


# University knowledge spillovers and innovation of hidden champions: evidence from Italy

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**Hidden champions (HCs) are niche market leaders and innovation is key for them to stay competitive and retain market and technology leadership. While prior research has stressed the importance of customers and internal R&D as sources of innovation for HC, we know little about the role of universities in this regard. Using a knowledge spillover lens, we investigate how the regional proximity of HCs to universities influences their innovation output. Drawing on a sample of 124 Italian HCs, we show that HCs located in proximity to universities have higher innovation output as compared to other HCs. The size of the spillover effect depends on university characteristics and thus both on the size and type of the knowledge base. Our study contributes to a better understanding of the innovation process of HCs and how they interact with universities in a regional innovation ecosystem.**

## 1. Introduction

Hidden champions (HCs) represent a significant yet often overlooked facet of the Italian economy. Operating within highly specialized sectors and niche markets such as the automotive supply industry and the engineering of specialized machinery, they make substantial contributions to the country's economic advancement. Located both in urban and rural regions with concentrations in Lombardy, Emilia-Romagna, and Trentino-Alto Adige, they have a significant impact on regional knowledge production and development.

In their respective home regions, HCs frequently serve as anchors for the local economy and attract talent and investment (Audretsch et al., 2021b). While extant research has investigated such positive effects of HCs on the regional economy (see Benz et al., 2021; Rietmann, 2021; Vonnahme and Lang, 2021), we

know little about how HCs benefit from their regional environment. Anecdotal evidence from Simon (2009) suggests that HCs often colocate in selected regions leading to knowledge spillovers between them. However, more research is needed to understand the role of HCs in regional innovation ecosystems and how they benefit from regional knowledge spillovers. Prior research on the innovation processes of HCs has stressed the role of customers and internal R&D as important sources of innovation but has neglected spatial agglomeration as a source of innovation (Audretsch and Belitski, 2022). Our study aims to reduce this gap and focuses on regionally proximate universities as a source of innovation for HCs. Specifically, we investigate how the innovation output of HCs benefits from proximity to universities and how university characteristics influence this relationship.

Drawing on a sample of 124 Italian HCs and 96 universities, we show that HCs located in close

proximity to universities have higher innovation output as compared to other HCs. The size of the spillover effect depends on university characteristics and is highest with universities strong in the field of engineering. With these results, our study contributes to several literature streams. First, we contribute to the small but growing literature on HCs (Benz et al., 2020, 2021; Audretsch et al., 2021b; Johann et al., 2021; Schenkenhofer, 2022). This literature is mostly based on empirical findings from German HCs. We add an Italian perspective to this line of research. Second, we contribute to our understanding of how HCs interact with their regional environment. It seems that they both contribute to but also benefit from their regional environment. Our results show that they benefit from local knowledge spillovers from regionally close universities. Hence, HCs use universities next to their R&D and customers as sources of innovation, which has been overlooked in HC research so far. Our finding that the effects of knowledge spillovers are highest for universities strong in engineering indicates that HCs benefit mostly from knowledge that is applied and technical in nature.

Next to the contributions to HC research, our study contributes to research on university–industry spillovers (Acs et al., 1994; Audretsch et al., 2012). Prior research has investigated the extent, form, and type of university knowledge spillovers for (large) high-tech firms (Saxenian, 1985), (venture capital financed) start-ups (Audretsch et al., 2005, 2021a), and university spinoffs (Hahn et al., 2024). So far, the *Mittelstand* and HCs have been overlooked in this literature. Our study shows that HCs as market leaders in niche markets seem to possess the absorptive capacity to benefit from university knowledge (Cohen and Levinthal, 1990; Díez-Vial and Fernández-Olmos, 2015). This can be explained through their own R&D and their deep understanding of customer needs helping them to translate university knowledge into commercially attractive innovations and products (Scandura, 2016; Szücs, 2018; Messeni Petruzzelli and Murgia, 2020). Thus, our theoretical foundations are grounded on the concept of absorptive capacity and argue that next to the size of the knowledge base, both its quality and technological relatedness play an important role (Makri et al., 2010; Bishop et al., 2011).

The remainder of the article is structured as follows: Section 2 introduces the HC concept. It discusses the role of university knowledge spillovers as a source of innovation for HCs and reviews past research on university knowledge spillovers. Section 3 combines research on university knowledge spillovers and absorptive capacity to develop

hypotheses about the knowledge spillovers between universities and HCs. Sections 4 and 5 introduce our samples of Italian HCs and universities and report regression results exploring how regional proximity to universities is associated with the innovation output of HCs. Section 6 concludes.

## 2. Literature review on hidden champions and university knowledge spillovers

### 2.1. Definition and characteristics of hidden champions

The HC concept was introduced by Hermann Simon in the 1990s trying to explain the German export success. He credited a large share of Germany's thriving exports to small- and medium-sized firms. Simon (2009) termed a particularly successful subgroup of them as HCs, defining them as firms that (1) rank among the top 3 market leaders in their market across the world or are number 1 on their respective continent, (2) have revenues below US\$5bn, and (3) have little visibility in the public.

HCs pursue niche market strategies and are market leaders in their respective niches. The niche market strategy (Porter, 1980) is central to their business model and characterizes them. The demands of customers in niche markets are often highly demanding and specific. Niche market leaders therefore often face high pressures for constant innovation. The high level of specificity in these markets also places special demands on the human capital of the firm's employees (Lehmann et al., 2019, 2022). Long and intensive training programs are the result leading to specific investments and mutual lock-ins. Quasi-rents exist on both sides. Quitting the employment relationship, especially after vocational education, would cause high switching costs on both sides. Long-term planning horizons are also supported by the governance structures of HCs. Many of them are owned by business families and run by owner-managers. This is also reflected in the leadership style of HCs. An autocratic and patriarchal leadership style prevails over what concerns the main corporate strategy, while a rather participative leadership style manages operational matters. This allows HCs to implement highly ambitious goals from the top management, while at the same time, they are able to benefit from the sophisticated knowledge of employees. Close customer contact allows for constant feedback loops regarding the innovation program. Accordingly, competencies are often

decentralized and located where employees have customer contact (Audretsch and Lehmann, 2016).

Research shows that HCs are a worldwide phenomenon and can be found in many countries (Audretsch et al., 2021b). They are especially prevalent in Scandinavia, the German-speaking countries (Austria, Switzerland, and Germany), South Korea, and Japan. Literature so far has mainly investigated the HC's innovation strategies (Rammer and Spielkamp, 2015, 2019), their economic performance (Johann et al., 2021) and impact on regional development (Benz et al., 2021), their rural endowment (Vonnahme and Lang, 2021), listing status, (Benz et al., 2020), and institutional contextualization (Audretsch et al., 2021b). The latter study shows that the concentration of HCs is associated with certain institutional patterns. In particular, a publicly regulated vocational education system, dualistic board structures, and a civil law regime seem to be complementary with HCs. Among the fields displayed above, HC research mainly studies HC innovation strategies. One exemplary study is from Rammer and Spielkamp (2015), who analyze a set of German HCs and find that their success factors comprise proficient innovation management, prioritizing market share, and rapid international expansion. They outperform in market share, revenue growth, and innovation, with a strong focus on technology-oriented knowledge and R&D collaboration. HCs systematically acquire knowledge, cooperate with academia, and protect their expertise through speed and legal measures like patents and trademarks. In another study, Rammer and Spielkamp (2019) highlight the innovation-based business strategy of HCs. They find their innovation strategy to focus on technological excellence and customized solutions for their niche market customers. This strategy leads to significantly higher profit margins and productivity compared to other firms of the same sector and size (Audretsch and Belitski, 2020; Johann et al., 2021). Despite their strong innovation focus, HCs are argued to not spend more on innovation and R&D as compared to other firms but are highly efficient in their innovation processes and resource allocation. This efficiency is attributed to four management practices, including in-house R&D, open innovation, complex IP management, and substantial investment in human capital (Enkel et al., 2009). HCs thus build and maintain distinctive competitive advantages that are difficult to replicate.

Vonnahme and Lang (2021) find that HCs apply unique innovation strategies to overcome the lack of dense regional innovation systems in rural regions. This distinctive approach sets them apart from their

urban counterparts. The study helps to understand how innovation emerges from contexts outside of urban agglomerations. In line with this, Benz et al. (2021) investigate how HCs influence regional development. They show that HCs are not evenly distributed across regions and have a significant impact on various dimensions of regional development. Regions with a higher HC concentration exhibit stronger regional innovation and economic performance. Importantly, the study also highlights that the influence of HCs extends beyond their home region to neighboring regions, indicating the presence of spillovers across regions.

## 2.2. *Absorptive capacity of hidden champions*

As described above, HCs are characterized by their high-tech and knowledge-intensive products and services, which pose particular challenges in terms of acquiring and training specific human capital (Lehmann et al., 2019; Audretsch et al., 2021b). Simon (2009) describes how HCs adopt a specific form of open innovation both in their organizational structure and interaction with customers. Their constant effort to improve their products and services involves sizable investments in external cooperation. This investment in open innovation complements HC's own R&D activities and deep product knowledge. Therefore, it is reasonable to assume that HCs exhibit a high absorptive capacity for integrating external knowledge into their innovation processes (Audretsch et al., 2021b). Absorptive capacity is defined as the ability to value, assimilate, and apply new knowledge (Cohen and Levinthal, 1990). While the valuation of new knowledge is dependent on past experience to process similar knowledge, the assimilation of knowledge depends on knowledge characteristics such as technological overlap between internal and external knowledge. The application of external knowledge rests on the identification and exploitation of technological opportunities and the ability to protect innovation (Zahra and George, 2002). While the exchange of HCs with customers and the proximity to other niche firms in the same or similar industries has been studied at least conceptually (e.g., Audretsch et al., 2023), it remains unclear which role universities and research institutes play for HCs as a knowledge source.

## 2.3. *University knowledge and university knowledge spillovers*

The ability of universities to generate and accumulate academic knowledge can generate local

knowledge spillover effects (Anselin et al., 1997; Mowery and Ziedonis, 2015), which regionally close HCs and other firms can absorb to increase their knowledge base. Knowledge spillovers describe the unintentional and unconscious exchange of knowledge (Fallah and Ibrahim, 2004). It can be understood as a positive externality that (intentionally or unintentionally) spills over from knowledge providers to other parties. The potential for knowledge spillovers has been shown to increase with regional proximity, the frequency of contact between the parties involved, and the absorptive capacity of the receiver (Fallah and Ibrahim, 2004; Belitski et al., 2023). Thus, knowledge spillovers can be distinguished between companies in the same industry (Marshall-Arrow-Romer spillover; Marshall, 1890; Arrow, 1962; Romer, 1986) or in different industries (Jacobs, 1969). Another form is knowledge spillovers from universities or research institutes to private firms (Wennberg et al., 2011). These knowledge providers are often embedded in regional ecosystems or clusters. Some often-cited examples of knowledge clusters that benefit from the presence of strong research institutes are the Silicon Valley cluster (benefitting from Stanford University and the University of California, Berkeley) and the Route 128 cluster (benefitting from MIT and Harvard University). Here, university research contributes to an increase in firm-level innovation, start-up business activities, and overall regional wealth (Acs et al., 1991; Audretsch and Belitski, 2023).

Prior research has emphasized how agglomeration spillovers are generated by a “formal institution whose sole mission is the creation and dissemination of knowledge – the research university” (Kantor and Whalley, 2009, p. 3). Especially, the emergence of high technology after the Second World War in high-tech industries such as pharmaceuticals, software, biotechnology, and semiconductors was largely influenced by research endeavors from universities and the presence of subsequent spillovers from and between privately held firms (Zucker et al., 1998; Mowery and Ziedonis, 2015). Universities foster the dissemination of knowledge and its commercialization through a direct and an indirect mode. The direct mode refers to the transfer of knowledge through technology transfer offices (Wennberg et al., 2011), while the indirect mode is associated with the role of universities in attracting talented students and researchers into regional innovation ecosystems (Meoli and Vismara, 2016). Universities nurture both the amount and quality of knowledge that is generated and disseminated through research and

teaching activities (Audretsch et al., 2022). Here, the transfer of knowledge from universities to firms has been described as a “*contact sport*,” in which the transfer and exchange of personnel between universities and firms are essential. Firms benefit from tacit knowledge and information, which is difficult to codify in published research. This is why the informal exchange of information matters and is a driver of the successful commercialization of research and innovation (Mowery and Ziedonis, 2015). Universities often attract a young and skilled workforce, which is why firms benefit from universities not only as knowledge hubs but also by thickening labor markets. Hiring qualified workers becomes easier for firms in areas where universities are located. In turn, young and skilled talents “mitigate their unemployment risk and raise their own chances of a quality employer match” (Kantor and Whalley, 2009, p. 3).

But how do knowledge spillovers from universities occur? What are the channels, supporting factors, and mechanisms?

Prior research has analyzed these questions in great detail. Combining the knowledge base of universities with the human capital of students and researchers, universities may spin off new ventures leading to direct knowledge spillovers. Indirect knowledge spillover can occur through the education of (doctoral) students, industry–university research projects, and contract research (Hahn et al., 2024). Similarly, Liu (2015) distinguishes two types of university spillovers. The first type is direct in its nature and emerges from research and education activities at the university. The second type is indirect in its nature and is derived from general agglomeration economies, that is, the population that a university attracts. Liu (2015) describes that the direct university spillover thus results from “direct interaction between faculty and local business establishments and training of students” and through continuing their careers after university in nearby firms and thus “enhance the quality of the labor pool” (p. 28).

Among the studies that focused on university spillover effects, Acs et al. (1994) explore the extent to which university and corporate R&D activities spill over to influence innovation at the (federal) state level in the US. Their study finds substantial evidence that spillovers are facilitated by the geographic proximity of universities and research laboratories within the state. Additionally, corporate R&D seems to play a more prominent role in generating innovation in large firms, while spillovers from university research laboratories are more significant in stimulating innovation in small firms.

Anselin et al. (1997) investigate local geographic spillovers between university research and regional innovation levels. The study employs spatial econometric analysis and the Griliches–Jaffe knowledge production framework to explore these relationships across 43 U.S. states and 125 Metropolitan Statistical Areas (MSAs). The findings confirm a positive and significant relationship between university research and innovative activity in a region, both directly and indirectly through its impact on private sector R&D. The spillovers from university research on innovation extend over a range of 50 miles from the innovating MSA.

Audretsch et al. (2005) investigate the impact of locational choice as a strategy for accessing knowledge spillovers from universities among high-tech startups in Germany. The study explores how proximity to universities is influenced by different spillover mechanisms (research and human capital) and types of knowledge spillovers (natural sciences and social sciences). The findings reveal that regional proximity to universities as a factor for locational choice is influenced by the type of knowledge being sought and the specific spillover mechanism. While technology startups generally have an inclination to locate near universities to access knowledge spillovers, the precise role of regional proximity varies based on the specific knowledge type and spillover mechanism examined.

In another study, Audretsch et al. (2012) compare the effects of regional resources and university spillovers on innovation among young and high-tech firms. The study finds that the innovation activity of these firms is significantly influenced by both above-average regional resources and the presence of research-intensive universities. Their findings further suggest that public policy can impact the innovative process by providing infrastructure support and incentives for entrepreneurs and researchers to engage in knowledge transfer. In particular third-party funding from the (regional) industry seems to matter.

Mowery and Ziedonis (2015) distinguish between knowledge spillovers from university research and market-mediated channels such as technology licensing or academic scientist–firm employment relationships. They study the geographical localization of knowledge flows from university inventions through market contracts (licenses) and nonmarket spillovers exemplified by patent citations. Their findings reveal that knowledge flows through market transactions are more geographically localized than those operating through nonmarket spillovers, suggesting that proximity has a more significant impact on market transactions.

Our study connects research on university knowledge spillovers with HC research to investigate the role of university spillovers in the innovation output of HCs. Our context is Italy, which has both a significant number of HCs and (research) universities.

### 3. Hypotheses about knowledge spillovers from universities to hidden champions

As outlined above, universities can provide important knowledge spillovers to firms in their regional innovation ecosystem. To what extent firms actually benefit from these knowledge spillovers depends on their absorptive capacity, that is, their ability to value, assimilate, and apply new knowledge to produce innovations and new products (Cohen and Levinthal, 1990). A higher absorptive capacity enables firms to understand and subsequently capture the value of external information, which then might lead to a higher innovation output. In this regard, the absorptive capacity can be regarded as an example of organizational learning that describes how an organization integrates and makes use of new external knowledge. Knowledge spillovers from universities are an example of such new external knowledge.

In line with our characterization of HCs as market leaders within the highly specialized niches above, we assert that HCs possess sophisticated and highly specialized knowledge themselves. They constantly invest in R&D and innovation to remain competitive and to defend their niche market leadership. Investing in R&D enhances the knowledge base and technological capabilities of HCs, cultivating the flexibility and adaptability necessary to effectively utilize and exploit new knowledge, thereby amplifying their absorptive capacity. Hence, we argue that HCs should be able to make use of and benefit from the academic research and knowledge that is generated by universities that are located within spatial proximity. The absorptive capacity literature further distinguishes between potential and realized absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002). While the former encompasses the absorptive capacity dimensions of (new) knowledge acquisition and assimilation, the latter comprises activities related to knowledge transformation and exploitation. Due to their focused strategies, their high-tech innovations, and the resulting profound understanding of their markets, we contend that HCs are well-positioned to recognize the

commercial opportunities presented by academic research and knowledge (Kobarg et al., 2018). In this manner, HCs not only possess the capability to comprehend and assimilate knowledge but also to translate the knowledge diffusion from universities into actual innovations and products.

Therefore, our baseline hypothesis is as follows:

H1 The regional proximity of HCs to universities has a positive impact on the innovation output of HCs.

Building on the arguments raised in H1, we propose that the absolute size of the knowledge base matters (Tödtling et al., 2009; Hewitt-Dundas et al., 2019). Larger universities typically produce more and a larger variety of knowledge as compared to smaller universities. Hence, the likelihood that complementarities exist between the knowledge needs of HCs and the university knowledge should increase with the size of the university (Acosta et al., 2011). Moreover, from a human capital perspective, we argue that successful knowledge transfer and the resulting knowledge spillovers do not only depend on the mere exchange of ideas but also entail the exchange of qualified and motivated personnel and human capital. In particular, large universities fulfill an important function in this regard, as they can be considered as a regional engine in attracting talent towards a certain region. This proves particularly important for the specific human capital requirements of HCs, as prior empirical HC research underscores that the provision of complementary human capital is a key requirement for the business model of HCs (Audretsch et al., 2021b). The underlying logic stems from their sophisticated and highly specialized technologies, which require well-trained and talented employees. A larger pool of potential employees brought into the regional ecosystem by one or several large universities should therefore be advantageous for HCs that especially rely on young, ambitious, and highly qualified talents to innovate and grow.

Hence, we hypothesize:

H2 The positive spillover effect between HCs and regionally proximate universities increases with larger universities.

Furthermore, we shall argue that it is not only the absolute size of the knowledge base created by universities that matters but also the type and quality (Schartinger et al., 2002). Prior research shows that universities differ very much in the type and quality of research and knowledge that they produce (Bentley et al., 2015). It has also been shown that this heterogeneity influences not only the extent to

which knowledge spillovers are created but also the extent to which they lead to regional innovation and growth (Wixe and Andersson, 2017). While those universities that are primarily oriented towards teaching increase the available pool of talents, they commonly do not offer new knowledge. Ultimately, it is research-based universities that produce new knowledge. For HCs that are already leading in their specific niches, it is precisely this cutting-edge knowledge that holds paramount importance (Bishop et al., 2011; Barra et al., 2019). They require highly specific and novel technology knowledge. To summarize, we posit that the quality of the university's research should increase the knowledge spillover potential of universities (Hewitt-Dundas, 2012) and hence the spillover effect on HCs should also be larger.

The following hypothesis should apply:

H3a The positive spillover effect between HCs and regionally proximate universities increases for universities that are strong in research.

In addition to the absolute size of the knowledge base and the research orientation, the actual knowledge domain also holds significant implications (Audretsch and Lehmann, 2005). Previous research on absorptive capacity has highlighted the pivotal role of the knowledge relatedness between the acquirer and producer in shaping absorptive capacity and subsequent innovation and growth outcomes. HCs produce mainly technical products and are active in industries such as the manufacturing of machinery, non-metallic products and electrical equipment (see Table 2). As leaders in their niche markets, they therefore benefit in particular from sophisticated applied knowledge in technical fields that can be turned into specific products. Thus, it is important at this stage to distinguish between more basic natural sciences research and applied engineering research. Due to their unique characteristics, we argue that HCs benefit more from applied engineering research than from basic natural sciences research. The latter would be more suited for large firms that have a more sophisticated research infrastructure and larger R&D departments. Also, they have larger R&D budgets and their innovation cycles are typically also longer. In contrast, HCs as small niche players, excel in turning knowledge into specific products fast. Their innovation cycles are shorter than those of large firms and they typically do not have the budget available to fund large and uncertain research projects with uncertain outcomes, which is why they benefit in particular from applied engineering knowledge that

is complementary to their own knowledge (Makri et al., 2010; Frankort, 2016).

We posit the following hypothesis:

H3b The positive spillover effect between HCs and regionally proximate universities increases for universities that are strong in engineering.

## 4. Research design

### 4.1. The sample of Italian hidden champions

Starting with a list of HCs from Simon (2009), we searched various sources such as local market registers from Italian regions and newspaper articles (e.g., Welt, 2015; SWZ, 2021). This information was then used to create a list of Italian HCs. In total, we were able to identify 124 Italian HCs. Table 1 shows some examples of Italian HCs. On average, the Italian HCs in our sample are 33 years old, with the oldest being Leitner (135 years) and the youngest being Marposs Societa' Per Azioni (8 years). The average firm age of Italian HCs is lower as compared to German HCs (average age of 103 years). Not surprisingly, their average firm size measured in revenues (140.9 million €) or employees (468 employees) is also lower than in Germany (Schenkenhofer, 2022).

The most common industries in which Italian HCs are active are the manufacture of machinery and equipment, non-metallic mineral products, and electrical equipment (see Table 2). There are some similarities to German HCs, which are also strong in mechanical engineering and electrical engineering (see Simon, 2009 or Schenkenhofer, 2022). Other main industries German HCs operate in include chemicals and medical engineering. Overall, it appears that Italian HCs have an ever higher manufacturing and engineering focus as compared to the somewhat more diversified nature of German HCs. The geographic distribution of HCs in Italy reveals interesting insights (see Figure 1). Strong concentrations of HCs can be found in Bolzano, Milan, and Bologna. Most of the Italian HCs are located in the northern regions with strong concentrations in the regions of Lombardy, Emilia-Romagna, and Trentino-Alto Adige. Thus, there appear to be HC clusters in Italy.

### 4.2. Sample and variables

In this study, we investigate the impact of universities on the technological innovation output of HCs. We postulate that HCs benefit from the geographical

proximity to universities in the form of knowledge spillovers. For our identified set of 124 HCs, we collect firm-level data from the Italian office of Bureau van Dijk (the AIDA database) for the years 2015 and 2019. To identify universities in geographical proximity to these HCs, we use a list from the Italian Ministry of Education, Universities, and Research (MIUR), which has been used in prior studies (e.g. Horta et al., 2016; Civera et al., 2024). We use this list of 96 universities to calculate the network centrality of university–firm pairs. Thus, a particular university is likely to produce knowledge spillovers to more than one HC. Locating geographically close to a university might enhance these knowledge spillovers. Hence, we build our network centrality measure on the actual geographical distance between HCs and universities (see also Döring and Schnellenbach, 2006). For this purpose, we use the Haversine formula to calculate the network centralities of HCs.

Table 3 provides an overview of the variables used in our analysis. Our dependent variable is the technological innovation output of HCs as measured by the yearly stock of granted patents (see also Acs et al., 2002; Delgado et al., 2014). The independent variables in our study refer to the geographical proximity of HCs to universities. Measuring knowledge spillovers is challenging, as they can hardly be captured directly. Literature therefore supports an indirect measurement using distance metrics or the number of knowledge-emitting units in a certain geographical area. One can distinguish quantitative (location quotient: Wennberg and Lindqvist, 2010; cluster index: Sternberg and Litzenger, 2004) from qualitative (case studies: Saxenian, 1985; cluster star method: Hollander, 2020) approaches. We follow a quantitative approach and use the Haversine distance for distance measurement. Thus, we use the calculated distances to measure an embedding as a form of network centrality. Cluster network centrality measures in terms of closeness centrality have been used before in economic geography (Provan et al., 2007). The network centrality describes a global centrality measure that indicates the closeness of all involved actors within the whole network. Network logic underlines that the actors are possibly interrelated to exchange social resources and knowledge. The centrality of a given actor is thus described by the sum of distances to reach all other nodes. Shorter distances to other nodes thus increase closeness centrality (Sabidussi, 1966). This rationale is based on the centrality concept as applied within social network analysis. Here, the degree centrality counts the number of direct connections between two nodes in the network.

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**Table 1.** Exemplary Italian HCs

Hidden champion	HQ location	Description
Leitner S.P.A.	Sterzing	Leitner S.P.A. is a world-leading manufacturer of cable cars and was founded in 1888 in Sterzing (Southern Tyrole) by Gabriel Leitner. It employs ca. 3,800 employees worldwide, bestowing revenues of about 860 Mio. € (2021). Leitner built the first aerial tramway in Europe from Bolzano to Kohlern (1908). Leitner also managed to install Italy's first chairlift in Corvara in 1947. A major prestige project, the Matterhorn Glacier ride, was realized in 2018, which is the highest 3 s lift in the world. The biggest competitors in the world market are world market leader Doppelmayr/Garaventa from Austria and 2nd place in the world market Pomagalski from France
Brembo S.P.A.	Curno	Brembo S.P.A. is an automotive supplier from Curno (Bergamo). The firm was founded in Bergamo and totaled revenues in 2021 of 2.78 Bn € with 12,000 employees worldwide. It ranks among the top 3 in the world market for automotive braking systems. It has been listed on the Borsana Italiana since 1995 and equips, among others, some Formula 1 teams such as Ferrari, Red Bull, and Toro Rosso with braking systems. In addition to BMW and Chrysler, its main customers include Daimler Benz AG from Stuttgart. Other Brembo brands include AP car brakes, AP Racing, which produces racing motorcycle brakes, Marchesini wheels, or Villar aftermarket discs
Reusch International S.P.A.	Bolzano	Reusch International S.P.A. is a sporting goods manufacturer based in Bolzano, Italy, specializing in winter sports gloves, goalkeeper equipment, and in particular goalkeeper gloves and other applications in soccer and winter sports. The firm was founded in 1934 by Karl Reusch in Metzingen, Baden-Württemberg. A milestone was the world's first-ever goalkeeper glove. It was developed in 1973 in close cooperation with the goalkeeper of Bayern Munich, Sepp Maier. In the 1990s, the firm was completely relocated to Bolzano. In the meantime, Reusch is also an outfitter for many of the world's most successful ski associations, such as Austria, Switzerland, Norway, and Liechtenstein
Mapei S.P.A.	Milan	Mapei S.P.A. was founded by Rodolfo Squinzi in 1937 in Milan, where its headquarters are still located. Mapei specializes in adhesives for the building industry and employs 10,000 people worldwide, who generate revenues of 2.8 bn € (2020). The firm employs over 1,000 people in R&D in 31 centers worldwide. Thus, the R&D/revenue ratio is about 5%
Technogym S.P.A.	Cesana	Technogym S.P.A. was founded by Nerio Alessardi in 1983 (Cesana). The firm is a manufacturer of equipment for fitness, sport, and health. Still based in Cesena, one of its earliest products was a 1985 strength training line and the multistation Unica, which was introduced in 1986. The firm achieved revenues of € 509 million in 2020, employing 2,300 employees. Technogym became the official exclusive supplier of the Summer Olympics 2016 in Rio de Janeiro (Brazil) and later for Pyeongchang 2018 and Tokyo 2020. Formula 1 teams Ferrari and McLaren use Technogym as suppliers and partners for their athletic preparation programs. Furthermore, some of the world's leading football clubs Juventus FC, Milan AC, and Inter Milan FC use Technogym equipment

While between centrality instead counts the capacity to bridge certain nodes, the eigenvector centrality is based on the connectedness towards well-connected nodes. The concept thus displays the actual flows of social resources. Yet, the actual nodes of spillover transfers are not observable as spillovers appear both indirectly and unconsciously. Thus, research on knowledge spillovers

commonly assumes spillovers to appear through regional proximity.

Based on our hypotheses, we calculate network centrality measures for large universities as well as for universities strong in basic research and engineering. In our regressions, we control for a number of firm-level and regional-level factors that might also have an impact on the technological innovation

output of HCs. The innovation output of firms might also be generated through industrial spillovers from firms in the same industries (so-called

MAR spillovers). Accordingly, we also measure a location quotient for *industrial spillovers*, which measures the regional agglomeration of economic activity of the same industries (Wennberg and Lindqvist, 2010). It is a commonly used measure to capture spillover effects between firms. We further account for a region's *population size* and *student density* (Soh and Subramanian, 2014). On the firm level, we control for *prior firm performance*, *prior R&D intensity*, as well as *lagged firm size* and *firm age*. Finally, we include *industry*, *region*, and *year dummies*. Table 3 describes the operationalization of the variables in detail, Table 4 presents the descriptive statistics of the variables, and Table 5 shows their correlations.

**Table 2.** Industry overview of Italian HCs

NACE2	Share (%)
Manufacture of machinery and equipment	29.8
Manufacture of other non-metallic mineral products	8.1
Manufacture of electrical equipment	7.3
Manufacture of fabricated metal products, except machinery and equipment	7.3
Wholesale trade, except for motor vehicles and motorcycles	7.3
Manufacture of other transport equipment	4.8
Mining of coal and lignite; extraction of peat	4.8
Manufacture of basic metals	2.4
Manufacture of motor vehicles, trailers, and semitrailers	2.4
Other	25.8

Please note: Nace 2 industry classes. Industries appearing <3 times are summarized into "other."

### 4.3. Calculating distances

For our main independent variables, we use distances between universities and HCs. For this purpose, we use length distances between coordinates as a basis. One method to calculate these distances is the Haversine formula, which can be used to calculate distances between any two points on the



**Figure 1.** Map of Italian HCs. Source: Own depiction.

**Table 3.** Variable definitions

Variable	Description
Dependent variable	
Technological innovation output	Number of granted patent stock by year
Independent variables	
Regionally close universities	Number of universities within a distance of 100 km to an HC
Regionally close large universities	Number of large universities within a distance of 100 km to an HC; large is defined through the number of students and the 0.75 percentile
Regionally close universities with overall research excellence	Number of universities that are strong in research within a distance of 100 km to an HC; use of Times Higher Education ranking sub score for citations
Regionally close universities with engineering excellence	Number of universities that are strong in engineering within a distance of 100 km to an HC; use of QS Higher Education Ranking sub-score for top universities in the fields of engineering and technology
Control variables	
Industrial spillover dummy	Dummy variable equaling 1 if the location quotient >1.25, see Wennberg and Lindqvist (2010)
Family ownership dummy	Dummy variable equals 1 if the firm is controlled by a business family; use of AIDA's (Bvd) ownership definition of Global Ultimate Ownership using a cut-off value for ownership control of 25%
Prior firm performance	Operating margin, calculated using the operating income divided by revenues, lagged by one year
Prior R&D intensity	R&D expenditures in € by year (multiplied by 10,000 for better readability of the coefficient) divided by the number of employees
Firm age	Natural logarithm of the number of years since the foundation of the firm, lagged by one year
Firm size	Natural logarithm of the number of employees, lagged by one year
Population size	Number of inhabitants of the respective NUTS 2 region
Student density	Number of students per capita of the respective NUTS 2 region
Industry dummies	10 dummy variables equaling 1 for the respective industry (see Table 2 for details)
Region dummies	Dummy variables equaling 1 for the respective NUTS 2 region where the HC is headquartered
Year dummies	Dummy variables equaling 1 for the respective year

surface of the globe for which latitude and longitude coordinates exist. Developed by the mathematician Johann Haversine at the beginning of the 19th century, the formula emerged from spherical trigonometry and the law of great circle distances. The globe is regarded as a perfect sphere, which is a simplification as the ellipsoidal earth actually resembles an oblate spheroid. Nevertheless, the Haversine formula provides an excellent approximation for distances on the earth's surface. The Haversine formula is applied a lot in traffic navigation (Soe, 2020), astronomy (Veness, 2011), and air travel (Hopfe et al., 2022).

The exact formula for calculating the Haversine distance is as follows:

$$d = 2r \arcsin \sqrt{\sin^2 \left( \frac{\Delta \text{lat}}{2} \right) + \left( \cos(\text{lat}_1) \times \cos(\text{lat}_2) \times \sin^2 \left( \frac{\Delta \text{lon}}{2} \right) \right)}$$

where,  $d$  describes the distance between two points on the sphere (in km);  $r$  describes the radius of the globe, which is about 6371 km;  $\text{lat}_1$  and  $\text{lat}_2$  describe the latitudes of the two points in radians;  $\Delta \text{lat}$  describes the difference between the latitudes of the two points in radians;  $\Delta \text{lon}$  describes the difference between the longitudes of the two points in radians.

## 5. Results and discussion

Table 6 presents our regression results. Models 1 to 4 perform random-effects negative binomial regressions accounting for both the skewness and count variable nature of our dependent variable. Model 1 includes our first independent variable (*Regionally close universities*) and all of the control variables. The effect is positive and strongly significant ( $p < 0.01$ ), and therefore supports hypothesis 1. Model 2 includes the second independent variable (*Regionally close large universities*). The effect is positive and significant ( $p < 0.01$ ), therefore supporting hypothesis 2. Model 3 shows our results for the independent variable *Regionally close universities with overall research excellence* (hypothesis 3a). Again, the effect on innovation performance is positive and strongly significant ( $p < 0.01$ ). Finally, model 4 contains the results for the independent variable *Regionally close universities with engineering excellence* (hypothesis 3b). As in model 3, the results show a strongly positive effect on innovation performance ( $p < 0.01$ ). Overall, when comparing the effect sizes of models 1 to 4, it becomes apparent that both the size of universities and the technological complementarity

**Table 4.** Descriptive statistics

	Obs	Mean	SD	Min	Max
Technological innovation output	620	170.355	459.744	0	3,565
Regionally close universities	620	11.298	8.775	0	26
Regionally close large universities	620	2.444	2.18	0	8
Regionally close universities with overall research excellence	620	5.613	2.956	0	11
Regionally close universities with engineering excellence	620	2.097	1.209	0	6
Industrial spillover dummy	620	0.903	1.403	0	5.905
Family ownership dummy	620	0.363	0.481	0	1
Prior firm performance	510	-10.153	172.291	-3,629	72.317
Prior R&D intensity	524	0.34	1.205	0	10.692
Firm age	620	32.556	19.027	0	94
Firm size	525	468.086	878.198	1	8,036
Population size	620	5,224,495.4	3,271,504.6	902,138	9,839,177
Student density	620	26.509	5.402	20.56	43.59

of knowledge seem to be most influential. When comparing model 3 to model 4, we assume that the knowledge needed by HCs can be best supplied by universities that possess a strong engineering background. Thus, it seems that the knowledge proving to be complementary to the manufacturing business models of HCs serves best in supporting innovation performance. Moreover, the control variables contain interesting results backing findings in the literature. In all of the models, the industrial firm spillover dummy indicates a positive effect on innovation performance. This backs a large literature that has underlined the Marshall–Arrow–Romer spillover on a firm level (Marshall, 1890; Arrow, 1962; Romer, 1986). Also R&D intensity, in line with numerous studies, seems to exert a small but significant positive effect (Maietta, 2015).

Overall, our models strongly support our hypotheses 1 to 3. Therewith, our findings underline the meaning of regional agglomeration of HCs and universities. We assume that academic spillovers underlie and therewith contribute to a literature that has investigated the role of universities in innovation performance on a firm level (Audretsch et al., 2005, 2012; Acs et al., 2013). While the highly specific knowledge intensity of HCs could theoretically impede them from absorbing and utilizing external knowledge (Audretsch et al., 2021b), we find proof that HCs benefit from the regional proximity to nearby universities. Thus, we find empirical evidence for an academic spillover for niche market leaders. Here, our results align with the literature underlining the positive impact of academic spillovers for firm-level innovation (Audretsch et al., 2005, 2012). Moreover,

these insights underline that the type of knowledge generated in universities impacts the magnitude of the positive agglomeration effect found in the first hypothesis. In fact, HCs benefit strongly when locating nearby universities that especially are likely to generate knowledge important for engineering. As the majority of HCs originate from an engineering background, their knowledge complementarity proves especially beneficial. This finding aligns with former research that showed that the kind of science matters for the absorption and use of knowledge (Landry et al., 2007). Thus, while former research analyzed high-tech startups or spin-offs (Civera et al., 2020), we extend this stream of research on HCs. Finally, our findings support research analyzing the importance of university size for the positive spillover effect (Casper, 2013). We conclude that niche market technologies might need a greater pool of potential knowledge bearers to commercialize knowledge. While less knowledge-specific firms might not be affected by size, HCs are especially dependent on finding complementary knowledge resources (Lehmann et al., 2019).

## 6. Conclusion

In this paper, we pursue two objectives. First, we present and illustrate a sample of Italian HC. We present their descriptive characteristics and analyze their geographical distribution in Italy. Furthermore, we use this sample to investigate the role of academic spillovers and thus the proximity to universities for the innovation performance of

**Table 5.** Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Technological innovation output	1.000												
(2) Regionally close universities	0.161***	1.000											
(3) Regionally close large universities	0.159***	0.965***	1.000										
(4) Regionally close universities with overall research excellence	0.147***	0.936***	0.879***	1.000									
(5) Regionally close universities with engineering excellence	0.138***	0.850***	0.897***	0.849***	1.000								
(6) Industrial spillover dummy	0.329***	0.076*	0.024	0.081**	0.015	1.000							
(7) Family ownership dummy	-0.154***	-0.236***	-0.208***	-0.253***	-0.185***	-0.002	1.000						
(8) Prior firm performance	0.023	-0.044	-0.046	-0.027	-0.030	-0.023	0.044	1.000					
(9) Prior R&D Intensity	0.206***	-0.032	-0.028	-0.070	-0.094**	0.072*	-0.071*	0.008	1.000				
(10) Prior firm age	0.154***	0.036	0.021	0.024	0.040	0.078*	-0.245***	0.023	0.090**	1.000			
(11) Prior firm size	0.239***	-0.058	-0.022	-0.024	0.021	-0.022	-0.231***	0.012	0.393***	0.188***	1.000		
(12) Population size	0.200***	0.849***	0.786***	0.822***	0.644***	0.142***	-0.290***	-0.056	-0.018	0.046	-0.057	1.000	
(13) Student density	0.019	0.027	0.094**	0.136***	0.000	-0.109***	0.041	0.024	0.127***	-0.163***	0.131***	0.106***	1.000

\*\*\* $p < 0.01$ ;  
\*\* $p < 0.05$ ;  
\* $p < 0.1$ .

HC. We use longitudes and latitudes to calculate distances using the Haversine formula. Based on this, we calculate cluster centrality measures and investigate the role of proximity to universities in general. In the next step, we investigate the role of university size, basic research intensity, and a university's focus on engineering. The results show that HCs benefit from academic spillovers in their innovation performance, therefore supporting hypothesis 1. Moreover, also hypothesis 2 finds support as we find that the regional distance to larger universities especially impacts the innovation output of HCs. As we assumed in our theoretical underpinning, the regional proximity to universities strong in engineering exhibits a stronger effect on innovation performance than the proximity to universities strong in basic research. Thus, our results support a view that underlines the importance of technological and knowledge complementarity (Milgrom and Roberts, 1990). These results support hypotheses 3a and 3b.

However, our assumptions are conditioned by some limitations. The concept of HC was first explored by Hermann Simon in the 1990s. For a decade now, it has been part of a broader academic discussion. Finding and identifying HCs is a challenging endeavor. For example, samples of HCs rely on self-statement with regard to market leadership. This criticism has been discussed in many articles on HCs (Audretsch et al., 2021b). Furthermore, spillover research is subject to the challenge that a direct measurement of spillovers is difficult. Therefore, they are usually measured as an indirect and latent construct (Nelson, 2009). Moreover, the use of patents has often been debated, and other measurements have been proposed. On the other hand, the use of patents has some advantages as it is an objective construct that is transparently available to a wide mass. The use in research on spillover effects and innovation at the firm level has been established in the past (Acs et al., 2002; Delgado et al., 2014; Fang, 2015).

Finally, our results have implications for both managers and representatives from public policy. This study found academic spillovers to positively impact the innovation performance of HCs. Thus, HCs should proactively seek proximity and cooperation with universities and acknowledge that, in addition to the direct transfer of knowledge, spillover effects might enhance their innovation output. Managers thus should nourish their firms' willingness and ability to cooperate with other actors within a cluster. Finally, also representatives of public policy are called upon to design a coordinated cluster

**Table 6.** Negative binomial random effects regressions

	(1)	(2)	(3)	(4)
	Technological innovation output	Technological innovation output	Technological innovation output	Technological innovation output
Regionally close universities	0.268*** (0.062)			
Regionally close large universities		1.101*** (0.314)		
Regionally close universities with overall research excellence			0.570*** (0.111)	
Regionally close universities with engineering excellence				1.081*** (0.244)
Industrial spillover dummy	0.477** (0.214)	0.501** (0.237)	0.694*** (0.208)	0.736*** (0.230)
Family ownership dummy	0.401 (0.580)	0.477 (0.624)	1.379*** (0.504)	1.147** (0.511)
Prior firm performance	0.001 (0.003)	0.001 (0.004)	0.000 (0.003)	0.000 (0.002)
Prior R&D intensity	0.027*** (0.007)	0.026*** (0.007)	0.034*** (0.007)	0.033*** (0.007)
Firm age	0.073 (0.058)	0.062 (0.052)	2.023*** (0.225)	1.923*** (0.239)
Firm size	-0.011 (0.042)	-0.011 (0.043)	0.013 (0.036)	0.008 (0.038)
Population size	0.108 (0.200)	0.366** (0.185)	0.121 (0.164)	0.506*** (0.152)
Student density	0.146** (0.068)	0.030 (0.080)	-0.031 (0.056)	-0.104 (0.063)
Industry dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Constant	-1.659 (2.792)	1.597 (3.418)	-2.930 (2.755)	-2.908 (2.622)
Firm-year observations	481	481	481	481

Standard errors in parentheses.

\*\*\* $p < 0.01$ ;\*\* $p < 0.05$ ;\* $p < 0.1$ .

policy to take up and support cooperation efforts by the various cluster stakeholders.

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## Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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