SME modes of innovation in European Catching-up Countries: The impact of STI and DUI drivers on technological innovation

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Abstract:

At the intersection of SME innovation and innovation systems, this study investigates the characteristics of SME innovation modes in catching-up European countries (Southern, and Central and Eastern European) and compare it with selected among the most advanced countries in Europe as a mean to show key differences. Distinguishing between STI (*Science, Technology and Innovation*) and DUI (*learning-by-Doing, Using and Interacting*) innovation drivers, and analyzing their impact on technological innovation we study 29,834 SMEs innovation in 15 countries. We argue that the most effective SME innovation modes in catching-up countries are peculiar vis-à-vis other types of countries (e.g. advanced economies). Results show how their economic, institutional and innovation context influence SME forms of knowledge and learning. In general, catching-up countries show effective DUI-type collaborations for process innovations, while showing more limited returns than advanced countries from the STI mode of innovation.

Key words: modes of innovation; innovation systems, Catching-up countries, Europe

1. Introduction

This study is positioned at the intersection of SME innovation (e.g. Radziwon and Bogers, 2018; Kapetaniou and Lee, 2018; Parrilli and Radicic, 2020) and scholarly work on innovation systems (e.g. Fitjar and Rodríguez-Pose, 2013; Haus-Reve et al., 2019; Jensen et al., 2007; Parrilli and Alcalde Heras, 2016), and directly investigates the differences between SME modes of innovation in advanced and catching-up countries in Europe. By catching-up countries we refer to those from the South, Central and Eastern Europe. Relative to more advanced economies (e.g. Germany or Norway), these countries present medium per capita incomes and thin innovation systems. This research area addresses firms' modes of innovation through specific innovation drivers made up of internal and external (collaborations) innovation activities and their specific institutional context. In this literature, it is argued that the measurement of innovation requires the study of the firm-level in their spatially-bounded context, that is, how innovation systems and their contextual and spatial specificities shape innovation patterns across countries and regions. From this perspective, our study follows Jensen's et al., (2007) discourse on innovation modes, which distinguishes between STI (internal and external or collaboration *Science, Technology and Innovation* drivers, primarily R&D and collaboration with universities and research centers) and DUI (internal and collaboration *Doing, Using and Interacting* drivers, primarily collaboration with value-chain actors) forms of knowledge and learning.

Within this theoretical realm, the literature is limited because the large majority of studies – apart from very recent contributions (Parrilli et al., 2020 on European regions; Parrilli and Radicic, 2020 on SMEs in Europe and the US) - are based on individual countries and their own contextual specificities. This limitation prevents developing cross-country comparisons that can help discovering differences in firms' innovation modes due to distinctive country patterns that reflect their own innovation and institutional systems. In addition, there is less research on innovation systems in catching-up countries (e.g. Fijałkowska et al., 2018), thus making this study timely.

Upon this theoretical basis, our study offers a characteristic approach. First, we focus on catching-up countries, those in Southern and Eastern Europe (e.g. Apanasovich et al., 2017, 2016; Castellacci and Archibugi, 2008; Szczygielski et al., 2017) , which represent a scope that is less researched, thus requiring more thorough understanding (European Commission, 2020). Second, our approach focuses on SMEs as units of analysis. This responds to the fact that small and medium-sized enterprises (SMEs) are pervasive in Europe, constituting around 99% of the total firms in Europe and contributing two-thirds of total employment (e.g. Papadopoulos et al., 2020)[1]. In addition, the literature on SMEs research innovation without contextualizing firms within their respective institutional and innovation context. Third, we relate innovation modes with different technological innovations (product and process innovation) in an attempt to find modes of innovation not only based on innovation systems where SMEs are embedded, but that are also moderated by the different types of technological innovation pursued by firms. Fourth, our study builds upon existing debates in the modes of innovation literature, like that on

[1] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Statistics_on_small_and_medium-sized_enterprises&oldid=463558

the simultaneous combination of DUI and STI collaborations. According to empirical evidence, firms that combine a strong version of the STI-mode with a strong version of the DUI-mode excel in product innovation, a fact evidenced in studies contextualized in countries such as Denmark (see Jensen et al., 2007), Spain (González-Pernía et al., 2015; Parrilli and Alcalde Heras, 2016), Portugal (Nunes and Lopes, 2015), Belarus (Apanasovich et al., 2016), Norway (Hause-Reve et al., 2019) or Europe as a whole Parrilli et al., 2020). Specifically, this sub-line of inquiry has produced non-conclusive results, showing a substitution (negative) effect that indicates that the above mentioned simultaneous collaboration with STI and DUI external sources of knowledge does not yield multiplicative benefits on innovation performance (Haus-Reve et al., 2019) and, in contrast, pointing out complementary or positive returns (Jensen et al., 2007; Parrilli and Alcalde, 2016, among others). While the direction of the effect is a question mark, whether positive or negative, it seems that the different types of country and their specific innovation and institutional systems might produce divergent outcomes (see Parrilli et al., 2020 for European regions). This study also attempts to resolve this tension of the different direction of the effects of collaboration on innovation (complementarity vs substitution) by comparing groups of countries and controlling for their different innovation and institutional systems in order to decipher whether that effect is country-dependent.

Lastly, this study's insights complement and extend the general SME innovation strand focused only on internal and external innovation drivers but not considering innovation systems where they are embedded (e.g. Radziwon and Bogers, 2018). Overall, we attempt to contribute by presenting findings from a large-scale database covering 29,834 SMEs in 15 countries from the Community Innovation Survey (CIS) 2014, which goes beyond existing evidence on specific/individual countries. We do this by classifying countries according to their different scale of development and degree of integration in the world economy: *Northern-Europe* (Advanced countries, here Norway and Germany), and more importantly *Southern-Europe* (Spain, Portugal and Greece, namely *SEC*), and *Central and Eastern Europe* Countries (named *CEEC*). The latter two categories are the center of this analysis as they represent countries that are on a prospective catching-up trajectory, to increase their competitiveness and innovation. The advanced countries (in this case Norway and Germany) are only utilized for benchmark and comparison, but do not constitute this research's main target.

In doing so, our study contributes to the literature on business modes of innovation by: i) analyzing the relationship between technological innovation (product or process innovation) pursued by SMEs and their innovation modes; ii) studying whether scientific and industry collaborations are complementary or substitute, and; iii) aiming to study in more depth how SMEs in European catching-up countries (with their own resources and capabilities) specifically combine STI and DUI drivers and get returns, vis-à-vis advanced countries and among themselves (Central and Eastern European vs Southern European countries). This work delivers special depth to holistic scholarly interpretations of regional innovation systems linked to specific technological and institutional assets (Asheim and Gertler, 2009; Cooke et al., 2004; Isaksen and Trippl, 2016; Parrilli et al., 2016a).

The paper is organized in five sections. In Section Two and Three, we discuss the relevant literature to theorize on the different innovation systems and related business innovation modes in different country contexts, thus setting our research hypotheses. In Section Four, sample, data and variables are presented. Section five shows and discuss the results of the empirical analysis, while Section Six concludes and presents key policy implications.

2. Innovation studies: firm-based and innovation systems

Innovation has been at the forefront of economic research for the past thirty years both within management literature (Kline and Rosenberg, 1986; Laursen et al., 2020; Laursen and Salter, 2006; Rothwell, 1974), and within economics literature (Fagerberg and Verspagen, 2020; Freeman, 1987; Lundvall, 1992; Nelson, 1993). Businesses, regions and countries innovate, and yet this process happens in a quite heterogeneous form with a number of successful firms, regions and countries on the one hand, and a larger number of ordinary or even unsuccessful cases on the other (Hollanders et al., 2009). This is expected, and nevertheless it leaves the feeling that more can be done to produce processes of catching-up and convergence of the less successful cases towards the average or even the best performing ones.

With this objective in mind, we combine innovation systems and firm-based innovation strands to understand the way businesses innovate within their contexts. Innovation modes are based on both internal innovation drivers and collaborations. The latter implies a relational-based approach that also helps to build new innovation capabilities. We assume that innovation is systemic and that collaborations constitute a way to build capabilities and absorb knowledge (Cohen and Levinthal, 1990; Dyer and Singh, 1998; Kline and Rosenberg, 1986). In addition, these capabilities and this knowledge are context-based as those collaborations depend on the cultural, institutional and technological context where they operate (Asheim and Gertler, 2009; Cooke, 2001; Doloreux and Parto, 2005; Lundvall, 1992; Rodríguez-Pose, 2013, among others). Following this chain of thought, this paper addresses research questions on firm innovation that go beyond the micro-level to incorporate country effects that represent the impact of specific innovation and institutional systems made up of individual firms and their innovation decisions, as well as of the way they interact and cooperate in their contexts. It entails understanding innovation management by developing innovation activities that can be considered internal, like the decision to develop R&D programs or train workers (e.g. Lane et al., 2006) with those external or inter-firm cooperation. The latter also extended to public and private science and technology organizations such as universities, technology centres, science and technology parks, business incubators, amongst others (Alberdi Pons et al., 2016; Asheim and Gertler, 2005; Cooke et al., 2004; Isaksen and Trippl, 2017; Rodríguez-Pose and Crescenzi, 2008). These inter-firm and organizational collaborations generate alliances, projects or simple knowledge spillovers that benefit firms in the form of spatially-bounded collective efficiency (Asheim et al., 2011; Camagni and Capello, 2013; Cooke, 2001; Isaksen and Trippl, 2017; Schmitz, 1995). Government policies and programs complement these collaborations through instruments that help build up territories that innovate and progress in the form of innovation systems (Boschma, 2015; Grillitsch and Asheim, 2018; Isaksen and Trippl, 2017; Rodríguez-Pose, 2013; Sotarauta, 2017; Tödtling and Trippl, 2005).

The literature on innovation systems has identified relevant typologies of entrepreneurial, institutional or grass-roots based innovation systems (Asheim and Gertler, 2005; Cooke et al., 2004), and development trajectories of these systems towards higher innovation and competitive outputs (Camagni and Capello, 2013; Isaksen and Trippl, 2017). The former set of studies identified representative, technological and institutional drivers of innovation systems, while the latter emphasized the broad drivers that support the dynamic growth trajectory in those particular contexts. However, few have implemented a thorough empirical assessment of these features (Alberdi Pons et al., 2016; Camagni and Capello, 2013; Rodríguez-Pose and Crescenzi, 2008), while none have gone beyond classical indicators of innovation (e.g. R&D expenditure, skilled human capital, or expenditure on new machinery and equipment), by considering also different types of supply chain-based collaborations as well as collaborations with science and technology-based agents. This much needed effort has been made within the sub-strand of the literature on innovation systems that is known as "business innovation modes" (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli and Alcalde Heras, 2016; Parrilli and Radicic, 2020; Thomä, 2017, among others).

This body of literature has adopted the innovation system approach to explore country-based modes of innovation where a relational perspective is capital (e.g. Haus-Reve et al., 2019; Parrilli et al., 2020; Parrilli and Alcalde Heras, 2016). On these bases, our study connects this relational perspective to the strand on firm innovation modes that emphasizes how firms pursue different innovation modes that in part reflect their territorial, cultural and institutional ascription (Fitjar and Rodríguez-Pose, 2013; Jensen et al., 2007; Parrilli et al., 2020, among others). Within the latter stream of literature, firms organize their innovation modes based on their context specificities which explains why some countries and regions tend to innovate through the application of scientific and analytic types of drivers (e.g. R&D and collaborations with universities and technology centres) while others tend to innovate through the application of practice and interaction-based drivers, such as the purchase of new machinery and equipment, or collaborations along the value chain (with suppliers, customers and service providers). The former is called the science and technology-based innovation (STI) mode, while the latter is called the learning-by-doing, by-using and by-interacting based (DUI) mode (Jensen et al., 2007).

3. Modes of innovation across catching-up countries

In this present work, we take a special perspective as we focus on specific types of economies that can be named non-advanced or even "catching-up" economies. These are economies that suffer from gaps in their approach to innovation, which are then reflected in their competitiveness levels. In these countries businesses take a secondary role in the coordination of global value chains (de Marchi et al., 2017; Gereffi et al., 2005) as their business systems mostly depend on lead firms based in the most advanced countries. For instance, it is the case of the automotive industry in the Czech Republic, Slovakia, Hungary and Romania, where local firms are second, third and fourth tier suppliers of lead German manufacturers such as Volkswagen and Audi (Blažek et al., 2018). In addition, these countries present lower than average investments in R&D, develop intensive non-R&D innovation activities, have high proportion of SMEs primarily in traditional industries and present thin institutional systems (e.g. Hervas-Oliver et al., 2011). In general, catching-up countries show lower innovation capacity that reflects a lower set of institutional and technological skills and capabilities in their innovation systems (Isaksen and Trippl, 2017). These countries show policies, norms and institutions centered around short/medium term economic profits, while put less emphasis on technological investments and intangible research and development activities that are likely to render returns over the long term.

Vis-à-vis the most advanced Northern economies, Central-Eastern and Southern European countries (CEEC and SEC) and their firms show heterogeneous and typically lower innovation capacity that reflects a lower set of institutional and technological capabilities developed and managed over time in their contexts (Alberdi Pons et al., 2016; Iammarino, 2005). To a certain extent, SEC and CEEC, exhibit a lack of "organizationally thick innovation systems", while counting instead on "specialized innovation systems" (e.g. Northern and Central Italy; Catalonia in Spain) or "organizationally thin innovation systems", in the case of most CEEC countries as well as regions in Spain, Greece, Italy and Portugal (Camagni and Capello, 2013; Isaksen and Trippl, 2017). From a different perspective, these countries represent the "moderate" and "modest innovators" vis-a-vis the "leaders" and "strong innovators" identified with the PRO-INNO study of the *Regional Innovation Scoreboard* (Hollanders et al., 2009) and would represent those Southern and CEE countries.

Overall, these catching-up countries present different features that explain their lower innovation capacity and competitiveness. In addition, these are contexts in which the ideal combination of STI and DUI drivers might not work as effectively as in more advanced contexts (Nunes and Lopes (2015) for Portugal; Parrilli and Elola (2012) for the Basque Country), and perhaps align to the differentiated strategy purported by Haus-Reve et al. (2019) in the context of Norway, where the two strategies (STI and DUI) are seen as mutually exclusive or substitute one another.

In this study, we analyze these economies in more depth through the application of a number of key drivers of innovation as a means to verify whether and where these specificities exist and what impact they have on the innovation performance of these economies and their businesses. On the aforementioned bases, we consider that catching-up economies present their own approach to innovation that is only in part effective and efficient. This situation justifies our current study as a means to explore opportunities to improve said efficiency and effectiveness in the application of key drivers of innovation.

Previous evidence on the most advanced economies (Fitjar and Rodríguez-Pose (2013) for Norway; Jensen et al. (2007) for Denmark; Parrilli et al. (2020) for Europe) shows that firms use and exploit science and technology drivers, both internal and external, to the highest extent. Well-endowed innovation systems allow the use of research-based and scientific innovation drivers and collaborations. These are well-rounded countries where the application of practice and interaction-based drivers (DUI) are also likely to work effectively as the overall absorptive capacity of the workforce is high and supports the joint work of all types of employees for the development of higher outputs of innovation, both in terms of new products and new processes (Parrilli et al., 2016b).

On the other hand, in the case of the European catching-up economies the situation is different. In this context, we aim at putting forward two main arguments. The first argument is based on the premise that the large majority of firms are SMEs and non-R&D innovators (Hervas-Oliver et al., 2011); this means that the majority of firms tend not to invest and apply STI drivers and modes, and particularly internal STI drivers (i.e. internal R&D). However, echoing the literature on innovation systems, SMEs need the support of these systems (Asheim et al., 2011; Cooke, 2001; Lundvall, 2007; Parrilli et al., 2010) as is also shown by recent studies on European and US SMEs (Parrilli and Radicic, 2020). These firms are expected to use external STI drivers (i.e. collaborations with universities and technology centers) to a high extent. Simultaneously, most firms in these catching-up countries are expected to use DUI drivers to a much higher extent, in part because they represent a cheaper solution (day-to-day collaborations with clients and suppliers), and in part because they target incremental innovations based on practice, learning-by-doing and problem-solving, which is something produced to a significant extent in catching-up economies. In particular, these countries represent an important part of the non-R&D based moderate and modest regions of Europe in the Regional Innovation Scoreboard[2]

[2] https://ec.europa.eu/growth/industry/policy/innovation/regional_en; Hollanders, H., Nordine Es-Sadki and Iris Merkelbach (2019) Regional Innovation Scoreboard, European Commission, ISBN 978-92-76-08724-3

(Hollanders et al., 2019; Parrilli et al., 2020). However, the widespread practice of using internal and external DUI drivers does not guarantee that such drivers are effectively exploited, that is, that they produce significant returns on innovation. Instead, our argument is that they may be quite ineffective, especially once compared with the fewer firms that implement other more scientific-based practices (e.g. deeper application of STI drivers or even a combination of STI and DUI drivers). As a result, in the context of these countries we might have a tiny group of enterprises that are capable of generating positive and large impact on innovation outputs through the adoption of specific STI drivers (Parrilli and Radicic, 2020), while most of their SMEs are primarily DUI-oriented.

Our second argument is about the substitution effect of STI and DUI drivers within this set of countries (Haus-Reve et al., 2019) vs. the complementarity effect of such drivers purported by several previous studies (Apanasovich et al., 2016; Jensen et al., 2007; Nunes and Lopes, 2015; Parrilli et al., 2020; Parrilli and Alcalde Heras, 2016). In the case of catching-up countries we argue that the different innovation and institutional systems, where the firms are embedded, limit the type of knowledge and the learning mechanisms derived from collaborations. In these innovation systems or technology-follower countries (e.g. Hervas-Oliver et al., 2011), characterized by low investment in R&D, informal collaboration mechanisms and weak internal capabilities (see Hervas-Oliver et al., 2015; Hollanders et al., 2019; Isaksen and Trippl, 2017) there is a lack of internal innovation capabilities characterized by weak in-house R&D activities. This leads to high dependence on external sources of knowledge typically absorbed through value chain-based collaborations (i.e. DUI-based). This innovation profile implies limited absorptive capacity (vis-à-vis advanced economies), thus firms in those innovation systems find it more difficult to access formal and scientific-based sources of knowledge such as universities or research centers: their weak in-house capabilities also constrain the type of collaborations and limits their innovation output. These countries and their firms, primarily driven by DUI innovation drivers, make the best of the DUI mode, while every effort made in more formal STI or research-based innovation activities is likely to deliver lower returns.

Finally, our third argument is about technological innovation, that is, product and process innovation, and its relationship with the modes of innovation. In catching-up countries SMEs present lower innovation capabilities, develop non-R&D innovation activities and DUI-like collaborations, specifically within the supply-chain (suppliers, customers, etc.).

While these SMEs can develop both product and process innovation, they are primarily process-based (Hervas-Oliver et al., 2014). SMEs that are process-oriented usually are second- or third-tier actors in large supply chains where they implement product innovations developed by the leading firms, or act as simple subcontractors of those in low-technology industries. Process-oriented innovators are firms that are predominantly focused on developing process technologies that can improve production processes and products. It is proved empirically that SME innovation is more closely related to embodied knowledge (i.e. acquisition of machinery and equipment) than to investment in intangible R&D activities. Along these lines, Clausen et al. (2012) establishes a distinction between technological product and process orientations. While product innovation is related to persistent R&D, formal innovation programs and presents large overhead costs (lab equipment and maintenance, patent management, etc.), process innovation is less formalized, more based on problem-solving and practice-based activities and non-R&D activities. In this context, SMEs in low-tech industries and catching-up countries are non-R&D performers that primarily develop process-oriented innovations (e.g. Barge-Gil et al., 2011) that are supported by DUI-like activities that provide information and knowledge from suppliers and embodied knowledge (machinery, equipment, etc.). These SMEs also present limited internal innovation capabilities. On the contrary, product innovation is related to STI drivers such as R&D, and also to a wide range of collaborations, from industry actors to science-based ones (Hervas-Oliver et al., 2020; Parrilli and Alcalde, 2016). Therefore, SMEs tend to link STI drivers, like R&D or scientific-based collaborations, to product innovation, and DUI-like drivers to process innovation.

In general, SMEs in this context are likely to pursue both STI- and DUI-type innovation activities but less intensively than those in advanced countries with stronger innovation systems. Similarly, we expect SMEs in low-tech contexts and thin innovation systems to get lower returns than SMEs localized in more innovative countries and innovation systems. On these bases we set the following hypotheses that distinguish between adoption and return of the different innovation modes:

H1: SMEs in catching-up countries are more likely to adopt DUI rather than STI modes of innovation.

H2a: In relation to external drivers or collaborations, SMEs in catching-up countries are more likely to benefit from the use of DUI drivers of innovation and less likely to do so from STI drivers.

H2b: In relation to internal drivers, SMEs in catching-up countries are more likely to benefit from the use of STI drivers related to product innovation, and DUI drivers related to process innovation.

H3: SMEs in catching-up countries are likely to combine and exploit STI and DUI drivers simultaneously, although they do so less effectively than in advanced countries.

4. Data and methods

The sample consists of 29,834 innovative active SMEs from the CIS 2014 data that covers 15 countries across Europe, targeting those Catching-up that are the center of our analysis. As observed in Table 1, there are 13 countries named as *Catching-up* that represent 83.1% of the sample; they are *Central and Eastern European Countries* (CEEC), which represent 36% of the sample (10,750 firms), along with 3 countries (Greece, Spain and Portugal, while data for Italy were not available) that make up the *South* (SEC, Southern European Countries) group, covering 47.1% of the sample (14,051 firms, where Spain stands out with 9,458 firms). Finally, Germany and Norway – whose data were available – represent the *Advanced* countries, representing 16.9% of the sample (5,033 firms). It is important to consider that this research's scope centers on the role of Catching-up countries (CEEC and SEC), while the advanced countries represent our control group. Additionally, 2 CEEC (Poland and Slovenia) were omitted as information was only available in the Safe Center. The UK was also not available, while Belgium, France, Italy submitted information in the form of 'secure use files' in Eurostat's Safe Center in Luxemburg (which we could not access in this case). Denmark, Ireland, Malta, the Netherlands, Austria, Poland and Slovenia did not provide CIS data. See Table 1.

Insert Table 1 here

In Table 2 variables and their description is presented, with dependent (product innovation, radical product and process innovation), independent STI- and DUI-type variables (R&D_internal; BUY_EQUIP; University_degree, DUI Collaborations, STI Collaborations and DUI&STI) and control variables (*International Markets and Size*), as long Industry (dummies) fixed-effects. DUI and STI variables are defined as innovation co-operation, that is, active participation with other enterprises or organizations on innovation activities. The variables STI Collaborations and DUI Collaborations, reflecting the modes of innovation from external sources of knowledge are tested through a *Factor Analysis*, seeking to find evidence of the latent unobservable variables (factors or constructs) that represent those variables. Our results, through the analysis of the factor loading of the different variables quantifies the extent to which variables are relate to a given factor (either STI or DUI). Maximum common variance explained is 75.32 (Rho), obtaining 2 factors (STI –Universities and Public Research Organizations-- and the DUI ones –Competitors, Suppliers, Clientes--; KMO 77.9; N=29,834; all variables showing KMO higher than 75; rotation Varimax). See Table 2 and their codification.

Insert Table 2 here

Then, as the dependent variables are dummies (whether SMEs innovation or not in product or process), we use *logistic regressions*. Each specification uses a specific sub-sample of advanced or catching-up countries and is tested for the three types of (technological innovation: *Inno_Product*, *Inno_Prod_Newmarket and Inno_Process*) dependent variables. Therefore, the 29,834 SMEs in 15 countries are split in different sub-samples for each group of countries and each dependent variable utilized. Specifications and sub-samples account for 10,750, 14,051 and 5,033 SMEs for CEE, South and advanced countries, respectively.

5. Empirics

5.1 Descriptive statistics and adoption rates

In Table 3, descriptive statistics are shown, depicting means, standard deviations, minimum, maximum and correlations. Specifically, we observe how out of 11 variables, 9 are zero-one variables with mean values in the range 0 - 1, often close to 0.500. Furthermore, it should be noted that Std. Dev. are even greater than the mean value, which indicates high scatter. Correlation coefficients indicate one medium-strong correlation between the variables INNO_PRODUCT and INNO_PRODUCT_NEW MARKET (0.530), then some medium correlations are observed in the pairs of INNO_PRODUCT_NEW MARKET and R&D internal (0.224) and INNO_PROCESS and BUY_EQUIP (0.340). Finally, low-medium correlations for the pairs of DUI&STI

and INNO_PRODUCT (0.1245) and DUI&STI and INNO_PRODUCT_NEW MARKET (0.174). The rest are very low, still significant. See Table 3.

Insert Table 3 here

Table 4 shows interesting results from ANOVA tests of mean comparison (for the sake of brevity, Scheffé tests for specific pairs of groups available upon request). See Table 4. We use ANOVA tests to show, on average, how each group innovates, showing its main innovation pattern.

Insert Table 4 here

ANOVA tests in Table 4 show that there are some differences among groups regarding process innovation (INNOP_PROCESS, 0.665, 0.655 and 0.506 for Eastern and Southern and Advanced countries, respectively, $p<0.01$), indicating that non-advanced countries (Eastern and Southern European countries) innovate more in process, a fact that is also reinforced with the embodied hypothesis or the utilization of embodied knowledge (BUY_EQUIP variable, equipment and machinery renewal) that presents higher figures for Catching-up countries vis-à-vis Advanced countries (0.718, 0.407, 0.328, respectively at $p<0.01$). Put differently, non-advanced countries are more likely to innovate in process vis-à-vis advanced ones.

Additionally, CEEC collaborate more through the DUI mode (developing solely DUI-type) than the South and the Advanced ones (0.226, 0.136 and 0.135 respectively, DUI collaboration $p<0.01$). This fact shows that CEEC basically develop DUI-type of drivers that constitute their preferred type of collaboration.

On the contrary, Eastern European countries show less collaboration through simultaneous DUI&STI collaborations (0.112), vis-à-vis the South and the Advanced countries, 0.171, 0.213 respectively, $p<0.01$). In the case of solely developing STI collaboration, similarly, CEEC collaborate less than the South and the Advanced group (0.026, 0.069 and 0.064, respectively, $p<0.01$). These results clearly indicate that both CEEC and Southern European countries are largely represented by process innovation, embodied knowledge and DUI-type collaboration (CEEC more than Southern in this latter case).

Similarly, the proportion of tertiary degrees in each group (UNIVERSITY_degree variable, 2.173, 3.262, 3.121 respectively, $p<0.01$) shows lower numbers for the CEEC, vis-à-vis the South and the Advanced countries. Lastly, investment in in-house R&D (R&D) reveals that the Advanced countries invest larger amounts than the South and the CEEC (respectively 0.656, 0.425, 0.888, $p<0.01$). Overall, Table 4 points out that the Advanced countries systematically develop STI activities (both internal innovation activities -R&D- and collaborative ones -STI and simultaneous DUI&STI-) with a higher intensity than catching-up countries. Instead, in the case of BUY_EQUIP and value chain-based collaborations (internal and external DUI drivers) CEEC show higher intensity followed by Southern European countries. This means that, according to the above ANOVA tests, CEEC countries show a lower intensity in all internal activities and external/collaborative STI activities vis-à-vis both Southern European countries and the most advanced countries. Instead, they exhibit higher intensity in the use of internal and external DUI drivers that more typically lead to process innovation. Southern European countries show a more intermediate position between CEEC and Advanced countries (see Table 4).

5.2 Returns on STI and DUI drivers

Following the hypotheses presented above, the econometric model adopts the following form for the logistic regressions:

$$SME\ technological\ innovation_i = \beta_0 + \beta_1 STI_i + \beta_2\ DUI_i + \beta_3\ Control\ variables_i + \vartheta_i + \epsilon_i \quad (1)$$

Specifically,

$$SME\ technological\ innovation_i = \beta_0 + \beta_1 R\&D\_internal_i + \beta_2\ BUY\ EQUIP_i + \beta_3\ DUI_i collaboration_i + \beta_4 STI\ collaboration_i + \beta_5\ DUI\ \&\ STI\ collaboration_i + +\beta_6 Control\ (University\_degree, International\ market\ and\ size)_i + \vartheta_i + \epsilon_i \quad (2)$$

In the model (2), i represents a SME

SME technological innovation represents product or process innovation in three variables; then, ϑ_i are industry fixed-effects;[3] while ϵ_i stands for the error term.

[3] A total of 15 countries

We use the STATA command "logit", that produces results in terms of coefficients scales in log odds. For this reason, we interpret results as coefficients.

Insert Table 5 here

In Table 5 the logit regressions show the determinants that explain the successful product innovation, radical product innovation (i.e. new-to-the-market), as well as process innovation. In other words, in Table 5 the returns from innovation are measured through the probability to introduce innovations, obtaining insights that differ from those obtained from the ANOVA tests. In Table 5 the sample of 29,834 SMEs in 15 countries is split in different sub-samples, presenting 10,750, 14,051 and 5,033 SMEs for CEE, South and advanced countries, respectively.

As regards R&D, this internal STI innovation activity is positively related to product[4] (0.62, 0.56, 0.78) and radical product innovations (0.64, 0.56, 0.814) for all CEEC, South and Advanced countries, respectively (at $p<0.01$; Specifications 1-to-6). In this case, the Advanced group stands out with the highest coefficients in any type of product innovation, while R&D does not work for process innovation, being non-significant or negative. It is clearly pointed out that R&D is not related to process innovation, but it is for both product innovation and radical product innovation across the different groups of countries, showing higher impacts for the Advanced countries. Interestingly, R&D effects in the different groups of countries is non-significant or even negatively related to process innovation (Specifications 7-to-9). This confirms our expectation that STI (represented by R&D innovation activities) is primarily related to product innovation and not to process. The result looks robust as it applies to all types of countries.

Following with the 1-to-6 specification, when observing embodied knowledge (BUY_EQUIP variable), only the Advanced group shows a positive and significant relationship with product innovation (0.33, $p<0.01$; specification 3), while CEE countries show it only for radical product innovation (0.146 at $p<0.05$; specification 6). The embodied knowledge activity is rather weak for product innovation of any kind, but it turns out to be impactful when considering process innovation. As such, in all three

[4] Either incremental and/or radical

groups of countries the variable is significant and positively related to process innovation (1.10, 1.92 and 0.93, $p<0.01$ respectively for CEEC, South and Advanced; specifications 7-to-9). Here, the South signals the highest coefficient (1.92), followed by CEEC. Therefore, the embodied knowledge (DUI-type innovation activity) shows its highest impact (return) on process innovation in all cases, led by the Southern group. This result confirms the hypothesis about the fact that DUI is more linked to process than product innovation in the case of catching-up countries (H2b).

Afterwards, the tertiary degree education (UNIVERSITY_degree) shows the highest impact for the Advanced group for product (0.335; specification 3 $p<0.01$) and process innovation (0.219, specification 9, $p<0.01$), with lower coefficients for CEEC (0.171, specification 4, $p<0.01$) and South (0.073, specification 5 at p0.01) for radical product innovation (Specifications 1-to-6). In any case, the advanced countries are the economies that get the most from tertiary degree education and are also the only ones getting positive returns from both product and process innovation. This supports the argument that robust utilization and higher returns from STI activities are linked to highly-skilled human resources.

Both STI and DUI collaborations show interesting insights. For the DUI type, it is significant and positively related to all groups (specifications 1-to-9); specifically, the Advanced ones stand out in the case of product (0.668, specification 3) and radical product innovation (0.46, specification 6), and the South for process innovation (0.647, vis-à-vis 0.477 and 0.394 for CEEC and Advanced, $p<0.01$, specifications 7-to-9). The Advanced ones are the countries showing the highest DUI collaboration impact (returns) for product and the South for process innovation. This result also reinforces the previous one related to embodied knowledge, where the South was standing out. CEEC are the ones collaborating the most in the (solely) DUI type, albeit they do not get more returns from it, vis-à-vis the other groups, but similar or even lower ones. Therefore, these empirical results show the gap that exists between introducing specific innovation activities and getting related satisfactory returns.

In the case of STI collaborations, coefficients are significant and positively related to product and process innovation in all cases except for CEEC (Specifications 1-to-9). In STI mode of collaboration, the Advanced countries stand out in product (0.6 specification 3), radical product innovation (0.443, specification 6) and even for process innovation (0.493, specification 9), while the Southern European group shows less intensive collaborations in product (0.177, specification 2, $p<0.05$) and radical product innovation (0.342, specification 5, $p<0.01$), and no effect in process (specification 8). It is particularly interesting how CEEC do not achieve returns from investing in STI collaborations, reinforcing the argument that CEEC countries collaborate less than the rest and do not convert investments in STI collaborations into innovations. Lastly, the simultaneous collaboration of DUI&STI is significant and positively related to all types of innovation (specifications 1-to-9), with the Advance group standing out in product (1.089) and process (0.801) innovation at $p<0.01$. This result also confirms that the complementary or positive interaction effect is inconclusive in the literature. In any case, while CEEC do not get returns from STI collaborations alone (they do in combination with DUI collaborations), the South does with product innovation, although not in process innovation, thus confirming our expectations. Only the advanced economies get significant returns from STI in all types of innovation.

Lastly, as regards control variables, Industry is always (specification 1-to-9) significant. Size presents interesting insights, as it is very important and positive for catching-up countries in the case of process innovation (specifications 7 and 8, 0.275 and 0.363 for CEE and South countries, respectively; $p<0.01$) and less in product. Also, the advanced countries with highly innovative SMEs are the ones that do not show any relationship between size and innovation. This means that in catching-up countries size matters, at least for process innovation and for the case of advanced ones, size is not important. See Table 5.

Lastly, as a robustness test, we run a *Probit* model, as many author do when analyzing a dichotomous or binary response to innovation (e.g. Ayllon and Radicic, 2019; Gomez et al., 2016; Nieto and Santamaría, 2010; Reichstein and Salter, 2006). Results are basically similar and all variables and significances hold, except for some variation in the magnitude of coefficients. For the sake of brevity, more results available upon request.

5.3 Discussion of main findings

Interestingly, both groups of catching-up countries (CEEC and SEC) benefit from the joint application of STI and DUI collaborations, although to a lower extent than more advanced countries do (Hypothesis 3 confirmed). CEECs seem to show higher returns than SECs in total product innovation and process innovation, while the latter obtain higher returns in radical innovation. The first positive outcome is that both are benefiting from the joint utilization of the two types of drivers/collaborations. This outcome indicates that catching-up countries (and their businesses) can invest in STI collaborations as well as in internal STI drivers (R&D) because this helps to add an increasing innovation capacity. Moreover, these results confirm the complementary/positive interaction effect between the two types of drivers. It clashes with the recent work on Norway of Haus-Reve et al. (2019) while supporting several other studies that showed the importance to pull together both types of drivers (Jensen et al., 2007; Nunes and Lopes, 2015; Parrilli and Alcalde, 2016; Apanasovich et al., 2016; Parrilli et a. 2020).

The different approach of CEECs, vis-à-vis SECs, matters as they show different patterns and capabilities. CEECs tend to take a clear DUI approach to innovation in terms of collaborations while STI collaborations are used with more limited impact. When STI collaborations are utilized by SECs, they pay-off in product innovation but not in process innovation. Both types of catching-up countries also exploit DUI-like embodied knowledge (i.e. new machinery and equipment) for product and process innovation, although obtain the highest returns in the latter. When observing internal STI drivers (i.e. R&D) they only work for product innovation and radical product innovation, but not for process innovation. As CEECs are more prone to develop process than product innovation, DUI-type collaborations matter significantly more than STI cooperation. These results confirm what Clausen et al., (2012) and Parrilli and Alcalde (2016) point out: STI – represented by R&D activities - is primarily related to product innovation and not to process. Only the advanced ones get returns from STI collaborations in all types of innovation.

SECs show a more balanced approach in terms of adoption of different types of internal and external STI and DUI drivers. In terms of returns they show a peculiar pattern. R&D (STI) expenditure is highly impactful for product and radical product innovation while the DUI drivers (i.e. embodied knowledge) are extremely important for process innovation only. In terms of external sources of knowledge and innovation, DUI collaborations are highly impactful, while STI collaborations also are, although to a much lower extent. In this respect, these countries are different from the CEEC group where STI collaborations are less effective. In any case both groups of countries rely mostly on DUI collaborations. Overall, hypotheses 2a and 2b are supported.

Of course, all catching-up countries are less effective than the advanced countries in almost all respects, including the capacity to combine STI and DUI types of collaborations. In terms of internal drivers, advanced countries are also superior in the exploitation of R&D and highly skilled human capital (STI), while they are less successful in the usage of new machinery and equipment (DUI) that is predominantly linked to process innovation, which is pervasive in catching-up countries. This was very much expected, and it is aligned with the literature. However, the above-mentioned patterns of CEECs and SECs show that they are on different catching-up trajectories: CEECs benefit in a still limited way from STI collaborations, and yet the latter have an additive and multiplicative effect on DUI collaborations as was highlighted by previous research (Apanasovich et al., 2016; Parrilli et al., 2020). SECs exploit STI collaborations better and maintain the same additive and multiplicative effect on DUI collaborations as found in previous research (Nunes and Lopes, 2015; Parrilli and Alcalde, 2016).

Lastly, evidence indicate two additional facts regarding education and size. The advanced countries are those getting the most from tertiary degree education; they are also the only countries that obtain significant returns from both product and process innovation. This supports the robust utilization and return from STI activities that are science-based and linked to superior and highly skilled human resources. In catching-up countries size matters, at least for process innovation, while it is not important in the case of advanced countries where SMEs of any size are innovative.

In short, in advanced countries SMEs are more innovative and get higher returns from almost all modes of innovation. Simultaneously, catching-up countries get worse returns from STI drivers while they depend more on DUI collaborations; moreover, they primarily develop process innovation, particularly through embodied knowledge. This indicates that the type of process innovation developed by catching-up countries is less knowledge-intensive and requires less scientific activities vis-à-vis advanced countries. Among catching-up countries interesting differences are shown: CEECs get limited return from STI collaborations (i.e. only when firms can make STI&DUI work together), while SECs benefit from STI and DUI (internal and external) drivers in a more balanced form.

6. Conclusions

Our study attempts to contribute to the literature on modes of innovation by comparing SMEs that are embedded in different types of countries and their respective innovation systems in Europe, focusing specifically on catching-up countries. This would help to decipher how innovation systems and their specificities influence SME modes of innovation. Using a large-scale database covering 29,834 SMEs in 15 European countries, our study investigates: i) the relationship between technological innovation (product or process innovation) pursued by SMEs and their innovation modes; ii) whether scientific and industry collaborations are complementary or substitute, and; iii) how SMEs in catching-up countries in Europe (i.e. Southern Europe and Central & Eastern Europe) - that count on heterogeneous resources and capabilities - present a differentiated capacity to combine STI and DUI drivers and get returns, vis-à-vis advanced countries. Using CIS 2014 from *South* (Spain, Portugal and Greece), *Northern-Europe* (Norway and Germany, referred to as *Advanced Countries*) and Eastern European countries (*CEECs)* (Bulgaria, Cyprus, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia), all hypotheses are confirmed: (H1) SMEs in catching-up countries are more likely to adopt DUI than STI modes of innovation; (H2a) SMEs in catching-up countries benefit from the use of DUI drivers of innovation more than STI drivers; (H2b) SMEs in catching-up countries are more likely to implement and exploit process innovation, which is strongly related to DUI drivers; and, (H3) SMEs in all catching-up countries combine and exploit simultaneously STI and DUI drivers in a less effective form vis-à-vis more advanced countries. Our insights contribute to positioning SME innovation within their specific institutional and innovation context (e.g. innovation system), along lines that are currently still under-researched.

Overall, our findings point out how different SME innovation is across countries. In particular, SME innovation heterogeneity is in no small part due to specificities of their innovation and institutional systems. This insight complements general SME innovation strands focused only on internal and external innovation drivers, while neglecting the systems where they are embedded. Our insights contribute to the SME innovation literature (e.g. Radziwon and Bogers, 2018; Kapetaniou and Lee, 2018l Parrilli et al., 2020) which stress that (i) innovation systems influence SME innovation; (ii) the types of technological innovation are related to SME innovation modes; (iii) returns from STI are different across innovation systems; (iv) catching-up countries primarily apply the

DUI mode and produce process innovation; and, (v) catching-up countries show limited returns from STI drivers.

While SMEs in all countries -albeit with differences- combine DUI & STI drivers effectively, the different SME innovation capabilities reflected in their respective context/system moderate the returns from innovation. In addition, different typologies of SME technological innovation seem to be related to specific drivers, showing a rather heterogeneous map of modes of innovation and innovative outputs across Europe. Advanced countries are getting the highest returns from DUI, STI and joint DUI&STI collaboration modes for both product and process innovation; except for process innovation where Catching-up countries get the highest impact embodied knowledge and DUI-type collaborations. Advanced countries outperform the rest in terms of in-house R&D activities. SECs represent an intermediate group between CEECs and Advanced countries. They achieve good returns from STI, DUI and DUI&STI, showing a clear pattern of embodied knowledge and DUI collaborations orientated towards the generation of process innovation. The CEEC group is similar, although it does not capture significant returns from STI collaborations, nor get the most from DUI-type collaborations.

The policy implications of this study are of utmost importance as they signal both adoption and returns from modes of innovation. First of all, the different innovation modes applied across these categories of countries need to be recognized and considered for proper policy making. Catching-up countries cannot be supported in the same way as advanced countries. They require more focus on i) use and intensity of DUI-type innovation drivers based on active collaboration, and ii) stimulating a transition towards the effective exploitation of STI innovation activities. It is vital to support the effective exploitation that catching up countries get from their modes of innovation: it is not only about adopting DUI or STI practices but also of getting the most from them, as advanced countries do. Secondly, effective policy-making for catching-up countries might also develop process innovation, as it is extensively produced by these countries through the adoption of DUI drivers. Simultaneously, product innovation needs to be promoted, as it is primarily linked to STI drivers. Overall, only STI-based innovation polices focused on developing R&D are insufficient, and not fully adequate for SMEs, as process innovation and DUI-type innovation activities might clash with those research-based initiatives.

Interestingly, our findings reveal catching-up countries' heterogeneity. Specifically, CEECs show different patterns, *vis-à-vis* SECs. Catching-up countries are quite good at adopting and effectively exploiting internal and external DUI drivers. This needs to be maintained and even extended throughout the larger proportion of firms that adopt neither DUI nor STI drivers and modes. Moreover, these countries exploit STI drivers to different extents. SECs obtain higher returns from both internal (R&D) and external (STI) collaborations with universities and research centers. This capacity needs to be spread to the whole sector of firms in those countries based on the role model of the leading enterprises. In CEECs, however, firms present the ability to use and exploit internal STI (R&D), but not external STI collaborations. The latter need to be introduced more slowly perhaps, through a) programs to facilitate technology transfer from scientific sources (universities, research centers, etc.) and b) programs that may include the promotion of foreign direct investments by firms (e.g. from advanced countries) that are managing both innovation modes and that can transfer this new approach across the local business fabric. As our findings show, it is also necessary to upgrade human capital among SMEs in CEECs as they show significantly lower human capital vis-à-vis not only advanced countries but also SECs. Human capital also influences SME absorption capacity, as (Lane et al., 2006; and Parrilli et al. (2016) stress. Therefore, in-company training, off-work training as well as higher education levels across the workforce would be critical elements of this innovation strategy throughout these CEECs.

This work is not exempt of limitations. In particular, it is based on cross-section data of SMEs in fifteen countries that may lead to a rather static view of innovation. In spite of the undertaking a static analysis, due to the lack of panel data availability, according to findings based on CIS data, it is observed that the position of CEECs and SECs in terms of innovation practically does not change over time. We also want to recognize a potential limitation for the lack of some SECs (e.g. Malta) and CEECs, such as Poland and Slovenia, due to non-availability of data. In any case, our purpose was to analyze the innovation patterns of Catching-up countries, and not of the advanced ones that were instead taken as a control group. Also, results might not necessarily be generalized to all types of firms, as we focused only on SMEs. Additionally, the type of data that have been used for this first approximation to this topic are quite limited, particularly in the area of internal STI and DUI drivers. For future research, the study of industry variations would also help to get a more complete interpretation of the different modes of innovation implemented by countries. In this study the industry variable was considered as a dummy control, while a more specific application to, for instance, advanced manufacturing or knowledge-intensive business services (e.g. see for instance the work of Lee and Miozzo (2019) on KIBS in the UK) could help to achieve an in-depth evaluation of the innovation capabilities of different segments of firms within specific countries.

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Tables

Table 1: SME distributions by country and research group

Innovation systems	Country	Number of SMEs		%
EASTERN (CEEC)	Bulgaria	2,437	10,750	36%
	Cyprus	446		
	Czech Republic	2,339		
	Estonia	463		
	Croatia	909		
	Hungary	1,486		
	Lithuania	1,125		
	Latvia	385		
	Romania	651		
	Slovakia	509		
SOUTH (SEC)	Greece	1,054	14,051	47.1%
	Spain	9,458		
	Portugal	3,539		
ADVANCED	Germany	2,653	5,033	16.9%
	Norway	2,380		
Total		29,834	29,834	100%

Source: own, from CIS 2014

Table 2: Variables: definition and codification

Dependent Variables	*Description*	*Codification*
INNO_PRODUCT	Indicates if the firm has Introduced onto the market a new or significantly improved good or service	Scale 0-1
INNO_PRODUCT_NEWMARKET (radical)	Indicates if the firm has Introduced a new or significantly improved good or service new to the market	Scale 0-1
INNO_PROCESS	Indicates if the firm has introduced a new or significantly improved: method of production, logistic, delivery or distribution system or supporting activities	Scale 0-1
Independent variables	*Description*	
R&D_internal (internal STI)	Indicates whether the firm has been engaged in intramural R&D	Scale 0-1
BUY_EQUIP (external DUI)	Engagement in acquisition of machinery	Scale 0-1
DUI Collaborations	Innovation co-operation is active participation with other enterprises or organisations on innovation activities with clients or customers, suppliers or competitors	Scale 0-1
STI Collaborations	Innovation co-operation is active participation with other enterprises or organisations on innovation activities with universities or public or private research institutes	Scale 0-1
DUI & STI Collaborations	Innovation co-operation is active participation with other enterprises or organisations on innovation activities simultaneously with customers, suppliers or competitors and with universities or public or private research institutes; jointly undertaking of DUI and STI	Scale 0-1
Control	*Description*	*Codification*
SIZE	Number of employees classified into two group: – 1:<50 – 2: 50-250	Dummy
INTERNATIONAL_MARKET	Indicates whether the firms sells to international markets	0-1
UNIVERSITY_degree	Percentage of employees with university degree measured as: – 0: 0%	Scale 0-6

	– 1: 1-4% – 2: 5-9% – 3: 10-24% – 4: 25 -49% – 5: 50-74% – 6: 75-100%	
INDUSTRY_DUMMIES	Two digits NACE classification	Categorical

Source: own

Table 3 Descriptive statistics

		Mean	Std. Dev.	Min	Max	1	2	3	4	5	6	7	8	9	10
1	INNO_PRODUCT	0.633	0.482	0	1	1									
2	INNO_PRODUCT_NEWMARKET	0.374	0.484	0	1	0.530*	1								
3	INNO_PROC	0.633	0.482	0	1	0.008	0.024*	1							
4	R&D_internal	0.612	0.487	0	1	0.146*	0.224*	-0.114*	1						
5	BUY_EQUIP	0.506	0.500	0	1	0.021*	-0.002	0.340*	-0.284*	1					
6	UNIVERSITY_degree	2.846	1.958	0	6	0.084*	0.097*	-0.049*	0.193*	-0.129*	1				
7	DUI	0.168	0.374	0	1	0.077*	0.054*	0.101*	-0.030*	0.125*	-0.000	1			
8	STI	0.053	0.223	0	1	0.01	0.014*	-0.039*	0.128*	-0.103*	0.051*	-0.105*	1		
9	DUI & STI	0.157	0.364	0	1	0.124*	0.174*	0.059*	0.260*	-0.014*	0.137*	-0.194*	-0.101*	1	
10	SIZE	1.687	0.754	1	3	0.016*	0.081*	0.079*	0.103*	0.030*	-0.145*	0.047*	-0.008	0.130*	1
11	INTERNATIONAL_MARKET	0.713	0.452	0	1	0.114*	0.122*	0.018*	0.138*	0.006	0.016*	0.000	0.028*	0.086*	0.102*

Source: own. All specifications significant at *p<0.01

Table 4: ANOVA analysis of the mean value of the main variables of the model

VARIABLES	**EASTERN (CEEC)**	**SOUTH (SEC)**	**ADVANCED**	**F**	**Differences observed**
INNO_PRODUCT	**0.663**	0.607	**0.641**	42.07***	Differences among every pair
INNO_NEW MARKET	0.362	0.343	**0.489**	176.86***	Differences among every pair
INNO_PROCESS	**0.665**	**0.655**	0.506	214.77***	Differences among every pair
R&D internal	0.425	0.656	**0.888**	1866.99***	Differences among every pair
BUY EQUIP	**0.718**	0.407	0.328	1747.11**	Differences among every pair
UNIVERSITY_degree	2.173	**3.262**	**3.121**	1072.85***	Differences among every pair
DUI	**0.226**	0.136	0.135	203.18***	Differences (except the pair South-Advanced)
STI	0.026	**0.069**	**0.064**	123.03***	Differences (except the pair South-Advanced)
DUI&STI	0.112	0.171	**0.213**	153.52***	Differences among every pair

Source: own; *** p<0.01

Table 5. Logit model: Innovation drivers on product and process innovation

	INNO_PRODUCT						INNO_PROCESS		
	INNO_PRODUCT			INNO_PROD_NEWMARKET					
Specifications	**Spec.1**	**Spec.2**	**Spec.3**	**Spec.4**	**Spec.5**	**Spec.6**	**Spec.7**	**Spec.8**	**Spec.9**
Variables and standard errors	***CEEC***	***SOUTH***	***Advanced***	***CEEC***	***SOUTH***	***Advanced***	***CEEC***	***SOUTH***	***Advanced***
R&D_internal	**0.621*****	**0.561*****	**0.783*****	**0.640*****	**0.560*****	**0.814*****	**0.0588**	**-0.194*****	**-0.327*****
	0.060	0.046	0.112	0.068	0.058	0.144	0.059	0.053	0.108
BUY_EQUIP	-0.234***	0.0353	**0.330*****	**0.146****	-0.0055	0.167	**1.106*****	**1.920*****	**0.934*****
	0.056	0.043	0.113	0.063	0.053	0.123	0.053	0.054	0.097
*UNIVERSITY_*	0.039*	0.075***	**0.335*****	**0.171*****	**0.073*****	0.0121	-0.011	-0.0260*	**0.219*****
Degree	0.022	0.013	0.025	0.026	0.017	0.032	0.021	0.015	0.024
DUI	0.617***	0.540***	**0.668*****	0.262***	0.374***	**0.464*****	**0.477*****	**0.647*****	**0.394*****
	0.065	0.060	0.113	0.070	0.068	0.119	0.064	0.068	0.097
STI	0.109	**0.177****	**0.603*****	0.176	**0.342*****	**0.443*****	-0.192	0.0598	**0.493*****
	0.161	0.077	0.150	0.170	0.095	0.157	0.148	0.080	0.129
DUI&STI	0.892***	0.574***	**1.089*****	0.595***	0.826***	0.570***	0.619***	0.468***	**0.801*****
	0.103	0.060	0.105	0.098	0.070	0.103	0.094	0.062	0.086
SIZE	0.046	0.222***	-0.381***	0.092**	0.046	0.081	**0.275*****	**0.363*****	0.013
	0.037	0.029	0.049	0.042	0.036	0.057	0.037	0.032	0.044
INTERNATIONAL_MARKET	0.083	0.332***	0.229***	0.343***	0.136**	0.400***	0.105*	0.0466	-0.0276
	0.062	0.047	0.083	0.075	0.065	0.096	0.063	0.053	0.075
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES	YES
Intercept	0.379	-0.488*	-0.854**	-1.136***	-0.191	-0.896*	-1.364***	-0.719**	-0.2
	0.351	0.287	0.412	0.371	0.348	0.496	0.325	0.341	0.381
Observations	10,750	14,051	5,033	10,750	14,051	5,033	10,750	14,051	5,033
Log-likehood	-4,988	-8,137	-2,534	-3,631	-5,212	-1,897	-5,004	-6,981	-3,020
LR chi2	1,118	1,584	1,245	659	686	276	1,302	3,128	657
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.10	0.09	0.20	0.08	0.06	0.07	0.12	0.18	0.10

Source: own, *p<0.01; **p<0.05; *p<0.1