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Wearing failure as a path to innovation☆

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ABSTRACT

Innovation is a widely acknowledged key component of corporate performance management. However, most of the literature on this topic has tended to focus on determinants of corporate failure, thereby neglecting to look at the role of innovation failure in triggering innovative initiatives. By using a sample of companies covered by 2014 Community Innovation Survey data and applying econometric models, this study sought to analyze the impacts of innovative project failure. The results show that innovation failure is negatively correlated with companies' experience and acquisition of external knowledge. The main findings are consistent with the scarce literature on this research topic, and highlight the positive role that companies' accumulated experience has in their assimilation of knowledge flows.

1. Introduction

Companies are not always able—or may not choose—to innovate. The reason for this lack of innovation is a particularly important issue because many authors argue that innovation plays a key role in companies' economic performance (Ferreira, Fernandes, & Ferreira, 2019; Kodama, 2006, 2009). Innovation is the process by which opportunities are transformed into practical utilities (D'Este, Amara, & Olmos, 2016; Kleinknecht, Oostendorp, & Pradhan, 1997). The literature acknowledges that the effective implementation of innovations is synonymous with developing sustained competitive advantages, thus reinforcing organizational performance (Fernandes, Ferreira, Mota Veiga, & Marques, 2019; Geroski, Machin, & van Reenen, 1993; Koch & Strotmann, 2008).

Despite these benefits, the basic question remains of why many companies do not engage in innovation. This choice has to do with various types of risks and uncertainties that contribute to high failure rates. According to Asplund and Sandin (1999) and Cozijnsen, Vrakking, and van Ijzerloo (2000), only one in five business projects already started is feasible. In this context, researchers need to conduct more systematic assessments of factors behind successful and, perhaps more important, failed attempts to innovate (D'Este, Rentocchini, & Vega-Jurado, 2014). Various authors suggest that innovative projects often fail because of their intrinsic characteristics, uncertainty, and information asymmetries (Amara, D'Este, Landry, & Doloreux, 2016; Hölzl & Janger, 2014; Mancusi & Vezzulli, 2014). In recent years, the literature on empirical studies of innovative project success and failure has flourished (Efthyvoulou & Vahter, 2016; Mohnen, Palm, Van Der Loeff, & Tiwari, 2008; Tiwari, Mohnen, Palm, & Van Der Loeff, 2008).

However, only the latest research emphasizes that failure can play a positive role in organizations' activities (Chesbrough, 2010; Danneels & Vestal, 2020). Other authors (Dorfler & Baumann, 2014; Haunschild & Sullivan, 2002) argue that the difficulties companies experience when dealing with external pressures ultimately focus the attention of these firms on their inability to meet market needs, and thus cause organizations to initiate a process of fruitful discovery (Desai, 2010a, 2010b; Leoncini, 2016).

Recently, due to the coronavirus pandemic, innovators are asked for help. Beermakers and distilleries, for instance, have shifted production to hand sanitizers. As such, when we look back on the current health crisis, it seems clear that it resulted in some innovations. For example, new drugs and medical devices, improved healthcare processes, manufacturing and supply chain breakthroughs, and novel collaboration techniques (Clark, 2020). Innovations resulting from turbulent environments or adverse situations lead to a process in which companies learn that the only way to respond to market challenges and failures is creativity (García-Quevedo, Segarra-Blasco, & Teruel, 2018; Leoncini, 2016).

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The present study thus sought to answer the following research question: Can failure be a path to innovation? In other words, can companies learn from failures and transform them into successes? Experts have only recently recognized innovation as one of the key elements in determining successful firms' improved performance. Overall, the existing research has mostly focused entirely on determinants of company failure, neglecting the role that failed projects play in stimulating innovative activities. This gap in the literature inspired the current study's definition and approach.

The primary aim is, therefore, to test empirically the relationship between innovative performance, failure, and organizational learning. This research sought to make two main contributions. The first objective is to deepen the knowledge on this subject and fill the gap found in the academic literature in this field. The second objective is to contribute to practitioners' effectiveness by helping managers and entrepreneurs understand that failure in innovative projects also provides opportunities and new paths to success.

The next section presents the literature review that provided the basis for the research hypotheses. The subsequent sections detail the methodology, results, and discussion. The final section offers relevant considerations, implications, limitations, and future lines of research.

2. Theoretical underpinnings and hypotheses

2.1. Theoretical underpinnings

Leoncini (2016) notes that learning is a dynamic process that results from repeated attempts to resolve problems. Failure, in this sense, triggers learning processes that are associated with organizational routines stored within the company (Levinthal & March, 1993; Scott, 2011). These routines can thus adequately represent a company's response to the challenges arising from the external environment (Nelson & Winter, 1982), which can be defined based on the strength of past actions and result in new strategies to explore business opportunities (Becker, 2004; March, 1991). According to Haunschild and Sullivan (2002) and Dorfler and Baumann (2014), this means that problems are usually identified and resolved by innovative companies. For companies seeking to adopt innovative behavior, it is essential to create, maintain and develop their ability to build and/or recognize internal knowledge. Learning is thus the primary means to redefine existing processes, and restructure operating routines and procedures (Baum & Dahlin, 2007; Stalk, Evans, & Shulman, 1992).

2.2. Hypotheses

2.2.1. Operational experience and innovative projects

Operational experience occurs when organizations draw conclusions from regularly evolving and adapting to a changing business environment (Erthal & Marques, 2018). In this way, these entities can ensure continuous improvement through constantly changing, developing, and renewing dynamic organizational structures (Akgün, Ince, Imamoglu, Keskin, & Kocoglu, 2014; Senge et al., 1999). Several authors argue that research and development (R&D) can be used as a proxy for operational experience when focusing on the study of innovative companies (Chesbrough, 2010; Chiou, Magazzini, Pammolli, & Riccaboni, 2012; Dorfler & Baumann, 2014; Madsen & Desai, 2010).

The process of creating or gathering information allows companies to gain knowledge from their employees and other organizations' experiences or even the failures observed (Desai, 2010a; Marsick, 2013; Tortorella, Cawley-Vergara, Garza-Reyes, & Sawhney, 2020). For this reason, new knowledge—regardless of its origin—is important to companies because this knowledge allows them to progress faster and more effectively than competitors through discovery and exploration (Chesbrough, 2010; Chiou, Magazzini, Pammolli, & Riccaboni, 2012). In addition, one of the most important and essential steps in creating an innovative organizational culture is encouraging the sharing of knowledge and experience. Knowledge about innovation and knowledge production also shape innovation (Leoncini, 2016).

In this context, the inclusion and use of information in innovation processes can also shape organizations' actions (Amarakoon, Weerawardena, & Verreynne, 2018; Andrews, Boyne, & Walker, 2006). The production of organizational knowledge and experience is thus a prerequisite for innovation. Firms' capability to achieve or improve innovations must increase, and employees have to apply their knowledge widely, especially any expertise generated by failures (Kermally, 2004).

Management theories thus place great emphasis on the crucial relationship between innovation and operational experience with regard to gaining and maintaining competitive advantages (Brockmand & Morgan, 2003; Darroch & McNaugton, 2002; Ferreira, Fernandes, Alves, & Raposo, 2015). The central assumption underlying this line of thinking is that learning and essentially failing through experiences play a major role in all innovation-based activities and make companies' innovation processes more flexible (Brown & Svenson, 1998; Jiménez & Sanz-Valle, 2011; Weerd-Nederhof, Pacitti, da Silva Gomes, & Pearson, 2002). Operational experience, innovation, and performance are, therefore, positively interrelated (Keskin, 2006; Lee & Tsai, 2005; Salavou & Lioukas, 2003).

The present study formulates the following hypotheses based on the existing research:

H1a. The greater companies' operational experience is, the lower their propensity for failure in innovative projects.

H1b. The greater companies' operational experience is, the greater their propensity to engage in innovative projects.

2.2.2. Knowledge and failure

Firms do not exist in isolation. The benefits of open innovation are increasingly recognized in the literature on innovation management as the trend toward innovation collaboration intensifies (Podmetina, Teplov, Albats, & Dabrowska, 2016; Schroll & Mild, 2012). The results of prior research confirm that increasing business openness is associated with the development of the dynamic resources needed to deal with turbulent environments (Cruz-González, López-Sáez, Navas-López, & Delgado-Verde, 2015; Zouaghi, Sánchez, & García-Martínez, 2018). During detected failures, companies that actively resort to absorbing external knowledge present effective, adaptive behaviors that ensure their survival while maintaining internal innovation capabilities for future growth (Chesbrough & Garman, 2009; Di Minin, Frattini, & Piccaluga, 2010; Khan & Khan, 2019).

Using external knowledge allows companies to acquire different skills, pool complementary resources, update and modify learning routines, and access market information (Miotti & Sachwald, 2003; Walsh, Lee, & Nagaoka, 2016). The processing of all this knowledge brings external expertise to companies. These processes tend to make firms stronger than their competitors (Silverman & Baum, 2002). Collaboration with suppliers is another way to increase efficiency and complement companies' technology base (Belderbos, Carree, & Lokshin, 2004; Un & Asakawa, 2015). Thus, external knowledge is an important source of innovation for companies, especially in fast-paced or turbulent markets (von Hippel, 2005).

Companies have distinct characteristics that differentiate firms from each other, so some can also appear to be more resilient to failure than other companies. Firms' ability to learn is related to their organizational complexity, but the latter is not determined by their size because companies of the same size may have different degrees of organizational complexity (Rhee & Haunschild, 2006). Learning processes and knowledge acquisition are also critical elements in organizations' attitude toward failure as they use their reservoir of knowledge to focus on tackling and solving complex, challenging tasks. Thus, after facing failure, organizations can build on a broad knowledge base built up

through a variety of experiences (D'Este et al., 2014; Desai, 2010b; Leoncini, 2016).

The current research posits the following hypotheses to reflect the findings of prior studies:

H2a. Companies that experience failures are less likely to fail again.

H2b. Companies that experience failures in innovation projects benefit from outside expertise.

3. Methods

3.1. Data

The empirical analysis of this research uses statistical data generated by the Community Innovation Survey (CIS), which is Eurostat's leading business innovation survey based on the conceptual framework detailed in the *Oslo Manual* (Leoncini, 2016; Tiwari et al., 2008). The CIS's target population is all companies with more than 10 employees listed in the European Community's Statistical Classification of Economic Activities (NACE) Rev. 2 sections A through M. The CIS excludes NACE Rev. 2 industries from sections O to U. The excluded entities comprise organizations in the areas of public administration, education, health and social care, arts, entertainment and leisure, and other service activities—that is, professional organizations and personal services—as well as family businesses and extraterritorial bodies. Firms with at least 20 employees answered questions concerning the nature of their technological innovations, the supervision of these innovations (innovation projects), the internal and external sources involved in R&D, the objectives of their technological innovations, the sources of information used, cooperation to innovate, and obstacles to innovation projects.

The data included in the present study are from CIS 2010, CIS 2012, and CIS 2014. The statistics used are from each observation period for the respective three-year period, namely, CIS 2010, beginning of 2008 until end of 2010; CIS 2012, beginning of 2010 until end of 2012; and CIS 2014, beginning of 2012 until end of 2014. The reference periods are 2010, 2012, and 2014.

This research used random sampling to select the sample in each country, based on up-to-date official company registers. To ensure a stratified sample, the data included firms' activity classification (NACE), and size class measured by the number of employees. Table 1 shows the volume of companies included by year and country.

3.2. Econometric methods

To minimize the potential problems of endogeneity and inverse causality inherent in the use of cross sections, this study adopts a two-step model strategy to evaluate the defined hypotheses:

1. Determinants of abandoned innovation—subsequent to continuous innovation—are estimated using probit models.
2. The role of failed innovative projects in companies' innovative activities is determined by using the values estimated in step one as predictor variables, with calculations based on multiple linear regression models.

Econometric modelling follows the model developed by Crepon et al. (1998) to evaluate the impact of innovative activities on a company's performance. The original model by Crepon et al. (1998) is a three-step structural model. First, it estimates the R&D equation—that is, how firms decide whether or not to invest in R&D and, if so, with what intensity. In the second step, the expected R&D values are inserted in an equation that models the relationships between innovative inputs and outputs—that is, share of innovative sales or patent counts. In the third and last step, the innovative outputs are used as an explanation of the productivity equation. Following Leoncini (2016) example, this third step was not implemented in the present study.

For the model estimation, this research relies on Stata Version 13 statistical software produced by StataCorp, which is based in Texas in the United States. The calculations include estimating clustered standard errors at the country level.

3.3. Variables

3.3.1. First step

The two dependent variables of this step are dummy variables (0 = "No" vs. 1 = "Yes"). The first variable corresponds to the abandonment of innovations, termed ABAIN. The item assessing this variable is as follows: "From 2010 to 2014, were any innovation activities abandoned or suspended before completion?" The question focused on on-going innovation or ONGIN is the following: "From 2006 to 2008, did your company have any innovation activities that did not result in a product or process innovation because the activities were still ongoing at the end of 2008?"

The set of independent variables includes the log of research and development (R&D) expenses or R&DLn and the dummy variable (0 = "No" vs. 1 = "Yes") that describes whether product or process innovations originate from outside companies or KNOWEXT. In addition, the firms' size is the log of the turnover of the reference year or TURNLn, while whether or not they belong to an industrial group or IG functions as an identification variable. Other independent variables are the CIS year, and dummies for countries and sectors of activity.

3.3.2. Second step

The dependent variable in this step is the proportion of innovative sales or INTURN. The data for the dependent variable were collected as "the percentage of total turnover in 2010—or 2012 or 2014—coming from new or significantly improved goods and services that were new to the market".

The independent variables are predicted values obtained from estimates of abandoned innovation made in the first step, termed PINABA. The types of cooperation with partners by location are, first, a dummy variable (0 = "No" vs. 1 = "Yes") for cooperation in the companies' home country or HCCOOP. The second component is the dummy variable RWCOOP, given a value of 1 for cooperation with the rest of the world and 0 otherwise. The CIS year and dummies for countries and sectors of activity are also included as independent variables. Table 2 presents a summary of the variables included.

Table 1
Study sample by country and year.

	2010	2012	2014
Bulgaria	14.617	14.296	14.255
Cyprus	1.060	1.205	1.346
Czech Republic	5.151	5.449	5.198
Germany	5.817	6.328	6.282
Estonia	1.735	1.723	1.760
Greece	0	0	2.507
Spain	34.550	32.120	30.333
Croatia	3.390	3.193	3.265
Hungary	4.638	5.152	6.817
Lithuania	2.175	2.231	2.421
Latvia	0	0	1.501
Norway	5.320	5.083	5.045
Portugal	6.160	6.840	7.083
Romania	8.625	7.670	8.206
Slovenia	2.290	1.869	0
Slovakia	2.363	2.897	2.790
Total	97.891	96.056	98.809

Table 2
Summary of variables used in study.

Variables	Description	Authors	Hypotheses
Dependent			
Innovation project failure = innovation abandoned (ABAIN)	• Responses recorded as 1 if a firm answered "yes" and 0 if the answer was "no" to the first part of question 4 in the CIS questionnaire (i.e., "From 2010 to 2014, did your enterprise have any innovation activities that did not result in a product or process innovation because the activities were abandoned or suspended before completion?")	Amarakoon et al. (2018), Andrews et al. (2006) and Leoncini (2016)	H1a H1b H2b
Ongoing innovation (ONGIN)	• Proportion of innovative sales as captured by the "percentage of total turnover 2010—or 2012 or 2014—coming from new or significantly improved goods and services that were new to the market"		H2a
Independent			
Operational experience (R&DLn)	• Log of R&D (R&DLn) expenditure since the expectation is that a larger stock of R&D indicates firms with more experience and thus less likely to experience failure	Chesbrough (2010); Madsen and Desai (2010); Chiou et al. (2012); Dorfler & Baumann, 2014; Cruz-González et al. (2015), Di Minin et al. (2010), Khan and Khan (2019), Leoncini (2016), and Zouaghi et al. (2018)	H1a H1b
Experience of organizational failures (PINABA)	• Predicted values obtained from the estimates made in the first stage: abandoned innovation		H2a
External knowledge (KNOWEXT)	• Variables describing the origin from which product (question 2.2) and process (question 3.2) innovation develops, used to obtain information on how firms are able to produce and gather the knowledge they needed to innovate, for example, from outside the company (KNOWEXT) • Company size represented by the log of the reference year's turnover (TURNLn), as well as whether or not firms belong to an industrial group, used as the identifying variable • Cooperation in the companies' home country (HCCOOP) is 1 and 0 if not present, with the other dummy variable (RWCOOP) given a value of 1 for cooperation with the rest of the world and 0 otherwise		H2b

4. Results and discussion

4.1. First step

The descriptive statistics and correlation values from the first step appear in Table 3. These data reveal that the covariates' correlations are weak and that they do not invalidate the inclusion of all predictor variables simultaneously. Table 4 presents the results from the first step.

These statistics show that the probability of an innovative project being abandoned is negatively related to statistically significant R&D expenses ($\beta = -0.357$; $dx/dy = -0.036$; $p < 0.05$). The ability to acquire knowledge externally decreases the likelihood that companies will abandon an innovative project ($\beta = -0.277$; $dx/dy = -0.028$; $p < 0.05$). Thus, the results support hypothesis H1a—that is, the greater companies' operational experience is, the lower their propensity for failures in innovative projects.

Various authors argue that organizations acquire knowledge from their operational experience and learn from failures, thus becoming less likely to make the same mistakes (Brockmand & Morgan, 2003; Darroch & McNaugton, 2002; Ferreira et al., 2015). This improvement can happen for various reasons. According to Desai (2010a), what organizations gain from their previous operational experience comes from at least two different sources. First, operational experience gives companies the ability to learn. Second, this experience generates an absorptive capacity through which knowledge becomes more easily accessible.

Table 4
Stage one: probit estimation of probability of abandoned (ABAIN) or still ongoing (ONGIN) innovation.

	ABAIN		ONGIN	
	Coefficients (SE)	Marginal effects (dx/dy)	Coefficients	Marginal effects (dx/dy)
R&DLn	−0.357*	−0.036	0.610*	0.130
	(0.172)		(0.272)	
KNOWEXT	−0.277*	−0.028	−0.133*	−0.029
	(0.103)		(0.051)	
IG	0.263*	0.027	0.249*	0.053
	(0.035)		(0.029)	
TURNLn	−0.172*	−0.018	0.178*	0.038
	(0.025)		(0.028)	
Number	166,151		166,152	
AIC	109.774.90		173,700.50	
BIC	109,795.00		173,750.60	

Note: SE = standard error; *$p < 0.05$; adjusted for year, country, and activity.

Table 3
Summary statistics for stage one.

Variable	Mean	SD	Min	Max	ABAIN	ONGIN	R&DLn	KNOWEXT	IG	TURNLn
ABAIN	0.11	0.31	0.00	1.00	1					
ONGIN	0.28	0.45	0.00	1.00	0.301*	1				
R&DLn	−0.60	0.41	−0.69	11.90	−0.067*	0.196*	1			
KNOWEXT	0.04	0.20	0.00	1.00	−0.040*	−0.052*	−0.022*	1		
IG	0.35	0.48	0.00	1.00	0.119*	0.192*	0.017*	−0.059*	1	
TURNLn	15.32	1.87	2.30	25.06	−0.148*	0.233*	0.104*	−0.043*	0.428*	1

Note: SD = standard deviation; *$p < 0.05$.

Thus, learning from experiences involving failures plays a prominent role in all innovation-based activities and makes firm innovation processes more flexible (Jiménez & Sanz-Valle, 2011; Weerd-Nederhof et al., 2002).

Regarding the likelihood that a project will last longer than the present study's research period, R&D expenditures positively influence ($\beta = 0.10$; $dx/dy = 0.130$; $p < 0.05$) the probability that companies will have ongoing innovative projects in place. The likelihood that an innovative project is still underway is also negatively related to the acquisition of external knowledge ($\beta = -0.133$; $dx/dy = -0.029$; $p < 0.05$). Thus, the results support hypothesis H1b—that is, the greater companies' operational experience is, the greater their propensity to engage in innovative projects.

These findings confirm that firms' innovative activities and operational experience can be defined in terms of their R&D. More specifically, when improving innovation and integrating it into company management, a focus on R&D is natural because its function is to produce knowledge. Therefore, operational experience increases organizations ability to engage in new innovative projects.

4.2. Second step

Table 5 presents the descriptive statistics and correlation values from the second step. As in the first step, the results reveal that the covariate correlations are weak and that the statistics fail to invalidate the simultaneous inclusion of all independent variables. The likelihood of successful innovations—that is, companies' percentage of turnover resulting from the introduction of new or significantly improved goods or services into the market—is presented in Table 6.

These results show that firms' propensity for project abandonment (PINABA) has a positive, statistically significant impact on those organizations' innovative capabilities ($\beta = 1.240$; $p < 0.05$). Thus, hypothesis H2a—that is, companies that experience failures are less likely to fail again—is supported.

These findings corroborate what various other authors have argued, namely, that failures generate knowledge and the latter helps prevent new failures similar to those that have already occurred (Podmetina et al., 2016; Schroll & Mild, 2012). Through failures, companies acquire survival skills, thereby building up an absorption capacity that translates into operational learning (Khan & Khan, 2019; Zouaghi et al., 2018). Therefore, contrary to the common sense notion that failures are a tragedy, they do not necessarily have only negative effects. Failures present opportunities for knowledge creation, and, through this process, companies can avoid future failures.

Firms' cooperative stance with regard to organizations inside ($\beta = 0.018$; $p < 0.05$) and outside these companies' home country ($\beta = 0.017$; $p < 0.05$) has a statistically significant positive impact on the likelihood of successful innovations. These results support hypothesis H2b—that is, companies that experience failures in innovation projects benefit from external expertise.

These findings confirm work by other authors who argue that firms that use external knowledge can more easily acquire different skills (Miotti & Sachwald, 2003; Walsh et al., 2016). External knowledge is thus an important source of innovation for companies (von Hippel, 2005). According to Rhee and Haunschild (2006), organizational complexity varies between companies, with size having no influence on complexity and, therefore, firms' ability to acquire new skills. Through contact with their environment, companies absorb this knowledge from outside their home country, allowing them to correct future failures (D'Este et al., 2014; Desai, 2010b; Leoncini, 2016). The processing of this knowledge brings external expertise to companies (Belderbos et al., 2004; Silverman & Baum, 2002; Un & Asakawa, 2015). As such, external knowledge is an important source of innovation for companies, particularly in turbulent external environments.

Table 6
Stage two: estimation of probability of producing successful market innovations after abandoning other innovations.

	Coefficients (SE)	
PINABA	1.240*	(0.251)
HCCOOP	0.018*	(0.004)
RWCOOP	0.017*	(0.054)
IG	−0.024*	(0.006)
TURNLn	−0.024	(0.021)
Number	166,158	
R squared	0.296	
Adjusted *R* squared	0.132	

Note: SE = standard error; *$p < 0.05$; adjusted for year, country, and activity.

5. Implications

The results of the present research suggest that examining the mechanisms by which organizations learn from their failures is an important step toward strengthening their innovative activities, supporting the findings by Dahlin, Chuang, and Roulet (2018) and McMillan and Overall (2017). The current findings include that companies need to make certain efforts to learn from past failures to improve their ongoing innovations. Firm tolerance for failure alone does not contribute to innovation. In this way, the present study overcomes an important limitation in the existing research on failure-related operational learning, namely, a lack of focus on the ways that organizations can acquire knowledge and skills from failures.

The above findings on how to learn from failure can greatly benefit organizations because a dearth of empirical evidence is available on this topic (Cannon & Edmondson, 2001). Some authors note that failure receives more praise than good practices do (Latham, 2009). Despite a general acknowledgment of the importance of improving innovation based on "failure lessons", most companies find this strategy difficult to implement (Danneels & Vestal, 2020; Edmondson, 2011; McGrath, 2011). Although organizations consider their employees' ability to learn from failure a "standout best practice" (Cooper, Edgett, & Kleinschmidt, 2004), the vast majority of firms find this capability challenging to develop.

The variables included in the present research constitute a checklist for assessing organizations' learning practices and operational experience. As implication for practitioners, Madsen and Desai (2010) suggest that companies that stigmatize failure may be depriving themselves of outstanding opportunities for improvement. Thus, the current study's

Table 5
Summary statistics for stage two.

Variable	Mean	SD	Min	Max	INTURN	PINABA	HCCOOP	RWCOOP	IG	TURNLn
INTURN	0.05	0.16	0.00	1.00	1					
PINABA	0.11	0.09	0.01	0.99	0.441*	1				
HCCOOP	0.19	0.39	0.00	1.00	0.237*	0.359*	1			
RWCOOP	0.10	0.30	0.00	1.00	0.210*	0.375*	0.467*	1		
IG	0.35	0.48	0.00	1.00	0.056*	0.435*	0.179*	0.184*	1	
TURNLn	15.32	1.87	2.30	25.06	0.066*	0.429*	0.177*	0.199*	0.445*	1

Note: SD = standard deviation; min = minimum; max = maximum; *$p < 0.05$.

most significant contribution to better practices is confirming that organization leaders should not ignore failures or castigate employees involved in them. Rather, leaders should treat failures as an invaluable learning opportunity by encouraging open sharing of information about them. Firms must encourage tolerance for failure in company behavior and culture, meaning non-stigmatization in failure analysis and that the treatment of failures should allow for learning opportunities.

A recommendation arising from the findings of this research is specifically related to the issue of non-stigmatization, as failures do not necessarily have to affect companies' innovation and innovative projects negatively. Another recommendation is the need to foster constructive debate by conducting further studies of this topic. Universities—together with innovation intermediaries and consultants, government agencies, and companies in other relevant sectors—can be horizontal partners who are essential to overcoming failures or achieving business goals (Belderbos et al., 2004; Stefan & Bengtsson, 2017). Collaboration with higher education institutions and research centers can provide access to state-of-the-art technologies tailored to meet business needs (Tether & Tajar, 2008; Tsai, 2009).

However, to gain access to these technologies, companies may also need to collaborate with other actors to implement innovations (Berg-Jensen, Johnson, Lorenz, & Lundvall, 2007). Thus, another recommendation is to form alliances with intermediaries that provide support for innovative projects. Companies and their partners in innovation activities both have to achieve goals while reducing the time spent developing these innovations. External knowledge assets are more likely to reduce the risk of failure because companies can explore relevant new knowledge and skills. Strategic planning involves careful thinking through innovation projects based on metrics, milestones, and *a priori* goals. In addition, joint efforts should include identifying crucial lessons and taking into consideration each partner's responsibilities regarding factors contributing to companies' successes or failures (Corbett, Neck, & Detienne, 2007).

6. Final considerations, limitations, and future research

The main objective of this research is to test empirically the relationship between innovative performance, failure, and organizational learning. Even common sense suggests that failures provide learning opportunities and that past-initiative failures can provide the foundation for the success of future projects. More specifically, accepting failures can be thought of as a way to encourage innovation. Despite the popularity of this perspective, little empirical evidence is available for the link between organizations' failure tolerance and innovation.

Regarding the research question addressed—Can failure be a path to innovation? —That is, can companies learn from failures and transform them into successes?, the results are in line with various previous studies (D'Este et al., 2014; Desai, 2010b; Leoncini, 2016) that confirmed companies can learn by failing.

We thus conclude that learning mode is crucial for innovation. For companies seeking to adopt an innovative behavior, it is essential to generate, maintain and develop their ability to build and/or recognize internal knowledge. We add to our conclusions that learning is the main means to redefine existing processes and restructure operational routines and procedures. In this way, companies can reduce the probability of failure by improving their efficiency, which impacts on their resilience.

Our research also provides valuable information on the importance of the experience and external knowledge provided by failures to the level of success in new innovative projects. In our empirical analysis, we confirm that operational experience not only leads companies to have more innovative projects but also to have fewer failures in these same projects. We also confirm that failures prevent new failures at the same time that companies benefit from external knowledge through their absorption capacity. In January 2020, the World Health Organization (WHO) declared COVID-19 (coronavirus) a global health emergency. This pandemic has led to economic impacts, business struggles, social distancing and even national lockdowns. During this critical period, learning and development play an important role for companies and businesses, enhancing the importance of maintaining a healthy and productive workforce.

As with any research model or methodology, the specific limitations and assumptions of the current study require further discussion. An important aspect of this research is that it only assumes that operational experience has an impact on the occurrence of new failures.

Future research could examine the empirical evidence for the link between the transformational failures observed and specific interventions within companies' functional dynamics. Using case study methodology in further studies may also be an option worth considering. In addition, an extension of the current study could be a systematic review of all possible combinations of interventions at the time companies' structural decline begins. The review results should be used to identify the possible combinations of dynamics that can overcome failures in firms.

A second limitation is that the research only included countries that appear in the CIS data. As the latter are aggregated statistics at the country level, only a country-level study could draw conclusions on how to develop the best policies to promote the three main variables of the present research.

Future studies may produce more specific insights into the contents and mechanisms of operational experience. Researchers could also benefit from examining failures in organizations' different activities and functions. Some types of failures may be more causally ambiguous than others. Further research might also generate particularly important results by focusing on the nature of technological and non-technological failures, especially because the latter is difficult to identify. Other future research could analyze lessons learned from failures and ways they can be coded and communicated throughout organizations. Only when companies learn effectively from their failures through deliberate, straightforward extraction of key lessons will these firms be able to innovate more successfully than their competitors.

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