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Organizational and technological innovations: Is there a virtuous circle?

Meriam Attia¹, Ouidad Yousfi²

Abstract

Purpose: The main aim of the current paper is to determine whether organizational innovations influence technological ones or vice versa.

Design /approach: This study is drawn a sample of listed firms on the SBF120³ index and French Community Innovation Surveys (CIS)s carried out between 2004 and 2016.

Findings: Our study provides the following: First, we show that the introduction of new technological innovations could stimulate organizational changes in a firm's structure. Second, the adoption of new management practices is likely to increase the introduction of new processes, however, it is not sufficient to favor the development of new or significantly improved products.

Research limitations/implications: We studied different types of innovations, but we have ignored other forms of non-technological innovation, such as marketing innovations. It would be interesting to analyse the interaction between marketing and technological innovations.

Practical implications: From a business perspective, we emphasize that firms should introduce new organizational methods in the firm's business practices, workplace organization, or external relations, and adopt managerial transformations to boost their innovation potential.

Originality/value: To the best of our knowledge, this is the first paper that looks at the dynamic character between organizational and technological innovations, especially through a longitudinal study.

Keywords: Product innovation, process innovation outcomes, technological innovations, organizational innovations.

JEL Classification Codes: G30, O30, O31, M21

¹ PhD in Finance at MRM-MBS (University of Montpellier, France). Corresponding-Email: meriamattia@gmail.com

² Associate Professor of Finance at MRM-MBS (University of Montpellier, France). Corresponding-Email: ouidad.yousfi@umontpellier.fr

³ The SBF120 index consists of the largest 120 capitalizations listed on the French stock Exchange market (SBF: Société des Bourses Françaises).

1. Introduction

Innovation activities are traditionally perceived to comprise product and process innovation. Both types of innovation are often associated with the development or application of new technologies. Technological view on innovation has been well criticized: indeed, technological innovation deals with the introduction of new products and processes directly for customers (OCDE, 2005; Mairesse and Mohnen, 2005), while, organizational innovation describes the application of new and/or improved ideas and processes within the firm's workplace such as employee management, marketing, database management, distribution of responsibilities, and managing external relationships to help reduce costs and create value for the firm and other external stakeholders (Weerawardena, 2003; OECD, 2005; Chetty and Stangl, 2010; Damanpour and Aravind, 2012). Thus, innovation strategy cannot be focusing only on technological innovation (Cozzarin and Perzival, 2006). In France, for instance, 30% of firms have developed non-technological innovations and introduced new organizational methods between 2012 and 2014 (CIS 2014, Community Innovation Survey⁴).

Organizational innovation is a critical output for firms (Liao and Wu, 2010; Camisón and Villar-López, 2014; and Karlsson and Tavassoli, 2015), a source of value creation (Hwang et al., 2008; Hamel, 2009), and an indicator for the intra-firm diffusion of different organizational practices (Armbruster et al., 2008). Furthermore, organizational innovations could be a precondition for the development of new products, driven by the necessity of introducing changes in job positions and organizational processes to favor the introduction of new processes and new products (Damanpour and Gopalakrishnan, 2001; Arranz et al., 2019; and Donbesuur et al., 2020). Actually, organizational innovations such as improved communication channels, new relationships with external networks, and new and improved information sharing in international markets could improve firms' efficacy in new product introductions in the international markets, which in turn could improve the sales and profitability of these introductions. Thus, organizational innovations such as new or improved systems and structures are necessary conditions for a firm's overall innovativeness (Gunday et al., 2011; and Donbesuur et al., 2020).

⁴ Insee (Institut national de la statistique et des études économiques)

1 Moreover, according to socio-technical system theory, any change in an organization's
2 technological system requires changes in the administrative system to adjust to the demands
3 created by the technological system. In other words, when a company introduces new products to
4 the market, it could generate changes in the organizational infrastructure to design the production
5 process and to effectively support the design and marketing of new products (Sapprasert and
6 Clausen, 2012; Camisón and Villar López, 2014; Karlsson and Tavassoli, 2015). Therefore, a
7 causality perspective should be adopted to achieve a better understanding of the interaction
8 between organizational and technological innovations.

9 Despite the significance of organizational innovation, the number of studies on organizational
10 innovation has only increased in recent years (Damanpour and Aravind, 2012; Doran, 2012;
11 Camisón and Villar-López, 2014; Ballot et al., 2015; Favoreu et al., 2018; and Arranz et al.,
12 2019). Unlike technological innovation, the literature on organizational innovation is still
13 scattered (Armbruster et al., 2008; and Mol and Birkinshaw, 2009): The first studies have
14 focused primarily on the determinants of organizational innovation (Hamel, 2006; Armbruster et
15 al., 2008; Birkinshaw et al., 2008; Mol and Birkinshaw, 2009; and Battisti and Stoneman, 2010).
16 They conclude that organizational innovation depends on several environmental or organizational
17 factors, such as managerial knowledge, technological skills, and market (Schmidt and Rammer,
18 2007; and Damanpour et al., 2018).

19 Another brand of the literature argues that there is a synergistic interaction between
20 organizational and technological innovations (Piva et al., 2005; Damanpour et al., 2009; Battisti
21 and Stoneman, 2010; Ballot et al., 2015; and Arranz et al., 2019). In fact, each innovation is
22 specific, however, it is their combination that contributes to the firm's performance (Schmidt and
23 Rammer 2007; Ballot et al. 2015; Arranz et al., 2019; and Donbesuur et al., 2020) conclude that
24 firms need to combine organizational innovation with product and process innovation to achieve
25 higher profit margins.

26 Then, several authors have extensively explored the complementarity link between organizational
27 and technological innovations. (Piva and al., 2005; Damanpour et al., 2009; Battisti and
28 Stoneman, 2010; Ballot et al., 2015; Anzola-Román et al., 2018; Azar and Ciabuschi, 2017; and
29 Arranz et al., 2019). Drawing upon two large samples of French and UK manufacturing firms

1 using CIS4, Ballot *et al.* (2015) show how firms could take advantage of the interplay between
2 different forms of innovation. They find conditional complementarities between product and
3 process innovations in French and UK firms and between organizational and product innovations
4 in French firms. They show that the presence of complementarities depends on the national
5 context as well as on firm size and firm capabilities, this is consistent with the contingency
6 perspective. In the same line, Doran (2012) analyses whether different forms of innovation act as
7 complements or substitutes in Irish firms' production functions. He suggests that there is a
8 substantial degree of complementarity among different forms of innovation. Out of six possible
9 innovation combinations, three are complementary, and none exhibits signs of substitutability.

10 In the light of the previous discussion and to the best of our knowledge, there are no studies on
11 the dynamic character between organizational and technological innovations. In other words, the
12 existing literature has ignored the perspective of how increasing organizational innovations could
13 influence technological ones and vice versa.

14 Furthermore, the existing evidence is based on cross-sectional method to assess the links between
15 organizational and technological innovations (Doran, 2012; Camisón and Villar-López, 2014;
16 and Azar and Ciabuschi, 2017). However, the cross-sectional nature of the data cannot capture
17 the dynamic character in these associations. The use of longitudinal data, such as CIS data, over a
18 long period can overcome such limitations and help to shed the light on how different innovation
19 types could influence each other.

20 In the light of the previous discussion, we aim to contribute to the literature on how innovations
21 could interact. To the best of our knowledge, there are no studies on the dynamic interaction
22 between organizational and technological innovations. This study is conducted on longitudinal
23 data from the Community Innovation Surveys (CIS)s carried out between 2004 and 2016 in firms
24 listed on SBF120 index⁵. It determines how increasing organizational innovations could influence
25 technological ones and vice versa.

⁵ The SBF120 index consists of the 120 largest capitalizations listed on the French Stock Exchange market (SBF: Société des Bourses Françaises).

1 The choice to focus on the French market is timely because of the huge number of initiatives and
2 programs introduced to foster innovation in the last years (EUROPE 2020, Horizon 2020,
3 Innovate Europe⁶, Entrepreneurship and Innovation Program⁷, the European Innovation Council
4 EIC, and the EU Agency on disruptive innovation and Bpifrance). In 2020, France has the 12th
5 position in the Global Innovation Index GII (16th position in 2019).⁸

6 This paper provides the following results:

7 First, our findings highlight that introducing successful technological innovations would be
8 constrained to reorganize their production, workforce, sale, and distribution systems (Mohnen
9 and Röller, 2005; Polder et al., 2010; Gunday et al., 2011; and Donbesuur et al., 2020). This
10 result is in line with Camisón et al. (2010) who show that innovation process could generate
11 organizational innovation through the adaptation of job positions to the new process.

12 Second, our study puts forward that organizational changes, help firms to easily introduce a
13 successful process innovation (Damanpour and Gopalakrishnan, 2001). They are a necessary
14 precondition for process innovation to be fully implemented and exploited (Lam, 2005, and
15 Donbesuur et al., 2020). Also, they could enhance coordination and cooperation mechanisms
16 inside organizations, which, in turn, create an appropriate environment for the adoption of
17 process innovation (Gunday et al., 2011).

18 However, our study provides evidence that implementing new advanced management practices is
19 not sufficient to favor the development of new products. One explanation is that product
20 innovation is multidimensional. It depends on appropriate organizational infrastructure,
21 engineering, and technology skills to design the process production, layout, and logistics to
22 effectively support the new product design and its commercialization (Camisón and Villar López,
23 2014). Our result is not consistent with previous findings (Arranz et al., 2019) arguing that
24 innovation capabilities operate through reciprocity and complementary relation, where
25 technological product and organizational innovation are all determining factors of one another.

⁶ <https://www.eppgroup.eu/newsroom/publications/innovate-europe-we-put-people-at-the-heart-of-innovation>

⁷ http://ec.europa.eu/cip/eip/index_en.htm

⁸ <https://www.capital.fr/entreprises-marches/la-france-bondit-au-classement-mondial-de-linnovation-1379354>

1

2 This paper is structured in the following. The literature review and hypotheses are presented in
3 section (1). The data and methodology are detailed in the “Sample and Research Design” section.
4 Section (3) discusses the models and the results. The last section concludes the study and presents
5 future research perspectives.

6 **2. Literature review and hypotheses**

7 According to resource-based perspectives, firm's superior performance depends on its capacity to
8 deploy these resources using organisational processes (Barney et *al.*, 2001). In fact,
9 organizational innovation in business practices, innovations in workplace organization, or new
10 organizational methods in external relations could favor a more efficient organization, innovative
11 manufacturing, and technological processes (Lam, 2005; Camisón and Villar-López, 2014).

12 Moreover, the dynamic capabilities perspective describes how managers acquire resources, alter
13 the resource base, integrate, and recombine these resources to create firm value. Thus, these
14 capabilities are made up of both organizational and managerial routines that help in coordinating,
15 learning, and resource reconfiguration (Easterby-Smith et *al.*, 2009; Prange and Verdier, 2011;
16 Michailova and Zhan, 2015; and Lewandowska et *al.*, 2016). Indeed, introducing a new
17 organizational structure to facilitate teamwork and project type organization, or introducing a
18 new human resources management system leads to enhanced intra-organizational coordination
19 and cooperation mechanisms, which, in turn, create an appropriate environment for the adoption
20 of product and process (Gunday et *al.*, 2011).

21 In the same vein, Prajogo and Sohal (2006) observe that quality control in a company improves
22 technological innovation when developing a product. They underline that adequate organizational
23 innovation, for example, job task design, affects the efficiency of the new product development
24 process. Moreover, Teece (2010) shows that in order to profit from process innovations, firms
25 must adopt new organizational methods. For example, business practices such as quality control
26 can promote an increase in efficiency, and therefore, could improve the capability to develop

1 process innovation (Damanpour and Gopalakrishnan, 2001; and Shoenmakers and Duysters,
2 2006).

3 In addition, using a set of innovative work practices such as teams, flexible job assignments, or
4 training leads to higher output levels and product quality (Mol and Birkinshaw, 2009). Hence,
5 organizational innovation could be a precondition for the development of new products, meeting
6 the necessity of introducing changes in job positions and in organizational processes to facilitate
7 the new product development.

8 Regarding the reciprocal interactions between technological innovation and organizational
9 innovation, it has been argued that, according to socio-technical system theory (Emery and Trist,
10 1965; Damanpour and Gopalakrishnan, 2001), any change in an organization's technological system
11 requires changes in the administrative system to adjust to the demands created by the
12 technological system (Arranz et al., 2019). In the other world, the introduction of a flexible
13 production system leads to changes in the way tasks and job shifts are assigned. Hence, the
14 development of a new production process could generate organizational innovation through the
15 adaptation of job positions to the new process (Camisón et al., 2010).

16 To fully understand the drivers of organizational innovation, it is necessary to analyze the history
17 of the firm's innovations. Organizational changes have been shown to be arising from the
18 development of the latest innovations in firms (Sapprasert and Clausen, 2012; Karlsson and
19 Tavassoli, 2015). Indeed, when a company introduces new products to the market, it could
20 generate changes in the organizational infrastructure to design the production process and
21 effectively support the design and marketing of new products (Sapprasert and Clausen, 2012;
22 Camisón and Villar López, 2014; and Karlsson and Tavassoli, 2015). In the same vein, Danneels
23 (2002) focuses on the impact of product innovation on organizational innovation and concludes
24 that technological innovation is likely to induce organizational changes in the firm.

25 Therefore, firms embracing organizational changes as an ongoing effort and part of their
26 organizational routines are prone to foster continuous improvements in the technological sphere.
27 Adopting organizational innovation could enhance a firm's overall innovativeness (Gunday et al.,
28 2011). Similarly, to introduce successful technological innovations, firms would be constrained

1 to reorganize their production, workforce, sale, and distribution systems (Mohnen and Röller,
2 2005; and Polder et al., 2010). The extant literature is silent and provides limited insights on the
3 extent to which organizational innovations could generate technological ones or vice versa. In
4 light of the previous discussion, this study supposes that there could be a dynamic interaction
5 between organizational and technological innovations. It assumes that there could be a virtuous
6 circle between these types of innovation.

7 *H1a: The introduction of new organizational practices is likely to favor the development of*
8 *new processes and vice versa.*

9 *H1b: The introduction of new organizational practices is likely to drive the development of*
10 *new products and vice versa.*

11

12 **3. Sample and Research Design**

13 *3.1. Sample and data collection process*

14 The study is conducted on firms⁹ listed on the SBF120 index between 2004 and 2016.
15 Governance and ownership structure datasets are hand-collected from annual reports available on
16 the firms' websites. Based on Factset-IODS and Bloomberg databases, we have collected the
17 financial dataset. Finally, innovation datasets are provided by the Community Innovation Surveys
18 (CIS) and the R&D surveys of the INSEE¹⁰.

19 *3.2. Variables and measures*

20

21 Table (1) lists the definition of all the variables used in this analysis.

22 Innovation variables are taken from a question on CIS survey. The question defined product
23 innovation as the market introduction of a new good or service or significantly improved good or
24 service respective to functionalities. In line with Galia and Zenou (2013) and Attia et al., (2020),
25 we defined product innovation (**PROD**) as a dummy variable equal to 1, if the firm has
26 introduced at least a new good/service or significantly improved existing good/service, and 0
27 otherwise. Similarly, we defined process innovation (**PROC**) as a dummy variable equal to 1, if

⁹ This study does not exclude firms belonging to the banking and finance sector (Financial services firms) from the final sample. In our sample, we have 12% of firms belonging to the financial sector have introduced organizational innovations.

¹⁰ <https://www.insee.fr/en/statistiques/4631323?sommaire=4631329>

1 the firm has introduced at least a new or a significantly improved process in the
2 production/supply procedures, and 0 otherwise. Finally, organizational innovation (**OI**) is defined
3 as a dummy variable equal to 1, if the company has been successfully engaged in any type of
4 organisational innovation, and 0 otherwise.

5 Moreover, directors board could provide large and diverse resources to the firms, such as
6 strategic advice, knowledge, and networking which could be value-enhancing for innovation
7 (Talke et al., 2010; Torchia et al., 2011; Pathan and Faff, 2013; Galia and Zenou, 2013; Galia et
8 al., 2015, Attia et al., 2020). In fact, directors could have a positive impact on innovation
9 (Torchia et al., 2011; Pathan and Faff, 2013). Thus, we introduce in our analysis board variables
10 that could affect the relationship between organizational and technological innovations.

- 11 • **IND** is the percentage of independent directors on board. The board independence has
12 been one of the indicators that reflect corporate transparency. Board independence could
13 be an innovation catalyst based on the previous literature (Attia et al., 2020; Lu and
14 Wang, 2018).
- 15 • **GEN** is the percentage of female directors on boards. After the introduction of the gender
16 quota law of Copé-Zimmermann in 2011, French companies have to appoint at least 40%
17 of female directors. Attia et al. (2020) and Diaz-Garcia et al. (2013) argued that gender
18 diversity could increase innovation. Female directors generate a certain dynamism and
19 creativity that promote radical innovation.
- 20 • **FOR** is the percentage of foreign directors on board. Directors of different ethnic
21 backgrounds may stimulate a firm to improve or develop new products sold abroad as they also
22 possess knowledge about global markets and customers' tastes (Kerr and Lincoln, 2010), this
23 could stimulate innovation.
- 24 • **SIZE** is the total number of directors on board. A larger board size can grant resourceful
25 coalition (Xie et al., 2009). In line with the dependence resource theory, more directors
26 provide more resources and ideas.
- 27 • **CEO-TEN** is the CEO tenure and it is given by the number of years since the executive
28 has been appointed to the CEO position.

- 1 • **DUL** is a dummy variable that takes 1 if the company has CEO-Chair dual structure. The
2 CEO duality establishes strong leadership. Indeed, the separation between the
3 management function of the CEO and the control function of the chairman reduces the
4 disciplinary power which harms innovation. Yet, Blibech and Berraies (2018) found a
5 negative effect of the CEO duality on innovation since it might stimulate the CEO
6 opportunistic behavior.

7 In addition, ownership structure is a critical determinant when it comes to innovation strategy
8 (Chang et al., 2006; Belloc, 2011; Choi et al., 2012; Lodh et al., 2014; Diéguez-Soto et al.,
9 2016). In line with Singh and Vinnicombe (2003), Terjesen et al. (2009), and Nekhili and
10 Gatfaoui (2013), we add ownership structure in our models:

- 11 • **IN-O** is the share of capital held by institutions. Indeed, institutional investors foster
12 innovation by reducing career risks (Aghion et al., 2013; Schain and Stiebale, 2020).
13 • **ST-O** is the state ownership measured by the share of capital held by the State. Wang et
14 al. (2019) claimed that governmental ownership provides support that enhances
15 innovation.
16 • **FO-O** is the share of capital held by foreign investors. Guadalupe et al. (2012) concluded
17 that foreign owners drive product and process innovation and foster foreign technology
18 adoption.
19 • **FA-O** is the share of capital owned by family members. Indeed, 2/3 of firms listed on the
20 French Stock Exchange are family firms (Nekhili et al., 2019).

21 Furthermore, we introduce some financial characteristics of the firm such as firm's size (**TA**) is
22 the total assets. Subrahmanya (2015) shows that smaller companies have greater better flexibility.
23 They can develop and implement easier new innovative ideas. Yet, size might indicate better
24 solvency and higher financial capacities due to the economy of scale, which supports innovation.
25 Turning to the financial structure we use:

- 26 • **LEV** is the debt book to total asset ratio. It measures corporate leverage. Indeed,
27 increasing the corporate debt affects corporate innovation negatively. It increases the risk
28 level, which in return limits the innovation investment (Attia et al., 2020).

1 The sample consists of 120 listed companies on the SBF120 index between 2004 and 2016: 20%
2 of the firms belong to the consumer goods, and services, 24% of the firms belong to the
3 technology and communication sector. Almost 21% are in the machinery and industrial sector,
4 and 15% are in the banking and finance sector (Table 2).

5
6

7

Table 2: Sample composition

Industry	Percentage (%)
Technology and Communication	24
Consumer goods and services	20
Industrials	20.70
Financial	15
Utilities	4.15
Drugs and Healthcare	7
Oil and Gas	4.15
Basic Materials	5

8

9 Statistics on innovation measures (Table.3, Panel A) show that only 19.09% of firms have
10 introduced a new or a significantly improved product or service, 18.38% have implemented a
11 new or a significantly improved process, and 26.32% have been successfully introduced
12 management innovations. Innovation proxies seem lower in our sample than in some other
13 studies. For instance, Galia and Zenou (2013) found that 65% of firms have implemented product
14 innovation, thus introduced at least a new or significantly improved good or service, 63% of
15 firms have implemented process innovation from 2006 to 2008. With only one type of innovation
16 studied, Østergaard et al. (2011) found that 55% of firms of their sample implemented product
17 innovation from 2003 to 2005. In fact, their studies have been conducted on larger samples of
18 listed and non-listed firms.

19 Furthermore, in line with Godard and Schatt (2005), descriptive statistics on board directors
20 (Table 3, Panel B) show that the average board consists of 12 members, half of them (50%) are
21 independent and 20% have a foreign nationality. We underline that the percentages of
22 independent and foreign directors significantly vary among firms, particularly in multinational

1 companies. Regarding gender diversity, the percentage of female directors on boards is almost
 2 18% despite the introduction of gender legislation on board composition.

3 Finally, the average CEO tenure is almost 7.5 years. Furthermore, despite the New Economic
 4 Regulation (NRE)¹¹ act passed in 2001 on the separation between control and management
 5 functions, 55.56% of boards display dual structure (Table.3, Panel A).

6 **Table 3: Descriptive statistics of variables**

7 Panel (A). Descriptive statistics of qualitative variables: Table of frequencies

Variables		N	Percentage (%)
PROD	0	568	80,91
	1	134	19,09
PROC	0	573	81.62
	1	129	18.38
OI	0	518	73.68
	1	185	26.32
DUL	0	312	44.44
	1	390	55.56

8

9 Panel (B). Descriptive statistics of quantitative variables

Variable	Obs	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
FOR	702	20.19281	20.01874	0	95.45454	1.269866	4.563018
IND	702	49.79591	21.60189	0	100	-.0098385	2.759103
GEN	702	17.6465	13.79327	0	57.27273	.3991883	2.127211
CEO-TEN	703	7.517781	8.162045	0	46.5	1.349185	7.119305
SIZE	702	12.40741	3.475609	0	23	.0837806	2.990964
ROA	701	3.788092	5.878992	-38.73175	53.32191	-.5975894	20.35753
LEV	695	24.9085	15.04501	.1467355	74.50291	.3609613	1.935184
IN-O	702	32.06893	24.78117	0	89.3595	.3609613	1.935184
ST-O	702	4.427831	14.92768	0	94.25	4.145128	20.67524
FA-O	702	8.773573	17.61349	0	80.45	2.06652	6.23012
FO-O	702	11.12875	16.93292	0	90.725	2.070482	7.227676
TA	701	76705.66	260758	26.3283	2035576	5.259083	32.34139
R&D	702	.0007183	.0046295	0	.073609	10.23015	128.2471

¹¹https://www.diplomatie.gouv.fr/IMG/pdf/Mandatory_reporting_built_on_consensus_in_France.pdf

1
2 **Notes:** PROD is a dummy variable equal to 1, if the firm has introduced at least a new good/service or significantly improved
3 existing good/service, and 0 otherwise. PROC is a dummy variable equal to 1, if the firm has introduced at least a new process in
4 the production/supply procedures, and 0 otherwise. OI is a dummy variable equal to 1, if the company has successfully
5 engaged in any type of organizational innovation, and 0 otherwise. FOR is the percentage of foreign directors on board. IND is
6 the percentage of independent directors on the board. GEN is the percentage of female directors on the board. CEO-TEN is given
7 by the number of years since the executive has been appointed to the CEO position. DUL is a dummy variable equal to 1, if the
8 CEO is also the chairman of the board, and 0 otherwise. SIZE is the total number of directors on board. IN-O is the institutional
9 investors' share of capital. ST-O is the state's share of capital. FO-O is the foreign investors' share of capital. FA-O is the
10 family's share of capital. TA is the total asset. ROA is the return on asset ratio. LEV is the debt book value to total assets. R&D is
11 the R&D expenses to total assets ratio.
12
13
14
15
16

Table 4: Industry distribution of firms with organizational innovation

Industry	Percentage (%)
Technology and Communication	10.34
Consumer goods and services	41.37
Industrials	15.51
Financial	12.06
Utilities	6.89
Drugs and Healthcare	5.17
Oil and Gas	0.04
Basic Materials	8.62

17
18 Table (4) shows that 58 firms operating in varied industries, have introduced organizational
19 innovations between 2004 and 2016: 41.37% of firms are in consumer goods and services sector
20 while 15.51% of firms belong to the industrial sector, and 12% are financial institutions.

21 The correlation matrix in table (5) shows some significant coefficients that exceed 0.5. However,
22 the variance inflation factor values range from 1.08 to 1.34: They are below the accepted
23 threshold of 2. Accordingly, we conclude that there is no multicollinearity problem.

24 Table (6) presents the mean difference tests between firms with at least one innovation and firms
25 without innovation. In line with Attia *et al.* (2020), it shows that, on average, innovative firms
26 have large boards and spend more money in R&D activities. However, non-innovative firms
27 display a significantly high percentage of foreign directors on board. Finally, the table reports
28 that firms with family ownership are more prone to introduce innovation.

Table 5: Pearson Correlation Matrix

	PROD	PROC	OI	R&D	CEO-TEN	DUL	IND	FOR	GEN	SIZE	ROA	LEV	INT-O	ST-O	FA-O	FOR-O	TA
PROD	1																
PROC	0.8833* (0.0000)	1															
OI	0.2443* (0.0000)	0.2171* (0.0000)	1														
R&D	0.1205* (0.0014)	0.0979* (0.0094)	0.0932* (0.0135)	1													
CEO-TEN	0.0122 (0.7463)	0.0129 (0.7327)	-0.0233 (0.5377)	0.1318* (0.0005)	1												
DUL	0.0916* (0.0152)	0.1061* (0.0049)	0.0470 (0.2136)	-0.0113 (0.7653)	0.1450* (0.0001)	1											
IND	-0.0292 (0.4400)	-0.0070 (0.8540)	0.1044* (0.0056)	-0.0135 (0.7207)	-0.122* (0.0012)	-0.083* (0.0273)	1										
FOR	-0.154* (0.0000)	-0.145* (0.0001)	-0.0184 (0.6267)	-0.074* (0.0486)	-0.0210 (0.5791)	-0.0394 (0.2969)	0.2630* (0.0000)	1									
GEN	-0.0191 (0.6136)	-0.0398 (0.2923)	0.0528 (0.1622)	-0.155* (0.0000)	0.0665 (0.0782)	0.0921* (0.0146)	0.0654 (0.0835)	0.1264* (0.0008)	1								
SIZE	0.1251* (0.0009)	0.1344* (0.0004)	0.1132* (0.0027)	-0.110* (0.0033)	-0.124* (0.0009)	0.0723 (0.0555)	-0.0448 (0.2356)	-0.0157 (0.6778)	0.0294 (0.4363)	1							
ROA	0.0494 (0.1910)	0.0569 (0.1326)	0.0419 (0.2685)	0.0847* (0.0249)	0.0792* (0.0361)	0.0086 (0.8196)	-0.082* (0.0298)	-0.0218 (0.5648)	-0.0721 (0.0562)	-0.0724 (0.0555)	1						
LEV	-0.0204 (0.5911)	-0.0430 (0.2571)	-0.077* (0.0414)	-0.085* (0.0246)	-0.098* (0.0096)	0.0056 (0.8824)	-0.0189 (0.6189)	-0.0167 (0.6599)	0.0168 (0.6575)	0.1578* (0.0000)	-0.183* (0.0000)	1					
INT-O	-0.0252 (0.5052)	-0.0683 (0.0707)	0.0156 (0.6804)	-0.0544 (0.1500)	-0.0651 (0.0849)	0.0175 (0.6427)	0.0417 (0.2694)	0.0575 (0.1280)	0.4020* (0.0000)	0.1631* (0.0000)	-0.0631 (0.0951)	0.1050* (0.0056)	1				
ST-O	0.0416 (0.2711)	0.0477 (0.2072)	0.0244 (0.5186)	-0.0405 (0.2835)	-0.110* (0.0034)	0.0921* (0.0146)	-0.206* (0.0000)	-0.078* (0.0387)	0.0640 (0.0902)	0.363* (0.0000)	-0.096* (0.0106)	0.0147 (0.6983)	0.1777* (0.0000)	1			
FA-O	0.1268* (0.0008)	0.0979* (0.0095)	0.1060* (0.0049)	0.0239 (0.5277)	0.1618* (0.0000)	-0.0482 (0.2026)	-0.148* (0.0001)	-0.0377 (0.3189)	0.0026 (0.9460)	-0.134* (0.0003)	0.1150* (0.0023)	-0.154* (0.0000)	-0.127* (0.0007)	-0.13* (0.0005)	1		
FOR-O	-0.120* (0.0014)	-0.121* (0.0013)	-0.0316 (0.4026)	-0.0147 (0.6974)	-0.098* (0.0090)	0.0074 (0.8441)	0.1152* (0.0022)	0.1913* (0.0000)	0.0556 (0.1411)	-0.0311 (0.4101)	0.0466 (0.2183)	0.0490 (0.1973)	0.2235* (0.0000)	-0.09* (0.0095)	-0.17* (0.0000)	1	
TA	0.0194 (0.6089)	-0.0146 (0.6998)	0.1232* (0.0011)	-0.0391 (0.3015)	-0.096* (0.0108)	-0.103* (0.0061)	-0.0112 (0.7671)	-0.0256 (0.4983)	0.1091* (0.0038)	0.3212* (0.0000)	-0.134* (0.0004)	0.1643* (0.0000)	0.1076* (0.0044)	0.0366 (0.3331)	-0.11* (0.0018)	-0.08* (0.0306)	1

Notes: PROD is a dummy variable equal to 1, if the firm has introduced at least a new good/service or significantly improved existing good/service, and 0 otherwise. PROC is a dummy variable equal to 1, if the firm has introduced at least a new process in the production/supply procedures, and 0 otherwise. OI is a dummy variable equal to 1, if the

company has successfully engaged in any type of organizational innovation, and 0 otherwise. FOR is the percentage of foreign directors on the board. IND is the percentage of independent directors on the board. GEN is the percentage of female directors on the board. CEO-TEN is given by the number of years since the executive has been appointed to the CEO position. DUL is a dummy variable equal to 1, if the CEO is also the chairman of the board, and 0 otherwise. SIZE is the total number of directors on board. IN-O is institutional investors' share of capital. ST-O is the state's share of capital. FO-O is the foreign investors' share of capital. FA-O is the family's share of capital. TA is the total asset. ROA is the return on asset ratio. LEV is the debt book value to total assets. R&D is the R&D expenses to total assets ratio. * significant at the 5% levels.

Table 6: Mean difference tests between firms with at least one innovation and firms without any innovation

Variables	OI			PROC			PROD		
	0	1	MDT	0	1	MDT	0	1	MDT
FOR	20.41	19.58	0.84	21.58	14.04	7.53***	21.69	13.83	7.87***
GEN	17.21	18.86	-1.65	17.91	16.49	1.42	17.77	17.10	0.67
IND	48.58	53.56	-4.98**	49.99	49.48	0.51	50.22	48.50	1.72
CEO-TEN	7.63	7.20	0.43	7.47	7.72	-0.25	7.47	7.73	-0.26
SIZE	12.17	13.06	-0.89**	12.19	13.39	-1.21***	12.20	13.30	-1.11***
ROA	3.64	4.20	-0.56	3.63	4.49	-0.86	3.65	4.39	-0.74
LEV	25.55	22.96	2.59**	25.17	23.55	1.63	25.01	24.28	0.74
IN-O	31.84	32.71	-0.88	32.87	28.51	4.36*	32.07	30.78	1.28
ST-O	4.21	5.04	-0.83	4.09	5.93	-1.84	4.13	5.71	-1.58
FA-O	7.66	11.89	-4.24**	7.96	12.40	-4.45**	7.69	13.37	-5.68***
FO-O	11.45	10.23	1.22	12.10	6.81	5.29***	12.12	6.92	5.20***
LnTA	10.96	11.78	-0.82***	11.27	11.14	0.13	11.22	11.37	-0.16
LnR&D	0.001	0.002	-.001**	0.0005033	0.00	-.0011698**	0.002	0.003	-.001***

Notes: FOR is the percentage of foreign directors on board. IND is the percentage of independent directors on board. GEN is the percentage of female directors on board. CEO-TEN is given by the number of years since the executive has been appointed to the CEO position. SIZE is the total number of directors on board. IN-O is the institutional investors' share of capital. ST-O is the state's share of capital. FO-O is the foreign investors' share of capital. FA-O is the family's share of capital. TA is the total asset. ROA is the return on asset ratio. LEV is the debt book value to total assets. R&D is the R&D expenses to total assets ratio. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels

1 **4. Empirical model**

2 To assess the association between organizational innovation and technological innovations. In
3 the first time, we consider a bivariate logit regression:

$$4 \quad INNOV_{i,t} = \beta_0 + \beta_1 * OI_{i,t} + \sum \beta_2 * X_{i,t} + \mathcal{E}_{i,t} \quad (1)$$

$$5 \quad OI_{i,t} = \beta_0 + \beta_1 * INNOV_{i,t} + \sum \beta_2 * X_{i,t} + \mathcal{E}_{i,t} \quad (2)$$

6

7 Where $INNOV_{i,t}$ is the measure of product and process innovations of the firm i , at the year t .
8 It could be $PROD_{i,t}$, $PROC_{i,t}$. $OI_{i,t}$ is a dummy variable equal 1 is the firm i has introduced an
9 organizational innovation at the year t . $X_{i,t}$ is the independent variables that could affect the
10 relationship between OI et $INNOV$. $X_{i,t}$ consists of board characteristics (the percentage of
11 independent directors **IND**, foreign directors **FOR**, women directors **GEN**, size of board
12 **SIZE**, duality **DUL**, and CEO tenure **CEO-TEN**), ownership structure (**FAM-O**, **FOR-O**,
13 **ST-O**, and **IN-O**), some financial characteristics of the firm (Firm's size **LnTA**, industrial
14 affiliation), and financial structure (Return on asset **ROA**, debt ratios **LEV**, and the ratio of
15 R&D expense **LnR&D**).

16
17 Then, to provide a better understanding of causality between technological and organizational
18 innovations, we perform the Granger causality test (Granger, 1969): the most common
19 methodology for evaluating the nature of the causal relationship between two variables.
20 Specifically, we test whether technological innovations are Granger-caused by organizational
21 innovation or the reverse.

22

Table 7: Results of logit regressions and Granger causality test

Logit regressions				
Variables	PROC	PROD	OI	OI
OI	1.27** (-2.82)	1.71*** (-3.43)		
PROD			1.70*** (-3.85)	
PROC				1.27** (-3.07)
DUL	0.97* (-1.77)	0.99* (-1.80)	-0.11 (-0.29)	-0.13 (-0.33)
CEO-TEN	-0.03 (-0.85)	-0.03 (-0.68)	0.01 -0.41	0.01 -0.46
FOR	-.05** (-2.74)	-.07** (-3.15)	0.01 -0.70	0.01 -0.56
IND	0.01 -0.94	0.01 -0.78	0.01 -1.38	0.01 -1.42
GEN	-0.01 (-0.38)	0.02 -0.86	0.01 -1.07	0.01 -1.18
SIZE	0.15 -1.52	0.12 -1.09	0.05 -0.65	0.06 -0.75
INT-O	0.00 (-0.02)	0.00 (-0.32)	0.00 (-0.05)	0.00 -0.01
LN-ST-O	-0.40 (-1.18)	-0.39 (-1.04)	0.07 -0.32	0.06 -0.28
LN-FA-O	0.15 -0.64	0.19 -0.78	0.18 -1.16	0.18 -1.17
LN-FOR-O	-.36* (-1.73)	-0.16 (-0.78)	0.01 -0.08	0.01 -0.11
ROA	0.06 -1.11	0.06 -1.03	-0.01 (-0.29)	-0.01 (-0.30)
LEV	-.04* (-1.66)	-0.03 (-1.24)	-0.03 (-1.62)	-0.03 (-1.59)
LnR&D	0.00 -1.11	0.00 -0.97	.002* -1.65	.002* -1.71
LnTA	0.68 -1.01	1.06 -1.47	0.41 -0.97	0.44 -1.03
Industry-effect	YES	YES	YES	YES
Const	-6.34** (-2.50)	-8.46** (-3.00)	-5.11** (-3.16)	-5.23*** (-3.20)
N	664	696	689	689
N of firms	111.00	117.00	116.00	116.00
Wald chi2	33.78	33.47	36.84	32.60
P> chi2	0.04	0.06	0.02	0.05
Causality Wald Test				
OI	5.833** (0.045)	0.366 (0.545)		
PROC			5.498** (0.019)	
PROD				5.037** (0.025)

1 **Notes:** PROD is a dummy variable equal to 1, if the firm has introduced at least a new good/service or significantly improved
2 an existing good/service, and 0 otherwise. PROC is a dummy variable equal to 1, if the firm has introduced at least a new
3 process in the production/supply procedures, and 0 otherwise. OI is a dummy variable equal to 1, if the company has
4 successfully engaged in any type of management innovation, and 0 otherwise. FOR is the percentage of foreign directors on
5 the board. IND is the percentage of independent directors on the board. GEN is the percentage of female directors on the
6 board. CEO-TEN is given by the number of years since the executive has been appointed to the CEO position. DUL is a
7 dummy variable equal to 1, if the CEO is also the chairman of the board, and 0 otherwise. SIZE is the total number of
8 directors on the board. IN-O is the institutional investors' share of capital. ST-O is the state's share of capital. FO-O is the
9 foreign investors' share of capital. FA-O is the family's share of capital. TA is the total asset. ROA is the return on asset
10 ratio. LEV is the debt book value to total assets. R&D is the R&D expenses to total assets ratio.
11 *, **, *** indicate statistical significance at 10%, 5%, and 1% level of significance, respectively.
12

13 Bivariate logit regressions in the table (7) confirm that technological and organizational
14 innovations are interconnected. Our findings provide evidence that there is a close
15 relationship between organizational and technological innovations (Damanpour and
16 Gopalakrishnan, 2001; Camisón et al., 2012; and Hervas-Oliver et al., 2012). Our results are
17 consistent with previous findings (Damanpour and Gopalakrishnan, 2001; and Hervas-Oliver
18 et al., 2012) arguing that organizational innovations are beneficial for other types of
19 innovation, especially process innovation (Hollen et al., 2013), and for product innovation
20 (Doran, 2012).

21 Moreover, the Granger causality test (Table 7) confirms the existence of a reciprocity relation
22 between organizational and process innovation: OIs drive, in the Granger sense, more PROC
23 innovations and vice versa. It seems, therefore, there is a virtuous circle between these types
24 of innovation. We can accept *H1a*.

25 Our findings conclude that the development of innovation process could generate
26 organizational innovation through the adaptation of job positions to the new process. Indeed,
27 the introduction of a flexible production system could lead to changes in the way tasks and
28 job shifts are assigned (Camisón et al., 2010). For instance, when a firm adopts a quality
29 system in the control of production, it drives many changes in processes (Damanpour, 2010).

30 Similarly, organizational changes, such as improving job task design, inter-organizational
31 collaboration, or developing business practices, could easily introduce a successful process
32 innovation (Damanpour and Gopalakrishnan, 2001). In other words, organizational innovation
33 seems to be a necessary precondition for process innovation to be fully implemented and
34 exploited (Damanpour et al., 1989; Lam, 2005). This result is in line with Gunday et al.
35 (2011), based on an empirical study of manufacturing firms in Turkey, they find that
36 structural improvements stimulated by organizational innovations (for example, introducing a

1 new organizational structure to facilitate teamwork and project type organization, introducing
2 a new human resource management system) enhances intra-organizational coordination and
3 cooperation mechanisms. They, in turn, could create an appropriate environment for the
4 adoption of process innovation.

5 Surprisingly, when we focus on product innovation, Granger causality test shows that
6 causality runs in one direction from innovation product to organizational innovation. Hence,
7 we reject *H1b*. Our finding underlines that the development of new products is likely to
8 increase organizational changes in firm's structure (Mohnen and Röller 2005; Polder et al.,
9 2010). According to socio-technical system theory, when a company introduces new products to
10 the market, it generates changes in the organizational infrastructure in order to design the
11 production process and effectively support the design and marketing of new products
12 (Camisón and Villar López, 2014). However, the introduction of new organizational practices
13 does not necessarily lead to the development of product innovation. Our results provide
14 evidence that implementing new advanced management practices is not sufficient to favor
15 product innovation. One explanation is that product innovation is multidimensional. It
16 depends on appropriate organizational infrastructure, engineering, and technology skills to
17 design the process production, layout, and logistics to effectively support the new product
18 design and its commercialization (Camisón and Villar López, 2014). This is in line with
19 Prajogo and Sohal (2006), who demonstrate that only simply implementing new advanced
20 management practices (OI) is not sufficient to favor product innovation. For instance, the use
21 of total quality management does not directly favor product innovation if that relationship is
22 mediated by technology and R&D management. Another explanation is that in the current
23 study we have analyzed only direct association between technological and organizational
24 innovations without exploring the moderating channels through which they could interact.

25 In addition, table (7) provides some interesting results about the influence of board attributes
26 on innovation. Unlike Yuan and Wen (2018) who provide evidence that managerial foreign
27 experience is positively associated with corporate innovation, our findings show that the
28 presence of foreign directors on board is negatively and significantly associated with both
29 proxies PROC and PROD. FOR coefficients are significant at the 5% level. One explanation
30 could be the low percentage of foreign members in French boardrooms: 20 % on average
31 (panel B, table 3). Also, directors who have different cultural backgrounds could provide
32 diverse perspectives that are not automatically supported by the other board members. Also,

1 they could be non-valuable for innovation and solving problems because of their lack of
2 connection with everyday operations and the local business culture (Berliant and Fujita,
3 2011). Even though ethnic diverse directors have better knowledge of global markets and
4 customers' tastes, they may not be powerful enough to influence the business strategy.
5 Consequently, they could be less influential on the firm's ability to develop new products
6 (Kerr and Lincoln, 2010). Also, we found that CEO-duality is positively associated to PROD
7 and PROC regressions. This result is not consistent with Blibech and Berraies (2018) who
8 found that CEO duality is negatively associated to innovation as the duality of functions
9 diminishes the disciplinary power of the board and affects the strategies. In fact, Goel and
10 Jong (2017) find positive moderating effects of CEO duality on the associations between
11 corporate risk-taking and innovation and between prior innovations and performance in IT
12 companies. This moderated effect is due to effective and strong CEO incentives. In fact, some
13 recent studies highlight the benefits of the CEO-chair structure (Dalton et al., 2007), such as
14 the unity of command in complex environments (Boyd, 1995) and in turnaround situations
15 (Mueller and Barker, 1997). In fact, the duality structure strengthens the CEO power
16 (Brockmann et al., 2004; Bach and Smith 2007) and increases the CEO influence over the
17 decision-making process (Sheikh, 2018).

18 **5. Conclusion**

19 The present study contributes to the emerging literature on how innovations may interact,
20 specifically organizational and technological innovations (Damanpour and Schneider, 2006;
21 Damanpour and Wischnevsky, 2006). The aim of our contribution is to show whether the
22 existence of a reciprocity relation between organizational and technological innovations.

23 Our study provides evidence that the introduction of new technological innovations could
24 stimulate organizational changes in a firm's structure. We may conclude that process
25 innovations may shape the business management in several ways such as driving more
26 partnerships, designing differently existing jobs, and creating new tasks. The development of
27 innovation process could generate organizational innovation through the adaptation of job
28 positions to the new process. Moreover, when a company introduces new products to the
29 market, it could generate changes in the organizational infrastructure in order to design the
30 production process and to effectively support the design and marketing of new products
31 (Camisón and Villar López, 2014).

1 Second, our study highlights that the adoption of new organizational practices is likely to
2 increase the introduction of new processes: The successful introduction of new organizational
3 methods of business management in the workplace seems to boost creativity and to stimulate
4 firms to improve or develop new processes. While product innovation is multidimensional, it
5 depends on appropriate organizational infrastructure, engineering, and technology skills to
6 design the process production, layout, and logistics to effectively support the new product
7 design and its commercialization (Camisión and Villar López, 2014). The implementation of
8 new advanced organizational practices is not sufficient to promote the development of new or
9 significantly improved products.

10 Finally, this study provides evidence of the influence of boards on innovations: it shows that
11 directors who have different cultural backgrounds could provide diverse perspectives but are
12 not automatically valuable for innovation and solving problems. Although ethnic diverse
13 directors know global markets and customers' tastes, they may not lead the firm to develop
14 new products sold abroad as they.

15 From a business perspective, we emphasize that firms should introduce new organizational
16 methods in the firm's business practices, workplace organization, and develop new
17 management practices to easily introduce successful technological innovations which, in turn
18 could challenge the business management and lead to new management changes. Moreover,
19 firms should well choose and select their technological innovations because the introduction
20 of these innovations could impact the organizational infrastructure.

21 To the best of our knowledge, this is the first paper to analyze the dynamic interaction
22 between organizational and technological innovations through a longitudinal study. However,
23 this research has several limitations. First, we have not explored non-technological
24 innovation, such as marketing innovation and its influence on organizational and
25 technological innovations. Moreover, we have neglected the lag structure between the
26 introduction of innovation and its impact on the other ones. In fact, innovation strategies are
27 long-term projects and need some time to be implemented and produce outcomes. Finally, our
28 data analysis is exclusively drawn on French firms; empirical evidence conducted on many
29 countries would be valuable to test the robustness of these findings. All these issues are left
30 for future papers.

1
2
3 **Reference**
4

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