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European SMEs' engagement in open innovation When the important thing is to win and not just to participate, what should innovation policy do?

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ABSTRACT

This exploratory study proposes an original methodology to operationalize and signal SMEs' engagement in challenging dimensions of implementing Open Innovation. We verify whether the European SME Instrument is achieving its goal of providing public funds to the best SMEs in Europe, the '*EU Innovation Champions*'. We test our methodology on a sample of SMEs operating in the digital sector. We found that the SMEs awarded the grants are less engaged in the challenging dimensions of Open Innovation than companies that did not receive any funding. This is contrary to the intended goals of the grants. We provide policy and methodological implications relevant for the design of better OI-informed policy and the more effective evaluation of companies participating in the SME Instrument.

1. Introduction

Small businesses are a relevant player in the innovation ecosystem and significantly contribute to employment rates and economic growth. This role has been gradually recognized, leading not only to greater interest from innovation scholars, but also more awareness of governments about the need of supporting the small business sector development through tailored policy measures. This is particularly evident in the European Union (EU), where Small- and Medium-Sized Enterprises (SMEs) account for the great majority of the business sector. Policy support tends to reduce fiscal and administrative burdens and provide financial support, but often neglects other challenges that SMEs face in their innovation activities. To compensate for the constraints related to limited availability of resources, SMEs open up their organizational boundaries and embrace open innovation strategies engaging in challenging dimensions of collaborative R&D.

The interest of scholars, practitioners and policy makers for Open Innovation (OI) in the SMEs has been growing, particularly in the European Union (EU). Nonetheless, many aspects of the phenomenon remain underexplored: among the others, scholarship has been calling for new metrics to monitor OI efforts (West et al., 2014), and additional research to shed light on how OI can inform a better design of public policy (Santos, 2015). This study aims at addressing these topics.

The paper proposes an original methodology to detect and signal SMEs' engagement in challenging OI dimensions. We test this methodology on a selected sample of European SMEs that achieved a positive evaluation of their entrepreneurial projects proposals (awarded the grants or a Seal of Excellence, SoE) in the most recent EU funding scheme supporting R&D activities in the small businesses, the SME Instrument (SMEi), which aims at fostering SMEs' contribution to the European innovation ecosystem. The European Commission (EC) embraced the OI paradigm as a key approach to unlock innovation and growth in the EU ecosystem. Therefore, to maximize the impact, the public funding should be allocated to organizations that practice OI to achieve higher levels of innovation. This, in turn will lead to greater employment and economic growth. Because we identify the characteristics of the SMEs associated to the emergence of engagement in OI, our implications contribute to more OI-informed policy and better allocation of the public funding to SMEs practicing OI strategies.

The paper is structured as follows. Section two introduces the theoretical background and briefly presents the context of this exploratory study: the SMEi, along with the challenging dimensions of OI, and the digital sector. Section three describes the methodology proposed. Section four presents the results of the analysis, comparing the engagement of the SMEi awardees and SoE in OI dimensions. Section five highlights managerial and policy implications of the study, and concluding remarks follow.

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2. Theoretical background

Scholars and policymakers have widely acknowledged that the Small- and Medium-Sized Enterprises (SMEs) are important players in the innovation ecosystem, because they significantly contribute to innovation, jobs and growth creation (Acs et al., 1999; EC, 1995; Storey, 2016). Back in 1934, focusing on the European industrial landscape, Schumpeter highlighted the role that small firms and new entrepreneurs play in the innovation activities (Schumpeter, 1934): they introduce new products, processes and ideas that create discontinuities in the R&D activities conducted by large companies in highly specialized and knowledge-based labs. Building on this literature and on the distinction of Schumpeterian Mark I and II innovation patterns (Nelson and Winter, 1982), Malerba and Orsenigo (1995) showed that the higher share of new innovators falls into the Schumpeterian Mark I pattern, composed of small-sized firms. These company showed better technological performance when compared to Schumpeterian Mark II, including large-sized innovators (Malerba and Orsenigo, 1995). In the same study, the scholars urged a focus on innovation policy on new and small firms, as a complement to the support for the R&D activities of large and established firms, calling for 'actions directed towards the support to innovation in new, small firms' (Malerba and Orsenigo, 1995, p. 64).

Nonetheless, the literature also recognizes the limitation of SMEs' innovation activities, deriving from their constrained resources and limited access to capital (Acs and Audretsch, 1990; Vossen, 1998). Indeed, these limitations push SMEs to rely on the external environment and practice Open Innovation strategies to access the assets they miss (van de Vrande et al., 2009). Indeed, research showed that, while for large companies OI is a strategic choice to access complementary assets and capabilities better mastered by their partners; for SMEs, OI is a need as it help compensating the resources and assets that they lack (Spithoven et al., 2013; Di Minin et al., 2016a; Hossain and Kauranen, 2016). In addition, it has also been demonstrated that collaborative activities positively impact innovation capabilities of companies, and this positive effect is more significant for new, small-sized firms than for large ones (for a review, see Castellacci et al., 2005).

The paradigm of OI gained the attention of innovation scholars and practitioners since its introduction by Chesbrough (2003). From the initial exploration of OI practices in large-sized corporation, scholars expanded their focus to different levels of analysis that include the micro-foundation of OI (Bogers et al., 2018), non-profit organizations and the public sector (Bogers et al., 2018b; Chesbrough and Di Minin, 2014), and SMEs (Laursen and Salter, 2006; Vanhaverbeke, 2017). A recent bibliometric review on OI showed that the research on SMEs and public policy started increasing in 2010 (Santos, 2015). On one side, scholars showed how OI differs between large and small companies in terms of motives, practices, strategies and challenges (van de Vrande et al., 2009; Spithoven et al., 2013; Brunswicker and van de Vrande, 2014). On the other side, OI can contribute to value creation and innovation in the public sector, enhancing transparency and efficiency (Obama, 2009; West and Bogers, 2017). In the EU, OI was embraced in what Carlos Moedas, Commissioner for Science, Research and Innovation, defined 'the three Opens' approach: open science, open innovation, open to the world (Moedas, 2015). In the words of the European Commission, OI "encourages dynamic knowledge circulation and facilitates the translation of that knowledge into socio-economic value" (EC 2016, p. 17). The OI represents such a strategic approach in the EU innovation policy, that the forthcoming Horizon Europe, ninth Framework Program for Research and Innovation for 2021–2028, includes OI as one of its three pillar along with Open Science and Global Challenges. Under the OI pillar, € 13.5 billions will be allocated to stimulate 'market-creating breakthroughs and ecosystem conducive innovation'.[1] The SMEi will be funded under the OI Pillar of Horizon Europe: it means that, in the strategy of the Commission, the intended effect of public funding would be achieved and maximized when the budget is allocated to organizations that practice OI to achieve higher levels of innovation and growth, in line with the EU strategy.

2.1. The research context

As in Europe SMEs account for 99.8% of the overall number of companies contributing to employment and growth (Muller et al., 2017), the EU has gradually increased the policy support to SMEs' innovative activities (for an overview, see Di Minin et al., 2016b). Most recently, the EC acknowledged the need of thorough public policy and funding to help small companies innovating and paving the way for a 'new era of European technological leadership' (EC, 2018, p. 6). In 2013, under the eighth Research and Innovation Framework Program, Horizon 2020, the EC launched the SME Instrument (SMEi), an innovative funding tool that targets the Schumpeterian Mark I type of companies, small-sized innovators, defined as the 'EU innovation champions' (EASME, 2016, 2018). The SMEi awards companies' proposals of high-risk and ambitious innovation projects that could potentially disrupt the European business, matching close-to-market innovation with market-oriented approaches (Padilla et al., 2018). Moreover, the SMEi aims at unlocking SMEs' contribution to the European OI ecosystem, and its impact can be amplified awarding the best innovators that ease knowledge circulation and value creation though OI activities (EC, 2016).

The SMEi pursues a leverage effect of its financial support (Hyytinen and Toivanen, 2003): bridging the equity gap affecting SMEs, the tool works as a "de-risking" factor to attract financial investments in SMEs that private investors would not dare to finance (EC, 2013). The first SME Instrument Impact Report (EC & EASME, 2018) shows positive results of the policy,[2] proving additionality and positive contribution to the EU added value (EC, 2017a). The SMEi provides subsidy-type investments (Fresco et al., 2015; APRE, 2016) that do not foresee the obligation for awardees to repay the money received (Zúñiga-Vicente et al., 2014; Bronzini and Piselli, 2016; Zhao et al., 2018). Despite the effectiveness recognized to this type of instruments, criticisms highlighted that public subsidies generally cannot aid all the deserving companies (Becchetti and Trovato, 2002). The low success rates in the SMEi confirmed that the number of companies benefiting from the funding is much more limited than the number of deserving ones (Di Minin et al., 2016a). Between 2014 and 2017, the SMEi received 46,772 applications and awarded not only a total of €1,318 million in direct, equity-free funding to 3,208 companies, but also 3,011 Seals of Excellence (EASME, 2018), a quality label for valuable proposals that score above the evaluation threshold required for the grant, but are not awarded the funds for lack of budget (EC, 2016; Interreg Europe, 2017).

Given the role of the public support to SMEs' innovation and the SMEi purposes, some questions on the efficacy and scope of the instrument remain open. Therefore, the aim of this study is to understand whether the SMEi is achieving its goal of selecting the real 'EU Innovation Champions' that better contribute to the innovation ecosystem with an OI approach.

[1] https://ec.europa.eu/info/sites/info/files/horizon-europe-presentation_2018_en.pdf

[2] The first projects funded in 2014 under Phase 2 (with up to €2.5 million grants for demonstration, market replication and R&D activities) were concluded in 2016. In 2017, 10% of tech IPOs in the EU was of SMEi-funded companies; the turnover and employment of awardees increased (respectively +118% and +158%); equity investments on awardees doubled if compared with 2016, and the EU budget invested through the SMEi increased its value, generating €1.6 of private investment per each euro invested in the tool.

2.2. The challenges of implementing OI in SMEs

This study explores the engagement that SMEs with positive evaluation in the SMEi competition show on crucial dimensions of OI, previously identified through a systematic literature review on the challenges of implementing OI (De Marco, 2017). We focused on both large companies and SMEs as units of analysis and, through the investigation of a selected sample of 156 studies (out of 509 screened in the selection process), identified challenges that companies face both within and beyond organizational boundaries. Internal OI challenges include organizational and cultural changes; and external ones include internal assets protection, relatedness and management of external relations. Across these two categories, the business model innovation challenge presents both internal and external aspects. On one hand, large companies engage more efforts on the internal challenges because of their lack of flexibility and complex bureaucracy, while SMEs benefit from being small, which guarantees them flexible organizational processes allowing smooth responses to internal organizational adjustments. On the other hand, being small is a double-edged sword as it concerns not only the size of the firms, but also the dimensions of their resource stocks, the so-called liability of smallness (Spithoven et al., 2013). Because of this lack of resources, SMEs struggle more than large-sized companies in OI external challenges: Internal Assets Protection, Management of External Relations, Relatedness and Business Model Innovation (De Marco, 2017).

Internal Assets Protection. SMEs practicing OI strategies are concerned about suffering losses of internal relevant knowledge and strategic assets. To avoid such risk, companies engage in selective revealing strategies (Henkel, 2006) to pursue effective collaboration while protecting their internal knowledge. To secure value from OI, SMEs are active in developing appropriation strategies, bearing the connected complexities, costs of and risks of hampering collaboration (Spithoven et al., 2013; Laursen and Salter, 2014; Jang et al., 2017; Marullo et al., 2018).

Management of External Relations. To implement OI, SMEs engage in challenging searches for the right partners, but once they find a good match, negotiation and management of collaboration are costly and time-consuming. This can drive transaction costs and opportunistic behaviour of the partners (van Der Meer, 2007; Minshall et al., 2010; Di Minin et al., 2016a; Usman et al., 2017), but also additional challenges in managing administrative and bureaucratic burdens, especially when the public sector is involved in the collaboration (Ojasalo and Holopainen, 2016).

Relatedness. Exploring the external environment can lead to infinite opportunities, which are not always related to company's core capabilities. Screening these opportunities requires SMEs to engage in bearing search costs and uncertainty of the outcome, but also to commit time and human resources to screen, and then integrate relevant external assets. SMEs need to dynamically balance the screening and exploitation of new relevant opportunities beyond the organizational boundaries, and the focus on companies' R&D priorities (Laursen and Salter, 2006; van de Vrande et al. 2009; Dahlander and Gann, 2010).

Business Model Innovation. When embracing OI, companies need to pursue a balance of resources allocation between traditional business and OI projects. SMEs also engage in alternative approaches to penetrate the market and commercialize the outcomes of collaborative projects in order to capture their value, secure the success of the OI strategy and its sustainability in the long term (vad der Meer, 2007; Enkel et al., 2009; van de Vrande et al., 2009; Di Minin et al., 2016a).

These are the four challenging dimensions in which SMEs engage when practicing OI, which result from the extant literature on OI (Fig. 1). We use these theoretical constructs to build the original indicators of engagement in OI following the methodology presented in the next section.

2.3. SMEs and OI in the digital sector

This study focuses on SMEs in the digital sector for several reasons. First, SMEs are the favored actors in implementing digital transformation. This is due to their ability to develop and implement IT structures from scratch far more easily than large corporations (Deloitte, 2015), hence being able to gain competitive advantage from the fast pace of the digital technological changes (Mas and de Guevara, 2017).

Second, the digital sector is a pioneer in OI, because the Internet and ICTs enable open flows of information and knowledge across different levels of the innovation process, pushing digital companies to pursue OI in their integrative and modular innovation processes (Hafkesbrink and Schroll, 2010). In turn, "digital technologies make science and innovation more open, collaborative and global" (Moedas, 2015).

Third, the ICT and digital sector is a driver of the EU single market and a EU priority. The growth of this sector can add more than €110 billions of annual revenue in Europe in the next five years (EC, 2014, 2017a, 2017b; Schrauf and Berttram, 2016), and will receive about €5.5 billions in public and private investments in the next five years.

3. Methodology

3.1. Company selection and database construction

We built an original database of comprehensive financial and legal information on SMEi applicants. We created our database and conducted the analysis between 2017 and 2018.

Starting from the universe of 33,056 proposals submitted to the SMEi between January 2014 and March 2017, we followed the sample construction procedure illustrated in Fig. 2.

The final sample includes 377 SMEs, 209 SMEi awardees and 168 SoE, for which we built a database integrating two different data sources:

- SMEi database, including exhaustive information of proactive EU SMEs applying to the SMEi;
- Amadeus BvD database, including companies' standardized financial accounts.

Then, we conducted a web-based research on the selected sample of 377 SMEs and included three additional tables: technology, events, and people. Fig. 3 shows the data enrichment protocol. This information was the basis of the operationalization process described in the next paragraph.

3.2. Operationalization of OI challenges

Once the enrichment of the database was completed, we operationalized the challenges of OI derived from the literature (Section 2.2). Starting from elementary data (i.e. Technology and Events tables, Fig. 3), we constructed the DeMarkers, four markers each signaling one external challenge of OI: M1-Internal Assets Protection, M2-Management of External Relations, M3-Relatedness, and M4-Business Model Innovation. The DeMarkers are complex indicators, built through the aggregation of elementary indicators according to an AND/OR logic defined a priori by the team (Table 1). In building these indicators, we adopted a multiple-investigators strategy including 7 scholars, avoiding single researcher's biases and limiting arbitrary choices through reiterative parallel confrontations and debates among multiple operators. The DeMarkers represent proxies of non-observable engagement of SMEs in challenging dimensions of conducting OI strategies.

3.3. Sample characteristics

We conducted descriptive analyses and tests to provide a

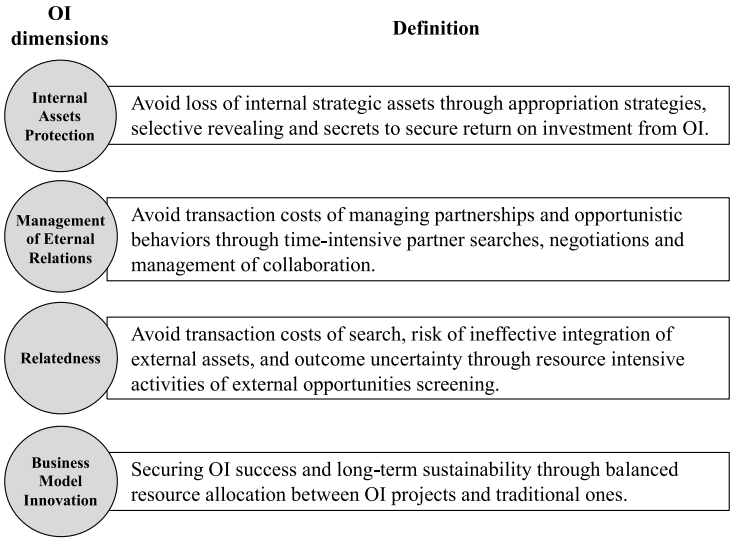

Fig. 1. The four challenging dimensions of OI.

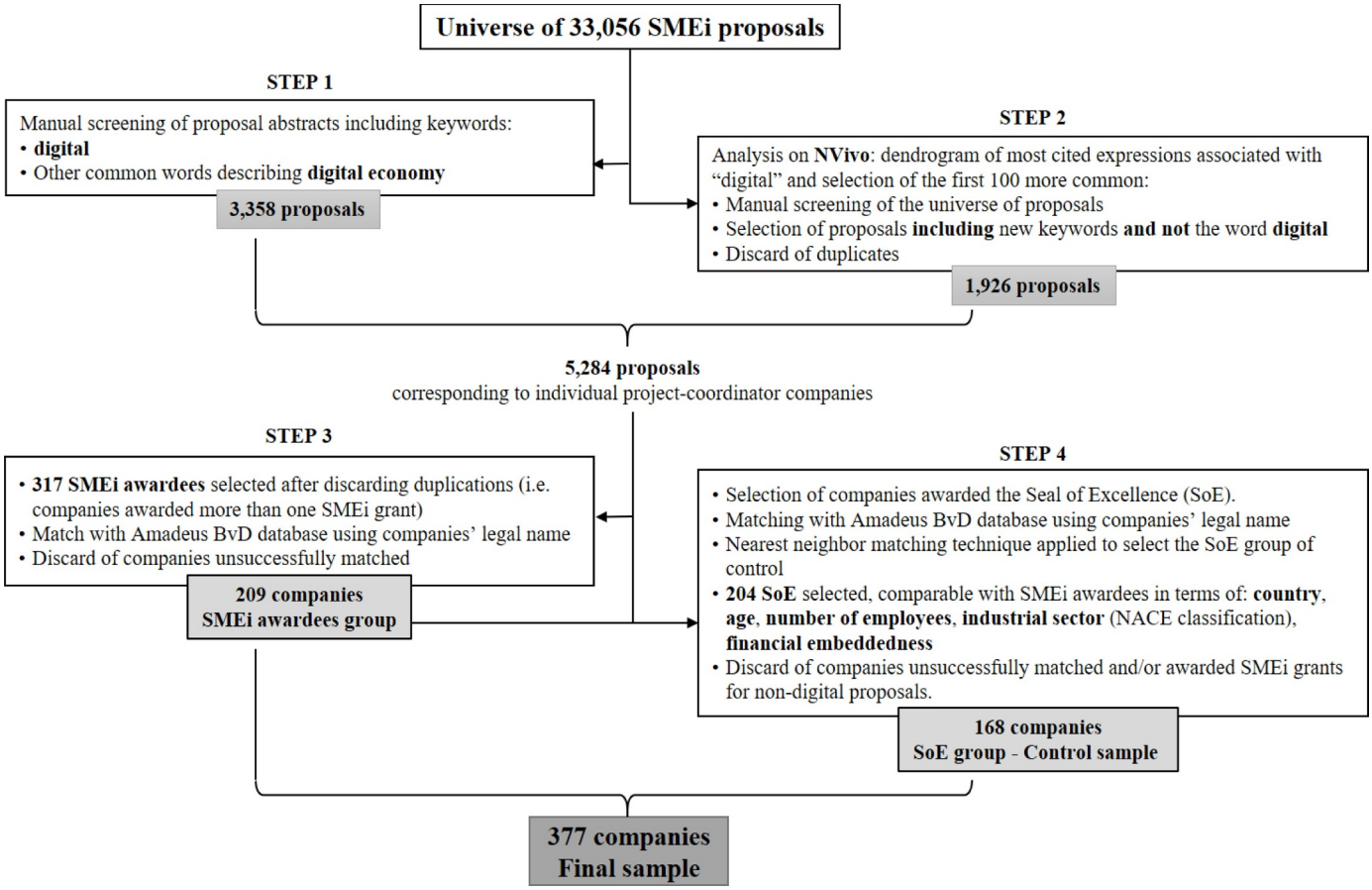

Fig. 2. Sample construction procedure.

characterization of (i) the selected sample of SMEi awardees and SoE groups active in the digital sector and (ii) the SMEs that have been engaged in the four OI challenging dimensions.

A correlation analysis confirmed the opportunity of including all the DeMarkers in the exploration of SMEs dynamism in OI challenging dimensions, since the indicators present weak or moderate pairwise correlations (values ranged between 0.214 and 0.437). For a deeper understanding of the relations existing among the DeMarkers, we built contingency tables[3] that show positive associations between the simultaneous presence of the DeMarkers. Moreover, to further explore how the analyzed variables influence the presence of the markers, we estimated an ordered probit model (see Wooldridge, 2010) whose results are presented in Section 4.5.

Table 2 shows the basic characteristics of the sample: SMEi

[3] The tables are available on request.

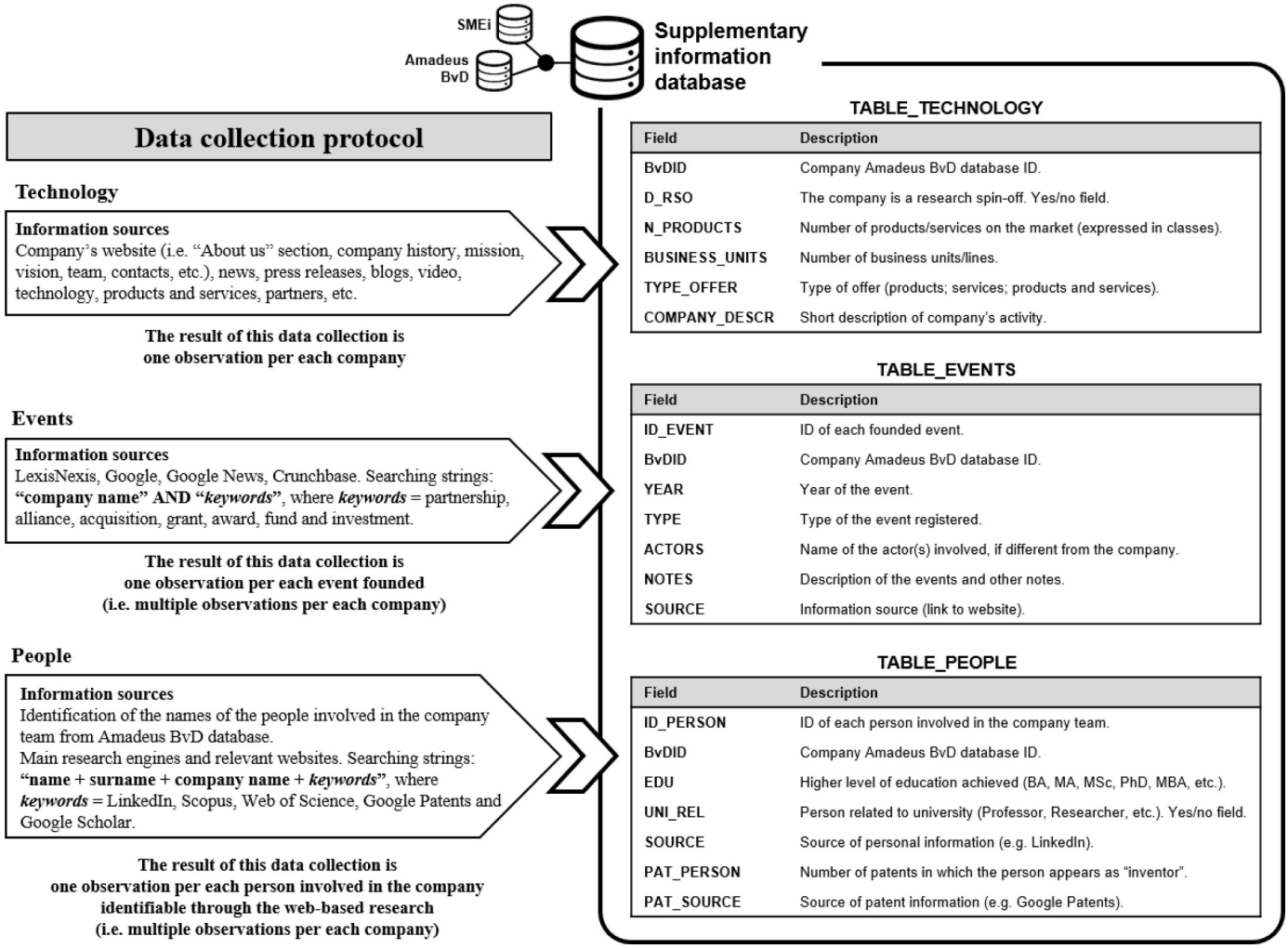

Fig. 3. Data enrichment protocol and tables.

Table 1
DeMarkers operationalization.

n	M1 Internal Assets Protection	M2 Management off External Relations	M3 Relatedness	M4 Business Model Innovation
Acceleration/ Incubation		X		X
Affiliation		X		
BMI				X
Branding		X		
Tech/Knowledge Acquisition	X			X
Funding		X		
Grant		X		
Hiring			X	X
Internationalization		X		X
Investors		X		
Joint Venture		X		X
P/S Launch				X
Partnership	X	X	X	
Procurement		X		
Spin-Out	X			X
VC		X		X
Patents (Amadeus BvD)	X			

awardees are slightly older and bigger, and show larger financial endowments when compared with SoE group. The knowledge base of the company assumes relevance in the award of the SMEi grant or SoE: companies in the SoE group mostly qualify as Research Spin-Off (RSO[4]; 33% vs. 21%), they employ individuals with high levels of education (MBA/PhD) or connected with the university.

Secondary data show that the SoE group presents higher activity in establishing innovation partnerships and gaining VC funding; public procurements events, on the contrary, characterize only SMEi awardees.

Interestingly, the variables signaling SMEs' engagement in OI challenging dimensions show that the SoE group presents higher presence of all the four DeMarkers. The differences between the two groups sampled are statistically significant for M1, M2 and M4.

4. Findings and discussion

The SMEs selected for this study are the "best in class" of the EU digital sector ranking above the evaluation threshold in the SMEi competition. The claimed scope of the SMEi is to identify the 'EU Innovation Champions', selecting the companies with the highest

[4] RSOs are companies *"operating in high-tech sectors and established by university-related individuals e.g. professors, researchers, students, etc."* (Bax et al., 2014).

Table 2
Descriptive characteristics of the sample.

	Variables – n (%); Mean (SE) for ◆	SMEi awardees (n = =209)	SMEi SoE (n = =168)	Test of equality p-value
Company details	Age ◆	9.80 (8.30)	8.80 (6.52)	0.242
	Number of employees ◆	20.89 (38.24)	18.29 (27.82)	0.500
	Research Spin-Off	44 (21.05)	53 (33.13)	0.009 **
	Patents	37 (17.70)	38 (22.62)	0.235
Basic financial information				
	Total assets ◆	2,491,135.00 (6,058,789.00)	2,386,691.00 (4,221,049.00)	0.845
	Operating revenue (Turnover) ◆	2,844,132.00 (7,280,372.00)	2,406,086.00 (5,065,520.00)	0.564
	Long term debts ◆	379,169.40 (104,364.80)	383,030.40 (56,312.47)	0.975
	Cash flow ◆	113,124.80 (78,597.78)	-59,996.66 (103,327.50)	0.179
HR	Staff with MBA or PHD	55 (26.32)	81 (48.21)	0.000 ***
	Staff owning patents	44 (21.05)	42 (25.00)	0.364
	University-related staff	29 (13.88)	54 (32.14)	0.000 ***
SMEi information	SMEi Ph. 2 awardee	53 (25.36)	NA	
	SMEi Ph. 1 and 2 awardee	5 (2.39)	NA	
	Partners in SMEi application	17 (8.13)	NA	
	SMEi Recommended EU Contribution ◆	435,798.80 (717,875.80)	NA	
	SMEi Recommended EU Contribution (Ph.2 only) ◆	1,566,637.00 (549,198.10)	NA	
Company dynamics	Partnership events	101 (48.33)	110 (70.51)	0.000 ***
	VC events	45 (21.53)	71 (45.51)	0.000 ***
	Procurement events	9 (4.31)	0 (0.00)	0.009 **
Engaging markers	Internal Assets Protection (M1)	53 (25.36)	62 (36.90)	0.016 *
	Management of external relations (M2)	134 (64.11)	124 (73.81)	0.044 *
	Over-searching (M3)	34 (16.27)	32 (19.05)	0.480
	Business model innovation (M4)	93 (44.50)	101 (60.12)	0.003 **

Financial data expressed in EUR; *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; a = $p<0.1$.

innovative potential of growth, internationalization, and market disruption. The scope of this study was to verify that the SMEi grants have been awarded to companies that, when compared with not-awarded ones, result more dynamic and engaged in challenging dimension of OI: M1-Internal Assets Protection, M2-Management of External Relations, M3-Relatedness, and M4-Business Model Innovation.

We proposed a methodology to operationalize the constructs of these challenges, and then detect and signal SMEs' engagement in each of them. We identify companies' characteristics associated with the emergence of engagement in the OI challenges and our findings show that the SMEs awarded by the EC as the best EU innovators show this engagement. However, our analyses show that the 'EU Innovation Champions' receiving SMEi grants are not the "best in class". Indeed, the SMEs showing more dynamism and engagement in OI challenging dimensions are the companies that achieved positive evaluation of their projects but were not awarded SMEi funding for lack of budget, getting only the SoE.

4.1. SMEs engaged in internal assets protection

Companies in our sample operate in the digital markets and are highly likely to work on software, which has limited patentability (art. 52(2)c EPC[5]). As foreseen, the percentage of SMEs engaged in M1-Internal Assets Protection (Table 3) is quite low. Nonetheless, this percentage is higher among the SoE group (37%) than among the SMEi awardees (25%). We find statistical significance that SMEi awardees are more prone to engage in appropriation strategies when they are older, while the age does not result significant for SoE companies. Both for awardees and SoE SMEs, the number of employees assumes relevance, but on opposite directions: SMEi awardees are more prone to engage in M1 if they are larger, while SoE companies engaged in M1 are generally smaller. Our results show that a huge majority of SMEs engaged in M1, both awardees and SoE, collaborates with the external environment through partnering activities.

It is interesting to notice that being a RSO only slightly enhances the possibility of engaging in the M1 dimension for SMEi awardees, while it is highly significant for SoE companies. The same observation arises for the characteristics of employing staff with MBA/PhD education level or having relations with the university: these characteristics are significantly associated with the engagement in M1 for companies awarded the SoE, but the association is not significant for SMEi awardees. Moreover, employing staff owning patents is associated with the engagement in M1. These results confirm the literature on research-driven SMEs: the low appropriability of codified knowledge drives selective revealing paradoxes and monitoring efforts to control the leaks of core internal assets (Laursen and Salter, 2014). In these cases, SMEs are inclined to engage in Internal Assets Protection and manage intellectual property through formalized relationships (Gardet and Fraiha, 2012). Furthermore, the low engagement in M1 is consistent with extant literature arguing that appropriation strategies are complex and expensive for SMEs (Klevorick et al., 1995; Mortara and Minshall, 2011; Granstrand and Holgersson, 2014). Indeed, for both groups of companies engaged in M1, the values for cash flow show a negative sign. However, only for SMEi awardees the variable is positively associated with the emergence of M1.

Concerning the performance in the SMEi, awardees engaged in M1 achieve positive results: 39% of companies presenting M1 received a SMEi Ph.2 grant and 6% received both Ph.1 and Ph.2. Reasonably, these companies received a more generous contribution from the EC.

4.2. SMEs engaged in management of external relations

A large majority of SMEs in both awardees (64%) and SoE (74%) groups results engaged in the M2-Management of External Relations (Table 4), as expected. Clearly, companies showing high dynamism on the dimensions related to the interaction with the external environment (i.e. partnerships, relationships with VC investors, and - for awardees - procurement contracts) enhance their possibilities of incurring in challenging and effortful relationships. It is interesting to notice that M2 is not associated with awardees performance in the SMEi competition, nor with firms' financial endowments, except for the total assets, which are larger for SoE companies presenting M2, and cash flow that presents negative sign for awardees and is associated with the

[5] "*2. The following, in particular, shall not be regarded as inventions within the meaning of paragraph 1: […] (c) schemes, rules and methods for performing mental acts, playing games or doing business, and* ***programs for computers****."* Convention on the Grant of European Patents, 1973.

Table 3
Baseline characteristics for SMEs engaged in M1-Internal Assets Protection.

	SMEi Awardees 209 (55.44)			SMEi SoE 168 (44.56)		
Variables – n (%); Mean (SE) for *	SMEs with M1 53 (25.36)	SMEs without M1 156 (74.64)	Test of equality p-value	SMEs with M1 62 (36.90)	SMEs without M1 106 (63.10)	Test of equality p-value
Company details						
Age *	11.96 (1.11)	9.06 (0.66)	0.028 *	15.92 (27.18)	22.13 (3.70)	0.174
Number of employees *	38.39 (9.60)	15.64 (2.85)	0.002 **	8.01 (0.57)	10.35 (0.94)	0.024 *
Research Spin-Off	15 (28.30)	29 (18.59)	0.134	28 (45.90)	25 (25.25)	0.007 **
Basic financial information						
Total assets *	5,340,068.00 (1,486,715.00)	1,509,408.00 (222,335.60)	0.000 ***	3,100,700.00 (604,164.50)	1,952,396.00 (396,535.00)	0.099 a
Operating revenue – Turnover *	5,806,495.00 (2,185,399.00)	1,960,620.00 (398,487.80)	0.006 **	3,045,628.00 (813,970.90)	1,963,326.00 (487,574,90)	0.229
Long term debts ♦	836,954.70 (346,267.70)	213,419.6 62,271.01	0.008 **	461,342.6 96,957.36	332,357.7 68,224.54	0.265
Cash flow ♦	-138,633.10 (277,188.90)	185,055.60 (62,358.22)	0.087 a	-129,657.30 (188,494.20)	-7,996.43 (113,893.00)	0.562
SMEs HR characteristics						
Staff with MBA or PHD	16 (30.19)	39 (25.00)	0.459	38 (61.29)	43 (40.57)	0.009 **
Staff owning patents	16 (30.19)	28 (17.95)	0.059 a	30 (48.39)	12 (11.32)	0.000 ***
University related staff	8 (15.09)	21 (13.46)	0.766	29 (46.77)	25 (23.58)	0.002 **
SMEi information						
SMEi Ph.2 awardee	19 (38.85)	34 (21.79)	0.042 *	–	–	–
SMEi Ph.1 and 2 awardee	3 (5.66)	2 (1.28)	0.072 a	–	–	–
SMEi Recommended EU Contribution *	667,421.60 (124,253.70)	357,105.10 (50,157.97)	0.006 **	–	–	–
Company dynamics						
Partnership events	38 (71.70)	63 (40.38)	0.001 **	47 (78.33)	63 (65.63)	0.090 a
VC events	14 (26.42)	31 (19.87)	0.317	29 (48.33)	42 (43.75)	0.576
Procurement events	4 (7.55)	5 (3.21)	0.179	0 (0.00)	0 (0.00)	–

Financial data expressed in EUR; *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; [a] = = $p<0.1$. Information on company patents omitted: this information was used to build the M1 indicator.

Table 4
Baseline characteristics for SMEs engaged in M2-Management of External Relationship.

	SMEi Awardees 209 (55.44)			SMEi SoE 168 (44.56)		
Variables – n (%); Mean (SE) for *	SMEs with M2 134 (64.11)	SMEs mwithout M2 75 (35.89)	Test of equality p-value	SMEs with M2 124 (73.81)	SMEs without M2 44 (26.19)	Test of equality p-value
Company details						
Age *	9.57 (0.70)	10.2 (1.00)	0.603	8.45 (0.56)	10.09 (1.08)	0.152
Number of employees *	22.13 (3.74)	18.51 (6.00)	0.593	21.72 (2.86)	7.92 (1.20)	0.007 **
Research Spin-Off	37 (27.61)	7 (9.33)	0.002 **	47 (37.90)	6 (16.67)	0.017 *
Patents	28 (20.90)	9 (12.00)	0.106	32 (25.81)	6 (13.64)	0.097 a
Basic financial information						
Total assets *	2,650,397.00 (52,051.30)	2,184,321.00 (673,818.90)	0.608	2,835,804.00 (440,475.70)	1,126,984.00 (281,361.50)	0.026 *
Operating revenue – Turnover *	2,949,472.00 (696,610.10)	2,649,658.00 (1,126,084.00)	0.812	2,832,649.00 (570,223.10)	1,350,904.00 (571,664.40)	0.129
Long term debts ♦	474,073.70 (153,735.00)	201,439.60 (80,441.78)	0.214	418,635.40 (69,027.57)	280,171.50 (89,780.01)	0.284
Cash flow ♦	-14,270.34 (91,392.41)	32,9696.50 (140,539.70)	0.034 *	-102,298.60 (141,486.90)	51,979.14 (41,184.55)	0.508
SMEs HR characteristics						
Staff with MBA or PhD	32 (23.88)	23 (30.67)	0.285	65 (52.42)	16 (36.36)	0.067 a
Staff owning patents	32 (23.88)	12 (16.00)	0.180	40 (32.26)	2 (4.55)	0.000 ***
University-related staff	21 (15.67)	8 (10.67)	0.315	43 (34.68)	11 (25.00)	0.238
SMEi information						
SMEi Ph.2 awardee	34 (25.37)	19 (25.33)	0.995	–	–	–
SMEi Ph.1 and 2 awardee	2 (1.49)	3 (4.00)	0.255	–	–	–
SMEi Recommended EU Contribution *	446,484.60 (63,511.69)	416,704.10 (79,706.70)	0.774	–	–	–
Company dynamics						
Partnership events	99 (73.88)	2 (2.67)	0.000 ***	103 (83.74)	7 (21.21)	0.000 ***
VC events	44 (32.84)	1 (1.33)	0.000 ***	68 (55.28)	3 (9.09)	0.000 ***
Procurement events	9 (6.72)	0 (0.00)	0.022 *	0 (0.00)	0 (0.00)	–

Financial data expressed in EUR; *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$;[a] = $p<0.1$.

emergence of M2. Noticeably, the characteristic of being an RSO is the main factor of significance in the emergence of M2 for both groups. For SoE, the science-base-related characteristics result to be significant: being a RSO, owning patents, hiring MBA/PhD staff and employees owning patents are elements associated with the engagement in M2. These results are consistent with the literature on the lack of managerial and entrepreneurial capabilities of companies spinning out from the academic world, which focus more on their technological assets and

Table 5
Baseline characteristics for SMEs engaged in M3-relatedness.

	SMEi Awardees 209 (55.44)			SMEi SoE 168 (44.56)		
Variables – n (%); Mean (SE) for *	SMEs with M3 34 (16.27)	SMEs without M3 175 (83.73)	Test of equality p-value	SMEs with M3 32 (19.05)	SMEs without M3 136 (80.95)	Test of equality p-value
Company details						
Age *	10.68 (1.29)	9.63 (0.64)	0.502	11.37 (1.03)	8.29 (0.56)	0.016 *
Number of employees *	21.42 (5.92)	20.78 (3.66)	0.941	33.23 (7.86)	14.62 (1.86)	0.001 **
Research Spin-Off	11 (32.35)	33 (18.86)	0.077 a	20 (62.50)	33 (25.78)	0.000 ***
Patents	9 (26.47)	28 (16.00)	0.143	10 (31.15)	28 (20.59)	0.195
Basic financial information						
Total assets *	2,903,897.00 (843,319.60)	2,409,080.00 (487,545.20)	0.669	4,051,564.00 (1,013,033.00)	2,006,523.00 (338,138.60)	0.018 *
Operating revenue – Turnover *	2,919,789.00 (971,287.80)	2,831,621.00 (679,810.10)	0.959	4,168,596.00 (1,213,853.00)	1,931,564.00 (446,657.60)	0.038 *
Long term debts ♦	248,935.60 (73,077.66)	404,821.60 (124,071.40)	0.581	379,146.50 (77,900.23)	384,001.30 (67,784.16)	0.973
Cash flow ♦	-61,871.63 (294,625.60)	136,653.70 (80,220.15)	0.416	-124,323.40 (286,098.10)	-42,091.29 (106,306.70)	0.744
SMEs HR characteristics						
Staff with MBA or PHD	6 (17.65)	49 (28.00)	0.210	19 (59.38)	62 (45.59)	0.160
Staff owning patents	8 (23.53)	36 (20.57)	0.699	13 (40.63)	29 (21.32)	0.023 *
University related staff	9 (26.47)	20 (11.43)	0.020 *	15 (46.88)	39 (28.68)	0.047 *
SMEi information						
SMEi Ph.2 awardee	8 (23.53)	45 (25.71)	0.789	–	–	–
SMEi Ph.1 and 2 awardee	0 (0.00)	5 (2.86)	0.318	–	–	–
SMEi Recommended EU Contribution *	399,697.90 (119,160.10)	442,811.50 (54,729.54)	0.749	–	–	–
Company dynamics						
Partnership events	33 (97.06)	68 (38.86)	0.000 ***	30 (93.75)	80 (64.52)	0.001 **
VC events	13 (38.24)	32 (18.29)	0.010 *	13 (40.63)	58 (46.77)	0.533
Procurement events	3 (8.82)	6 (3.43)	0.156	0 (0.00)	0 (0.00)	–

Financial data expressed in EUR; *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; [a] = = $p<0.1$.

skills while neglecting business and managerial ones. Furthermore, RSOs strive in interacting with the external environment because they struggle in achieving reliability and accountability, hence legitimacy on the market (Stuart et al., 1999; De Marco and Piccaluga, 2016).

4.3. SMEs engaged in relatedness

The linkage with academia is associated with the rise of M3-Relatedness (Table 5): 32% of awardees presenting M3 is a RSO, and 26% of them employs university-related staff. This evidence is even stronger for the SoE group, where these percentages increase to 62% and 47%, respectively. RSOs and SMEs employing staff connected with academia seem to be more prone to engage in external search strategies with many diversified partners and clients, tackling multiple potential applications for their technologies and, therefore, struggling in finding viable paths to market. The associations between M3 and the establishment of partnership are strongly significant for SMEi awardees, but less for SoE. Being VC-backed is associated with M3 only for the SMEi awardees; while, for SoE companies, it is significant to be older and larger in terms of employees, endowed with more financial resources, and employing staff owning patents.

Companies engaged in M3 are highly research-driven and generally lack market orientation. These results are consistent with extant literature on the risks embedded in conducting too broad search activities (Laursen and Salter, 2006, 2014; Lee et al., 2010). Only a small percentage of SMEs in our sample showed engagement in the M3, accounting for 16% in the awardees group and 19% in the SoE one. On the one hand, this finding is in contrast with the mentioned studies that report over-searching activities (i.e. Relatedness challenge) as a common risk faced by companies implementing OI. On the other hand, we find this limited diffusion of the Relatedness marker for SMEs coherent with the findings of the scholars arguing that SMEs are more prone to rely on internal knowledge, technologies, and expertise instead of excessively search the external environment for innovation opportunities (De Marco, 2017). This leads SMEs to mistrust searching and the capability of external sources to offer viable solutions to their businesses, and incur in the opposite risk of over-committing towards their company assets.

4.4. SMEs engaged in business model innovation

Our results show that the SMEs in our sample are highly engaged in M4-Business Model Innovation (Table 6): 45% of awardees and 60% of SoE.

While the number of employees of the firms engaged in M4 is above 22 for both awardees and SoE, for the latter being larger is also positively associated with M4. Moreover, the engagement in M4 for SoE companies is also associated with employing staff with MBA/PhD and company's higher total assets. For SMEi awardees, higher engagement in M4 is connected with being an RSO and engaged in patenting. Despite the two groups show similar percentage values of companies engaged in M4 that are RSO and own patents, for the SoE group these factors do not show any statistical significance. Among SMEi awardees, instead, the majority of companies presenting M4 spun-out from the academic world and have at least one patent filed. This is consistent with the literature on RSOs (De Marco and Piccaluga, 2016; Gubitta et al., 2016) and confirms that engaging in appropriation strategies positively impacts commercialization (Kang et al., 2013). Indeed, our results show that M4 is also strongly associated with dynamism on the dimensions of establishing partnerships and receiving VC investments for both SMEi awardees and SoE. Nonetheless, the SoE group shows percentage values of companies presenting the M4 systematically higher than the SMEi awardees group. These results confirm previous studies arguing that SMEs practice OI to make R&D activities more effective, but also – and more often – to pursue the path to the market together with industrial partners (van de Vrande et al., 2009; Spithoven et al., 2013; Hossain and Kauranen, 2016).

Our results also confirm the literature on the positive effects of business model innovation (Hossain and Kauranen, 2016): SMEi awardees engaged in M4 result more successful in obtaining SMEi Ph.2

Table 6
Baseline characteristics for SMEs engaged in M4-Business Model Innovation.

	SMEi Awardees 209 (55.44)			SMEi SoE 168 (44.56)		
Variables – n (%); Mean (SE) for *	SMEs with M4 93 (44.50)	SMEs without M4 116 (55.50)	Test of equality p-value	SMEs with M4 101 (60.12)	SMEs without M467 (39.88)	Test of equality p-value
Company details						
Age *	8.90 (0.76)	10.52 (0.83)	0.163	8.88 (0.61)	8.88 (0.87)	0.999
Number of employees *	22.85 (4.14)	19.26 (4.76)	0.578	22.39 (3.34)	12.02 (2.21)	0.069 *
Research Spin-Off	31 (33.33)	13 (11.21)	0.000 ***	36 (35.64)	17 (28.81)	0.376
Patents	23 (24.73)	14 (12.07)	0.017 *	25 (24.75)	13 (19.40)	0.417
Basic financial information						
Total assets *	2,361,728 (412,719.5)	2,595,837 (703,357.1)	0.787	2.885.969.00 (502,202.60)	1,629,720.00 (362,842.50)	0.069 *
Operating revenue – Turnover *	2,540,054 (564,419)	3,075,810 (965,309.5)	0.659	2,989,081.00 (684,677.00)	1,638,987.00 (468,499.60)	0.130
Long term debts ♦	221,876.20 (40,808.91)	521,301.90 (194,477.00)	0.153	408,431.30 (71,717.16)	342,577.00 (91,512.13)	0.571
Cash flow ♦	-46,182.17 (118,519.90)	233,122.20 (103,537.00)	0.078	-147,111.70 (165,903.00)	77,935.47 (44,479.12)	0.291
SMEs HR characteristics						
Staff with MBA or PhD	24 (25.81)	31 (26.72)	0.881	54 (53.47)	27 (40.30)	0.094 a
Staff owning patents	22 (23.66)	22 (18.97)	0.408	29 (28.71)	13 (19.40)	0.172
University-related staff	16 (17.20)	13 (11.21)	0.213	36 (35.64)	18 (26.87)	0.233
SMEi information						
SMEi Ph.2 awardee	30 (32.26)	23 (19.83)	0.040 *	–	–	–
SMEi Ph.1 and 2 awardee	2 (2.15)	3 (2.59)	0.838	–	–	–
SMEi Recommended EU Contribution *	566,113.9 (85,810.8)	331,320.2 (55,671.11)	0.018 *	–	–	–
Company dynamics						
Partnership events	59 (63.44)	42 (36.21)	0.000 ***	80 (80.00)	30 (53.57)	0.001 **
VC events	40 (43.01)	5 (4.31)	0.000 ***	55 (55.00)	16 (28.57)	0.001 **
Procurement events	6 (6.45)	3 (2.59)	0.171	0 (0.00)	0 (0.00)	–

Financial data expressed in EUR. *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; [a] = = $p<0.1$.

grants, with an associated higher contribution received by the EC.

4.5. The determinants of the DeMarkers

With the purpose of exploring the role of each variable considered in our analysis, we estimated an ordered probit model (see Wooldrige, 2010), considering as our dependent variable the sum of the DeMarkers. This analysis allows us to integrate the results obtained from the association analyses, showing which variables contribute to the sum of the four DeMarkers. In other words, we estimate what characteristics, dynamics or events of the firms are associated with engagement on more than one OI challenging dimension. From the ordered probit model estimation, we can see how the characteristics of the SMEs in terms of size (number of employees), being a RSO, owning patents and being active on OI practices (i.e. engaging in partnerships, being VC backed and obtaining procurement contracts) enhance the number of challenging dimensions in which companies engage.

It is interesting to notice that, even with a weak significance, the variable related to the SMEi competition, i.e. being awarded the SMEi grant, negatively influences the sum total of the four DeMarkers. The characteristics that show statistically significant results in determining the sum total of the DeMarkers are, overall, consistent with the ones associated to the emergence of the individual markers. This result strengthens the robustness of the association analyses presented in previous paragraphs (Table 7).

Table 7
Ordered probit estimation for the sum of DeMarkers.

	DeMarkers Sum	Coefficient	SE	$P>\|z\|$
Company details	Age	0.007	0.012	0.562
	Number of employees	0.013	0.005	0.006**
	Research Spin-Off	0.640	0.186	0.001**
	Patents	0.811	0.240	0.001**
Basic financial information	Total assets	$-3.02\cdot10^{-8}$	$3.83\cdot10^{-8}$	0.430
	Operating revenue - Turnover	$-1.23\cdot10^{-8}$	$4.27\cdot10^{-8}$	0.773
	Long term debts	$-2.50\cdot10^{-8}$	$9.62\cdot10^{-8}$	0.795
	Cash flow	$-4.61\cdot10^{-8}$	$8.76\cdot10^{-8}$	0.599
SMEs HR characteristics	Staff with MBA or PHS	-0.240	0.191	0.208
	Staff owing patents	-0.067	0.204	0.742
	University-related staff	0.151	0.214	0.479
SMEi information	SMEi Awardees	-0.322	0.173	0.063 a
Company dynamics	Partnership events	1.267	0.183	0.000***
	VC events	0.799	0.193	0.000***
	Procurement events	1.064	0.583	0.068 a
	Number of obs.	205		
	LR chi2(15)	150.380		
	Prob > chi2	0.000		

Financial data expressed in EUR. *** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; [a] = = $p<0.1$.

5. Implications

The findings of this work provide managerial and policy implications, as well as methodological contributions.

5.1. Managerial implications

Our findings suggest that managers could design OI strategies taking into consideration the characteristics of their firms. Companies with strong science and knowledge bases turn out to be highly dynamic on many of OI challenging dimensions. This means that, in order to benefit from collaboration, R&D and innovation managers should pursue strategies able to unlock value leveraging the skills of highly qualified staff and their connection to academia. SMEs with a high knowledge-base, need to design strategies in which their knowledge is protected, as it is their core asset. Indeed, OI practices and success require a strong awareness of the intellectual properties and other assets that can be

involved in the collaboration.

Our results offer managers valuable insights to balance the allocation of company's efforts and resources on the different OI challenging dimensions to enhance the chances of success for their OI strategy.

5.2. Policy implications

Concerning policy implications, our findings suggest that SMEi awardees show some engagement on OI challenging dimensions, but they are not the most engaged of the SMEs achieving a positive SMEi evaluation. Indeed, the SMEs receiving the grants are less dynamic than the ones not receiving funding. Our results contrast with the SMEi claimed scope of creating the "EU Innovator Champions League" since it seems that, despite recognizing their value through the SoE, the Instrument is not funding the 'best in class' in the arena of Schumpeter Mark I small-sized innovators, but is instead supporting the last mile of the 'second bests'.

We do not argue that the scope of the SMEi has not been achieved at all, nor that the policy is ineffective, but rather that the results are diverging somewhat from the scope declared in the policy design, and this creates inefficacies in the budget allocation. On the one hand, the SMEi could target the actual 'EU Innovation Champions', i.e. those showing the highest levels of ambition and risks, but also the highest engagement and dynamism in OI crucial dimensions, in order to create an exclusive and niche group of companies driving EU competitiveness and growth. On the other hand, the SMEi could target 'want-to-be champions': companies showing high levels of ambition and risks, but that are not yet the most engaged and dynamic in OI dimensions, in order to offer them the chance of developing their potentials and enhance the number of SME actors contributing to EU competitiveness and growth. According to the results of our study, up to now, the SMEi has been awarding these 'want-to-be champions'.

In Horizon Europe, the 9th EU Framework Program, the EC allocated € 13.5 billions on the Open Innovation pillar, under which the SMEi will be funded. Based on the results of this study, we argue that EU policymakers should enhance the level of details required to identify the companies to be supported under the SMEi. Indicators such as the DeMarkers would help the identification of actual dynamism and engagement of the SMEs in the four challenging dimensions of OI. Their introduction as evaluation criteria would allow pursuing the real 'EU Innovation Champions' as SMEi target, and support a better allocation of public funding through a more comprehensive evaluation procedures to effectively award SMEi grants.

Finally, building on the idea that these Schumpeterian Mark I champions are innovators introducing new products and services and with good technological performance, the SMEi could target the most innovative of EU SMEs addressing their activities towards pursuing the grand societal challenges (Kuhlmann, 2018). This would follow the current policy trend of the 'transformative innovation policy' (Fagerberg, 2018; Diercks et al., 2019) aiming at mobilizing not only policymakers, but also all the stakeholders of the innovation ecosystem, to identify innovative solutions to the current global challeges listed in the Sustainable Development Goals of the United Nations.

5.3. Methodological contributions

Our methodology operationalizes SMEs' engagement in OI challenges into the autonomous and self-reliant DeMarkers indicators that can be observed and monitored in a long-term application of this methodology. The DeMarkers are a tool to detect SMEs' engagement in OI, and European institutions are in the position of collecting the data needed to build this tool in the process of SMEs' proposal submission to EU funding programs. The DeMarkers would provide both EU policymakers and evaluators with clearer vision over the firm called to develop funded projects. Indeed, the EC has recently introduced a further step in the SMEi evaluation, consisting in a company pitch of the firm and project for which the EU funds is requested. This step seems to embrace an evaluation approach that considers elements beyond the mere proposal submitted for the application and involving factors related to the ambitions and commitment of company management, team and skills engaged in the innovation activities. The DeMarkers indicators could complement this approach.

6. Conclusive remarks

This exploratory study focused on the EU SMEi, which claimed to pursue the goal of selecting and awarding the most innovative SMEs in Europe to create the 'EU Innovation Champions League'. This study aimed at verifying whether this goal has been achieved, and we conclude that this goal is not being fully realized. Our purpose was to identify the elements that public sector should consider when drafting and implementing an innovation policy supporting small businesses' R&D, going beyond the mere scope of filling the equity gap, in order to effective allocate public funding to the most deserving candidates. Since the EC embraced the OI paradigm and the SMEi is a pillar of the support to the OI ecosystem, to maximize the impact of the SMEi the budget should be allocated to companies practicing OI. We proposed an original methodology to detect this engagement, operationalizing OI challenging dimensions into four complex indicators, the DeMarkers: Internal Assets Protection, Management of External Relations, Relatedness, and Business Model Innovation. We tested the methodology on a sample of 'EU Innovation Champions' receiving positive evaluation in the SMEi competition and operating in the digital sector - given its intrinsic openness and the relevance of the digital economy - and compared the companies receiving SMEi grants with the ones receiving the SoE.

We recognize that this study has many limitations. We acknowledge that the size of our sample can be limited and the DeMarkers methodology should be tested on larger samples including multiple industry sectors to provide wider generalizability of the results. Future research should explore the peculiarities of SMEs spinning out from the academic world since this study highlighted the significance of the RSO nature of the company and the connection with academia in the associations with the markers. RSOs represent almost a quarter of our sample, meaning that SMEs with research-driven approach are tackling public funds and the public sector should not neglect to address their peculiarities when supporting these ventures. In addition, scholars should conduct longitudinal analyses to assess the relations between the DeMarkers and the effects over SMEs' long-term growth and innovativeness. Finally, future research should evaluate the performance of SMEi awardees against the SoE group, to trace their capabilities to attract private funds leveraging public money, and bring innovative ideas to the market.

Despite the limitations and the room for further research, this exploratory study offers considerable insights, particularly for the purpose of identifying strategies to design more OI-informed policy. Often, the scarce clarity and awareness of policy strategic goals lead to unsuccessful implementation (Smallbone, 2016). This study uncovered a misalignment between the embracement of the OI paradigm in the EU innovation strategy and the allocation of the EU innovation funding. In addition, the study also provided a methodological tool that could contribute solving this misalignment.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.techfore.2019.119843.

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