radicic, D (2020): Business innovation modes and their impact on innovation outputs: Regional variations and the nature of innovation across EU regions, RESEARCH POLICY, 49(8), -, DOI:10.1016/j.respol.2020.104047

Robin, S; Schubert, T (2013): Cooperation with public research institutions and success in innovation: Evidence from France and Germany, RESEARCH POLICY, 42(1), 149-166, DOI:10.1016/j.respol.2012.06.002

Sabidussi, A; Lokshin, B; de Leeuw, T; Duysters, G; Bremmers, H; Omta, O (2014): A comparative perspective on external technology sourcing modalities: The role of synergies, JOURNAL OF ENGINEERING AND TECHNOLOGY MANAGEMENT, 33(), 18-31, DOI:10.1016/j.jengtecman.2014.02.001

Sapprasert, K; Clausen, TH (2012): Organizational innovation and its effects, INDUSTRIAL AND CORPORATE CHANGE, 21(5), 1283-1305, DOI:10.1093/icc/dts023

Sarpong, O; Teirlinck, P (2018): The influence of functional and geographical diversity in collaboration on product innovation performance in SMEs, JOURNAL OF TECHNOLOGY TRANSFER, 43(6), 1667-1695, DOI:10.1007/s10961-017-9582-z

Schmiedeberg, C (2008): Complementarities of innovation activities: An empirical analysis of the German manufacturing sector, RESEARCH POLICY, 37(9), 1492-1503, DOI:10.1016/j.respol.2008.07.008

Segarra, A; Teruel, M (2014): High-growth firms and innovation: an empirical analysis for Spanish firms, SMALL BUSINESS ECONOMICS, 43(4), 805-821, DOI:10.1007/s11187-014-9563-7

Tavassoli, S (2015): Innovation determinants over industry life cycle, TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE, 91(), 18-32, DOI:10.1016/j.techfore.2013.12.027

Tavassoli, S; Bengtsson, L (2018): The role of business model innovation for product innovation performance, INTERNATIONAL JOURNAL OF INNOVATION MANAGEMENT, 22(7), DOI:10.1142/S1363919618500615

Toshevska-Trpchevska, K; Disoska, EM; Stojkoski, V; Tevdovski, D (2020): A Comparative Perspective of National Innovation Systems in Europe, INTERNATIONAL REVIEW OF ENTREPRENEURSHIP, 18(2), 255-278

Urgal, B; Quintas, MA; Arevalo-Tome, R (2013): Knowledge resources and innovation performance: the mediation of innovation capability moderated by management commitment, TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT, 25(5), 543-565, DOI:10.1080/09537325.2013.785514

Woltjer, G; van Galen, M; Logatcheva, K (2021): Industrial Innovation, Labour Productivity, Sales and Employment, INTERNATIONAL JOURNAL OF THE ECONOMICS OF BUSINESS, 28(1), 89-113, DOI:10.1080/13571516.2019.1695448

Appendix

Authors	Objective	Country	CIS round / other source	Selected companies	Innovation input / innovation output / firm performance / context	Methodology	Key results
Aas & Pedersen (2011)	Do firms in (1) the service industries and (2) the manufacturing industries focusing on service innovation activities in the period 2004–2006 perform better financially in the following year (2007) than firms not focusing on such activities?	Norway	CIS: 2006 Other: economic accounting data 2006-2007	3575 manufacturing vs 1132 service companies	Inputs: product, process, organizational, marketing innovation Firm perf.: 1) operating result, 2) operating result growth (difference), 3) profitability (operating result/total assets = base earning power (BEP)), 4) profitability growth (difference), 5) productivity (sales revenue/number of employees), 6) productivity growth (difference)	Compare innovating and non-innovating firms by Mann-Whitney-Wilcoxon test	(i) In both industries, firms focusing on service innovation have significantly higher productivity (sales revenue per employee) growth. (ii) firms focusing on service innovation activities in the manufacturing industry outperform firms not focusing on them, both in terms of operating result growth and productivity. (iii) profitability, defined as the operating result divided by asset, is not influenced by firms' focus on service innovation activities.
Ahn et al. (2018)	Investigates the dynamic relationship between openness and firm performance addressing the financial crisis in 2008	UK	CIS 2008, 2010, 2012	480 manufacturing firms over 3 periods (1440 observations)	Inputs: ΔInternal R&D Firm perf.: Δturnover	cluster analysis (Ward+k-means), hierarchical linear regression	(i) Increasing a firm's openness is an effective way of enhancing its dynamic capability and hence its resilience, and (ii) of all the various configurations of openness, the collaboration with partners outside the firm's value chain and international partners have the highest impact on turnover recovery.
Bartoloni & Baussola (2018)	Considers the role of persistent technological and non-technological innovations in affecting firms' performance in terms of productivity and profitability.	Italy	CIS3, CIS4, 2008 Other: balance sheets and income statements	Total: 7923 observations, no. firms total: 3326	Inputs: technological innovator: product or process; complementery innovator: innovate in all tech and non-tech domains;persistent innovator: innovate at least in two consecutive years; occasional innovator: innovate at least ones Firm perf.: 1) operating profitability: return on sales, 2) labour productivity: value added per employee; 3) exposure to external financing resources: ratio of shareholders' funds to total debts; 4) physical capital: capital-to-labour ratio	panel: random effect (RE) estimation techniques	The capacities to develop market-oriented behaviour and introduce new organisational innovations, together with technological innovation, are the drivers of a firm's productivity and profitability. We find that these activities complement technological innovation and that their impact is greater when they persist over time.
Basit et al. (2018)	1) Explore whether firms in service sector that receive government subsidies engage more in marketing and organizational innovation activities than their counterparts. 2) focusing on the subsidized firms in the service sector, the impact of innovations	Germany	CIS: 2010 Other: public R&D subsidies	1039 service companies	Inputs: marketing, organizational innovation Outputs: copyright application	propensity score matching approach and probit model	Public subsidy has a significant positive effect on marketing and organizational innovation. In addition, within the firms that have received government subsidy, the impact of only marketing innovation is found to be significant on firm performance.

	(marketing as well as organizational) on firm performance has been analyzed.						
Battisti & Stoneman (2010)	Explore the simultaneous use of a wide set of innovations in an attempt to (i) map out the patterns of use across firms; (ii) explore the determinants of these patterns; (iii) isolate the synergies; and (iv) explore the impacts of joint adoption on firm performance.	UK	CIS3, CIS4	16383 companies (8172 in CIS3), 959 companies are in both samples	Inputs: process, product, machine, strategy, management, organization, marketing innovation Outputs: effect of the introduction of product and processes in increasing value added; impact of innovation upon turnover	correlation, factor analysis, cluster analysis	The range of innovations can be summarized by two multi-innovation factors, labelled here 'organizational' and 'technological', that are complements but not substitutes for each other. Three clusters of firms with distinctive characteristics are identified where intensity of use of the two sets of innovations is below average; intermediate but above average; and highly above average. Innovativeness tends to persist over time.
Belderbos et al. (2004)	Analyses the impact of R&D cooperation on firm performance differentiating between four types of R&D partners (competitors, suppliers, customers, and universities and research institutes). Examines the impact of R&D cooperation in 1996 on subsequent productivity growth in 1996–1998.	Nether-lands	CIS2, CIS3 Other: output, employment, value added	2056 firms	Inputs: R&D cooperation with competitors, customers, suppliers and universities/research institutes (and spillovers, generated from residuals) Outputs: growth in productivity in innovative (new to the market) sales (innovative sales productivity) Firm perf.: labour productivity growth (net value added)	Granger-causality test	(i) Competitor and supplier cooperation focus on incremental innovations, improving the productivity performance of firms. (ii) University cooperation and again competitor cooperation are instrumental in creating innovations generating sales of products that are novel to the market, improving the growth performance of firms. (iii) Customers and universities are important sources of knowledge for firms pursuing radical innovations, which facilitate growth in innovative sales in the absence of formal R&D cooperation.
Blind et al., 2017	Analyses the impact of formal standards and regulation on firms' innovation efficiency, considering different levels of market uncertainty.	Germany	CIS: 2010	4133 firms	Inputs: perform any kind of innovation Outputs: innovation costs	Heckmann model, 2 stages + OLS	Formal standards lead to lower innovation efficiency in markets with low uncertainty, while regulations have the opposite effect. In cases of high market uncertainty, regulation leads to lower innovation efficiency, while formal standards have the reverse effect.
Brem et al. (2017)	Studies the relationship between open innovation, the use of intellectual property rights (IPRs) and profitability in SMEs.	Spain	CIS: 2008, 2010, 2012 Other: PITEC (annual): e.g. turnover	2873 firms over 6 years (17238 observations)	Inputs: open innovation, patent, industrial design, trademarks, copyright, R&D intensity Outputs: turnover from innovation Firm perf.: turnover (log)	panel: random-effects regression analysis, 1 year time lag applied	(i) SMEs do not benefit from open innovation or from patenting in the same way as larger firms. (ii) SMEs profit in different ways from IPR, depending on their size and the corresponding IPR.
Cainelli et al. (2004)	Assesses the presence of innovation and the amount of resources devoted to innovation to explain the economic performance in the service sector.	Italy	CIS2 Other: economic indicators (1993-1998)	735 service companies > 20 employees	Inputs: total innovation expenditure/employee (log), R&D know-how design exp./emp. (log), acq. and development of software exp./emp. (log), capital equipment exp./emp. (log) Firm perf.: annual average growth rate of sales, annual average growth rate of employees, sales per employee = productivity (log)	pairwise comparison of innovating and non-innovating firms, OLS with robust error	(i) Innovating firms out-perform non-innovating firms in terms of productivity levels and economic growth. (ii) Productivity is linked to the amoiunt of innovation expenditures, especially those devoted to the acquisition and internal development of new software.
Caldas et al. (2019)	Analyzes to what extent spending on innovation activities	Italy	CIS: 2012	890 firms	Inputs: firms innovation spending (internal R&D, external R&D,	multiple linear regression	(i) Full support for the positive moderating effect of intra-industry innovation spending and

	and collaboration at the industry level affects the relationship between firm innovation and performance.				acquire machine, other)/firm turnover, intra-industry innovation spending, Firm perf.: firm turnover growth/industry turnover growth		(ii) partial support for the positive moderating effect of intra-industry collaboration, both regarding the relationship between firm innovation spending and performance. (iii) Knowledge spillovers affect performance.
Catozella & Vivarelli (2014)	Tests under what conditions the nature of the interactions between four different innovative inputs is one of complementarity or substitutability.	Italy	CIS3	2966 manufacturing firm with innovating at least in one examined area	Inputs: internal and external R&D, embodied and disembodied technological acquisition Outputs: the introduction of 1) product and 2) process innovations; 3) the share of firm's total sales due to sales of new products	Heckman correction + regression + correlations	(i) internal R&D and embodied technological acquisitions are complementary only after a minimum threshold of in-house R&D expenditure has been overcome, being substitutive otherwise; (ii) investing in internal R&D affects the nature of the relationships between alternative external sources of innovation, whose interaction proves to be complementary only for firms that invest in internal R&D.
Classen et al. (2014)	Exploratory analysis of differences between family and non-family firms in innovation investment, product and process innovation outcomes, and labour productivity	Germany	CIS: 2006 Other: credit rating, age of firm; industry concentration	2087 SMEs	Inputs: probability of investing in innovation, innovation intensity Outputs: product innovation, process innovation Firm perf.: labour productivity	CDM stepwise econometric model	(i) Family SMEs have a higher propensity to invest in innovation but do so less intensively than their non-family counterparts. (ii) Family SMEs tend to outperform non-family SMEs in terms of process innovation outcomes when controlling for innovation investment. (iii) Given the level of product and process innovation, family SMEs underperform regarding labor productivity.
Coad et al. (2016)	Explores the relationship between innovation and firm growth for firms of different ages.The hypothesis is that young firms undertake riskier innovation activities which may have greater performance benefits (if successful), or greater losses (if unsuccessful).	Spain	CIS: 2006, 2008, 2010, 2012 Other: PITEC	5200 (2006)	Inputs: R&D intensity (expenditure per employee); sales, productivity, employess (log); Firm perf.: sales growth, productivity (sales/employee) growth and employment growth	panel quantile regression	Young firms face larger performance benefits from R&D at the upper quantiles of the growth rate distribution, but face larger decline at the lower quantiles. R&D investment by young firms therefore appears to significantly riskier than R&D investment by more mature firms.
Crescenzi et al. (2015)	Looks at foreign Multinational Enterprises (MNEs) investing in the UK and at their impact on the innovation performance of domestic firms active in their same sector.	UK	CIS: 2006 Other: annual inquiry for FDI; firm level investments	8813 firms	Inputs: MNEs investment flows Outputs: ongoing or finished product/process innovation, organizational / strategic / marketing innovation	standard linear probability (regression) model (LPM)	Domestic firms active in sectors with greater investments by MNEs show a stronger innovative performance. However, the heterogeneity across domestic firms in terms of internationalization of both their market engagement and ownership structure is the main driver of this effect.
Dachs et al. (2017)	New employment created by product innovation may be offset by employment losses from process and organisational innovation and by general productivity increases. The paper investigates this effect empirically.	26 countries	CIS3, CIS4, 2006, 2008, 2010	361,865 observations	Inputs: process / organizational innovation, sales growth from new products Firm perf.: employment growth	panel analysis with pooled IV	The employment-creating effect of new products and services promotes job growth in general. However, employment gains are degraded by employment losses from innovation-related externalities, by employment losses from process and organisational innovation and by general productivity increases. Employment gains and losses increase with technology intensity of the

							sector. The net contribution of innovation to employment growth is mostly positive, an exception being manufacturing industries in recession periods.
Dachs & Peters (2014)	Examines how foreign-owned and domestically owned firms transform innovation into employment growth.	16 countries	CIS4 Other: producer price index data	64,600 firms	Inputs: sales growth due to new products (instrument: product range, R&D, client as source of innovation), process innovation Firm perf.: employment growth	OLS with IV	(i) Due to general productivity increases and process innovation, foreign-owned firms experience higher job losses than domestically owned firms. (ii) Employment-creating effects of product innovation are larger for foreign-owned firms. (iii) Even if foreign-owned firms in total result in net employment growth, this growth is still smaller than in domestically owned firms.
Doran (2012)	Provides an empirical analysis of whether differing forms of innovation act as complements or substitutes in Irish firms' production functions.	Ireland	CIS: 2006	582 firms	Inputs: new to firm product, new to market product, process and organisational innovation Firm perf.: turnover/employee	OLS	There is a substantial degree of complementarity among different forms of innovation. Out of six possible innovation combinations, three are complementary while none exhibits signs of substitutability.
Doran et al. (2019)	Explores the role of internal R&D and external knowledge on SMEs' innovation and performance.	Ireland	CIS: 2012	3245 SMEs	Inputs: knowledge sources: R&D, backwards, forwards, horizontal, public Outputs: product innovation, process innovation Firm perf.: turnover/employee	modified version of CDM	(i) SMEs generate knowledge internally through the performance of R&D, while also exploiting linkages to external agents. (ii) Backward (supplier) linkages have a positive impact on SME product innovation, but negatively affect SME process innovation, while public knowledge sources are positively related to the probability of product innovation occurring. (iii) Process innovation is a key determinant of SME productivity, while product innovation has no impact on SME performance.
Duch-Brown et al. (2018)	Shows that the innovation objectives of firms in the ICT industry are multidimensional by capturing the linkages between R&D, innovation, and productivity.	Spain	CIS4, 2006, 2008, 2010, 2012 Other PITEC (yearly), total R&D including expenditure abroad	1794 firms and 10639 observations, only ICT firms	Inputs: R&D decision and intensity Outputs: product / process / organizational / marketing innovation Firm perf.: productivity ((log) sales/employee for innovation modes: complex (4 types), intermediate (technical or non-technical), simple (only product)	CDM model	Results indicate strong innovation complementarities, different from those found by previous contributions for manufacturing and service sectors. This innovation complexity may be one explanation for the productivity advantage of ICT firms.
Estrada et al. (2016)	Addresses the impact of collaboration with competitors on product innovation performance.	Nether-lands	CIS: 2006	627 innovative manufacturing firms	Inputs: competitor collaboration Outputs: share of turnover attributed to new products	Tobit I regression	Competitor collaboration has a significant positive impact on product innovation performance only when internal knowledge sharing mechanisms and formal knowledge protection mechanisms are present.
Evangelista & Vezzani (2012)	Explores the employment impact of innovation extending the analysis to organizational change.	Czech Republic, Spain, France, Italy,	CIS4	57,856 firms	Inputs: innovation modes (product, process, organizational, complex) Firm perf.: 1) rate of sales growth, 2) rate of growth in number of employees	OLS: three-stage least squares (3SLS) model	Both technological and organizational innovation exert a positive impact on employment mainly "indirectly," that is by improving growth performances in firms. The evidence presented diminish the relevance of the labor displacing effects of the process

		Portugal, Slovenia					innovation, the latter being strong and clearly visible only within the manufacturing industry and only when process innovations are combined with organizational changes.
Falk (2005)	Examines the relationship between organizational innovation and labour productivity growth.	Finland, Germany, Austria, Sweden	CIS3 Other: annual company reports	n.a.	Inputs: percentage of new or significantly changed organizational structure Firm perf.: average annual change in value-added per employee	Simple statistics and correlation figures	(i) The introduction of ICT-enabled business practices (e.g. ERP) and new organisational practices are highly correlated. (ii) There is a positive relationship between labour productivity growth and the percentage of enterprises with new or significantly changed organisational structures.
Fassio (2015)	Analyzes innovation activities in medium-technology sectors in three countries and checks whether cross-country similarities or differences prevail. The results have important implications for the Sectoral Systems of Innovation (similarities within industry) and the Distance-to-the-Frontier (similaries within country) frameworks.	Germany, Italy, Spain	CIS4	4504 firms in mid-low tech sector	Inputs: R&D intensity (log of expenditures in R&D over turnover), sources of knowledge Outputs: new to market / new to firm product innovation, process innovation Firm perf.: turnover (log)	Tobit II regression: Heckman + OLS	The results show that relevant differences between the three countries exist in the intensity of R&D activities and in the economic impact of different types of innovations, providing support to the Distance-to-the-Frontier hypothesis.On the contrary, cross-country similarities emerge among the sources of knowledge used to develop innovations, in line with the Sectoral Systems of Innovation framework.
Fernandes et al. (2019)	Evaluates the impact of coopetition on the innovation activities and innovation performance of companies.	Portugal	CIS: 2012	6840 companies	Inputs: coopetition: cooperation with competitors; importance of information from competitors Outputs: product innovation, process innovation, marketing innovation, proportion of sales from new products	binary logistical regression + multiple linear regressions	Coopetition and the transfer of knowledge to and from competitors generates a statistically significant positive impact on company innovation-related activities and performance.
Ferreira et al. (2020)	Analyzes the impacts of innovative project failure.	16 countries	CIS: 2010, 2012, 2014	292,756 companies	Inputs: 1) log of R&D; innovation from external knowledge 2) predicted values of abandoned innovation; cooperation with home/rest of world partner Outputs: proportion of innovative sales	CDM 3 step structural model	Innovation failure is negatively correlated with companies' experience and acquisition of external knowledge.
Franco et al. (2014)	Extends findings on the antecedents and impact of the firm's absorptive capacity. Innovation cooperation is recognized as a driver of its potential side (PAC). Considering different forms of proximity, authors expect to find a higher impact for interactions occurring between close partners. Human capital (HC) is expected to be as important as	Germany, Italy, Spain	CIS4	10,151 firms	Inputs: *cooperation*: within/outside the country, in business realm, with research institutes, value chain partners; *information*: information provision, flexibility in prod/service provision; *HR*: training programs, lack of skilled workers Outputs: 1) proxi for firm's potential absorptive capacity; 2) share of turnover from new	factor analysis for proxi, OLS	The firm's cooperation with geographically closer partners (i.e., in the same country) increases its PAC, but it is cooperation with institutionally distant ones (e.g., research organizations) that augments it. Among the integration mechanisms of external knowledge, those increasing the firm's HC are the only ones that positively moderate the innovation impact of PAC.

	other organizational mechanisms for the innovation impact of PAC.				products; 3) introducing new products		
Greco et al. (2016)	Hypothesizes that the variety of external innovation channels (search breadth) used by a firm, the extent to which a firm draws deeply from them (search depth) and the extent to which a firm collaborates through different external channels (coupled OI) are curvilinearly related with innovation performance.	14 countries	CIS: 2008	84,919 firms	Inputs: search breadth, search depth, coupled OI (six sources) Outputs: turnover from new markets / new products, new to market / new to firm innovation	Tobit, logit and probit regressions	(i) Search breadth is curvilinearly related with all the measures of innovation performance. (ii) Search depth is not subject to diminishing marginal returns in most cases. (iii) coupled OI is curvilinearly related with the development and commercialization of radically new products.
Greco et al. (2017)	Investigates the relationship between public subsidies and open innovation by assessing how funds provided by local, national and European authorities are associated with open innovation efficiency.	14 countries	CIS: 2008	43,230 firms	Inputs: public subsidy: any / local /national / European Firm perf.: Collaboration intensity (six external channels), R&D collaboration intensity, horizontal collaboration intensity, vertical collaboration intensity, OI efficiency	Double censored Tobit regression	(i) The three typologies of public subsidies are associated with collaboration in beneficiaries.(ii) Local and national subsidies are associated with open innovation efficiency, whereas European subsidies are not statistically significantly associated with it.
Hashi & Stojcic (2013)	Assesses the drivers of the innovation process in two different institutional settings: mature market economies of Western Europe (WE) and advanced transition economies from Central and Eastern Europe (CEE). Four-stage model: decision -> investment (innovation input) -> knowledge production (innovation output) -> firm productivity.	16 countries (9 CEE, 7 WE)	CIS4	appr. 90,000 firms	Inputs: R&D and acquisitions expenditure Outputs: turnover from new products (log) Firm perf.: labour productivity (log of turnover / # empl)	multi-stage (CDM) approach	(i) There is a positive relationship between innovation activities and productivity. (ii) Firms decide to engage in innovation and on how much to invest under pressure of competition. In making these decisions firms rely on the knowledge accumulated from previously abandoned innovations and cooperation with other firms and institutions and other members of their group. (iii) Subsidies lead to additional spending on innovation by firms but do not lead to additional innovation output. (iv) Larger firms are more likely to embark on innovation activities and invest more in innovation but innovation output decreases with firm size. (v) There are several differences in behaviour of firms in CEE and WE countries.
Hochleitner et al. (2017)	Studies the relationship between a wide range of open innovation (OI) activities and the open development of new products, the non-financial innovation outcomes of SMEs and the entry-timing of these firms.	Spain	CIS, 4, 2006	8682 SMEs carried out at least one innovation activity	Inputs: inbound OI: cooperation, acquisitions and information gathering variables Firm perf.: outcomes from innovating products services (quality, product range, market share)	ordered logistic regression model	(i) Three groups of innovation activities (external information sources, cooperation and acquisition of machinery, knowledge or R&D) are suitable indicators of OI. (ii) These activities are related to three non-financial product-oriented outcomes of SMEs: quality, product range and market share. (iii)Distinguish between pioneers (the first to introduce innovations onto the market) and followers and find that most OI activities relate to the pioneering behaviour.

Iona et al. (2013)	Investigates the relationship between business group affiliation, innovation, internationalization, and firm performance.	UK	CIS4	12,828 firms	Inputs: organizational innovation, managerial innovation, technological innovation (product and process + machinery acquisition) Firm perf.: growth rate of sales turnover over 3 years	semiparametric estimation, IV and OLS	(i) Firm performance is higher for those firms that join business groups rather than for stand-alone firms; (ii) the introduction of innovation through organizational and/or managerial practices provides higher performance in business groups affiliated than in unaffiliated firms; (iii) the joint adoption of innovations is more beneficial than the individual adoption; (iv) the interplay between business group affiliation and innovation leads to better performance in those firms that face competition in international markets rather than in those whose product market is domestic only.
Lööf & Johansson (2014)	Studies the influence of metropolitan externalities on productivity for different types of long-run R&D engagement.	Sweden	CIS4 Other: human/physical capital data, value added, total assets, ownership (1997-2006)	3094 from CIS (total: 25,892 observations)	Inputs: R&D persistency Firm perf.: labour productivity (log)	dynamic general method of moments model (panel)	(i) The productivity premium associated with persistent R&D is close to 8 per cent in non-metro locations and about 14 per cent in the largest city. (ii) A firm without any R&D engagement does not benefit from the external milieu in metro areas. (iii) No productivity premium is associated with occasional R&D effort regardless of the firm's location.
Masso et al. (2013)	Studies the linkages between inward and outward FDI and the innovation inputs and outputs of domestic and foreign+E38 owned companies in Estonia.	Estonia	CIS3, CIS4, 2006 Other: outward firm-level FDI; financial data	CIS3: 3161, CIS4: 1747, CIS2006: 1924	Inputs: Cooperation, source of information, innovation expenditure Outputs: product and process innovation Firm perf.: sales/employee (log), value-added/employee (log)	CDM (based on Griffith et al. (2006) 1-2: generalized Tobit, 3: probit (not panel!)	(i) The higher innovation output of foreign owned companies vanishes after various company characteristics are controlled for, but there are significant differences in innovation inputs such as the higher use of knowledge sourcing and the lower importance of various impeding factors. (ii) Outward investment has a positive influence on innovativeness among both domestic and foreign owned companies.
Nylund et al. (2020)	Takes a knowledge-based view of the firm and sheds light on the moderating role of the processes of open innovation (OI) on the economic results of firms' subject to automation.	Spain	CIS: 2010, 2012 Other: PITEC	5287 companies (21148 observations through 4 years)	Inputs: automation: increase in machinery and software investments while reducing labour force; OI variables (partners, regions) Firm perf.: log of turnover (year after automation)	GLS regressions	Turnover is increased for those automating firms that engage in OI with suppliers. These results indicate that suppliers possess the knowledge required for successful automation, and firms that innovate together with suppliers are better at leveraging investments in automation. Automating firms should exercise caution when choosing collaboration partners from the same country.
Parrilli et al. (2020)	Inquires whether and how the regional context and its specific technological capabilities produce a differentiated impact of STI (Science and Technology-based Innovation) and DUI (learning by Doing / Using / Interacting) innovation modes	Many countries at regional levels	CIS: 2014	n.a.	Inputs: STI: R&D or cooperation with universities / research centres; DUI: in-house activities, cooperation with suppliers, customers, competitors, consultants Outputs: product innovation (goods/services), process	propensity score estimation for multiple treatments	Both regional specificities and the nature of innovation matter. In addition, the DUI innovation mode proves to be often more important than expected for most types of innovation output.

	on innovation outputs, alongside the nature of innovation outputs.				innovation, organizational innovation, marketing innovation, innovative sales		
Robin & Schubert (2013)	Evaluates the impact of cooperation with public research on firms' product and process innovations.	France, Germany	CIS4, 2008	20,672 France 5200 Germany	Inputs: cooperation with public research, openness (sources of knowledge), innovation expenditure/emp Outputs: product innovation (y/n), % of total sales from new products, process innovation (y/n), process innovation output measures: (1) the extent of unit cost reductions, (2) the extent of cost reductions in materials, (3) the increase in production flexibility, and (4) the increase in production capacity	two-equation Generalized Tobit model (selection + intensity) & Heckit model with endogeneity correction	Cooperating with public research increases product innovation, but has no effect on process innovation, which depends more on firms' openness.
Sabidussi et al. (2014)	Assesses the impact on innovative performance of alternative external sourcing strategies.The study compares external sourcing strategies based on specialization to those based on integrating various sourcing modalities (e.g.,alliances and M&As).	Nether-lands	CIS2, CIS3	3657 observations from 2862 manufacturing firms	Inputs: (1) a strategy based on M&As, (2) a strategy specialized in alliances, and (3) an integration strategy Outputs: sales ratio from new products	Tobit models	Synergies exist among external sourcing modalities: Integrating different external sourcing modes is more effective than specializing in a single mode, especially when the specialization is focused on M&As. Among the specialized strategies, focusing on the use of strategic alliances leads to higher levels of innovative performance than relying exclusively on M&As.
Sapprasert & Clausen (2012)	Studies organizational innovation, its persistence, its relationship with technological innovation, and their influence on firm performance.	Norway	CIS3, CIS4 Other: annual financial accounts (1999-2004)	1737 firms	Inputs: organizational innovation (0/1 based on three types of org inn) Firm perf.: effects of organizational innovation (factor score of six effects)	Heckman two-step estimation	Persistent in organizational innovation raises the (positive) effects on firm performance. Benefits of organizational innovation are increased by the combinative effect of organizational and technological innovation. Older and larger firms are more inclined to attempt organizational change, while smaller firms are more able to benefit.
Sarpong & Teirlinck (2018)	Studies the relation between functional and geographical diversity in innovation partners and new-to-the-market (NtM) and new-to-the-firm (NtF) innovation performance in SMEs.	Belgium	CIS: 2008, 2010	796 product innovator SMEs	Inputs: collaboration with functional partners (suppliers, clients, competitors, consultants, universities, research org), with geographical partners (domestic, Eu, USA, China/India, other) Outputs: average share of sales from new products	Pseudo-poison maximum likelihood (PPML) estimation (two-stage)	(i) There is positive relation between market partners and innovation NtF, and between science and global partners and innovation NtM. (ii) More diversity in science partners enhances the balance between NtF and NtM innovation. Diversity among international partners enhances NtF and NtM innovation, but not the balance between them. (iii) A cooperation strategy balancing functional with geographical partner diversity enhances the balance between NtF versus NtM innovation.
Schmiedeberg (2008)	Tests for complementarity / substitution of different innovation activities, i.e. internal R&D, R&D contracting, and R&D cooperation.	Germany	CIS3 Other: Mannheim	689 innovating manufacturing firms	Inputs: activities: internal R&D, contracted R&D, R&D cooperation, Outputs: patent, sales share of new products	multiple logit regressions, correlations	Evidence is provided for significant complementarities between internal R&D and R&D cooperation, but cast doubt on the complementarity of internal and contracted R&D, since a productivity effect on firms'

			Innovation Panel (yearly)				patenting probability or sales with new products cannot be found.
Segarra & Teruel (2014)	Analyses the effect of R&D investment on firm growth.	Spain	CIS4, 2008, 2010 Other: PITEC (2004-2008, yearly) growth rates (sales, employees)	3807 firms	Inputs: R&D effort, internal/external R&D Firm perf.: sales growth, employment growth	probit model (selection + Heckman correction), quantile regression	(i) R&D investments positively affect the probability of becoming a HGF (high-growth firm), however, differences appear between manufacturing and service firms. (ii) Internal R&D presents a significant positive impact for the upper quantiles. (iii) External R&D shows a significant positive impact up to the median.
Tavassoli (2015)	Analyzes how the influence of firm-level innovation determinants varies over the industry life cycle. Two sets of determinants are distinguished: (1) determinants of a firm's innovation propensity, i.e. the likelihood of being innovative and (2) determinants of its innovation intensity, i.e. innovation sales.	Sweden	CIS4 Other: data on sales, physical capital, human capital, employment, export, import and corporate ownership structure	3309 firms	Inputs: innovation propensity (measured as the sum of expenditures in six innovation activities) Outputs: innovation intensity: sales income from new products (log)	Heckman two-step 1) select innovative firms (probit) 2) determinants of 'intensity of innovation' for selected firms (linear)	The importance of the determinants of innovation propensity and intensity is not equal over the stages of an industry's life cycle.
Tavassoli & Bengtsson (2018)	Analyses the effect of business model innovation (BMI) on the product innovation performance of firms, based on a dynamic capabilities theoretical framework.	Sweden	CIS 2008, 2010, 2012 Other: characteristics of the firms (e.g., physical capital and number of employees) based on registered firm-level data	11,218 firms (three waves combined)	Inputs: Three exclusive BMI categories: 1) BMI (1 - introduce product innovation + 1 of each process/organizational/marketing innovation) 2) no innovation 3) ONLY product innovation Outputs: product innovation performance: innovative sales of firm/emp (log)	fixed effect estimator, random effect estimator regressions, 2SLS for endogenity	BMI in the form of product innovations combined with different complementary and simultaneous innovations in processes, marketing and organisation act as isolating mechanisms towards replication by competitors, resulting in superior firm performance.
Toshevska-Trpchevska et al. (2020)	Provides a comparative perspective among three different institutional settings in Europe: Central and Eastern European countries (CEE), Southern European countries and Northern European countries.The model directly links R&D engagement and intensity to innovation outcomes measured either as process or as product innovation and then estimates the effectiveness of the	11 countries, (CEE: 6; SE: 3; NE: 2)	CIS: 2014	CEE: 40,531 SE: 39,923 NE: 11,327	Inputs: applying organizational or marketing innovation activities, subsidies, sources of product/process innovation, R&D + acquisitions expenditure Outputs: turnover from new products (log) Firm perf.: labour productivity (log) - turnover / # empl	CDM	The links between innovation inputs, innovation outputs and productivity were found to be rather weak. Among those firms that innovate, innovation output is relatively higher for small firms (compared to large firms) in Northern Europe. This relatively important role for small firms in innovation was not found for the other two country groups.

	innovative efforts in terms of productivity gains.						
Tsinopoulos et al. (2018)	(a) How does engaging with open innovation (OI) support an organization's process innovation? and (b) How does the motivation to achieve legitimacy affect the relationship between engaging with OI and process innovation?	UK	CIS4, 2006, 2008, 2010	n.a.	Inputs: cooperation, external information, external R&D Outputs: Process innovation (0/1)	logit regressions	Engagement with OI increases the likelihood of introducing new processes and the motivation to achieve legitimacy affects this relationship. However, this moderating effect is different depending on how engagement takes place. It is positive on co-operation with external parties, and negative on the use of information.
Urgal et al. (2013)	This paper examines the process that links knowledge resources to innovation performance. As proposed, this relationship is mediated by innovation capability and management commitment moderates this mediation effect.	Spain	CIS: 2006	9432 firms with technological innovation activities	Inputs: internal/external knowledge resources, innovation capability (did innovation 0/1), management commitment (inhouse R&D) Outputs: the impact of innovation activities on products, processes and sustainability (9 effects)	OLS with robust estimation of SE	Knowledge resources not only have a direct positive effect on innovation performance but also an indirect effect by improving the firm's innovation capability. We also confirm the moderating role of management commitment, but with limitations.
Woltjer et al. (2021)	This article examines the relationship between firm-level innovation and employment growth for industrial firms. It extends the literature by making an explicit split between the expansion effect of innovation and the labour productivity effect.	Nether-lands	CIS4, 2006, 2008, 2010 Other: other non-public microdata	8210 manufacturing firms (2052 + 1780 + 2475 + 1903)	Inputs: process/product innovation Firm perf.: labour productivity per innovation: effect of innovation on employment per unit of sales (the inverse of labour productivity); sales by innovation: effect on sales	OLS	Both product and process innovation increase labour productivity and therefore induce direct reductions in employment. However, these negative employment effects are more than compensated by increases in sales, implying that both process and product innovations increase employment.