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INNOVATION IN TIMES OF CRISIS: A SYSTEMATIC LITERATURE REVIEW

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Today the world faces significant economic and financial crises, which have drawn firms into high levels of uncertainty and directly influences their innovation strategies. The literature on organizational decline reveals a lack of agreement about the effects of decline on innovation. This study aims to shed light on how economic crisis affects innovation and to provide a comprehensive picture of the innovation constraints and determinants with a focus on environmental factors. To add to the extant knowledge in the area of innovativeness in crisis, a systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses was conducted. 70 conceptual and empirical research articles published in the period 2000–2021 from highly ranked journals according to the Association of Business Schools rating were reviewed. The article presents three identified patterns related to a firm's innovation behaviour in crisis: a cyclical behaviour in which most of companies reduce their costs and become more unwilling to engage in innovation activities, a neutral behaviour with a view to keep the status quo, and a counter-cyclical behaviour when companies tend to boost their innovation activities. The three innovation behaviours are contingent on several factors that hamper innovation. Furthermore, the findings suggest that innovation positively affects the performance of firms in the context of crisis and this impact is contingent upon the level of environmental turbulence. This review contributes to the extant knowledge on the adaptation of firms to adverse environments. The study offers a nuanced understanding of the main innovation strategies to respond to the economic downturn at the firm and country level, highlights benefits of innovation in highly turbulent settings and gives a detailed description of factors that play an important role in counteracting the negative effect of crisis on firms' investment in innovations.

Keywords: innovation, innovativeness, crisis, R&D, innovative ambidexterity, systematic review.

INTRODUCTION

In his seminal article, J. A. Schumpeter [Schumpeter, 1939] emphasizes that innovation is an essential factor in the long-term success of firms and it lies at the very heart of the economic evolution. Since that time, this topic has attracted a great deal of attention [Damanpour, 1987; Subramanian, Nilakanta, 1996; Prajogo, Ahmed, 2006; Schot, Steinmueller, 2018]. Innovations can be classified into three categories: 1) product innovations (changes in product by providing a new good or service [Howells, 2000]); 2) process innovations (change in production processes by implementing new methods

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of organization and combination of inputs in the production process [Berchicci, Tucci, Zazzara, 2014]); and 3) organizational innovations (provision of a new or improved organization of resources within the company [Brancati et al., 2021]).

Based on this, we generally refer to two distinct innovation activities of a company: product innovation, which generally refers to a new product that is introduced on the market and used, and process innovation, which refers to new processes introduced in an organization in order to improve the quality of the product, to enhance the production methods or to lower the production costs [Berchicci, Tucci, Zazzara, 2014]. Following M. Benner and M. Tushman, it is possible to classify these types of innovations into two categories: exploratory innovations, which are radical innovations aimed to satisfy the needs of customers or emerging markets, and exploitative innovations, which are incremental innovations aimed to meet the requirements of existing customers or markets [Benner, Tushman, 2003]. The notion of ambidexterity has been emphasized in most studies [Gibson, Birkinshaw, 2004; He, Wong, 2004] which assert that organizations must become ambidextrous and develop exploratory and exploitative innovation capabilities across different organizational units [Tushman, O'Reilly, 1996; Benner, Tushman, 2003].

The world today faces considerable economic and financial crises, which create high levels of uncertainty. The 2008 financial crisis was broad, deep, and long [Archibugi, 2017], making business opportunities less precise [Archibugi, Filippetti, Frenz, 2013b] and generating significant downward shifts in demand levels [Cerrato, Alessandri, Depperu, 2016]. The ongoing COVID-19 pandemic has reached almost every country in the world and became the second-largest global recession in history, followed by rising geopolitical tensions. Companies have been greatly impacted by the drop in demand for goods and services, as well as supply disruptions [Krammer, 2022]. Due to high levels of turbulence and instability in crisis environments, firms are forced to cope with these changes [Grewal, Tansuhaj, 2001], changing strategy and behaviors to be able to survive and avoid deteriorating performance [McKinley, Latham, Braun, 2014].

In response to a crisis, the behavioural theory of the firm suggests risk-seeking behaviour and strategic changes firms engage in to restore an adequate performance level. On the other hand, the theory of threat rigidity argues that if performance is so low to threaten survival, firms may become risk-averse, refrain from any strategic change, and emphasize cost reductions and resource-saving [Colombo et al., 2016]. The ability of the firm to manage and adopt behavior and strategy that assist leaders in turning crisis-induced changes into opportunities is critical for organizational outcomes [Wenzel, Stanske, Lieberman, 2020; Klein, Todesco, 2021].

Severe recessions are primarily characterized by a significant decline in demand. Experts recognize that negative demand shocks affect investment [Filippetti, Archibugi, 2011; Armand, Mendi, 2018], and the lower profits experienced during recessions are expected to limit the ability of firms to invest in innovation [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]. The Schumpeterian tradition, centered on investment in innovations, asserts that economic growth is conditioned by attempts to in-

troduce new products and processes to the market, while in an unfavourable economic context investments are likely to be reduced [Freeman, Clark, Soete, 1982].

A number of studies highlight a significant effect of increased innovation expenditures on economic growth [Dobrzanski, 2018], while the fall in aggregate expenditure leads to a reduction in the proportion of companies investing in innovation [Armand, Mendi, 2018]. Following D. Archibugi and colleagues, "innovation related investment is captured in a wide sense, incorporating not only expenditures on in-house R&D but also technology embodied in the purchase of machinery, equipment and software, licenced-in technology (patents or other know-how), training of staff in support of innovation, and expenditures on design of products, process and services" [Archibugi, Filippetti, Frenz, 2013b, p. 1250].

Crisis response is a growing field because crises represent both threats and opportunities for companies; therefore, companies are searching for novel models of strategic behavior aimed at overcoming threats to maintain competitiveness and seek new opportunities [Krammer, 2022]. There are various types of firm behaviour in crisis and decline [McKinley, Latham, Braun, 2014]: responding with existing resources to ensure short-term survival or investing in innovative activities to build capacity to ensure long-term survival [Lavie, Stettner, Tushman, 2010]. Conceptual and empirical research has been conducted to shed light on the strategies to be implemented in periods of crisis [Klyver, Nielsen, 2021; Krammer, 2022]. A strategy of innovation proves to be effective during times of crisis and helps create optimistic prospects for the future [Klyver, Nielsen, 2021]. In addition, a recent study by S. Krammer [Krammer, 2022] found that innovators, especially younger one, are more likely to adapt to COVID-19 than non-innovators.

A large and growing body of literature has investigated the impact of the economic downturn on innovation, innovation related expenditures, and on investment in innovation projects [Filippetti, Archibugi, 2011; Paunov, 2012; Archibugi, Filippetti, Frenz, 2013b]. Detailed examination of innovation investments showed that the crisis sharply reduced the number of firms willing to increase their innovation investments from 38% to 9% [Archibugi, Filippetti, Frenz, 2013b]. In another major study [Archibugi, Filippetti, Frenz, 2013a], the authors found that the crisis led to a concentration of innovative activities within a few new firms and those already highly innovative before the crisis. Furthermore, in [Paunov, 2012] it was found that in response to the global financial crisis, one out of four companies has halted its innovation investment projects.

It has been argued that the effects of the economic downturn on innovation are not the same across companies and countries [Filippetti, Archibugi, 2011], some companies will continue to invest in innovation during a recession, others will not [Archibugi, Filippetti, Frenz., 2013a; 2013b]. Considering period of crisis, top managers, owners and policy makers need to understand the factors able to neutralize the effect of the economic slowdown on investment in innovation [Filippetti, Archibugi, 2011; Máñez et al., 2014; Amore, 2015], and understand all the aspects that influence the persistence of innovative activities [Antonioli, Montresor, 2021]. Some firms have survived over the crisis and emerge as winners; they conduct innovation and increase their investment in

spite of the adverse macroeconomic environment [Archibugi, Filippetti, Frenz, 2013a]. This article sheds the light on the key characteristics of these companies. The question of how firms react and respond to crises by adapting their innovation strategies remains relevant. This study therefore sets out to identify the type of innovation, which persists in times of crisis as well as the emphases of managerial attention in an economic downturn. To date, there has been significant advancement in understanding the performance implications of innovation and the impact of the external environment on innovativeness and performance [Jansen, Van Den Bosch, Volberda, 2006; Osiyevskyy, Shirokova, Ritala, 2020]; this study attempts to identify how certain environmental factors shape innovation-performance relationship.

For this context, this study followed a systematic review strategy. It provides a comprehensive and clear overview of the literature on a given topic and identifies gaps in our current understanding of a field. Furthermore, it can be explained as a search method or process to identify and appraise relevant research, as well as for collecting and analyzing data from prior research, by identifying empirical evidence that fits the pre-specified inclusion and exclusion criteria allowed to answer particular research questions using explicit and systematic methods when reviewing articles and all available evidence [Snyder, 2019].

This paper reviews and integrates the existing literature on innovation in times of crisis according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to develop a research framework which unites determinants, moderators, and outcomes of innovation in times of crisis. The reason for choosing PRISMA over other existing protocols is its comprehensiveness and its ability to increase consistency between reviews [Liberati et al., 2009]. The main objectives are to explore the behaviour of firms in their ability to maintain and advance innovative activities, to examine the barriers and determinants of innovation investment in times of crisis, to provide a comprehensive picture of the determinants of innovation persistence, and to understand how firms may respond when a new economic downturn occurs. This review provides insights into four important research questions.

RQ1. What is the impact of economic crises on innovation and investments in future innovation projects?

RQ2. Which factors determine the organizational tendency to engage or not in innovation activities during crisis? And which type of innovation persists in times of crisis?

RQ3. What are the factors that may offset the effect of the economic downturn on innovation? And what can make innovation work better in times of crisis?

RQ4. To what extent does innovation contribute to improving firms' performance during an economic downturn?

After searching for appropriate keywords, the relevance was assessed by checking abstract and deep reading of articles, and then the quality of papers was evaluated by focusing on peer reviewed and high quality journals. 70 papers were generated that focused on innovation in a crisis environment. This study compiled papers from highly ranked journals according to the Chartered Association of Business Schools (ABS) list published during the period 2000–2020.

The literature review results allowed identifying three patterns related to the innovation behaviour of a firm when the environment undergoes abrupt changes. These include retrenchment behaviour in which most firms react by reducing their investment in innovation, downsizing innovation related expenditures, preserving behaviour by maintaining innovation activities and continuing projects and commitment behaviour in which few companies seem willing to exploit the crisis situation by investing more in innovation, increasing their innovation activities and expanding their innovative related expenditures [Paunov, 2012; Archibugi, Filippetti, Frenz, 2013a; 2013b; Armand, Mendi, 2018].

The behaviour towards reducing investment in innovation depends on various factors that hinder innovation, such as financial constraints [Mazzucato, 2013; Máñez et al., 2014; Lee, Sameen, Cowling, 2015], lack of knowledge [Lichtenthaler, 2009; Zouaghi, Sánchez, Martínez, 2018], specific characteristics of the firm [Archibugi, Filippetti, Frenz, 2013b; Antonioli, Montresor, 2021], weakness of the national innovation system [Filippetti, Archibugi, 2011; Umemura, 2014; Kapetaniou, Samdanis, Lee, 2018], and market constraints [Gang, Choi, 2019]. The development of the financial system, the skills and quality of human resources, a robust national innovation system, and an R&D department seems to be the main factors neutralizing the effect of the crisis on firms' innovation investments. In addition, international alliances can be an effective method to make innovation a dominant model when a crisis occurs. The study results suggest that, in general, innovation positively affects firm performance in a crisis context and that this relationship is contingent on the level of environmental disruption.

This paper is organized as follows. The methodology for the literature review is presented in the first section. Then, in the second section, a description of the general characteristics of the reviewed studies follows. In the third section, themes related to the topic are identified. The fourth section contains discussion, theoretical and practical implications, future research directions. The fifth section concludes.

METHODOLOGY OF THE REVIEW

The approach followed in this study is a systematic literature review, which identifies and extracts relevant information about the area of interest from all published research and evaluates a large body of literature [Tranfield, Denyer, Smart, 2003]. The review had the following objectives namely: 1) to analyze relevant articles identified on innovation in times of crisis; 2) to develop an integrative framework for a comprehensive understanding of innovation research in the context of the crisis; 3) to identify critical gaps in the literature and suggest directions for future research.

A systematic review is conceived to summarize evidence accurately and reliably and analyze the quality of published peer-reviewed journal articles according to the PRISMA [Liberati et al., 2009]. Following A. Liberati and co-authors [Liberati et al., 2009], a systematic review is intended to gather evidence in an accurate and reliable manner and to analyze the quality of articles published in peer-reviewed journals. Sample identifica-

tion, selection, eligibility assessment and analysis of studies included in the review are the four phases of the PRISMA protocol.

To conduct this literature review, four steps will be followed: 1) development of inclusion and exclusion criteria to select studies; 2) identification of relevant and quality studies; 3) assessment of relevant literature; 4) presentation of results.

Establishment of inclusion and exclusion criteria. Table 1 lists the inclusion and exclusion criteria used to select and evaluate studies included in our systematic review.

Table 1. **Inclusion and exclusion criteria**

Criterion		Rationale of criterion
Inclusion criterion	Articles related to the concept of innovation in period of recession	The relevant concept for the study
	Articles published between 2000 and 2021	To encompass all recent crises
	Articles in the English language	The language in which the main scholarly business journals are published
	All types of articles (empirical as well as conceptual/theoretical) were included in this review	Broad approaches and methodologies lead to exhaustive systematic review
	Web of Science database	The indexing of the most recognized management journals (e.g., all ABS list journals, Financial Times list — FT50, and ABDC list) WoS is one of the most comprehensive sources of management
Exclusion criterion	Theses, books, book chapters, working papers and conference proceedings were excluded	Journal articles in well-established journals undergo a serious peer-review, while everything else might not
	Professional journals were excluded	Only academic journals considered because of their more rigorous selection procedures
	No ABS ranked and below ABS 3	Providing a higher quality standard to meet the rigorous peer-review process

Sample identification. The search strategy and sample identification involved three separate search activities, namely: 1) appropriate keyword search; 2) relevance assessment; 3) quality assessment.

Appropriate keywords. This study conducted the data search by mining the largest multidisciplinary database of peer-reviewed research literature — Web of Science. This database is a scientific tool growing in significance across countries and knowledge domains and is exploited in published research and scientific articles [Li, Rollins, Yan, 2018]. The search string was formed by regrouping chosen keywords into two categories. The first category covers terms to represent innovation activities, and the second category is composed of keywords referring to the economic crisis. The relevant keywords for this review are presented in Table 2.

Table 2. **Search string**

Category	Keyword
Innovation	"innovat*" OR "R&D" OR "explorat*" OR "exploitat*" OR "Ambidexterity"
Economic crisis	"financial crisis" OR "downturn" OR "recession" OR "in times of crisis" OR "in a context of crisis" OR "environmental jolt"
Search String: 7 457 articles	("innovat*" OR "R&D" OR "explorat*" OR "exploitat*" OR "Ambidexterity") AND ("financial crisis" OR "downturn" OR "recession" OR "in times of crisis" OR "in a context of crisis" OR "environmental jolt")

N o t e s: the use of quotation marks implies the search for an exact phrase in a search engine; the use of * symbol at the end of a word implies that the words having to root the whole character of this symbol will be identified in research.

The keywords were searched in titles, abstracts, and/or keyword sections. This search identified 7 457 articles. Appropriate journals were screened and the search period was ultimately limited based on inclusion and exclusion criteria. In total, 2 044 articles were identified, as shown in Figure 1.

Assessing relevance. A first sorting of article titles and abstracts excluded articles that did not explicitly addressed innovation in times of crisis. As a result, 165 articles were subjected to further reading, which resulted in the exclusion of eight working papers. After these two steps, the resulting sample consisted of 157 articles.

Assessing quality. Even if an article is relevant, it does not mean it is of high quality. For this particular reason, this study have opted to focus on high quality peer-reviewed journals. The journal rankings criteria were applied according to the ABS Academic Journal Guide and this study only included the top journals ranked 4*, 4, and 3 to generate high-quality articles. This procedure yielded 70 articles for inclusion in the systematic review (Figure 2).

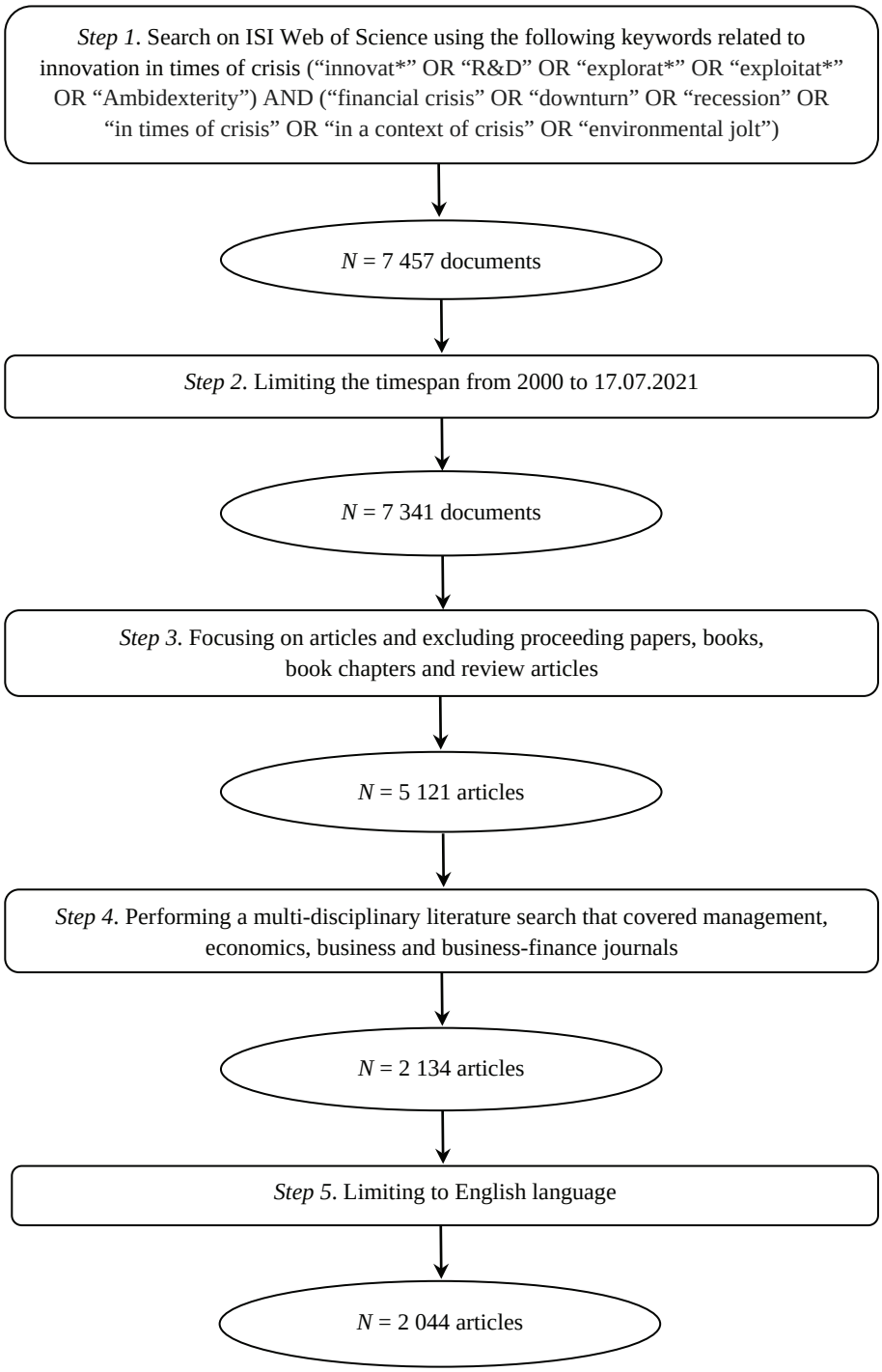

Figure 1. Identification of inclusion criteria

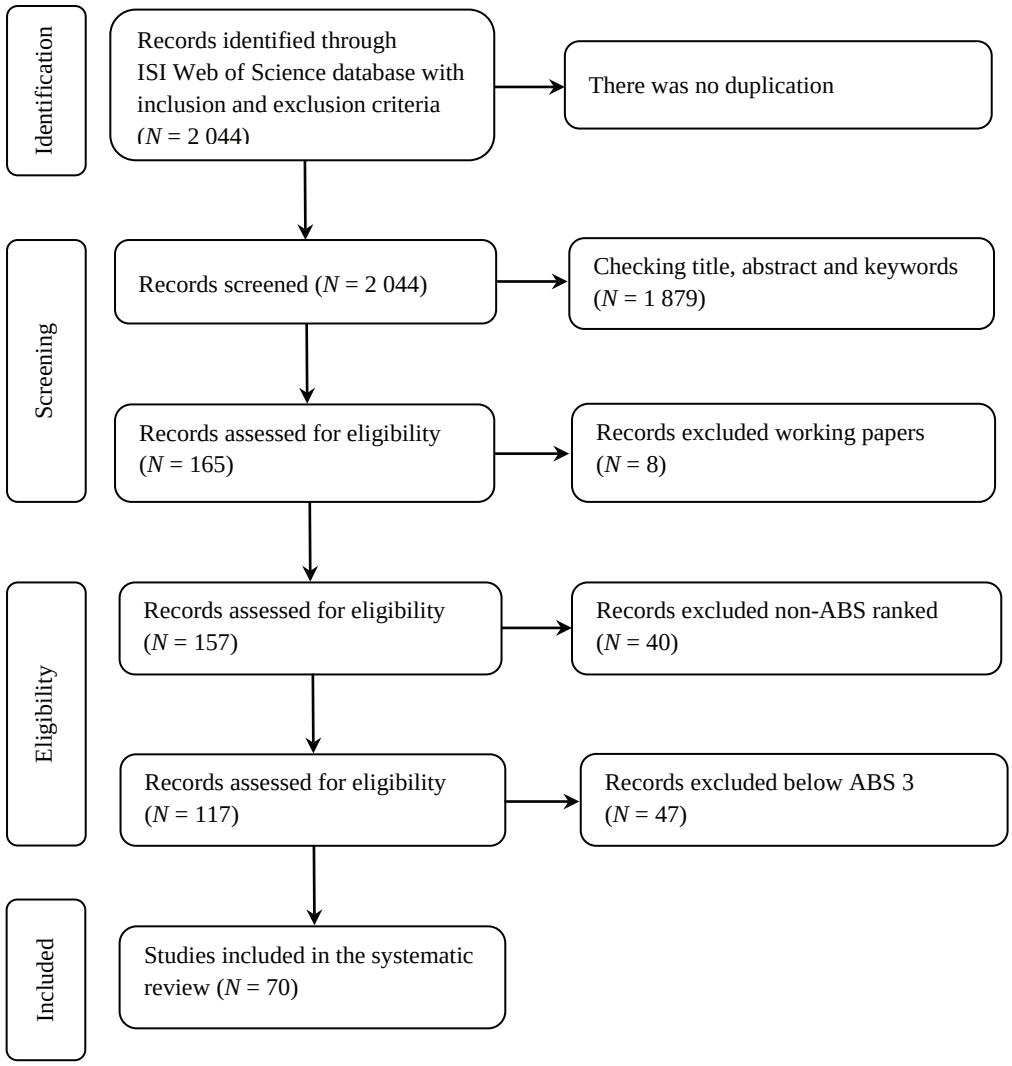

Figure 2. Flow chart of the study selection process

GENERAL CHARACTERISTICS OF THE SELECTED STUDIES

Distribution of sample articles by publication year and outlet. Table 3 lists the 70 selected articles published in 26 academic journals covering the fields of economics, entrepreneurship, marketing, management and international business. The diversification of publications suggests that innovation in times of crisis is a transdisciplinary research area that attracts researchers from different fields. The journals that publish the most articles are Journal of Business Research (12 articles), Research Policy (10), Industrial and Corporate Change (9) and Technological Forecasting and Social Change (5 articles).

Table 3. **Bibliographic sources of the 70 studies on innovation in times of crisis**

Academic journal	Source	Number of articles
1	2	3
Journal of Business Research	[Hausman, Johnston, 2014; Makkonen et al., 2014; Petrakis, Kostis, Valsamis, 2015; Martin-Rios, Parga-Dans, 2016; Malik et al., 2019; Martinez, 2019; Ngo et al., 2019; Battisti et al., 2019; Brem, Nylund, Viardot, 2020; Osiyevskyy, Shirokova, Ritala, 2020; Ebersberger, Kuckertz, 2021; Weaven et al., 2021]	12
Research Policy	[Flippeti, Archibugi, 2011; Paunov, 2012; Archibugi, Filippetti, Frenz, 2013a; Makkonen, 2013; Amore, 2015; Brautzsch et al., 2015; Hud, Hussinger, 2015; Lee, Sameen, Cowling, 2015; Archibugi, 2017; Armand, Mendi, 2018]	10
Industrial and Corporate Change	[Mazzucato, 2013; Berchicci, Tucci, Zazzara, 2014; Máñez et al., 2014; Walrave et al., 2017; Ahn, Mortara, Minshall, 2018; Brancati et al., 2018; D'Agostino, Moreno, 2018; Cefis, Marsili, 2019; Giebel, Kraft, 2019]	9
Technological Forecasting and Social Change	[Sharif, 2012; Archibigu, Filippetti, Frenz, 2013b; Papadopoulos et al., 2013; Jung, Hwang, Kim, 2018; Kapetaniou, Samdanis, Lee, 2018; Zouaghi, Sánchez, Martínez, 2018]	6
Journal of Small Business Management	[Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Xia, Dimov, 2019]	2
Small Business Economics	[Brancati, 2015; Antonioli, Montresor, 2021; Brancati et al., 2021]	3
Long Range Planning	Fan, Rao-Nicholson, Su, 2020; Iborra, Safón, Dolz, 2020; Colombo et al., 2021]	3
R&D Management	[Martin-Rios, Pasamar, 2018; Dimitropoulos, 2020]	2
Journal of Product Innovation Management	[Schöle, Skiera, Tellis, 2014; Cooper, 2021]	2
Journal of Banking & Finance	[Beck et al., 2016; Giebel, Kraf, 2020]	2
Industry and Innovation	[Colombo, 2016; Busom, Vélez-Ospina, 2021]	2
International Journal of Human Resource Management	[Zagelmeyer, Heckmann, Kettner, 2012; Hansen, Güttel, Swart, 2019]	2

End of Table 3

1	2	3
Technovation	[Kramme, 2021; Yamashita, 2021]	2
Academy of Management Review	[McKinley, Latham, Braun, 2014]	1
Academy of Management Journal	[Lichtenthaler, 2009]	1
Management Science	[Jansen, Van Den Bosch, Volberda, 2006]	1
Journal of Monetary Economics	[Argente, Lee, Moreira, 2018]	1
Strategic Entrepreneurship Journal	[Knudsen, Lien, 2015]	1
Journal of Financial Intermediation	[Brown, Petersen, 2015]	1
Business History	[Umemura, 2014]	1
Journal of Common Market Studies	[Archibugi, Filippetti, 2011]	1
Industrial Marketing Management	[Naidoo, 2010]	1
Journal of Economic Behaviour & Organization	[Nemlioglu, Mallick, 2020]	1
Technology Analysis & Strategic Management	[Gang, Choi, 2019]	1
European Financial Management	[Nemlioglu, Mallick, 2017]	1
Management International Review	[Ghauri, Park, 2012]	1
Total		70

Figure 3 summarizes the distribution of articles by year of publication. It reveals that the rate of published articles dealing with innovation in times of crisis has increased remarkably since 2010, peaking in 2019 with ten published articles.

After the great recession of 2008, interest in innovation has increased significantly and currently, with the COVID-19 pandemic, scholars are looking for innovation as a critical strategy.

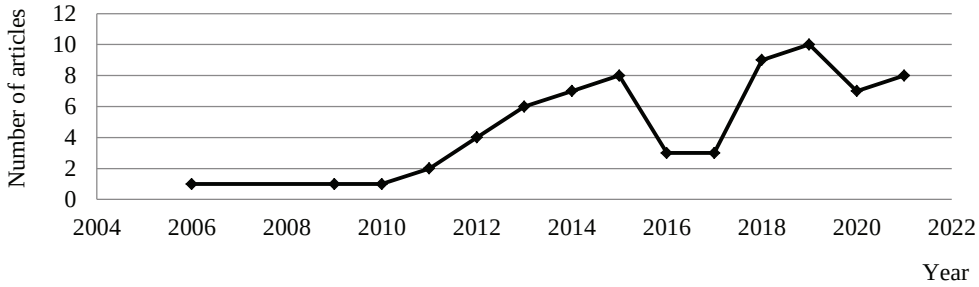

Figure 3. Distribution of articles by years of publication

Distribution of articles by crisis type. The financial crisis of 2008, which is also referred to as the "global financial crisis" (GFC), led to a severe global economic recession. It has been called the most severe financial crisis since the Great Depression. Table 4 lists how the selected articles were distributed according to the different crisis types. 48 of 63 empirical studies focus on the global financial crisis. The COVID-19 impacted businesses worldwide and also began to generate significant academic interest in many disciplines.

Table 4. **Published articles based crisis**

Type of crisis	Year	Number of articles
Three downturns of the US economy	1980, 1990 and 2001	1
Japan's economic crisis	1991	1
Asian financial crisis	1997	1
USA crisis	1980, 1990, 2001	1
Indonesia crisis	1997–1998	1
Global financial crisis	2007–2008	48
Greek sovereign debt crisis	2010	2
Sovereign debt crisis	2013	1
Spanish financial crisis	2008–2014	2
Russian crisis	2014–2016	2
COVID-19 crisis	2019–2021	3

Countries in the study focus. As shown in Table 5, the distribution of the selected empirical studies by country reveals that the most studied area is Europe, with 71.76% of the articles because the global economic crisis of 2008 generated a significant economic decline in Europe. However, this affected some states more than others [Kastrinos, 2013]. Europe is followed by Asia and Americas with 13.11% and 11.47% of the articles respectively.

Table 5. **Distribution of the empirical publications by investigated countries, 2000–2021**

Region	Number of articles
Australia	1
China	1
Europe	12
Cyprus	1
France	1
Finland	1
Germany	6
Greece	2
India	1
Israel	1
Italy	7
Japan	1
Korea	2
South America	1
Norway	1
Netherlands	1
New Zealand	1
Russia	1
Spain	9
Switzerland	1
United Kingdom	4
United States	6
Vietnam	1
Total	63

N o t e: Europe — 45 publications (71.43%); Asia — 8 (12.7%); North and South America — 7 (11.11%); others — 3 publications 4.76%.

Distribution of articles by type of methodology. The distribution of articles by type of research design shows that 91.04% are empirical studies and 8.95% are conceptual ones (Table 6). Regression analysis is the statistical method widely used to explain the impact of the crisis on innovation [Archibugi, Filippetti, Frenz, 2013a; 2013b; Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Berchcci et al., 2014; Giebel, Kraft, 2019] and impact of the financial crisis on innovative performance [Zouaghi, Sánchez, Martínez, 2018]. However, time-series data would provide deeper insights to assess the impact of the investment in innovation before, during, and after the crisis.

Table 6. **Distribution of analytical techniques in empirical articles**

Methodology	Technical analysis	Number of articles		Percentage
Qualitative	Case study	6	6	8.57
Quantitative	Structural equation modeling (SEM)	2	55	78.57
	Hierarchical regression	1		
	Multiple linear regression (OLS)	15		
	Fixed effect estimation method	4		
	Logistic regression	2		
	Probit regression	8		
	System Generalized Method of Moments (GMM) regression analysis	3		
	Competing risk model (CRM)	1		
	Tobit regression	1		
	Cox proportional hazard model	3		
	Heckman regression	2		
	Random-effects panel Tobit models	4		
	Logit regression	2		
	Poisson quasi maximum likelihood (QML) regression	1		
	Piece-wise exponential hazard model	1		
	Cluster analysis	2		
	Fuzzy clustering	1		
	Difference-in-difference (DID) estimations	2		
Mixed	Structural equation and case study	1	2	2.86
	Expert panel and case study	1		
Conceptual			7	10
Total			70	100

Recent research has used more complex statistical models to analyze the conditions that affect innovation during economic crises. For example, N. Lee with co-authors [Lee, Sameen, Cowling, 2015] attempted to answer whether the sources of funding for innovative firms changed during a crisis by using Heckman regression. For time-varying explanatory variables associated with event history data, the Cox proportional hazard model was employed by the studies [Jung, Hwang, Kim, 2018; Cefis, Marsili, 2019; Martinez et al., 2019]. A conceptual model linking market orientation, marketing innovation, competitive advantage, and firm survival was tested using structural equation modelling [Naidoo, 2010]. Structural equation modelling was also employed to understand how

technological and market turbulence moderates the effect of learning on innovation and performance through absorptive capacity [Lichtenthaler, 2009].

Innovation/crisis theoretical foundations. In his theory of business cycle, J. A. Schumpeter [Schumpeter, 1942] developed a theoretical framework in which the concept of innovation is introduced as a main driver of the cyclical evolution of the economy. He emphasized the importance of technological development and innovation policies for economic development. Recent papers have revisited Schumpeter and his innovation theory to provide valuable starting points for their work [Archibugi, Filippetti, Frenz, 2013a; 2013b; Brem, Nylund, Viardot, 2020]. The two models of innovation called "creative destruction" and "creative accumulation" are derived from the theory of Schumpeter, who suggested that business cycles are the consequence of innovation, and also that innovative activities and organizations are reshaped by economic crises.

Creative destruction characterizes a dynamic environment where new firms appear as the most significant innovators due to a significant discontinuity such as an economic downturn. On the other hand, creative accumulation is supported by a more stable routine of innovation, which highlights the cumulativeness and persistence of innovative activities in response to the crisis [Archibugi, Filippetti, Frenz, 2013a; 2013b; Brem, Nylund, Viardot, 2020]. With a focus on investment in innovation, the Schumpeterian tradition indicates that attempts to introduce new products and processes to the market can be the key determinant of economic growth. C. Freeman with co-authors [Freeman, Clark, Soete, 1982] took Schumpeter's insight further by arguing that in adverse economic environments, investment is likely to be reduced by low-profit margins [Filippetti, Archibugi, 2011].

In response to a crisis, the behavioural theory of the firm, suggests risk-seeking behaviour and the theory of threat rigidity, refrain from any strategic change [Colombo et al., 2016]. Previous studies have found that innovation has declined during the recent economic crisis, confirming the demand-driven model of innovation [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013], where a decline in aggregate demand can influence the decision to invest in innovation [Armand, Mendi, 2018].

Transaction cost theory specifies that intangibility and specificity linked to the investments can be a barrier to the funding of innovation through debt, while agency theory implies that the high risk of innovative activities and the existence of information asymmetries are likely to restrict the availability of debt financing [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]. While a number of studies have found that the crisis caused the concentration of innovative activities in new companies and those that were already highly innovative, this approach confirms the behavioural theory of the firm, which suggests risk-seeking behaviour [Colombo et al., 2016] and the opportunity cost of innovation, which is explained by the fact that during a downturn, rents from a company's current activities decrease and companies are encouraged to introduce innovations [Berchicci, Tucci, Zazzara, 2014]. Other theoretical approaches have been applied to explain the innovation process and firm's outcomes in times of crisis. The most important theories adopted in the empirical studies are presented in Table 7.

Table 7. **Main theories used in empirical studies**

Theory	Review's study using the theory	Finding
1	2	3
Schumpeter's Theory of Economics Development	[Archibugi, Filippetti, Frenz, 2013a; 2013b; Makkonen, 2013; Mazzucato, 2013; Amore, 2015; Lee, Sameen, Cowling, 2015; Nemlioglu, Mallick, 2017; Jung, Hwang, Kim, 2018; Brem, Nylund, Viardot, 2020]	Two major theories on the innovation process. The first, based on the notion of creative accumulation, is based on a stable innovation model highlighting the accumulation of knowledge and the persistency of innovative activities in the face of crisis. The second, creative destruction, depicts an environment where new firms appear to be the most significant innovators after a major discontinuity. Consistent with Schumpeterian theories of creative destruction, in which outdated products are replaced by new and better ones
Schumpeterian growth theories and innovation growth view	[Paunov, 2012; Makkonen, 2013; Brautzsch et al., 2015; Beck et al., 2016; Argente, Lee, Moreira, 2018]	The rate of product reallocation is substantially influenced by the firms' innovation activities, as predicted by Schumpeterian growth theories, and has major repercussions for revenue growth and product quality improvements. Financial innovation is associated with higher bank growth
Schumpeterian view of innovation-based competition	[Brancati et al., 2021]	Technology and product quality-related factors are far more important than cost-related aspects in explaining export performance
Schumpeterian view of recessions	[Busom, Velez Ospina, 2021]	During recessions, the opportunity cost of profitability-improving R&D investments drops, relative to regular physical capital investments, offering incentives to ramp up these activities
Innovation-fragility view	[Beck et al., 2016]	Financial innovation is linked to a higher level of risk-taking on the part of banks. It considerably amplifies the volatility of banks' benefits, their fragility and their falls during a banking crisis
Microeconomic theory of innovation and institution based view	[Filippetti, Archibugi, 2011; Gang, Choi, 2019]	The microeconomic theory of innovation from the neo-Schumpeterian literature, highlights the role played by institutions on economic activities

1	2	3
Demand pull model of innovation	[Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Lee, Sameen, Cowling, 2015; Brancati et al., 2021]	Firms that embrace innovation will continue to bring new products and processes to meet changing consumer demand. When a major crisis strikes, one of the most serious threats to a company's viability is the collapse of aggregate demand. Lower demand might stimulate innovation by lowering the opportunity cost associated with the needed financial investment. Schmookler's "demand-pull" theory of innovative activity suggests that investment in innovation is significantly pro-cyclical
Transaction cost	[Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]	The intangibility and specificity associated with investments, according to transaction cost theory, may be a barrier to enterprises funding innovation with debt
Agency theory	[Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]	According to agency theory, the risk exposure of innovative activities and the presence of information asymmetry should certainly limit debt funding availability
Prospect theory	[McKinley, Latham, Braun, 2014]	Overall, the logic of prospect theory implies that managers who are experiencing conditions of organizational decline will be more risk seeking than those who are experiencing conditions of organizational growth. If risk seeking is conducive to innovation, organizational decline should be positively related to innovation
Dynamic capabilities view	[Lichtenthaler, 2009; Naidoo, 2010; Makkonen et al., 2014; Ahn, Mortara, Minshall, 2018; Martinez et al., 2019; Ngo et al., 2019; Iborra, Safón, Dolz, 2020; Nemlioglu, Mallick, 2020; Colombo et al., 2021; Weaven et al., 2021; Krammer, 2022]	All forms of open approaches and a high level of openness are helpful for firms to acquire the dynamic capabilities necessary for good strategic adaptation. Ventures that used the two dynamic capabilities — new product development and internationalization — exhibited superior sales growth
Organizational learning theory	[Jansen, Van Den Bosch, Volberda, 2006; Lichtenthaler, 2009; Ghauri, Park, 2012; Knudsen, Lien, 2015; Petrakis, Kostis, Valsamis, 2015; Brancati et al., 2018; Battisti et al., 2019; Malik et al., 2019; Melnychuk, Schultz, Wirsich, 2021]	Firms become more resilient in times of uncertainty and volatility as a result of their learning. Higher levels of learning orientation of leaders are highly linked to long-term, consistent performance

End of table 7

1	2	3
Opportunity cost theory	[Berchicci, Tucci, Zazzara, 2014; Máñez et al., 2014; Hud; Hussinger, 2015; D'Agostino, Moreno, 2018; Giebel, Kraft, 2020; Yamashita, 2021]	When industrial activity slows down, companies allocate their resources to innovation activities — they create new products at the expense of new processes, thus making the link between the opportunity cost and the cash flow effect
Equilibrium theory	[Mazzucato, 2013; Brancati et al., 2018]	Technology and innovation, in contrast to equilibrium theories, are viewed as disequilibrium processes that affect both company efficiency and demand through the generation and exploitation of new opportunities
Resource-based view	[Naidoo, 2010; Ghauri, Park, 2012; Zagelmeyer, Heckmann, Kettner, 2012; Knudsen, Lien, 2015; Cefis, Marsili, 2019; Xia, Dimov, 2019; Dimitropoulos, 2020; Weaven et al., 2021]	The resource-based approach emphasizes the importance of valuable, scarce, difficult-to-replicate, and non-substitutable resources for long-term survival
Behavioural theory	[McKinley, Latham, Braun, 2014; Colombo et al., 2016]	According to the behavioural theory of the firm, when performance does not reach aspirations, companies start looking for alternatives and change their strategies
Threat-rigidity theory	[Colombo et al., 2016; Walrave et al., 2017; Osiyevskyy, Shirokova, Ritala, 2020]	Rigidity of threat theory argues that when performance is so poor that survival is threatened, firms may be unwilling to take risks
The evolutionary theory of technological change	[Makkonen et al., 2014; Antonioli, Montresor, 2021; Cefis, Marsili, 2019]	In numerous innovation systems, persistence has been highlighted as one of the characteristics that highlights technical advancement and industrial evolution. The key driver of performance, according to the firm's evolutionary approach, is innovation
Strategic adaptation theory	[Martin-Rios, Pasamar, 2018]	Strategic adaptation theory looks at how businesses adapt and renew themselves in the face of adversity and sees adaptation as indication that "firms have superior routines or efficient resource allocation procedures which account for competitiveness and, hence, survival"
Human capital theory	[Zagelmeyer, Heckmann, Kettner, 2012; Zouaghi, Sánchez, Martínez, 2018]	Individual talents, knowledge, and capacities are significant resources and a major source of economic productivity, according to human capital theory
Ambidexterity theory	[Ngo et al., 2019]	Ambidexterity theory suggests effective response strategies

Through application of the resourced-based view of the firm, many researchers report that exploring and exploiting internal and external knowledge, accelerate innovation processes and facilitate superior outcomes [Lichtenthaler, 2009; Ahn, Mortara, Minshall, 2018; Brancati et al., 2018; Battisti et al., 2019; Cefis, Marsili, 2019]. Pursuing innovation (both open and closed) during the crisis is an effective way of enhancing its dynamic capability, enabling firms to have resilience power high enough to achieve a sustainable growth in the long term [Ahn, Mortara, Minshall, 2018]. Learning are related to firm innovation and, in turn, short-term performance [Battisti et al., 2019], and the evolutionary theory of the firm states that innovation is the main driver of performance [Makkonen et al., 2014].

INNOVATION IN THE FACE OF CRISIS: EMERGING THEMES

Six themes were identified from an analysis of the selected articles, although many articles could be categorized under more than one theme. Table 8 shows the distribution of articles across the six themes.

Table 8. **Thematic distribution of the literature**

Theme	Source	Number of articles	Percentage
1	2	3	4
Investment in innovation in times of crisis	[Archibugi, Filippetti, Frenz, 2013a; Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Makkonen, 2013; Berchicci, Tucci, Zazzara, 2014; Archibugi, 2017; Argente, Lee, Moreira, 2018; Armand, Mendi, 2018; Giebel, Kraft, 2019; Hansen, Güttel, Swart, 2019; Brem, Nylund, Viardot, 2020; Fan, Rao-Nicholson, Su, 2020; Ebersberger, Kuckertz, 2021; Yamashita, 2021]	13	18.57
Barriers and factors able to offset the effect of the economic downturn on innovation investments	[Filippetti, Archibugi, 2011; Ghauri, Park, 2012; Paunov, 2012; Zagelmeyer, Heckmann, Kettner, 2012; Mazzucato, 2013; Hud, Hussinger, 2015; Schöler, Skiera, Tellis, 2014; Umemura, 2014; Máñez et al., 2014; Amore, 2015; Brancati, 2015; Brautzsch et al., 2015; Brown, Petersen, 2015; Knudse, Lien, 2015; Lee, Sameen, Cowling, 2015; Ahn, Mortara, Minshall, 2018; Brancati et al., 2018; D'Agostino, Moreno, 2018; Kapetaniou, Samdanis, Lee, 2018; Zouaghi, Sánchez, Martínez, 2018; Antonioli, Montresor, 2021; Batisti et al., 2019; Gang, Choi, 2019; Martinez et al., 2019; Ngo et al., 2019; Giebel, Kraft, 2020; Nemlioglu, Mallick, 2020; Cooper, 2021; Brancati et al., 2021; Busom, Velez-Ospina, 2021; Krammer, 2022]	31	44.28

End of Table 8

1	2	3	4
Performance outcomes of innovation in highly turbulent settings	[Jansen, Van Den Bosch, Volberda, 2006; Lichtenthaler, 2009; Naidoo, 2010; Paunov, 2012; Sharif, 2012; Hausman, Johnston, 2014; Makkonen et al., 2014; McKinley, Latham, Braun, 2014; Beck et al., 2016; Colombo et al., 2016; 2021; Martin-Rios, Parga-Dans, 2016; Nemlioglu, Mallick, 2017; Walrave et al., 2017; Ahn, Mortara, Minshall, 2018; Jung, Hwang, Kim, 2018; Martin-Rios, Pasamar, 2018; Cefis, Marsili, 2019; Malik et al., 2019; Ngo et al., 2019; Xia, Dimov, 2019; Dimitropoulos, 2020; Iborra, Safón, Dolz, 2020; Osiyevskyy, Shirokova, Ritala, 2020; Weaven et al., 2021]	25	35.71
Type of innovation that persist in times of crisis	[Jansen, Van Den Bosch, Volberda, 2006; Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Berchicci, Tucci, Zazzara, 2014; Knudsen, Lien, 2015; Walrave et al., 2017; Antonioli, Montresor, 2021; Cefis, Marsili, 2019; Malik et al., 2019; Xia, Dimov, 2019; Giebel, Kraft, 2020; Osiyevskyy, Shirokova, Ritala, 2020]	11	15.71
Innovation outcomes	[Amore, 2015; Colombo et al., 2016; Argente, Lee, Moreira, 2018; Jung, Hwang, Kim, 2018; Antonioli, Montresor, 2021; Brem, Nylund, Viardot, 2020; Nemlioglu, Mallick, 2020; Cooper, 2021]	8	11.43
Crisis related moderators	[Jansen, Van Den Bosch, Volberda, 2006; Lichtenthaler, 2009; Walrave et al., 2017; Zouaghi, Sánchez, Martínez, 2018; Martinez et al., 2019; Osiyevskyy, Shirokova, Ritala, 2020]	6	8.57

The analysis reveals that approximately 44% of the papers examine the factors that may offset the effect of the economic recession on innovation investments, followed by the performance outcomes of innovation in highly turbulent settings (36%), approximately 18% consider the impact of economic downturns on innovation investment. Roughly 16% and 11% examine respectively the different types of innovation that persist in crisis and the different innovations outcomes created by pursuing these types. Furthermore, approximately 9% of the papers examine crisis related moderators. This section discusses more deeply the six themes identified in order to answer the research questions.

The impact of economic crises on innovation. Previous literature describes economic crisis as an extreme, unexpected, or unpredictable change in the external macroeconomic environment that negatively affects most economic agents, making business opportunities less certain, requiring an urgent response from firms [Archibugi, Filippetti, Frenz, 2013b; Doern, Williams Vorley, 2019]. This study will examine the main findings of relevant articles devoted to firms' innovative behaviour in crisis (Table 9).

Table 9. **Investment in innovation in times of crisis**

Source	Sample used	Period	Database	Main conclusion
1	2	3	4	5
[Archibugi, Filippetti, Frenz, 2013a]	200	2006–2009	Innobarometer 2009	During the recession firms' innovation behaviour is closer to creative destruction, while before the recession there is an overall landscape of creative accumulation. The reduction in investment has not been uniform across companies and a few even increased their innovation expenditures. Before the crisis, incumbent enterprises are more likely to expand their innovation investment, while after the crisis a few, small enterprises and new entrants are ready to "swim against the stream" by expanding their innovative related expenditures
[Filippetti, Archibugi, 2011]	5 238	2005–2009	Innobarometer 2009; the European Innovation Scoreboard 2008	The effects of the economic downturn in terms of firms' innovation investment are not the same across European countries. Countries endowed with stronger national system of innovation (NSI) are less affected and are better able to respond to the recession
[Paunov, 2012]	1 223	2008–2009	The survey data used were collected under the direct guidance of the OECD Development Centre; survey data of Latin American firms	The crisis led many firms to stop ongoing innovation projects. Firms with access to public funding were less likely to abandon these investments. Younger firms and businesses supplying foreign multinationals or suffering export shocks were more likely to do so. This might suggest that the global crisis had only minor effects on firms' innovation capacities
[Archibugi, Filippetti, Frenz, 2013b]	2 500	2002–2008	UK Community Innovation Survey	The crisis led to a concentration of innovative activities within a small group of fast growing new firms and those firms already highly innovative before the crisis. The companies in pursuit of more explorative strategies towards new product and market developments are those to cope better with the crisis

End of Table 9

1	2	3	4	5
[Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]	716	2005–2009	Personal interviews with managers of small and medium manufacturing companies	Innovation among Spanish manufacturing SMEs declined during the recent economic crisis. The results demonstrate the importance of adopting innovation into SMEs strategy over the business cycle
[Brem, Nylund, Viardot, 2020]	15 504	1980–2013	OECD REGPAT and OECD Citations databases	There is a negative impact of the great financial crisis on innovation as measured by the emergence of dominant designs
[Giebel, Kraft, 2019]	616	2004–2012	IAB Establishment Panel	Innovative firms using external sources for investment finance reduce their capital expenditures during the financial crisis to larger extent than: 1) non-innovative firms using external finance; 2) innovative firms not using external finance

The review suggests that economic downturns have different effects on firms' innovation behaviour and investment:

1) reducing firms' innovation activities [Archibugi, Filippetti, 2011; Archibugi, Filippetti, Frenz, 2013a; 2013b; Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Giebel, Kraft, 2019; Brem, Nylund, Viardot, 2020]. To cope with the challenges that arise during a recession, some firms choose to reduce investments in innovation and R&D aimed at solving short-term problems, which is a common strategy to mitigate the negative effects of a recession, by reducing spending, especially capital and innovation spending [Archibugi, Filippetti, Frenz, 2013b];

2) maintain innovation activities and their innovation expenditures by adopting the firm's status quo to achieve both more stable and predictable operations [Archibugi, Filippetti, Frenz, 2013a; 2013b];

3) some firms increase their innovation activities and boost their innovation expenditures to capture the benefits of the awaited recovery [Archibugi, Filippetti, Frenz, 2013a; 2013b].

In a survey of economic crisis and innovation, D. Archibugi with co-authors [Archibugi, Filippetti, Frenz, 2013a] found that organizations that drive innovation during economic crises include: 1) a small group of fast-growing start-ups; 2) innovative young firms; 3) firms pursuing exploratory technology strategies. Moreover, an empirical study of the impact of the economic crisis on innovation [Archibugi, Filippetti, Frenz, 2013b] reports that incumbent firms are more likely than others to increase their innovation

investments before the crisis. On the other hand, after the crisis, a few small firms and some new entrants are willing to increase their innovation investments.

Constraints and determinants of innovation in crisis. The three behaviours in terms of innovation investment in times of crisis can be contingent on several factors that drive or hamper innovation. Finally, it is expected to find an array of different innovation constraints and determinants of innovation during a recession that this study is trying to identify by reviewing the main conclusions of the included articles.

Firm specific characteristics: size and stage of development. Does size matter in innovation? In 2012, C. Antonelli with co-authors stated that the level of innovation increases with size in stable periods [Antonelli, Crespi, Scellato, 2012]. When it comes to innovation in times of crisis, size does not matter. The paper [Archibugi, Filippetti, Frenz, 2013a] documented that before the crisis, incumbent firms were more apt to increase their innovation investments. However, after the crisis, some small firms and newly entered firms are willing to increase their innovation spending and encourage start-ups to engage in more radical innovations [Archibugi, Filippetti, Frenz, 2013b]. D. Antonioli and S. Montresor [Antonioli, Montresor, 2021] argued that in times of crisis, SMEs following the persistence of innovation and large firms persist to a different extent.

Innovation is an essential component at all stages of development. New and small firms emerge in a competitive market through innovation. In times of crisis, the survival of new firms depends on the introduction of innovative products early in their life cycle [Cefis, Marsili, 2019]. New firms in new sectors provide innovation generation that plays a more critical role than incumbent firms [Archibugi, Filippetti, Frenz, 2013a]. M. Amore [Amore, 2015] identified different profiles of firms that may be more resilient to economic downturns, namely: 1) established firms leveraging accumulated technological knowledge; 2) young innovative firms able to take advantage of technological discontinuities.

Different types of innovation are able to play different roles in different stages of development. In the expansion period, in the early stages, incremental innovation is able to improve the efficiency of firms and public services. On the other hand, in the later stages of development, high-tech innovation, based on R&D, is more important. As A. Madrid-Guijarro with co-authors [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013] have shown, during periods of economic weakness, investment in innovation by firms can make them stronger competitors as economies strengthen. Moreover, note that the probability of survival is only positively affected by R&D investments when firms are innovative and able to generate intellectual property [Jung, Hwang, Kim, 2018].

Strategies: innovation persistence and open innovation. Firms that use returns from previous innovations to overcome problems in financing new innovative projects place themselves in a position of innovation persistence [Antonioli, Montresor, 2021]. The experience with innovations accumulated over past recessions encourages firms to innovate more when a new recession occurs, improves a firm's ability to invest in high quality R&D projects, and produces much better patenting results because they are less financially constrained and benefit from larger innovation pools [Amore, 2015]. Because of their vast accumulated knowledge, these firms have the ability to move very quickly into new areas

and industries whenever new technological opportunities are identified [Laperche, Lefebvre, Langlet, 2011]. Furthermore, it has been argued that to maintain the high level of innovation in the future, it is essential to invest heavily in innovation projects in the present [Paunov, 2012]. In response to the crisis, innovators need to emphasize cumulativeness and persistence of innovation, while non-innovators respond by innovating [Archibugi, Filippetti, Frenz, 2013b; Amore, 2015; Antonioli, Montresor, 2021].

Open innovation has become an essential topic of innovation management research since its definition by H. Chesbrough in 2003 [Chesbrough, 2003]. Open innovation is a strategy that can be achieved through collaboration in innovation activities by seeking external knowledge and increasing the sources and variety of knowledge needed to develop innovation paths during a crisis [Ahn, Mortara, Minshall, 2018; D'Agostino, Moreno, 2018]. Furthermore, combining existing internal knowledge with new external knowledge can lead to the successful construction of new products, services or processes [D'Agostino, Moreno, 2018]. In [Zouaghi, Sánchez, Martínez, 2018; Máñez et al., 2014] it is confirmed that to make innovation a dominant model, it is necessary to find international alliances and alliances with other companies. It has been argued that new and relatively small firms adopting open innovation can overcome potential constraints in resources and financing [Archibugi, Filippetti, Frenz, 2013b].

Research and development investment. Firms invest considerable amounts of money in R&D activities to the extent that they are considered a key determinant of development and sustainability [Dimitropoulos, 2020]. However, investment in R&D is usually risky, and the results of this strategy are very uncertain and distant in time [Máñez et al., 2014] that is why companies are forced to reduce their investment in R&D in case of crisis [Schumpeter, 1939; Freeman, Clark, Soete, 1982]. This type of response can have disastrous consequences for the long-term growth [Añón-Higón et al., 2015]. Along the same lines, M. Amore argued that investment in high-quality R&D projects in future recessions is the result of innovation experiences during a recession [Amore, 2015], and in [Archibugi, Filippetti, Frenz, 2013a] it is pointed out that during a recession, the availability of an R&D department and its economic performance are of major interest. Furthermore, H. Jung with co-authors [Jung, Hwang, Kim, 2018] emphasize the value of this R&D investment strategy in times of crisis, especially for innovative firms capable of generating intellectual property. Public support is now essential for R&D activities in times of recession [Hud, Hussinger, 2015].

Internal and external financial constraints. Investment in innovation activities relies essentially on the use of financial resources [Mazzucato, 2013]. There is a consensus among scholars that innovative firms have a greater demand for external capital to cover the cost of innovation activities. In addition, these activities are highly uncertain, and this higher risk adds to the firms' need for cash; therefore, they face financial constraints as a serious problem that hinders their investment in innovation [Mazzucato, 2013; Máñez et al., 2014; Kapetaniou, Samdanis, Lee, 2018]. N. Lee with co-authors argued that innovative SMEs require more financing than other firms, but their access to financing is hampered [Lee, Sameen, Cowling, 2015].

The external financing of firms is mainly through bank loans, which constitute the major part of the financial debt of firms [Schiantarelli, Sembenelli, 2000]. Firms' financial constraints are primarily caused by the cost of borrowing and access to external financing is limited by capital market imperfections arising from agency conflicts, moral hazard, and adverse selection [Cowling, Liu, Ledger, 2012]. In [Cowling, Liu, Ledger, 2012] authors showed that lending to small businesses has declined significantly in times of crisis due to absolute credit rationing. In times of crisis, due to more difficult access to bank credit, firms have become more sensitive to internal financing, regardless of the cost of new debt [Máñez et al., 2014]. The availability of firms' own cash reserves and robust management of their financial liquidity plays a key role in circumstances where access to external financing is difficult; they use them for financing the development of innovations and their conversion into a dominant design [Brem, Nylund, Viardot, 2020].

To overcome financial barriers to innovation, firms need to build a close and strong relationship with the lending bank [Brancati, 2015], use cash and fixed assets to protect R&D [Brown, Petersen, 2015], and pursuit of public subsidies, ensuring the stability of innovation investments during recessions [Paunov, 2012]. Furthermore, a detailed examination of the financial crisis impact on capital investments in innovative firms by M. Giebel and K. Kraft [Giebel, Kraft, 2019] showed that in order to maintain loan financing and to support the supply of credit to firms that face difficulties in accessing external financing, it is necessary to strengthen banks' capital buffers. In addition to this, specific tax and accounting rules could be useful. Another way to overcome financial constraints was proposed in [Lee, Sameen, Cowling, 2015]. The authors suggest diversifying the types of loans in the banking system or relying on new forms of financing such as crowdfunding.

In sum, liquidity management, financial flexibility, and public financing of firms can support all types of investments, especially investments in innovation, by allowing firms to engage in new value-added projects and by preventing key ongoing projects from being cut in times of financial distress [Brown, Petersen, 2015].

Internal and external knowledge resources. Considerable human and financial resources are required to innovate [Malerba, Orsenigo, 2000]. Firms are more likely to do it when they have abundant resources to invest in new opportunities [Burgelman, Valikangas, 2005]. Qualified human resources play a key role in times of stability as well as crisis, shaping innovation within low-tech manufacturing industries [Hansen, Güttel, Swart, 2014], allowing for increased production and reduced costs [Bathelt, Munro, Spigel, 2013], and neutralizing the impact of the economic downturn in terms of investment in innovation [Filippetti, Archibugi, 2011].

Firms rely on knowledge generated by internal R&D efforts for innovation [Archibugi, Filippetti, Frenz, 2013b; Ahn, Mortara, Minshall, 2018], training programs [Knudsen, Lien, 2015]; however, internal learning alone cannot generate innovation in the face of an adverse environment and firms are also driven to supplement internal knowledge through knowledge from beyond the firm, innovation collaboration with firms, educational and other research institutions and, collaborations with foreign partners [Archibugi, Filippetti, Frenz, 2013b; Ahn, Mortara, Minshall, 2018], thus enabling

firms to better manage resource limitations as well as reduce risks associated with innovation, especially during the financial crisis [Zouaghi, Sánchez, Martínez, 2018].

Several studies have found that sustaining strong knowledge capabilities both internally and externally renders firms capable of powerful resilience sufficient to achieve long-term sustainable growth and mitigate the consequences of the financial crisis [Ahn, Mortara, Minshall, 2018; Zouaghi, Sánchez, Martínez, 2018].

National system of innovation. A large body of research has shown the substantial contribution of institutions to firm behaviour [Hall, Soskice, 2003]. Indeed, national institutions are responsible for both shaping of the structural context of countries and their adaptability to change [Filippetti, Archibugi, 2011]. The national system of innovation is defined as the network of institutions engaged in the development, importation, adaptation, and dissemination of innovative technologies in the public and private sectors [Freeman et al., 1987]. In [Filippetti, Archibugi, 2011] countries with stronger national innovation systems are shown to be less affected and better equipped in responding to crises. A case study of pharmaceuticals revealed that in the face of a crisis in economic and technological dimensions, an evolution of Japan's national innovation system took place from a closed, firm-based national system to a more open, network-based global structure [Umemura, 2014].

Market reforms. Korea implemented a range of market reforms following the 1997 Asian financial crisis, aiming to end state support for economic activities while emphasizing market-oriented ones [Gang, Choi, 2019]. The 1997 Korean reforms advance resource availability through measures such as opening the market to foreign investors, reducing imports and foreign ownership barriers, and removing limitations on labour movement [OECD, 1999].

By drawing on the concept of market reforms, the authors were able to show that Korean reforms have both driven and produced innovation, increased R&D investment, led to the development of new markets, and the creation of new opportunities, thus leading to greater competition, which in turn leads firms to increase their investment in innovation with the goal of developing firm-specific advantages in both technology exploration and exploitation [Gang, Choi, 2019].

Benefits of innovation in highly turbulent settings. The strategies that a firm adopts and the environment in which they are employed are key factors affecting its performance [Zajac, Kraatz, Bresser, 2000]. It has been argued from reviewing the selected papers that innovation improves performance during economic downturns [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Osiyevskyy, Shirokova, Ritala, 2020], increases financial performance [Jansen, Van Den Bosch, Volberda, 2006], and influences external competitiveness both directly and through improved productivity [Brancati et al., 2021].

E. Cefis and O. Marsili argued that during the early stages of their life cycle, the introduction of innovative products helps new firms survive in times of crisis, and process innovation provides a real advantage [Cefis, Marsili, 2019]. Furthermore, according to [Ahn, Mortara, Minshall, 2018], in order to have sufficiently high resilience power to achieve long-term sustainable growth, firms need to pursue innovation (both open and

closed) during the crisis. This view is supported by M. Iborra with co-authors who argue that adopting ambidexterity and strategic coherence leads to resilience [Iborra, Safón, Dolz, 2020].

In [Zouaghi, Sánchez, Martínez, 2018] it is pointed out that R&D intensity has a significant and positive effect on high-tech innovative performance. In the same vein, L. D'Agostino and R. Moreno in their study revealed that during the crisis, cooperation in innovation activities is positively associated with innovation performance [D'Agostino, Moreno, 2018].

To better understand the benefits of innovation activity and learning processes, Brancati and colleagues analyzed firms in Italy following the recent economic crisis and found that both innovation and learning processes boost export activity [Brancati et al., 2018].

The types of innovation persisting in times of crisis. Luck has nothing to do with the success of investment in innovation, but rather it is the result of long-term strategic commitments [Mazzucato, 2013]. Previous research has argued that the essence of the external environment exerts a significant influence on the degree of effectiveness of different forms of innovation [Zahra, Bogner, 2000]. L. Berchicci with co-authors pointed out that firms tend to make investments in product innovation in an industry downturn rather than process innovation [Berchicci, Tucci, Zazzara, 2014]. Conversely, D. Antonioli and S. Montresor reported that Italian firms significantly persisting in their radical process innovations survived the crisis [Antonioli, Montresor, 2021]. E. Cefis and O. Marsili noted that firms introducing any form of innovation and especially process innovations present a higher probability of surviving crises compared to non-innovators [Cefis, Marsili, 2019]. This view is supported in [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]. The authors highlighted the relative importance of different types of innovation during recessions and indicated that management innovation were the least important, followed by product and process innovation. Several studies have revealed that during recessions, firms that perform exploratory innovations increase their financial performance [Jansen, Van Den Bosch, Volberda, 2006; Walrave et al., 2017], impact firm performance level and variability [Osiyevskyy, Shirokova, Ritala, 2020] and generally pursue opportunities created in labour markets more actively [Knudsen, Lien, 2015].

In a dynamic environment, the revenues of current products may drop along with the value of existing products, which risk becoming obsolete, given that firms may decide to restructure their relatively less profitable product activities by reallocating resources to develop new ones [Jansen et al., 2006]. The business' success, therefore, depends on its ability to introduce new products and reduce the impact of obsolete ones. Therefore, firms seem to have incentives to engage in product innovation. By developing new products, companies are able to prepare for the next recovery, which can bring rent-generating product innovations to the market [Berchicci, Tucci, Zazzara, 2014]. Most empirical studies focus on the manufacturing sector. This is why the role of formal internal R&D is relevant and product development is a key issue [Armand, Mendi, 2018].

Given all that has been mentioned so far, it can be assumed that firms adopting some form of innovation are more likely to survive than non-innovative ones.

Innovation outcomes. According to [Quintane et al., 2011], innovation is not only a process but also an outcome. The number of patents and their derivatives (patent citations, active patents) are the most widely used operationalization of innovation. Some studies of this review examined innovation activities either in terms of patents [Amore, 2015] using patent data, it is possible of focusing on the magnitude and intensity of the innovation activities [Antonioli, Montresor, 2021]. Firms that are innovative and able to generate intellectual property during a recession use R&D investment as an effective strategy [Jung, Hwang, Kim, 2018]. Following [Brem, Nylund, Viardot, 2020], a dominant design emerges when a unique design evolves from an invention along a defined technical trajectory, it then becomes a marketed product that is trusted by both competitors and innovators, thus obliging an industry to adopt a standardized design for its essential components following the emergence of a dominant design. Furthermore, it acts as an indicator of innovation, however, in times of crisis, there is an increased unwillingness to embrace risky disruptive innovations that would generate new dominant designs.

Economists have known for a long time that product entry and exit are the key mechanisms by which product innovation leads to economic growth [Klepper, 1996]. Several studies have revealed that the adoption of new products necessitates the elimination of old ones, and the speed with which this occurs is highly dependent on the company's innovation activities [Jansen, Van Den Bosch, Volberda, 2006], new innovative products with better average quality that are launched have a significant impact on the firm's factor productivity [Cooper, 2021]. When a firm's reallocation rate is high, it launches higher-quality products and achieves greater productivity increases [Argente, Lee, Moreira, 2018]. Moreover, the decline in overall productivity of about 15% can be explained by the decline in reallocation during the recession and firms with larger R&D investments experience higher levels of reallocation [Argente, Lee, Moreira, 2018]. R. Cooper points out that the pandemic has led to accelerated development of new products through the reallocation of resources and the allocation of new product projects [Cooper, 2021]. Similarly, M. Colombo with co-authors asserts that the growth performance of high-tech entrepreneurial ventures was boosted by investments in the development of new products induced by the shock of the crisis, thus protecting them from the unfavourable economic situation [Colombo et al., 2016].

Moderators of the innovation-performance link in times of crisis. The relationship between innovation capacity and performance is largely influenced by the external environment [Zahra, Bogner, 2000]. However, the effects of innovation are likely to vary considerably depending on the degree of turbulence in the environment linked to the crisis context. How do moderators shape these relationships? Studies have shown that the relationship between innovation and performance is contingent on several influential environmental aspects, such as hostility, dynamism, or intensity of competition.

Moderation of the innovation–performance link in times of crisis is presented in Table 10. Jansen and colleagues show a positive relationship between exploratory innovation and financial performance when environmental dynamism is high [Jansen, Van Den Bosch, Volberda, 2006], while Osiyevskyy and co-authors argue that the severity of the cri-

sis functions as a positive contingency for the impact of exploration on the level and variability of firm performance [Osiyevskyy, Shirokova, Ritala, 2020]. In [Zouaghi, Sánchez, Martínez, 2018] it is pointed out that economic crisis positively moderates the relationship between R&D intensity and firm innovation performance. U. Lichtenthaler [Lichtenthaler, 2009] analyzed the data from 175 industrial firms and concluded that that technological and market turbulence moderate the effects of the individual learning processes (exploratory, transformative, and exploitative) and overall absorptive capacity on performance.

Table 10. **Moderators of the innovation-performance link in times of crisis**

Type of moderator	Relationship	Source	Main conclusion
1	2	3	4
Technological and market turbulence	Learning processes of absorptive capacity — innovation and performance	[Lichtenthaler, 2009]	The three learning processes exploratory, transformative, and exploitative and overall absorptive capacity have an equally positive effect on innovation at different levels of turbulence
Firm-specific crisis severity	Exploration-firm performance level and variability Exploitation-firm performance level and variability	[Osiyevskyy, Shirokova, Ritala, 2020]	The severity of crisis a firm is exposed to acts as a positive contingency for the impact of exploration on firm performance level and variability, and as a negative contingency for exploitation's level and variability effects
Environment dynamism and environmental competitiveness	Exploratory and Exploitative innovation financial performance	[Jansen, Van Den Bosch, Volberda, 2006]	Pursuing exploratory innovation is more effective in dynamic environments, whereas pursuing exploitative innovation is more beneficial to a unit's financial performance in more competitive environments
Financial crisis	Internal capabalities-innovative performance External coorporation-innovative performance	[Zouaghi, Sánchez, Martínez, 2018]	Strong internal knowledge bases yield strong absorptive capacity and lead to higher innovation performance. The value of external knowledge assets to support innovation activities in times of crisis. Maintaining strong internal and external knowledge capabilities enables firm to mitigate the effects of the financial crisis

As the main result of this systematic review, an integrated framework has been developed which maps insights within innovation in times of crisis on the 70 articles reviewed (Figure 4).

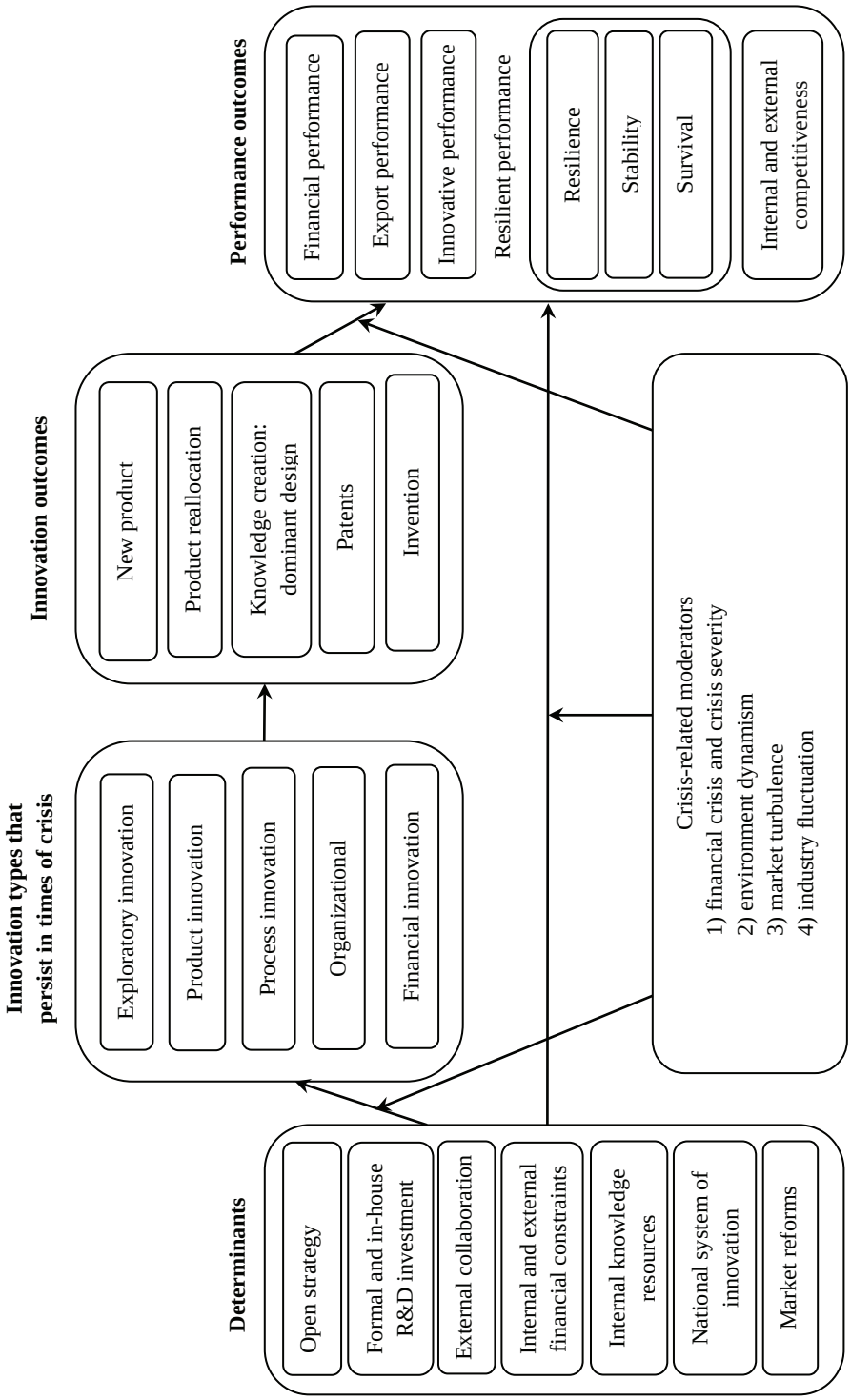

Figure 4. Conceptual structure of the findings

N o t e: solid arrows depict direct relationships while dotted arrows represent moderating effects.

The model brings the determinants driving or hampering innovation, the set of innovation types that persist in times of crisis, outcomes and consequences of innovation activities. It also emphasized that several factors act as moderator variables between innovation, outcomes and determinants.

DISCUSSION AND FUTURE RESEARCH DIRECTIONS

Discussion of the findings. It emerges from the findings that the effects of economic recession in terms of firms' investment in innovation are not the same from one firm to another and from one country to another; three behaviours can be described as follows: the first asserts that innovation is cyclical and that as a result firms tend to retrench their investment in innovation; fewer resources are then available for all firm operations during the recession, including innovation financing [Hall, 2005]; the second asserts that innovation is maintained, adopting a strategy of perseverance; the third asserts that it is countercyclical and that recessions are a favourable environment for firms to innovate. If an economic crisis creates instability and has an adverse influence, as predicted by Schumpeter, it creates losers who respond by reducing their investments in innovation. The winners, on the other hand, look for new opportunities created by the crisis and decide to respond by innovating [Archibugi, Filippetti, Frenz, 2013a; 2013b; Makkonen, 2013; Mazzucato, 2013; Amore, 2015; Lee, Sameen, Cowling, 2015; Nemlioglu, Mallick, 2017; Jung, Hwang, Kim, 2018; Brem, Nylund, Viardot, 2020].

The cyclical model is partially explained by the threat-rigidity theory, which states that when businesses perceive a threat to their survival, they may become risk averse and refuse to make any strategic changes [Colombo et al., 2016; Walrave et al., 2017; Osiyevskyy, Shirokova, Ritala, 2020], the "demand-pull" theory of innovative activity suggests that investment in innovation is highly pro-cyclical because in times of crisis, firms will experience a reduction in demand for their products [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013; Lee, Sameen, Cowling, 2015; Brancati et al., 2021]. Furthermore, debt financing and bank landing, according to transaction cost and agency theories, may lead to reduced innovative activities.

On the other hand, the counter-cyclical model is justified by the theory of strategic adaptation, affirming that businesses must rethink and adapt their strategies and behaviours in the face of adversity in order to adequately deal with environmental changes that could affect their long-term survival [Martin-Rios, Pasamar, 2018], in response to declining demand for their products, businesses will make investments in innovative products or services that can achieve commercial success as the economy recovers; firms that adopt innovation will continually design new products and processes to meet changing consumer demand [Lee, Sameen, Cowling, 2015]. According to the behavioural theory of the firm and the evolutionary theory of technological change, when performance falls short of expectations, firms begin to explore alternatives and reorient their strategies [Makkonen et al., 2014; McKinley, Latham, Braun, 2014; Colombo et al., 2016; Antonioli, Montresor, 2021; Cefis, Marsili, 2019].

The competitiveness of firms and, in turn, their survival depends on innovation [Madrid-Guijarro, Garcia, Van Auken, 2009], which contributes to improved performance in times of expansion and recession [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013]. However, both internal and external conditions are likely to produce an impact on the ability to innovate [Molina-Morales, Martinez-Fernandez, 2010]. Firm characteristics, financial and human resources, and internal and external knowledge capabilities were found to have a determining influence on the decision to engage in innovation [Lichtenthaler, 2009; Filippetti, Archibugi, 2011; Hud, Hussinger, 2015; Zouaghi, Sánchez, Martínez, 2018].

Through the application of the resource-based view of the firm, numerous academics claim that organizations pursuing innovation in times of crisis have a combination of dynamic capabilities and learning orientation that enable them to overcome the crisis and achieve better outcomes [Knudsen, Lien, 2015; Weaven et al., 2021; Xia, Dimov, 2019]. Microeconomic theory of innovation and institution based view highlight the role played by institutions to overcome the effects of crisis on countries' innovation investments. With strong national systems of innovation countries were relatively less affected by the recession [Filippetti, Archibugi, 2011; Gang, Choi, 2019].

Since the great financial crisis, external factors have received increased attention. The results reveal that the relationship between innovation and performance is contingent on a number of influential environmental aspects. The centrality of innovation as a catalyst for sustainable competitive advantage has led to a strong commitment by managers and policymakers to develop and implement measures to encourage innovation within firms. Thus, genuinely innovative organizations demonstrate innovative behaviour and adopt the creative accumulation strategy [Nieto, Santamaria, 2010].

A framework has been developed by combining resource-based theory, organizational learning theory, and firm behaviour theory, a combination that has proven to be theoretically fruitful. Innovation's key antecedents were identified, moderators and consequences in times of crisis. This framework shows the relative importance of different types of innovation during recessions and revealed that companies that embrace innovation are in a better position to remain competitive and achieve better financial performance and will be better positioned to deliver new products to the market than companies that have not adopted innovation.

Overall, this framework contributes to the literature on the impact of economic downturns on firms' ability to innovate by clearly illustrating that some innovation activities can be countercyclical, by engaging in product innovation, firms will benefit in the longer run, when the next expansion occurs.

Theoretical and practical implications. This review adds to the extant knowledge on a firm's adaptation to adverse environments and innovativeness in crisis and makes several theoretical contributions to the strategic management literature. Innovation's benefits in highly turbulent settings and a detailed description of factors that play an important role in counteracting the effect of the crisis on firms' innovation investment were proposed in this review, this study supplements the current knowledge of what

can make innovation work better in adverse conditions with a nuanced understanding of the main innovation strategies at firm and country level to respond to the economic downturn. This article improves knowledge on this topic by generating an integrative framework of innovation in times of crisis that considers the relationships among determinants, innovation, and its effects, focusing on environmental factors. Moreover, many research areas have been identified for potential scholars who will deal with this topic in the future.

The literature review suggests that during the current crisis, the sources of persistence in innovation are essentially three. In the first place, the presence of an R&D department implies that the firm has made a medium or long-term commitment to innovation. Secondly, this study shows the important contribution of the strategy intended at exploring new markets and new product developments [Archibugi, Filippetti, Frenz, 2013a]. Thirdly, the competencies and qualities of the human resources, the development of the financial system together with a robust national innovation system, a place-based policy action intended to increase the learning capacity of firms, seem to be the business factors which can offset the effect of the economic downturn on innovation investments of firms.

Finally, interesting implications can be drawn from the results that will help decision makers to adopt countercyclical innovation behaviour, according to J. A. Schumpeter's theory, firms that choose to adopt this behaviour and respond to the crisis by innovating fall into two categories: a) firms that produce, actualize knowledge, and innovate continuously in stable and adverse environments, this leads to the persistence of innovative activities and accomplish innovation as a routine; b) new innovators who are taking advantage of the crisis to challenge the market shares of incumbents or create new markets.

Both internal and external conditions are considered to have an impact on the ability to innovate; these results may be pertinent to the elaboration of a government policy that encourages investment in innovation by easing firms' access to external finance, especially targeting SMEs and new ventures, as those firms constraints in terms of access to external finance stem from capital market imperfections due to agency conflicts, moral hazard, and adverse selection and suffer more in hardship periods [Máñez et al., 2014], by diversifying the forms of loans, increasing the diversity of the banking system or proposing new forms of financing like crowdfunding [Lee, Sameen, Cowling, 2015]. Policies should support the promising innovators, in times of crisis, public support to the firms' business activities to help them increase innovation persistence [Brautzsch et al., 2015; Brancati, 2015; Hud, Hussinger, 2015; Giebel, Kraft, 2020].

Following [Zouaghi, Sánchez, Martínez, 2018], internal and external knowledge capabilities are key sources of innovation performance for businesses. Managers are advised to develop internal resources, human capital, education and training policy ensures the survival of companies in adverse conditions, because open innovation minimizes resource constraints and uncertainties associated with innovation, managers must be aware that external resources must be successfully integrated with internal

capabilities and a stronger and cooperative innovation policy could play a role in bad times [Lichtenthaler, 2009; Makkonen et al., 2014; Ahn, Mortara, Minshall, 2018].

For shareholders concerned about the company's long-term performance, the pursuit of new product development could play a role in finding new ways to make money in times of crisis [Colombo et al., 2021].

Future research directions. The conducted analysis allowed identifying a number of potentially promising future research directions that are discussed in details in the following paragraphs.

The multidimensionality of innovation. The findings of this literature review revealed different forms and dimensions of innovation. The innovation activities are manifested by the changes in the products and production processes which are captured by the technological innovation (product innovation and process innovation) and by changes introduced in the organizational structure of the company and administrative processes that refer to management innovation [Madrid-Guijarro, García-Pérez-de-Lema, Van Auken, 2013], and companies that enlarge the range of product, process and organizational innovations processes significantly increase their ability to penetrate foreign markets [Brancati et al., 2021].

Innovation-related investment includes expenditures on internal R&D, technology embodied in purchased machinery, licensed technology, training of personnel to support innovation, and expenditures on product, process and service design [Archibugi, Filippetti, Frenz, 2013a; 2013b]. Most empirical studies dealing with innovation in the manufacturing industry focus mainly on patents, R&D expenditures or the share of research personnel as indicators of innovative activity [Filippetti, Archibugi, 2011; Archibugi, Filippetti, Frenz, 2013b; Amore, 2015], other empirical studies have used exploitation and exploitative innovations [Jansen, Van Den Bosch, Volberda, 2006; Knudsen, Lien, 2015; Xia, Dimov, 2019; Osiyevskyy, Shirokova, Ritala, 2020].

Nevertheless, innovation is not just a process but also an outcome, the concept of dominant design is used as an indicator of innovation, the emergence of dominant designs formed the central focus of a study by A. Brem with co-authors in which the authors found that the science-based industries tend to have more dominant designs than other industries after the crisis. Future studies could include the concept of dominant design to have consistent empirical results about innovation investment in times of crisis within firms protected by patents [Brem, Nylund, Viardot, 2020].

Service sector. The manufacturing industry has often been used as a research context in the literature. Approximately 94% of the studies identified used data collected through personal interviews or datasets (Economic Barometers, Technology Innovation Panel) exclusively from the manufacturing industry.

In [Archibugi, Filippetti, Frenz, 2013b; Zouaghi, Sánchez, Martínez, 2018; Jansen, Van Den Bosch, Volberda, 2006] the authors have used data from the financial services sector in their studies, which is an interesting case for innovation researchers. C. Martin-Rios and S. Pasamar [Martin-Rios, Pasamar, 2018] examined long-term strategic adaptation activities with large service firms in response to an economic crisis. D. Ar-

chibugi argued that economic expansions relate to success in introducing new products, processes, and services [Archibugi, 2017]. However, future research could improve the generalizability of the results from the manufacturing industry by including the service sector. It would be of great policy interest to conduct a comparative study to determine the variety of innovation behaviour in each sector during an economic crisis.

Innovative ambidexterity. Due to the risky and costly nature of innovation, during times of crisis many companies are likely to focus more on surviving and less on pursuing new opportunities. One possible strategy is a combination of retrenchment and investment that involves the pursuit of new products or markets in certain areas, while engaging in cost-cutting measures and efficiency-enhancing activities in other areas [Archibugi, Filippetti, Frenz, 2013a]. A number of studies emphasize in particular the importance of allowing simultaneous capacities for alignment and adaptability [Gibson, Birkinshaw, 2004]. Consequently, an organization is expected to engage in sufficient exploitation to assure its present viability and, simultaneously, dedicate sufficient focus to exploration to ensure its future viability [Levinthal, March, 1993]. Most studies suggest that in a stable environment for firms to improve performance they should consider both exploration and exploitation, thus establishing ambidexterity [He, Wong, 2004]. Findings from studies on organizational ambidexterity in times of crisis [Stettner, Lavie, 2014] suggest that the balance or combination of exploration and exploitation can have a major impact on firm performance, far beyond the impacts of implementing these strategies separately.

Many studies have attempted to highlight the benefits of adopting innovative ambidexterity in times of crisis using the global financial crisis as a context [Makkonen et al., 2014; Walrave et al., 2017; Hansen, Güttel, Swart, 2019; Malik et al., 2019; Iborra, Safón, Dolz, 2020]. Although there are many studies dedicated to COVID-19 and its effect on innovation strategies, less attention has been paid to the impact of innovative ambidexterity strategy on firm performance under the pressure of the coronavirus pandemic [Krammer, 2022; Melnychuk, Schultz, Wirsich, 2021].

COVID-19 recession and crisis moderators. About 76% of the articles reviewed cover the global financial crisis, as the ghost of the 2008 economic crisis continues to affect the real economy. The fundamental reason why the recovery has not yet been fully satisfactory and states that the lack of confidence is at the root of the weakness of investments [Archibugi, 2017]; hence, entrepreneurs and investors fail to perceive the social and technological opportunities.

The COVID-19 pandemic is a health crisis, which has a significant impact on businesses around the world: a sharp drop in sales and limited access to financing [Krammer, 2022]. At the same time, an indigenous feature of the COVID-19 crisis concerns the increased technological complications of business processes that stem directly from the widespread adoption of remote technologies. Research needs to examine the impact of the external environment on innovative capacity and performance under the pressure of technological uncertainty that increased significantly during the COVID-19 pandemic.

Firm level and country level. About 96% of the reviewed empirical studies conducted their study at the firm level, thus favouring data collection. A. Filippetti and D. Archibugi [Filippetti, Archibugi, 2011] argued that the effects of economic recession in terms of business investment in innovation are not similar across European countries and assert that policies should support business and public R&D. Further studies should consider the country level and make explicit the government innovation policies taken during a recession in context.

Research questions. In times of stability, it is difficult to be successful innovators. In turbulent times, the challenge is likely to be amplified given the uncertainties associated with the crisis environment [Amore, 2015]. Thus, there is a need for additional research on the antecedents and consequences of innovation activities in difficult times. An overview of the new categories and directions that this study suggests future academics pursue is provided in Table 11, along with several research questions.

Table 11. **Future research directions and research questions**

Theme	Research question
Innovative ambidexterity	How do the combined implication of exploration and exploitation contribute to firm resilience? How do ambidexterity competences and capabilities contribute to firm survival during an economic downturn? What is the influence of the COVID-19 recession on exploratory versus exploitative firms?
Manufacturing versus service sectors	What is the impact of the economic crisis on performance in manufacturing and service sectors separately? What is the difference of innovation behaviour in manufacturing and service sectors in times of turbulence?
Open innovation	What is the relationship between open innovation and performance at firm and country level?
Crisis moderator	What is the moderating effect of technological and demand uncertainty on the relationship between innovation and innovative performance?
Firm-specific characteristics	Which are the key characteristics of companies that have survived to supply chain crisis? What is the impact of firm-specific characteristics on firm outcomes in stable and turbulent environment?
COVID-19 pandemic	How do firms respond to the challenges and opportunities of COVID-19 pandemic?

CONCLUSION

To respond to how the economic slowdown affects firms' behaviour in terms of their ability to maintain and develop innovative activities, this study relied on a systematic review of 70 conceptual and empirical articles dealing with innovation in times of crisis published between 2000 and 2021. The analysis enabled the identification of three firms' innovation behaviour. Some companies have reduced their innovation activities significantly, while others maintained their projects, and a third group significantly increased their activities to reap the benefits in the expected upswing. The cyclical pattern is almost entirely explained by barriers and constraints identified in this article which can be grouped into five categories: financial constraints, lack of knowledge, firm specific characteristics, weak national system of innovation and market-related constraints; maintaining innovative activities is underpinned by a more stable pattern of innovation which emphasizes cumulativeness and persistency of innovative activities in response to the crisis. The countercyclical pattern is likely to favour external and strategic alliances, which help overcome possible resource, finance and capability constraints.

Furthermore, the analysis identifies the set of innovation typologies that persist in times of crisis and their consequences in terms of performance and resilience. A conceptual framework was developed to account for the relationships among determinants, innovation, outcomes, and consequences in adverse economic conditions based on the results obtained. This framework explicitly illustrates that innovation in recession periods is complex and depends on many factors, grouped at the firm and country levels. Innovating in downturns can affect corporate success by improving a firm's position relative to competitors during the recovery period. Whatever the nature of the crisis, whether financial like the 2008 crisis, or a disruption of the global market supply chain like the COVID-19 ongoing pandemic, calls for an innovation crisis strategy, which seems to raise optimistic expectations for the future. Countries that maintain their innovation capabilities will be more likely to be ready to exploit market recovery and expansion into new emerging sectors. Finally, future research directions have been offered to advance the interest of investigation of all types of innovation, including the service sector, and to lean toward the country level.

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ИННОВАЦИИ В ПЕРИОД КРИЗИСА: СИСТЕМАТИЧЕСКИЙ ОБЗОР ЛИТЕРАТУРЫ

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В настоящее время мир сталкивается с серьезными экономическими и финансовыми кризисами, ведущими к возрастанию неопределенности бизнес-среды, что оказывает прямое воздействие на стратегии фирм в отношении инновационности. При этом в научной литературе нет согласованной позиции в отношении влияния кризиса на инновации. Цель данной статьи — систематизировать имеющиеся знания об инновационности фирм в кризисные периоды и идентифицировать факторы, способные сдерживать или стимулировать инновационную деятельность компаний. Исследование основано на систематическом обзоре литературы по протоколу PRISMA. Для анализа было отобрано 70 эмпирических и концептуальных статей, опубликованных в высокорейтинговых журналах списка Ассоциации бизнес-школ в 2000–2021 гг. В результате были выявлены три подхода к организации инновационной деятельности фирм в условиях кризиса: циклический, при котором большинство компаний сокращают свои расходы и становятся менее склонными к инновациям; нейтральный, направленный на сохранение статус-кво; контрциклический, когда компании стремятся активизировать свою инновационную деятельность. В работе рассмотрены факторы, от которых зависит применение указанных подходов. Кроме того, анализ литературы показал, что инновации положительно влияют на результативность компаний в условиях кризиса, а взаимосвязь между инновационными стратегиями и успешностью бизнеса зависит от уровня турбулентности внешней среды. Обзор вносит вклад в литературу об адаптации фирм к неблагоприятным условиям. В частности, рассмотрены вопросы повышения эффективности инноваций во время кризиса, уточнены основные инновационные стратегии на уровне компаний и стран в период экономического спада, определены преимущества инноваций в нестабильных условиях и описаны факторы, противодействующие негативному влиянию кризиса на инвестиции фирм в инновации.

Ключевые слова: инновация, инновационность, кризис, исследования и разработки, инновационная амбидекстрия, систематический обзор.

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