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Weak vs Strong Knowledge Spillover Effects. Evidence from Geographic Distribution of Innovative Startup in Italy*

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Abstract: This paper introduces the concepts of weak and strong knowledge spillover effects within the context of the Knowledge Spillover Theory of Entrepreneurship. In this context, the fundamental idea of our proposition is to provide a comprehensive analysis of the factors and conditions promoting and supporting entrepreneurship development at the regional and provincial level using a unique unbalanced panel database, consisting of 9242 Italian Innovative startups for the period 2008-2018. In general terms, we argue that the evidence from our unbalanced panel dataset indicates that these dynamics are as follows. First, spillover effects deriving from competition are initially strong at the province level, and later decay to weak spillover effects at the regional level. Second, in terms of specialization (intra-industry) spillover effects, they are initially strong at the provincial level, and later become weak at the regional level. Third, spillover effects deriving from diversity (inter-industry) are predominantly strong at the regional level, yet weak at the provincial level of aggregation. At the provincial level, higher levels of competition result in strong knowledge spillover effects leading to higher new firm formation, with weak knowledge spillover effects deriving from specialization. Furthermore, in line with the Knowledge Spillover Theory of Entrepreneurship, the existence of non-homogeneous distribution of opportunities and related knowledge spillover effects create heterogeneity of patterns of new firm formation across different units of geographic aggregation. These results provide evidence of constraint potential for growth that remains a puzzle and challenge for academics and policymakers.

Keywords: new firm formation; entrepreneurship; innovative startups; knowledge spillover effects; regional technological catch-up

JEL Codes: L26, M13, M21, O33, R11

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1. INTRODUCTION

Knowledge generation and location-specific factors related to the knowledge spillover effects are at the core of new firm formation, their sectorial composition, and spatial distribution across geographic regions and provinces within regions. As noted in the literature, creating knowledge is a complicated, expensive, and challenging process to successfully commercialize (see Acs and Audretsch, 1990; Audretsch and Belitski, 2013; Caiazza et al., 2020; Audretsch et al., 2021 among others). Of particular interest to the knowledge theoretical, empirical, and management fields is the study of how knowledge is generated, transmitted, and absorbed by Innovative Startups (Barboza et al., 2023) as a result of direct effects, as well as knowledge spillover effects, and their effects on new firm formation. Thus, in the study of the distribution of new firm formation across time and space, particularly small businesses, advances in the fields of Knowledge Spillover Effect (KSE) and particularly the seminal work of the Knowledge Spillover Theory of Entrepreneurship (KSTE – see Audretsch and Feldman's (1996) for further details) argue that these phenomena could potentially be more significant as it refers to the development of high-tech innovative startups. Audretsch and Belitski's (2021) following Bosma and Stenberg's (2014) and Glaeser et al.'s (2015) argue that location-specific decisions are central to entrepreneurial activity. Studying new firm formation at the granular level of analysis could prove very useful for policy development and consequently entrepreneurship development as well.

From the theoretical conceptualization and perspective related to new firm formation, and the corresponding geographical and spatial distribution that depicts it, the process appears to be sectorial in nature (Barboza, 2024). From this perspective, the derived managerial implications are several in relation to decision-making processes ranging from firm geographical and spatial location to being dependent on original knowledge availability as well as the reaching effects of knowledge generated elsewhere. More specifically, this paper argues that these processes are governed by two alternative potential KSE forces: we name them as weak and strong knowledge spillover effects. Furthermore, we argue that in the presence of decaying effects of knowledge spillover effects (Pede et al., 2021) as well as knowledge filters (Guerrero and Urbano, 2014), they can potentially limit the transmission and related absorption of knowledge as reflected by differentiated patterns of new firm formation (Barboza and Capocchi, 2020) under either weak or strong knowledge spillover effects. In this proposed theoretical conceptualization, considering potential limitations on the transmission of KSE, it follows that new firm formation and their effects on economic development, economic growth, and employment generation across economic regions and economic sectors may consequently follow heterogeneous and nonlinear patterns of development. Put simply, the same policy changes and related incentives may yield differentiated and not symmetrical results across different units of economic aggregation. We seek to further earlier research by Audretsch and Feldman's (1996), and Plummer and Acs's (2014) on the process of new firm formation and economic development.

On a related issue, several authors (see Parker, 2009; Stam and van Stel, 2011; Hessels et al., 2018; Audretsch and Belitski, 2021, among others) indicate that it is relevant and timely to differentiate among the variety of activities undertaken by entrepreneurs that will have a direct and positive effect on levels of regional economic development. It is indeed relevant to note that most of the extant literature focuses on studying regions, but not

necessarily more immediate and granular levels of data aggregation units in the form of provinces/cities. In the context of spatial separation models, Proost and Thisse's (2019) note that this separation endows firms with market power. It follows then that at lower levels of data aggregation – provinces and cities – competition among firms in relation to their customers increases and firm interaction is consequently larger. This larger interaction should result in more positive effects, and as such, we aim at exploring these relationships in this study.

To better understand these phenomena, this paper proposes to study the inner dynamics of knowledge spillover effects, intra-industry (specialization), competition, and inter-industry (diversity), and expand upon them while considering weak and strong forces. To accomplish this, we use the specific case of Italy, where legislative changes were specifically introduced aiming at promoting and facilitating the development of new firm formation in the Innovative Startup segment of the economy. In this sense, in 2012 a new Law (Decree 179/12) was introduced in Italy to precisely promote the development of Innovative Startups across all economic regions and economic sectors. We propose that using this country-specific policy initiative provides an excellent opportunity to test our hypotheses. In addition, Matricano's (2020) notes that in several countries, similar country-specific policies have been introduced to promote the development of innovative startups, such as the US government (see Zhao and Ziedonis, 2020); French Government Jeunes Enterprises Innovates (see Depret and Hamdouch, 2004; Savignac, 2007); Belgian efforts to support innovative startups (see Czarnitzki and Delanote, 2012) and Germany's financial and infrastructure support for innovative firms (see Hottenrott and Richstein, 2020). As noted elsewhere (Barboza and Capocchi, 2020), the Law Decree 179/12 eases regulations, fosters, and creates a specific legal framework to boost opportunities and aims at promoting the endogenous formation and development of new Innovative Startups firms (Audretsch and Keilbach, 2007, 2008; Audretsch and Belitski, 2013; Barboza and Capocchi, 2020; Audretsch and Belitski, 2021). Under these considerations, we hypothesize that the existing regional/provincial endowment of knowledge pools (approximated by human capital and creativity) in combination with the promotion of opportunities may also be industry-specific and consequently affect the process by which new firms enter, develop, succeed, or fail in the market in a non-homogenous manner.

Incidentally, on the one hand, this implies that knowledge could be or become sticky and demonstrate significant and persistent decaying effects across sectors, regions, or smaller units of aggregation such as provinces.[1] As noted above, we seek to expand earlier work by Plummer and Acs's (2014) and define this first process as weak knowledge spillover effects. That is, the successful commercialization of unrealized potential gains (as per the KSTE) may be restricted by both economies of scale and scope as reflected by the number and rate of growth of new firm formation in alternative competitive settings. At the core of the theoretical implication, we argue that in the presence of reinforcing forces, more firms are attracted to achieve and exploit benefits deriving from more competitive settings, whereas in highly specialized sectors and regions, firms may achieve higher efficiencies in less competitive settings.

[1]In the case of Italy, geographic units of aggregation go from larger to smaller as represented from 20 administrative regions to 110 provinces. Each geographic region is composed of a different number of provinces. One of the provinces is also designed as the capital of each region.

Conversely, in the innovation-implementation-absorption process, managers must allocate resources and make decisions at every step of the value-creating processes, so that new firm formation leads to a higher rate of firm survival and profit maximization. Assuming low presence of bounded reliability in the managerial decision-making process (Verbeke, 2013), managers/entrepreneurs will thus transform available knowledge into new firm formation. We define this alternative process as strong knowledge spillover effects. In this context, the fundamental idea of our proposition is to provide a comprehensive analysis of the factors and conditions promoting and supporting entrepreneurship development using new firm formation at the regional and provincial levels as our units of analysis, and determine the presence of weak knowledge spillovers or strong knowledge spillovers as drivers for new firm formation, in support or rebuttal of the KSTE.

The rest of the paper is organized as follows. The next section provides an extensive overview of the literature and conceptual framework relating to new firm formation with particular emphasis on how knowledge spillover effects occur. We then provide a detailed description of the data, followed by the description of our parsimonious modeling section. We provide a detailed analysis of the empirical results and draw some theoretical and managerial implications to conclude the study.

2. LITERATURE REVIEW, CONCEPTUAL FRAMEWORK AND THEORETICAL BACKGROUND

A primary contribution of growth theory is to study the process of new firm formation and the factors driving the spatial allocation of firms and their interaction with emphasis on the potential role that knowledge spillover effects play. Audretsch et al.'s (2021) remind us that entrepreneurship is conceptualized as the process by which firms recognize and exploit opportunities that are conducive for economic development. In several instances, the extant literature notes that this knowledge is created either by third parties, such as universities or research institutes, but could also be commercialized by entrepreneurs willing and able to assume the related risks (see Audretsch and Feldman's (1996) for further details on the KSTE); under the conditions that knowledge filters are limited, removed, or co-location processes may be put in place by managers (Verbeke, 2013). In other instances, knowledge may be developed by large, incumbent firms that do not find it optimal to commercialize this knowledge and consequently make it available to riskier entrepreneurs. In short, the fundamental premise of the Knowledge Spillover Theory of Entrepreneurship (Audretsch and Feldman, 1996) is that knowledge is endogenous to firms, and KSE develops as individuals capitalize on unused knowledge. Thus, the process by which knowledge becomes transferable may occur in the same or related economic sector willing and able to commercialize otherwise tacit knowledge. In addition, if conditions are ideal, then knowledge may be absorbed/captured from firms in the same industry (intra-industry spillovers of specialization), the same sector, or even in rare cases from diverse regions or geographically distant locations. In relation to this, Audretsch et al.'s (2021) also note that "due to knowledge incomplete excludability, knowledge spills over so that the producers of knowledge cannot appropriate the entire value themselves." The inner characteristics of this knowledge may make it either location-bound or non-location-bound (Verbeke, 2013), resulting in spatially conditioned and

uneven distribution of new firm formation. In this context, the role of KSE becomes more relevant when endogenous knowledge creation is difficult from within the firm or is limited in scope regarding its optimal size in a given sector in a given economic and geographical location.[2] In this context, we argue that in the presence of weak knowledge spillover effects, there are limited effects on new firm formation.

On a related strand of literature, Audretsch and Belitski's (2021) note that entrepreneurship is a fundamental process of economic geography; where entrepreneurship and knowledge are intrinsically related. But the relationship between both is neither direct nor symmetric. This is to say that, knowledge once created may suffer from decaying transferability effects, that are at the same time limited by the extended capabilities of human capital and its related potentiality to absorb this knowledge at the other end of the potential spillover effects (Barboza and Capocchi, 2020; Pede et al., 2021). Furthermore, knowledge transfer cannot be easily observed or measured directly between agents (Audretsch et al., 2021). This is, in fact, one of the most difficult challenges still remaining and that the literature provides little evidence on. However, as noted earlier, from the perspective of the endogenous growth theory, knowledge may have or achieve increasing returns to scale, when barriers to absorption are limited and thus knowledge flows relatively freely from development to execution across locations via high transferability and easiness of absorption. In the event that this is true, the theory would indicate that new firm formation may increase as a function of knowledge development with positive effects that extend far beyond the original intent; that is via strong knowledge spillover effects. According to (Fritsch et al., 019a,b), new activities and innovation contribute to regional economic development. The mechanisms by which knowledge may become available to firms in the same industry or across industries may come from a variety of sources. On the one hand, Audretsch et al.'s (2021) state "A compelling body of entrepreneurship research has found that investments in knowledge from other firms and public organizations spillover (Jaffe, 1989; Audretsch and Link, 2019) to enhance firms' performance (Link and Rees, 1990)." Conversely, if the links between knowledge development and applicability were to preclude others from benefiting from its transferability, a faster and potentially growing decaying effect develops, thus the presence of weak knowledge spillover effects. These decaying effects may be spatial in nature (that is related to geographic location and/or concentration of human capital and firms) or may instead be market-structure related, that is present or limited only under certain market conditions. The literature has placed significant emphasis on understanding particularly three alternative and complementary approaches. These approaches are Specialization (intra-industry) (MAR – Marshall, 1920; Arrow, 1962; Romer, 1990, Competition (Porter, 1990) or Diversity (inter-industry) (Jacobs, 1969). Because of their importance, let us briefly summarize the main prescriptions of each of these theoretical constructs. According to Acs et al.'s (2007), "the geographical specialization emphasized in the MAR model is assumed within industry, not across industries." In this context, Glaeser et al.'s (1992) indicate that the most important technological externalities occur within industry. Audretsch and Belitski's (2020a) refer to these forces as intra-industry spillovers. Regarding the second component, that is

[2]Colombelli and Quatraro (2018) note "As far as the analysis of new firm formation at a regional level is concerned, the Knowledge Spillovers Theory of Entrepreneurship (KSTE) has gained momentum over the last decade."

the debate between competition vs monopolies, Porter's (1990) indicates that competition, instead of monopolies, leads to growth and new firm formation, instead of monopolistic settings (Glaeser et al., 1992; Acs et al., 2007). Under Jacobs' approach, a different view is presented where the exchange of complementary knowledge across diverse industries yields greater returns (Acs et al., 2007). Jacobs argues that industries and consequently firms benefit from being in close proximity to a body of different firms, and thus knowledge could be adopted from other non-related firms. Audretsch and Belitski's (2020a) refer to this as inter-industry spillovers.

However, the well-known theoretical debate between specialization vs competition market structures and their role in the transmission of knowledge spillover effects still does not provide a clear differentiation of the strengths of these spillover effects. Because of this, and given the conceptualization we develop in this paper, we proceed to present our first set of hypotheses.

> ***Hypothesis 1:*** Knowledge spillover effects deriving from competition, specialization, and diversity are distributed not symmetrically across different units of data aggregation. This is to say, that KSE demonstrate the presence of both weak and strong effects, which are conditioned by the level of data aggregation.

> ***Hypothesis 1a:*** Increased (inter-) industry diversity results in differentiated patterns of new firms at the regional (weak knowledge spillover effects) and provincial (strong knowledge spillover effects) level in support of Jacobs' regional and inter-industry knowledge spillovers.

> ***Hypothesis 1b:*** Increased within industry competition at the regional and provincial levels results in higher new firm formation implying support for both Porter's and Jacobs' argumentation, with the presence of weak KSE at the regional level and strong KSE at the province level.

> ***Hypothesis 1c:*** Increased within (intra-) industry specialization results in higher new firm formation implying support for MAR and Porter argumentation; however, these KSE are strong in some regions while weak in provinces.

Our review of the literature leads to a second element of analysis as it relates to the arguments presented in Audretsch and Belitski's (2021); where they indicate that the study of entrepreneurship has gradually shifted towards ambitious entrepreneurship, job-creation entrepreneurship (Dvouleý, 2018, 2019; Barboza et al., 2023) and high growth innovative startups (Colombelli and Quatraro, 2018; Belitski, 2019; Barboza and Capocchi, 2020). Particularly, Audretsch and Belitski's (2020a) note "firms depend upon external knowledge collaborations and spillovers (Jaffe, 1989; Audretsch and Feldman, 1996; Durst and Evardsson, 2012)." A particularly interesting case is that this heterogeneity is often overlooked when researching knowledge management and its effect on firm performance in SMEs (Audretsch and Belitski, 2020a).

In this regard, it is rational to argue that new firm formation may follow patterns that are region, province or sector specific, or conversely specific sectors may best develop in specific regions; resulting in barriers for same sectors to successfully develop in other regions. The driving conditions for these patterns to develop may be based on competition, related to transportation cost of inputs or the development of knowledge and its related spillover effects. This is especially true in the presence of spatial competition models (Salop, 1979; Proost and Thisse, 2019). Particularly, Proost and Thisse (2019) indicate "Spatial Competition models deliver an important message: close competitors matter more to a firm than distant competitors." However, the evidence presented by Audretsch et al. (2021) note that "Local and national policy-makers worldwide are looking for insights into how to channel entrepreneurship to regional developments." If this were to be true then one could expect that the role of KSE derived from given market conditions may also be a fundamental piece of the firm-development-region effect conundrum. In support of this line of argumentation regarding the spatial distribution of new firm formation Audretsch and Belitski's (2020b) indicate that "Firms that are more resilient and have greater dynamic capabilities than their competitors in a market (Kothari et al., 2013; Del Giudice and Maggioni, 2014) can better adapt to the changing environment and grow." At the end both, provinces and regional alike, are a conglomerate of micro-decisions models taking place by economic agents (Proost and Thisse, 2019) where we argue that some are under the presence of weak others under strong knowledge spillover effects from innovation activities. More interesting, entrepreneurs may be unaware of the type of KSE present in their economic sector, geographical region, or time effect. To this end, Audretsch et al 2021 note that "the link between knowledge spillover and innovation is indirect, and that the mechanism that turns knowledge into innovation is not automatic." Furthermore, Proost and Thisse (2019) note "the issue that should rank first on the research agenda is to explain the existence of different types of economic agglomerations through the interplay of economic forces – some working toward concentration, and others toward dispersion".

Because of the importance of these inter-industry relations, Audretsch and Belitski 2020 note "Managerial acumen of knowledge includes the manager's understanding of structures and processes within the organization and how to engage with external partners (Del Giudice and Maggioni, 2014; Del Giudice et al., 2017). These external partners may be located in close proximity as well as in relatively far away locations. This knowledge, however, moves based on the pools of skilled workers available in the respective unit of spatial aggregation. In this line of thought, the most recent literature also indicates, as in Audretsch et al 2021 that "KSTE assumes two important components: knowledge spillovers emanating from incomplete excludability of knowledge and the role of knowledge filters." Particularly, Audretsch et al 2021 further elaborate and bring forth the argument that despite the significant advances in the understanding of firms' interaction and the resulting increase in new firm formation, the literature still has inadequately addressed the origins of KSTE and the potential outcomes of knowledge spillover – new firm creation. Furthermore, Proost and Thisse's (2019) note "Because regional economics focuses on issues arising on a global scale where spillovers are likely to be absent, regional economics relies on the combination of increasing returns and imperfect competition, while trading across regions is costly." But the argumentation at the regional level may well provide evidence of the presence of knowledge filters that also

occur at lower levels of data aggregation where the initial assumption might be the opposite; we aim at providing evidence of these potential differences.

Based on the extant literature and given the interest, data and nature of this study, we bring forth the following hypothesis to test the role of geographical distribution of new firm formation and the level, direction and relevance of knowledge spillover effects in this process.

> ***Hypothesis 2:*** Homogenous policy changes intended to promote new firm development and entrepreneurship across alternative units of spatial aggregation, undoubtedly result in geographically conditioned weak and strong differentiated patterns of new firm formation. The conditionality is directly related to the availability of pools of skilled workers.

With these considerations, we now proceed to outline our model, the data we use to test our hypotheses, and draw our analysis regarding the presence of weak and strong knowledge spillover effects.

3. MODEL AND EMPIRICAL APPROACH

This paper aims at making an empirical investigation of the innovative startup phenomenon using the case of Italy. We use a newly constructed unbalanced panel dataset consisting of 9242 Innovative Startup companies covering the 20 geographical regions (and by construct the 110 provinces that compose the 20 regions as well) in Italy for the period 2008-2018. Data was extracted from the AIDA database and it includes all innovative startup firms registered under the Innovative Startup Law of 2012. Data covers firms from 19 economic sectors as defined by 2-digit NAICS classification.[3] This dataset is the largest dataset available at the time of the study, and as far as we know, the first of its kind. We complement the database by including economic data to account for the state of the economy, and most relevantly the availability of pools of labor (high skilled labor) at the regional level.[4] In addition, we run a few robustness tests to determine the presence of spatial dependency and heterogeneity in our model. We conduct these estimations only at the provincial level given our data limitation at the regional level. Table 1 presents the overall summary statistics for the main variables used in the series of model estimations constructed. It is relevant to note that the Innovative Startup Law, while signed in 2012, was retroactive to the year 2008, and consequently, the database used in this paper dates back to 2008. In addition, another important consideration of the dataset is its unbalanced panel nature given that each firm has a different time of entry. Consequently, each firm may have a different number of years of operation. This creates particular conditions on the dataset and related treatment of it, as we will elaborate further below.

Based on the conceptual framework outlined in the literature review, we use a parsimonious model where the number of total firms, first, and second new firms (first difference in the data) innovative startup firms per year are used as dependent variables. The discrete

[3]NAICS is the North American Industrial Classification Standard; while we use data from Italy, we use NAICS to provide the context to the Italian data.

[4]Data is available from the authors upon request.

Table 1: Variables and Descriptive Statistics

Type	Code	Description	Mean	Min	Max	Std Dev	Obs
(U)employment Data	Nempl	Number of Employees	1.488283	0	262	4.527933	13,826
	Unemployment rate Total	Region Specific Total Unemployment	0.09959	0.0318	0.234153	0.04844	86,742
	Unemployment rate Males	Regional Unemployment for Males	0.089431	0.025812	0.224796	0.046683	86,742
	Unemployment rate Females	Regional Unemployment for Females	0.114188	0.039596	0.265085	0.053727	86,742
Population	Region	Total population in the Region	5,427,957	126,620	10,019,166	2,977,180	86,742
	Province	Total population in the Province	1,573,882	84,904.3	4,416,265	1,341,399	96,380
Per Capita Income	Income per capita	Level of Income measured in Euros	28,335.3	16,109.3	39,187.4	6,726.659	86,472
	IncGr	Rate of growth of Income per capita	0.008553	-0.073511	0.100153	0.025712	86,472
Education	Education (Instruction) Laurea e post laurea	Number of individuals with a college degree (per region)	597,839.4	8,993	1,315,394	360,167.1	86,472
Educ	Ratio						
Number of IS Firms	TF	Total Number of Innovative Startups	2,593.7	0	9,242	3,216.381	96,380
	TFR	Total Number of IS in each region	279.8278	0	2,285	492.8407	96,380
	TFP	Total Number of IS in each province	130.8834	0	1,609	307.9052	96,380
	TF2D	Total Number of IS per NAICS 2-digit classification	909.8276	0	5,244	1,494.778	96,380
	TFR2D	Total Number of IS per NAICS 2-digit classification per Region	104.9291	0	1,322	227.4795	92,410
	TFP2D	Total Number of IS per NAICS 2-digit classification per Province	50.31521	0	918	140.6728	92,410
Number of New firms	TNFirms	Total Number of New firms per year, all sectors and regions	924.2	0	2,386	919.9709	96,380
	TNFReg	Total Number of New Firms per year per region	100.4871	0	588	150.4911	96,380
	TNFProv	Total Number of New Firms per year per province	46.5003	0	405	94.40418	96,380
	TNF2D	Total Number of New Firms per year per economic sector	326.3622	0	1,344	450.8434	96,380
	TNFR2D	Total Number of New Firms per year per region per sector	36.47802	0	339	70.5795	96,380
	TNFP2D	Total Number of New Firms per year per province per sector	17.32671	0	238	43.40155	96,380
Firm Intensity	FIR	Number of firms per region as a ratio of region's population	12.65433	0	109.4912	23.06752	86,742
	FIP	Number of firms per province as a ratio of province population	8.845426	0	107.2696	20.4672	96,380
Firm Intensity at 2 dig	FIR2D	Number of firms per region per sector as a ratio of region's population	4.525383	0	61.91063	10.31299	86,742
	FIP2D	Number of firms per province as a ratio of province population	3.257708	0	61.20165	9.179026	96,380
Competition	Comp	Level of Competition at the Industry Level	1.166425	0	23.17647	0.75544	40,272
Specialization	Spec	Degree of Specialization at the Industry Level	1.050906	0	51.752	1.090243	45,349
Diversity Region	DivR	Degree of Diversification within Geographic Regions	0.549313	0	0.8125	0.205636	54,906
Diversity Province	DivP	Degree of Diversification within Geographic Provinces	0.568191	0	0.816327	0.159876	45,010

Source: **AIDA database. Competition** within an industry in a region is defined as the number of establishments per worker in this industry in the region relative to the number of establishments per worker in this industry in the country. Diversity measures the relative employment distribution with high value indicating that a similarity between regions and the nation exists. **Total Number of Firms and New Firms** refer to the absolute number of new firms created every year, which are defined at the national, regional, and provincial levels.

and non-negative nature of our dependent variables, plus their overdispersion appearance, suggest the use of a zero-inflated negative binomial estimation process as the optimal estimation technique (Hausmann et al., 1984; Ghio et al., 2016; Colombelli and Quatraro, 2018). In general, the model specification form is given by: The model specification form is given by:

$$y_{i,t} = \exp(\beta_0 + \beta_j x_{j,t} + \gamma_j z_{j,t} + e_i) \tag{1}$$

where $y_{i,t}$ is the number of total or new firms in each economic sector i at time t, $x_{j,t}$ is a vector of explanatory variables included in the descriptive statistics table. Of particular interest are the variables measuring the degree of (intra-)industry specialization, competition, and (inter-)diversity as related to the hypotheses outlined in the section above. Given the richness of the dataset and the alternative decomposition that we can construct, we estimate several alternative models to test the hypotheses at different levels of data aggregation. We estimate the models, therefore, using the number of new firms, total and new, by region, and by province as dependent variables. All estimations account for region and industry-specific fixed effects.

It is also relevant to note that the estimation of the negative binomial model in Eviews automatically computes the logarithm of the dependent variable, and thus there is no need to express the dependent variable in logarithmic terms. However, for the estimations of spatial models for the robustness check, we took the logarithm of both sides of equation 1, which gives us a linear model. The spatial estimations were done with GeoDa.[5]

In addition, $z_{j,t}$ is a vector of additional variables where we construct a series of dummy variables for each of the 19 economic sector classifications at 2-digit NAICS coding.[6] We use the regional dummy variables to control for possible spatial heterogeneity given that some regions are defined as typically slow-growing areas while others as fast and dynamic. Finally, we add a series of regional and economy-wide variables to control for the inherent economic differences across regions and provinces. For these variables, we have per capita income growth per region, tertiary levels of human capital divided by the respective region's population, which we approximate by the number of individuals with a University degree (Bloom et al., 2017) at the regional level. As in Audretsch and Lehmann's (2005) and Colombelli and Quatraro's (2018), we use two-digit sectoral data for 20 regions and 110 provinces covering the entire country. This allows us to account for possible local dimensions of knowledge spillovers and the capacity of each region (and province) to absorb knowledge, or create it.

In addition, since we use the entire population of registered firms for every year, we mitigate the possible presence of heterogeneity and omitted variables. Because of the potential spatial dependence at stake and the importance of the spatial distribution of observations/firms in explaining the generation and transmission of knowledge, we use the lagged dependent variable in all our models (here we followed a similar specification as outlined in Anselin, 1988 and further expanded by Colombelli and Quatraro, 2018). This is so because the inner dynamics of the distribution of new firm formation influence the transmission of

[5]https://spatial.uchicago.edu/geoda

[6]NAICS 2-digits classification is presented in Table 2

knowledge spillovers across neighboring regions. In addition, as noted above, we run a few robustness tests to examine further spatial dependency and heterogeneity in the model of equation 1. A full list and corresponding description of the variables is presented in Table 1 above.

Another key assumption of our parsimonious modeling technique is that the model, as presented above, may exhibit patterns of some spatial dependency and heterogeneity due to knowledge spillover effects and agglomeration economies. Applying a logarithm function on both sides of equation 1 yields a linear model. Given that there are too few regions (20 spatial observations), we only examined the potential spatial dependency and heterogeneity using data at the provincial level. We, therefore, considered a spatial distance-based weight matrix for the spatial estimations. The distance-based weight matrix is a Boolean weight matrix defining neighborhood based on a threshold distance. From the non-spatial estimation of equation 1 (logarithm version), we examined the Moran's I value of regression errors as well as the Lagrange Multiplier test (Error and Lag) as well as their robust versions to examine the existence of spatial dependence in the model.

For the new firm formation, we follow the literature closely and specifically the new firm formation modeling as presented in Glaeser et al.'s (1992). Of particular importance is the fact that the growth of national technology is assumed uniform across regions, and local technological progress is related to three types of externalities related to knowledge spillovers namely: (intra-) specialization, competition, and (inter-) diversity. It is assumed that the levels of technological diffusion are in this regard related to the capabilities for new firms to interact with each other, in the same industry, same geographic location or conversely as a process of technological catch up takes place. This is however conditioned by several factors such as the presence of decaying effects of technological transmission, the ability to capture and absorb knowledge, the length and stickiness of knowledge transferability within and across economic sectors and of course the spatial distribution of knowledge generation and diffusion (See Pede et al., 2021).

As proposed in the hypotheses, we have particular interest in testing the presence of weak and strong effects as it is expected that regional and provincial differences will be present in terms of the number and rate of new firm formation in the innovative sector in Italy, as initially represented by the data in Tables 3 and 4.

As done elsewhere (Pede et al., 2021), and following the specification developed in Glaeser et al.'s (1992), we define and calculate, using the available data, the specialization ($SP_{i,t}$) in an industry within a region as the fraction of the region's employment that this industry captures, relative to the share of the entire industry in national employment (see Henderson, 1997; Feldman and Audretsch, 1999; Cingano and Schivardi, 2003; Blien et al., 2005 for more details). We calculate and consider the Relative Diversity Index (RDI) as a measure of diversity ($DV_{i,t}$). To test Jacobs' hypothesis, intuitively a high value of the Relative Diversity Index signals that the regional employment distribution resembles that of the national economy. We follow Glaeser et al.'s (1992), and define and calculate competition ($CP_{i,t}$) within an industry in a region as the number of establishments per worker in this industry in the region relative to the number of establishments per worker in this industry in the country. Given the likely endogeneity related to these measures, estimated coefficients from our models are interpreted in terms of correlations with the new firm formation variables

Table 2: NAICS 2-Digit Classification

Code	Sectorial Description
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)

rather than causal effects.

4. RESULTS AND DISCUSSION

The main results are presented in Tables 5, 6, and 7. We begin with the baseline (unrestricted) estimations in Table 5 and proceed to elaborate on the estimations by adding explanatory variables and by estimating the models with new firm formation – dependent variable – at the regional level, and then at the province level respectively.

Before we proceed with the estimations and related analysis, it is relevant to note that, given that our dataset is an unbalanced panel, the presence of unit roots and cointegration are highly unlikely. We also recognize (and thank an anonymous reviewer) that these issues could be problematic in datasets accounting for longer time periods. Our data only includes a maximum of ten years, yet as displayed in Table 3, the larger concentration of firms occurs in the latter years. Furthermore, we proceed to conduct estimations using, first, the total number of firms (Table 5) and then New Firms (First-difference), removing any potential issue of cointegration. In addition, it is relevant to point out that the independent variables are expressed in rates of change, or in ratios; consequently, using a log transformation is not appropriate.

The benchmark results (unrestricted estimations reported in Table 5) indicate consistent estimated values across all alternative models, both when using total firms or new firms. Specifically, at the total and regional level, we observe positive and significant coefficients for the three alternative measures, providing support for all Hypotheses 1, 1a, 1b, and 1c;

Table 3: Total Number of Active Innovative Startups Registered as of Dec 31, 2017 by Region for 2011-2018

Region	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
N. Lombardia	1	1	62	339	708	1177	1765	2285
C. Lazio	0	5	75	194	359	525	773	1042
C. Emilia Romagna	0	0	16	120	273	458	660	833
N. Veneto	0	0	6	79	192	339	601	811
S. Campania	0	0	14	135	244	382	552	717
N. Piemonte	0	0	7	68	150	248	362	464
S. Sicilia	0	0	26	96	170	242	367	443
C. Toscana	0	0	11	62	146	211	321	401
S. Puglia	0	0	12	60	113	182	268	350
C. Marche	0	0	3	37	102	192	284	344
N. Trentino-Alto Adige	0	0	1	33	73	128	192	240
N. Friuli-Venezia Giulia	0	1	5	33	72	102	161	211
C. Abruzzo	2	9	17	38	72	127	176	207
S. Calabria	1	1	8	62	85	115	159	200
C. Umbria	0	0	5	27	56	98	129	181
C. Liguria	0	0	2	20	45	83	136	170
S. Sardegna	0	0	9	38	62	95	131	157
S. Basilicata	0	1	5	18	32	46	74	99
C. Molise	0	0	1	7	11	19	40	66
N. Valle d'Osta	0	0	0	1	6	13	17	21
Total	**4**	**18**	**285**	**1467**	**2971**	**4782**	**7168**	**9242**

Notes: Regional Classification is defined as follows: North includes Fiuli Venezia Giulia, Lombardia, Piemonte, Trentino Alto Adige, Val d'Osta, and Veneto; Center includes Abruzzo, Emilia Romagna, Lazio, Liguria, Marche, Molise, Toscana, and Umbria; and South includes Basilicata, Calabria, Campania, Puglia, Sardegna, and Sicilia.

while at the provincial level of aggregation, Competition and Specialization are negative (rejecting Hypotheses 1b and 1c), and diversity is positive (supporting Hypothesis 1a). Overall, Hypothesis 1 is supported as there is strong evidence of both heterogeneity effects as well as decaying effects given the observed differentiated economic significance of the coefficients.

In this line of analysis, it is also relevant to note that industry diversity provides the largest effect on new firm formation across all models. In sum, these results provide mixed evidence for Hypotheses 1, 1a, 1b, and 1c. As noted, these results are unrestricted, and their signs and statistical significance vary once we expand the models to account for some control variables as noted by the theoretical background of the potential conditioning factors of the knowledge spillovers theory.

However, in terms of coefficient sizes across models, there are marked differences. These differences in results, and the variation across estimations, are best explained by the results of models reported in Tables 6 and 7, as follows. At first glance, a general look at the results

Table 4: Total Number of Active Innovative Startups Registered as of Dec 31, 2017 by Sector. All Regions Included

Sector	2011	2012	2013	2014	2015	2016	2017	2018
S54. Professional, Scientific, and Technical Services	1	7	161	847	1701	2662	4006	5244
S31-33. Manufacturing	1	2	34	229	486	808	1220	1568
S51. Information	0	2	35	172	332	544	851	1123
S42. Wholesale Trade	0	1	19	65	134	218	298	342
S56. Administrative and Support and Waste Management and Remediation Services	1	1	10	46	97	162	227	270
S23. Construction	0	2	9	28	35	55	80	98
S22. Utilities	0	0	7	18	27	63	79	92
S61. Educational Services	0	0	0	11	22	36	56	71
S72. Accommodation and Food Services	0	0	0	5	22	32	51	63
S62. Health Care and Social Assistance	0	0	3	9	24	40	55	62
S11. Agriculture, Forestry, Fishing and Hunting	0	1	1	8	10	23	42	57
S53. Real Estate and Rental and Leasing	1	1	2	7	21	29	45	56
S81. Other Services (except Public Administration)	0	0	1	8	14	27	40	52
S44-45. Retail Trade	0	0	0	5	14	31	42	49
S71. Arts, Entertainment, and Recreation	0	1	2	6	13	25	38	47
S48.-49. Transportation and Warehousing	0	0	0	1	11	17	23	29
S52. Finance and Insurance	0	0	0	0	3	4	8	11
S55. Management of Companies and Enterprises	0	0	1	2	5	6	7	7
S21. Mining, Quarrying, and Oil and Gas Extraction	0	0	0	0	0	0	0	1
Total	**4**	**18**	**285**	**1467**	**2971**	**4782**	**7168**	**9242**

Table 5: Number of Firms: Total, New by Region, Province, and at 2-Dig NAICS Classification

Dependent Variable	Overall			New			2-Dig NAICS		
	Total	Region	Province	Total	Region	Province	Total	Region	Province
Competition, lagged one year	0.841	0.069	0.321	0.894	0.190	0.282	0.641	-0.270	0.068
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Specialization, lagged one year	1.458	0.643	0.438	1.396	0.620	0.364	1.002	-0.165	0.164
	(0.001)***	(0.001)***	(0.001)***	(0.062)*	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Diversity, lagged one year	9.964	9.126	8.008	8.205	7.264	6.438	7.857	7.915	5.689
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Number of Observations	40272	40272	38647	40272	40272	38647	40272	40272	38647
Akaike Info Criterion	19.725	14.992	13.244	17.458	12.949	11.152	15.587	10.777	9.083
Log Likelihood	-397179.8	-301876.4	-255915.7	-351521.7	-260737.2	-215482.0	-313861.4	-217000.7	-175514.7

Notes: These are the estimates for the unrestricted model, without control variables. ***, **, * represent 1%, 5%, and 10% statistical significance respectively.

clearly indicates that there are differentiated dynamics around the sources and potential size of knowledge spillovers developing across regions and provinces. This is in itself evidence supporting the existence of weak and strong knowledge spillover effects. Consequently, the evidence also provides support for Hypothesis 2. It is precisely the extent and richness of our dataset that allows us to decompose the estimations to a lower level of aggregation to further explore these interesting and revealing causality relationships.

Let us begin with the results corresponding to new firm formation at the regional level. First, Model 1 accounts for the presence of Total Regional Innovative Startups in the previous year (t-1) as an explanatory variable plus the measures of knowledge spillover effects, all lagged one period.[7]

Model 2 adds the Dummy variable to account for the Region's Capital. Model 3 adds Firm Intensity at the regional level (lagged one period), plus regional stock of human capital

[7]All model estimations in Table 6 and 7, control for region specific dummies as well as economic sector of activity dummies. These results are not reported in the Tables.

Table 6: Total Number of New Firms at the Regional Level

	Models					
	1	**2**	**3**	**4 (a)**	**5 (b)**	**6 (c)**
Total Firms in Region (t-1)	0.000	0.000	-0.004	-0.009	-0.010	-0.009
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Competition (t-1)	-0.002	-0.002	-0.001	-0.002	-0.001	-0.001
	(0.186)	(0.187)	(0.471)	(0.256)	(0.283)	(0.492)
Specialization (t-1)	-0.018	-0.018	-0.016	-0.016	-0.016	-0.016
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Diversity in Region (t-1)	3.031	3.032	2.838	3.135	3.115	3.175
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Region Capital Dummy		-0.002				
		(0.439)				
Firm Intensity in Region (t-1)			0.067	0.157	0.160	0.148
			(0.001)***	(0.001)***	(0.001)***	(0.001)***
Unemployment (t-1)				3.382	4.185	1.042
				(0.001)***	(0.001)***	(0.001)***
Income Per Capita Growth (t-1)				1.789	1.792	1.531
				(0.001)***	(0.001)***	(0.006)***
Education/Regional Population (t-1)				-12.099	-12.091	-12.338
				(0.001)***	(0.001)***	(0.001)***
Number of Observations	23973	23973	23973	23973	23973	23973
Log likelihood	-111744.3	-111744.0	-111462.7	-110674.8	-110617.8	-110730.2
Akaike Info Criterion	9.325934	9.325992	9.302522	9.237044	9.232287	9.241663

Note: Region and sectorial dummies included in all estimations as control variables, yet not included in the variables column. ***, **, * represent 1%, 5%, and 10% statistical significance respectively. (a), (b), and (c) correspond respectively to total, male, and female unemployment rates.

Table 7: Total Number of New Firms at the Province Level

Variables	Models					
	1	**2**	**3**	**4 (a)**	**5 (b)**	**6 (c)**
Total Firms in Province (t-1)	0.0017	0.0012	0.0003	-0.0362	-0.0379	-0.0303
	(0.001)***	(0.001)***	(0.736)	(0.001)***	(0.001)***	(0.001)***
Competition (t-1)	0.026432	0.00604	0.006291	0.011276	0.011545	0.025735
	(0.001)***	(0.201)	(0.184)	(0.044)**	(0.036)**	(0.001)***
Specialization (t-1)	0.022635	0.003431	0.003591	0.004717	0.002411	0.022414
	(0.001)***	(0.424)	(0.403)	(0.353)	(0.628)	(0.001)***
Diversity in Province (t-1)	1.132317	0.566466	0.557732	1.394545	1.35121	1.530137
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Region Capital Dummy		1.182127	1.182083			
		(0.001)***	(0.001)***			
Firm Intensity in Region (t-1)			0.012588	0.584172	0.611423	0.492542
			(0.397)	(0.001)***	(0.001)***	(0.001)***
Unemployment (t-1)				37.66478	37.6051	17.72104
				(0.001)***	(0.001)***	(0.001)***
Income Per Capita Growth (t-1)				2.188501	1.926213	-0.585743
				(0.001)***	(0.001)***	(0.165)
Education/Regional Population (t-1)				-37.44752	-34.84601	-45.55587
				(0.001)***	(0.001)***	(0.001)***
Number of Observations	23854	23854	23854	23854	23854	23854
Log likelihood	-115759.9	-109417.8	-109417.4	-113034.6	-112680.8	-113815.0
Akaike Info Criterion	9.709135	9.177476	9.17753	9.480974	9.451315	9.546406

Note: Region and sectorial dummies included in all estimations as control variables, yet not included in the variables column. ***, **, * represent 1%, 5%, and 10% statistical significance respectively. (a), (b), and (c) correspond respectively to total, male, and female unemployment rates.

divided by the region's population, and income per capita growth.[8] We use the last set of control variables to measure the level of economic activity in the region plus the potential pool of available and necessary human capital to promote the successful development of new firms in the Innovative sectors of the economy. With these considerations in mind, the results for the level of new firm creation at the regional level indicate the following:

The coefficient for Competition (lagged one period) yields a positive value across all models, indicating that, in general, competition at the regional level has a relevant effect on the rate of new firm formation; this provides support for Hypothesis 1b. Secondly, Specialization (intra-industry) also holds a positive, statistically significant, and stable coefficient across all models estimated. This is a very interesting result as it indicates that higher levels of industry specialization at the regional level will result in a large number of new firms created. That is, KSE from specialization into other firms are more likely to occur when industries are more concentrated and fully specialized, supporting Porter's approach and MAR argumentation.

Lastly, and perhaps the most surprising result, is that the coefficient for (inter-industry spillovers) Diversity is only positive and statistically significant in the last model (Model 4) but not in any of the alternative specifications. However, when Diversity is significant, then Competition is not, and Specialization is only statistically significant at the 10% level. Thus, the last model is the only model in which there is evidence supporting Jacobs' hypothesis. The combination of the results and relationships between the three measures of spillovers clearly indicates the presence of large heterogeneity across regions.

Control Variables

The control variables demonstrate the following general results. Firm Intensity in the Region (Firms divided by regional population) holds a positive and significant coefficient. Income per capita growth also holds a positive coefficient. In addition, the coefficient for Regional Capital (Dummy) has a negative sign and very small value but is not statistically significant at any level of conventional relevance. Finally, the ratio of education to population in the region holds a negative sign. This is an unexpected result.

In the last set of estimations, Provincial new firm formation in Table 7, we observe significantly different results regarding competition and specialization and large differences regarding the economic impact of the other variables in comparison with the regional estimates in Table 6. The main difference in the estimations is in magnitude, where the provincial estimates hold larger values for competition and diversity; but specialization is not statistically significant (only for model 2). Secondly, the coefficient for the regional capital dummy is now statistically significant, and income per capita growth is now negative and statistically significant. Furthermore, the estimate for human capital is negative, significant,

[8]In a previous version of the models we also included estimations accounting for regional levels of unemployment (total, female and male). Given the potential issues relating to correlation between income per capita growth and unemployment, we conducted separate estimations, one including income per capita growth and the others using the alternative measures of unemployment. These estimations serve as robustness tests for the model specification. We thank an anonymous reviewer for pointing to us the potential correlation issues in the original models.

and much larger in comparison to the regional estimates.

Robustness Tests

We performed robustness checks on our results by examining spatial dependence in our estimations. This was only done at the provincial level given that the number of regions is relatively small (20 regions) for performing spatial regressions. To perform the Spatial Diagnosis, we used a distance-based weight matrix (described above) on provinces. We estimated the spatial regression with the number of new firms (in logarithm form) as the dependent variable and the corresponding right-hand side independent variables. The residuals from the non-spatial regression show a negative and insignificant Moran's I statistic. Moreover, the Lagrange Multiplier tests (lag and error) and their robust versions were insignificant. This indicates that there is no spatial dependence in the dependent variable and the errors. We proceeded to investigate the potential presence of spatial dependence in the independent variables by adding the spatial lag of the competition, specialization, and diversity variables. The results from these estimations indicate that none of these spatial lag variables were significant at any conventional level of statistical significance. We interpret the results to indicate that our initial estimations remain robust, and no spatial dependency was detected.

5. DISCUSSION

In general, results of the alternative model specifications are robust to the study of the effect deriving from knowledge spillover effects on new firm formation in the Innovative Sectors across Italy. However, the results also indicate the significant and persistent presence of high levels of heterogeneity across regions and provinces in terms of inter- and intra-industry spillovers (similar results are found in Audretsch and Belitski, 2020a; Barboza, 2024; Barboza and Capocchi, 2020; Barboza et al., 2023), and thus provide support to our conceptual framework of the presence of differentiating knowledge spillover effects between weak and strong. In this analysis, the evidence also finds support for the argumentation that the dynamics of knowledge spillovers are significantly different across regions in comparison to provinces (more granular units of data aggregation), implying that the approach to new firm formation in the Innovative Startup segment of the economy is characterized by non-homogeneous and asymmetric operating mechanisms as we initially hypothesized (Hypothesis 1). We also claim that the presence of decaying effects in the transmission of knowledge spillover effects (weak form of knowledge spillover effects) is relevant.

We summarize the results as follows. First, our results provide some very interesting and useful insights to better understand the dynamics of new firm formation in the innovative startup sector as a result of legislative changes introduced to promote the development of these types of firms. Second, the results indicate that new firm formation is affected differently by the spillovers generated from competition and specialization across different levels of data aggregation, while diversity is predominantly relevant at the provincial level but not so at regional levels of aggregation.

As noted, at the regional level both competition and specialization affect new firm formation in a negative fashion. However, while specialization is robust and statistically significant

Table 8: Spatial Diagnostics Dependence Estimations with Total Number of New Firms at the Provincial Level as Dependent Variable

Constant	1.866
	(0.201)
Competition	-0.414
	(0.226)
Diversity	2.090
	(0.188)
Specialization	0.540
	(0.377)
Firm Intensity at the Provincial Level	0.210
	(0.001)***
Income Per Capita Growth	27.181
	(0.173)
Human Capital	-9.65E-08
	(0.786)
Diagnostics for Spatial Dependence	
Moran's I (error)	-0.118
	(0.906)
Lagrange Multiplier (lag)	0.427
	(0.514)
Robust LM (lag)	0.168
	(0.682)
Lagrange Multiplier (error)	0.278
	(0.598)
Robust LM (error)	0.019
	(0.889)

Note: *** = 1% level of significance. Total Number of new firms at the province level is expressed in logarithm form.

in all model specifications, competition is not. In addition, the diversity mechanism for KSE to transmit and develop yields statistically significant coefficients in all models. In this sense, the results indicate that at the regional level, higher industry specialization will result in fewer new firms being created. By the same token, the degree of regional diversity indicates that the more diverse a region is, the more new firm creation is going to take place as a result of firm interaction and potential spillovers developing from that interaction. These results are in line with the findings in Audretsch and Belitski's (2021) inasmuch as it appears that entrepreneurial ecosystems (EE) are more likely to develop at the inner core of the region, that is, in their economic capital, at least at early stages of development. However, if these inner region competencies are not scalable across economic sectors and across the region, then one should observe differentiated industries developing across the same industry, and more so, a decaying effect of knowledge spillover effects taking place across regions, as this study shows. Thus, at the regional level, we argue that specialization results in strong knowledge spillover effects, while competition effects are rejected. Diversity also demonstrates the presence of strong knowledge spillover effects.

Table 9: Spatial Lag Dependence Estimations with Total Number of New Firms at the Provincial Level as Dependent Variable (including spatially lagged independent variables)

Constant	4.941
	(0.090)*
Competition	-0.390
	(0.374)
Diversity	2.526
	(0.156)
Specialization	0.503
	(0.420)
Firm Intensity at the Provincial Level	0.210
	(0.001)***
Income Per Capita Growth	19.257
	(0.363)
Human Capital	
Spatial Lag Variables	
Spatial Lag of Diversity	-3.102
	(0.289)
Spatial Lag of Competition	-0.346
	(0.605)
Spatial Lag of Specialization	-0.816
	(0.467)

Note: ***, **, and *, refer to 1%, 5% or 10% level of significance. Total Number of new firms at the province level is expressed in logarithm form.

The inner dynamics of knowledge spillover effects using more granular level data at the province level are contrasting differently than those at the regional level. This in itself indicates the presence of divergence across regions beginning with the interrelations at the province level. When comparing these results with the estimations at the province level, we observe three essential and relevant differences. First, we observe that there is a reversal in direction of the effects of competition and specialization, where both are now positive but only competition is statistically significant. In fact, we argue that competition displays the presence of strong KSE, while specialization displays weak knowledge spillover effects (weak intra-industry) at the provincial level. The results also indicate several elements of relevance. Competition is statistically significant in all models, but not when the regional capital is included as a dummy (Models 2 and 3). Specialization, however, is only significant in the first and last models but highly insignificant in any of the other models. As noted, the reversal in signs and the reversal in statistical significance between competition and specialization point out significantly different dynamics deriving from knowledge spillover effects, between regions and provinces. Thus, on the one hand, the combination of results clearly supports Hypothesis 1, and on the other hand, it supports Hypothesis 2, weakly for the unrestricted model, and strongly for the restricted models. Nevertheless, at the provincial level, we now find that a positive presence of knowledge spillover effects deriving from competition within

the industry supports Porter's hypothesis and validates Hypothesis 1b. Furthermore, the positive sign on Specialization (in some models) indicates that industry specialization could spuriously generate positive effects in terms of new firm formation under specific conditions but not always; that is, Specialization denotes the presence of weak knowledge spillover effects. In addition, the economic size of competition is larger than that of specialization, which is also the reverse result in comparison with the regional estimates. We argue that at the provincial level, knowledge spillover effects are robustly present through industry competition and diversity, and only marginally (perhaps only for some sectors) when measured by specialization (See Barboza and Capocchi, 2020; Pede et al., 2021 for similar results). This is to say that at the provincial level, intra-industry spillovers tend to dominate. In other words, it appears that at the internal level of the province, competition among members of the same industries across regions generates more new firms within each province. The interaction of similar firms is the bedrock for knowledge spillover effects to develop and maximize their positive effects. By the same token, the result of diversity within provinces and regions appears to support this same rationale. While at the same time, specialization in key industries within each province yields a much more favorable setting for new firms to develop in that industry within that province, while negatively relating to the new firm formation across regions. Our results find, thus, that at the provincial level firms are more likely to benefit from the interaction with firms in the same industry. This is to say that at lower levels of data aggregation, the positive effects of firms' interaction are more likely to exist through competing settings than otherwise. These results are in line with the spatial competition models for the province and monopolistic competition (specialization) at the regional level (Proost and Thisse, 2019); supporting Hypotheses 1a and 1b at the regional level, and 1b and 1c at the provincial level.

On the other hand, the results at the regional level appear to indicate that the formation of new firms across regions may display decaying knowledge spillover effects when regions attempt to engage with other regions (see Matricano's (2020) for similar results). As in Charron et al.'s (2014) and Audretsch and Belitski's (2021), we find that resources (particularly human capital, which is the variable approximating innovation and RD capabilities in this research) appear to be distributed in a non-homogeneous fashion across regions, and more so, even across provinces within the same region. This is particularly reflected in the large difference in the magnitude of the estimated coefficients for human capital. However, we thank an anonymous reviewer for pointing out that there may be other issues at play here explaining the observed differences that unfortunately our parsimonious model design might not be considering. For instance, while we use levels of human capital at the regional level corrected by population size, we do not account for the RD expenditure at the firm level, or the presence of universities or research labs in each region/province. These are issues beyond the scope of this research, and clearly interesting fields of research for further exploration. Nevertheless, policy changes designed to promote entrepreneurial activity in the Innovative Startup segments (as it is the focus case of this study) are national in their design. This results in a policy conundrum.

An interesting potential implication of the combined reversed indicators for Specialization and Competition, from Provincial to Regional spatial agglomeration, may be that while at lower levels of data aggregation competitive settings serve as ideal mechanisms to promote

knowledge spillover effects to develop among competing firms, these positive effects tend to disappear as firms grow and they begin interacting with other firms in the same geographical region. In the second dimension of the interaction, the competition-driven knowledge spillover effect benefits become less important, and the specialization of a few firms, potentially larger firms, becomes the prevalent force for knowledge spillovers to settle in. In this context, then, regional specialization becomes the driving force, and this specialization results in fewer new firms being developed. This is, in fact, an interesting dynamic of knowledge spillover forces as they appear to transform themselves as units of aggregation are increased from smaller areas – provinces – to larger geographical dimensions – regions. Furthermore, it is also relevant to point out that the process by which these knowledge spillovers occur is non-homogeneous and clearly conditioned by the level of already existing firms as measured by the number of already existing firms in the region or province the period prior. This estimate also serves the purpose of a proxy for cluster measure as it controls for the size of the existing number of firms. The coefficient is negative and consistent across almost all estimations.

Relating to diversity (inter-industry) effects, the results indicate the presence of a predominantly positive sign at the provincial level with more consistent significance in comparison to the regional estimation. In fact, the provincial estimates are lower in magnitude than the corresponding estimates for the regions. The size of this effect is about a third of the respective effect at the regional level. Nevertheless, in both cases, we find support for Hypothesis 1a, albeit with significant differences in their respective economic size. Perhaps the most relevant element is that industry diversity serves as a mechanism to promote the positive development of knowledge spillover effects as manifested by an increase in the number of new firms. However, the results clearly indicate that these positive benefits of firm interaction across economic sectors are larger in the regional context over the smaller geographical area as determined by the provincial estimates (Hypothesis 1). The results are not surprising as one would expect that if positive, then the larger the number of firms located in a larger geographical setting, the more interaction is expected to occur. As in Acs et al.'s (2009) and Audretsch and Belitski's (2021), we find that diversity within a region and a province serves as an economic organizational structure to promote knowledge spillover effects to multiple enterprises. Consequently, the more knowledge that is available to begin with, larger diversity, the more benefits new firms may materialize in the form of feasible business ventures. In short, the results clearly indicate that promoting firm interaction within and across regions is a positive way to foster spillovers leading to more new firm creation. Incidentally, these results also provide supporting evidence for the spatial competition models being at play at the regional level.

We control for the region's capital, which is by definition one of the provinces, and obtain positive and statistically significant effects at the provincial level but not at the regional level. Intuitively, this implies that regions' capitals have a significant advantage over the rest of the provinces in that region in terms of new firm generation. It follows that if the regional capital is the most advanced segment of each region, then entrepreneurship activity may be higher than otherwise. Particularly, we hypothesize, in line with the KSTE, that this is possible because a larger amount of new knowledge is generated where most of the ideas come from, as reflected by a more diverse production structure, larger research

centers, universities, and potential incubators. This is in line with Jacobs' argumentation that proximity to other industries in larger cities versus more rural – less urban – areas may be significant drivers of innovation and spillovers. This result is also in line with the arguments brought forth by Audretsch et al. (2017), Fritsch et al. (019b), and Fotopoulos and Storey (2017), indicating that the specific conditions set forth in each environment yield different returns. That is, regions and provinces and possibly smaller units of aggregation such as cities, condition the same resources by the interaction that they create among competing and related firms. Furthermore, as it was stated in the literature review (see Proost and Thisse, 2019), we now argue that our results provide robust evidence indicating that provinces look at dispersion of economic activity through more competitive settings; while at the regional level, concentration through specialization prevails. These results also provide evidence supporting Hypothesis 2, and more importantly, indicate the presence of heterogeneity across units of aggregation.

As we continue exploring the implications of the estimates, the level of firm intensity at the region and province (number of firms per region divided by regional population, and number of firms at the province divided by the provincial population) are both statistically significant and significantly larger at the province level. The interpretation of this coefficient indicates that regions with more firms per population are indicators of more entrepreneurial mentality (EM). This EM appears to be related to the presence of larger pools of high-skilled workers, and consequently to more endogenous creation of knowledge. That is to say that those regions and provinces holding the largest populations are also more likely to develop new firms. In this context, we argue that our evidence is in line with previous work in favor of the argumentation that knowledge spillovers have a larger impact within close proximity, that is, centers of high population, mainly cities, are more likely to demonstrate a larger propensity to develop innovative startups in relation to other regions or provinces, as they also hold larger pools of high-skilled workers.

As noted earlier, the estimated coefficients for income per capita growth hold positive and statistically significant values at the regional but negative and significant at the provincial level. In this model, conversely, the coefficient for specialization is positive and statistically significant, being the only model in which this occurs at the provincial level. In addition, the concentration of university degree holders (Stock of Skilled Human Capital) as a ratio of the regional and provincial population has a negative and statistically significant coefficient.

The last variable that we look at is the ratio of higher education degree holders to the population by region and province. First, both sets of coefficients are negative and statistically significant at the 1% level of confidence. Secondly, the coefficients are significantly larger at the province than at the regional level. Recall that we use human capital levels to approximate the regions' and provinces' capacity to innovate, transmit, and absorb knowledge (along the prescriptions of the KSTE). We hypothesize that the observed difference could be due to the lower population size at the province level relative to the region in relation to higher degree holders. At any rate, the larger size at the province level indicates that the more higher degree holders in a province, the lower the number of new innovative startups that will develop in the next period.

These results are in line with our Hypothesis 2, which indicated that new firm formation is conditional on the available pools of skilled workers across regions and provinces. While

more research is needed in this regard, we argue that the evidence points to the presence of weak knowledge spillover effects at the province level and stronger knowledge spillover effects at the regional level. The negative coefficient is a puzzling and unexpected result. Consequently, these results are also deserving of further investigation. As noted by an anonymous reviewer, considering alternative forms of R&D and knowledge creation might be an interesting approach for future research; this is, however, beyond the scope of the present study.

6. THEORETICAL AND PRACTICAL CONTRIBUTION AND CONCLUSIONS

This paper's contribution is based on demonstrating, through the use of a highly comprehensive and disaggregated database, that the interaction between innovative startup firms via knowledge spillovers is highly conditioned by their geographical location. We provide robust evidence that the presence of knowledge spillover effects varies significantly between regional and provincial aggregation. Particularly, we claim that our results identify two forms of knowledge spillovers: weak and strong. The implications from our analysis indicate that the actual working mechanism of knowledge formation and its consequent diffusion across firms via competition, specialization, and diversity are conditioned by location but also by intensity. These results also advance the field of research studying the nature of heterogeneity of intra- and inter-industry spillovers.

In this regard, we observe that at low levels of data aggregation—provincial concentration—more competition leads to a higher number of new firm formations, specialization (intra-industry) provides no statistically significant effects, and diversity (inter-industry) of industries appears to be an important source of spillovers. At the regional level of data aggregation, new firm formation is affected negatively by high levels of industry specialization, indicating that monopolistic competition appears to be the driving force. In sum, the evidence supports the hypotheses of weak and strong spillover effects, in addition to the presence of heterogeneity of these forces. More importantly, these results also indicate the potential for policy development that emphasizes cherry-picking policies that build on the idiosyncratic nature of provinces and regions.

This is to say that the returns from firm interactions in terms of knowledge diffusion are highly conditional on the state of the economy at the provincial and regional levels. In other words, as the geographical units of economic aggregation increase from cities to provinces to regions, the dynamics of knowledge spillover effects change. In general terms, we argue that the evidence from our unbalanced panel dataset indicates that these dynamics are as follows: First, spillover effects deriving from competition are initially strong at the province level, and later decay to weak spillover effects at the regional level. Second, in terms of specialization (intra-industry) spillover effects, they are initially strong at the provincial level, and later become weak at the regional level. Third, spillover effects deriving from diversity (inter-industry) are predominantly strong at the regional level, yet weak at the provincial, more granular, level of aggregation.

From a theoretical point of view, our findings indicate that when modeling Knowledge Spillover Effects at the industry and regional levels, one is more likely to observe the per-

sistence of decaying effects. In other words, knowledge spillover effects in the Innovative Startup sector are sticky and geographically bounded, posing a further challenge for firms to acquire knowledge that is developed further away. This evidence supports previous findings, as in Audretsch and Feldman (1996), Plummer and Acs (2014), and Pede et al. (2021). A main contribution of this paper is expanding these findings while using a highly disaggregated dataset with data both at the regional and provincial levels.

Another novel result from our research is that we find evidence in favor of the initial hypothesis that knowledge transfer occurs in a non-symmetric and non-homogeneous fashion. The theoretical implication of these results is that when modeling knowledge transfer, the inclusion of spatially conditioned settings may provide a more realistic depiction of the actual relations observed in the data. Moreover, following Proost and Thisse's (2019), this paper brings forth the argument that a considerable explanation for economic activities to distribute unevenly in a non-homogeneous fashion, even after controlling for other relevant factors, is due to the presence and persistence of weak vs. strong knowledge spillover effects between alternative units of entrepreneurship agglomeration. We further argue that the weak and strong forces related to knowledge spillover effects are determined endogenously by the levels of economic activity within each unit of spatial aggregation. Further modeling of these forces is another interesting field for future research. Thus, expanding the research agenda to continue exploring more granular levels of data aggregation will provide necessary and useful data to further understand the process of economic development at the regional and provincial levels.

Furthermore, other implications derived from our study indicate that economic agents entering into the innovative startups sectors need to consider the nature and transferability of competencies, the extent of them, and the directionality that may be inherent to differences at the provincial and regional levels. Based on our results, we find that at lower levels of aggregation, firms benefit from a more competitive setting where efforts to share knowledge with direct competitors may indeed result in better decision-making processes benefiting all firms involved. However, the decision to cooperate and share knowledge decays faster as firms begin interacting with other firms in a monopolistic-like setting. This is another potentially interesting field of research, beyond the scope of this study.

7. LIMITATIONS AND FUTURE STUDIES

As with any other study, there are limitations that need to be acknowledged. As pointed out by an anonymous reviewer, the possibility of unit root and cointegration among the variables used in studies such as ours is a potential issue to address as more time series data becomes available. While our paper uses unbalanced panel data, with only ten years of data per firm at best, we acknowledge that this is something to keep in mind for future research ventures. In addition, another limitation of this study is that new firm formation in the Innovative Startups sector is going to face challenges resulting from the consequences and changes brought about by the COVID-19 pandemic and its aftermath. Because of the timing when our data was compiled, we do not cover the COVID-19 period. This is to say that while our work is robust to alternative modeling scenarios, the changing conditions in the way businesses will face challenges might require revisiting our findings. This, of course,

is a topic for further research once the new normality is in place. Further studies may also focus on much lower levels of aggregation, such as studying inner dynamics related to the spatial distribution of regions and neighboring regions and how knowledge availability affects entrepreneurship and new firm formation. On this end, expansion of research to include elements related to entrepreneurial ecosystems may also be beneficial.

Finally, as noted in the methodological section, issues related to the alternative measures of spillovers, namely competition, specialization, and diversity, require a research design that addresses potential endogeneity so that we could make reliable causal inferences. We thank an anonymous reviewer for pointing this out to us.

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