



Barriers to university–industry collaboration in an emerging market: Firm-level evidence from Turkey

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Abstract

University–industry collaborations (UICs) are one of the main sources of external knowledge and technologies for industrial firms, particularly in the context of emerging markets (EMs) and firm development. It is thus highly relevant to identify potential barriers internal to the firm as well as in the regional innovation system that might prevent firms from using UICs for innovation, in particular in an EM context. In order to address this issue, we conduct a firm-level study of the R&D-related segment of the manufacturing industry in Istanbul. Logistic regression analysis is used to test the effect of potential barriers on using UICs for innovative activities. With this approach, we are able to identify barriers that prevent innovation-related UICs and thus form a bottleneck to collaborations in the first place. Our findings show that lack of information about UIC opportunities as well as lack of financial support for UICs are the most relevant barriers that inhibit firms' usage of UICs for innovation. This firm-level evidence points out the importance of university technology transfer offices in regional innovation systems and for fruitful UICs. We further find that administrative barriers have no significant effect, while barriers related to trust and skill matching with scientific partners even have a reverse effect to what we would have expected from the literature. This finding might point towards an effect of perceived versus deterring barriers that has been observed in innovation studies before and might be relevant for studying UICs as well.

Keywords Innovation · Research and development · University–industry collaboration · Barrier · Emerging market · Turkey

JEL Classification O30 · O32 · O38

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1 Introduction

University–industry collaborations (UICs) are one of the most important interactions for transferring knowledge or technologies, stimulating growth and improving innovative activities. However, setting up collaborations between universities and industrial firms can be difficult to achieve. In fact, there are often differences between these institutions in terms of expectations, requirements and collaboration goals (Bjerregaard, 2010; Gilsing et al., 2011; Muscio & Pozzali, 2013). Additional barriers are the costs for firms to search partners that are willing to collaborate and that have a fitting level of skills as well as the costs that are related to the collaboration itself (Bruneel et al., 2010; D’Este et al., 2014; Garcia et al., 2019; Temel & Glassman, 2013). It is thus important to address potential barriers to UICs which is of particular concern in emerging markets (EMs) as UICs are discussed as an important external knowledge source to improve the innovative performance of firms in such contexts (Bastos et al., 2014; Guerrero et al., 2019; Mathews & Hu, 2007). In this article, we thus study the barriers to innovation-related UICs for the case of Turkey and Istanbul in particular.

The present body of literature about UICs covers various topics such as forms of collaboration or transfer channels, enabling factors for successful collaboration as well as barriers to its success. Most studies, however, stem from an industrialized country context and if not focus on EM firms’ insights, primarily from China, India or Latin America, leaving other EM contexts under-researched (Jormanainen & Koveshnikov, 2012). As a result, the question arises as to how well theories and implicit assumptions from a Western context apply to EMs and whether there are chances to gain new insights for the generalizability of existing theories (Beyhan & Cetindamar, 2011; Collings et al., 2010; Liefner, 2013; Ramamurti & Singh, 2009). It is thus highly relevant to extend existing knowledge towards explorative studies from EMs to understand different experiences on the basis of varying institutional contexts and diverse economic structures (Cetindamar et al., 2009; Kruss & Visser, 2017) and thus be able to inform policy in respective economies (Filipetti & Savona, 2017). This is even more important considering the fact that EMs will play a major role in the future globalized economy, meaning that we need to learn more about these diverse settings and further develop the field of EM research (Nielsen et al., 2018) as well as expanding or enriching existing theories in new ways (Ramamurti, 2016). This is particularly true for the seven largest EMs according to their gross domestic product (GDP), namely Brazil, Russia, India, China, Mexico, Turkey and Indonesia (Guégan et al., 2014). For the Turkish case, barriers to UICs are also still under-researched with only few studies concerning this topic. For this reason, we extend the empirical scope on the barriers to UICs for the EM of Turkey.

In order to understand the emergence of innovations through regional collaborations, the regional contexts or settings play a major role for research and development (R&D) activities of firms and for the emergence and success of UICs. In this regard, regional innovation systems (RISs) denote a concept that involve institutions from industry, academia and politics as well as their interactions with each other (Cooke et al., 1997, 1998; Etzkowitz & Leydesdorff, 2000). Lee (2019) points out that it is vital for EMs to build their own innovation systems in which domestic firms can grow their capabilities instead of imitating practices used in established economies that might not be suitable.

In our case study of the Turkish context, we observe industrial firms’ collaboration activities with universities based in Istanbul and the Marmara region. By using an original survey sample of the R&D-related segment of manufacturing firms, we answer our

research question about obstacles to UICs during the innovation process: ‘What barriers prevent firms’ use of UICs for achieving innovation?’. Hereof, we use a logistic regression analysis to test several obstacles to UICs for two groups of firms that either do or do not use collaboration with universities as an external knowledge source during their innovation process. By doing so, we are able to identify barriers that actually prevent UICs and thus form a bottleneck to collaborations. Our findings reveal a lack of knowledge about UIC opportunities as well as insufficient external financial support as the two most relevant barriers to successful collaborations, which are in contrast to previous findings from the context of Turkey and other EMs. Moreover, it becomes apparent that trust issues and skill mismatches are perceived more strongly as barriers from the perspective of firms that actually do use UICs for innovative activities. We thus contribute to the literature that in EM contexts, external support for UICs is crucial, in terms of providing information about collaboration opportunities as well as direct financial support, enabling firms to collaborate with scientific partners. Moreover, our results show that we might need to differentiate between barriers preventing UICs and barriers affecting existing collaborations.

This paper is organized as follows. Firstly, the theoretical frameworks about the setting for innovations and barriers to UICs in EMs are presented. In doing so, hypotheses are developed based on the literature review of underlying theories and existing studies, primarily from EM contexts. Secondly, we provide insights about the contextual setting for innovation and UICs in Istanbul. Thirdly, our survey sampling, data collection, measurement of the variables and subsequent empirical data analysis are outlined. Following this, logistic regression analysis is used to test the impact of barriers to UICs in view of firms’ innovation strategies. Finally, results are discussed, limitations are outlined and economic, managerial and policy implications are drawn.

2 Theoretical frameworks and hypotheses development

2.1 The role of UICs in EMs

Lee (2019) identifies the failure to build innovation capability as one of the main failures that keep EM firms from catching up on established economies. This is particularly important for firms in EMs in relation to an increase in competition from foreign direct investments (FDIs) and the need for upgrading their technology (Figueiredo & Piana, 2021; Kotabe et al., 2011; Pavitt, 1990; Prahalad & Hamel, 1990).

Chari (2015) developed an integrated model for the main literature strands on EM firms’ catch-up and upgrading process, namely upgrading through spillovers, linkages, acquisitions and internal R&D. One of the main mechanisms for building innovative capabilities are spillovers from FDIs or international R&D alliances (Blomström & Kokko, 1998; Görg & Greenaway, 2004; Kim & Inkpen, 2005; Zhang et al., 2010). However, prior to accessing knowledge sources that are external to the firm, it is necessary that companies achieve and obtain sufficient levels of internal knowledge or R&D capacities (Barney, 1991; Eisenhardt & Martin, 2000; Teece et al., 1997) to successfully identify, adopt and use innovation or technologies (Abreu, 2011; Chesbrough, 2003; W. M. Cohen & Levinthal, 1989, 1990; Lin et al., 2002). In this regard, FDIs or the import of technology can facilitate the building of technological capabilities of EM firms only if absorptive capacities are prevalent (Kumar et al., 1999). Together with a strategic positioning in network structures, firms need these absorptive capabilities in order to enhance their performance and innovativeness (Stojčić,

2021; Tsai, 2001; Zaheer & Bell, 2005). A similar argument is raised by Lee (2019), who points out that many firms in EMs are unable to conduct in-house R&D, as they need to cultivate basic R&D capabilities in the first place. He therefore suggests that a more effective form of learning might be transferring R&D outcomes from public research institutes for building basic capabilities in the first place. Other studies have shown that knowledge sourcing from universities plays a major role for manufacturing firms as it evidently influences firms' innovativeness (Löf & Broström, 2008). Moreover, a study by Findik and Beyhan (2015) shows the impact of UICs on the innovation performance of Turkish firms and find a strong positive relationship between firms' product and process improvements and their collaborations with external partners. UICs thus provide firms in EMs with the opportunity to increase their internal R&D capabilities as well as their innovativeness consequently.

For becoming more competitive, UICs in terms of knowledge and technology transfer are thus considered the most important external knowledge source for firms (Kaufmann & Tödtling, 2001; Mascarenhas et al., 2018), particularly in EMs (Bastos et al., 2014; Guerrero et al., 2019; Mathews & Hu, 2007) and with universities that are spatially close by, as geographic proximity facilitates all forms of UICs and is positively associated with the frequency and quality of collaborations (Broström, 2010; Crescenzi et al., 2017; D'Este & Iammarino, 2010; D'Este et al., 2013; De Fuentes & Dutrénit, 2016; Laursen et al., 2011; Tang et al., 2020). The importance of close proximity between actors in a RIS is summarized in the triple helix model, which was originally developed within advanced market contexts. This concept captures the activities and interactions between the political sphere, academia and firms on an institutional level, and thus provides an ideal systematic approach for observing the emergence and development of knowledge within a regional environment (Etzkowitz & Leydesdorff, 2000). In industrialized country contexts, RISs are major success factors for thriving regional economic growth. Governmental institutions thus try to implement measures to strategically support firms in their innovative efforts and encourage the emergence of UICs. Further developments and adaptations of the model also allow the realization of its usage within a developing or EM setting, where it has previously been a normative rather than an analytic concept (Etzkowitz et al., 2005). On that account, an increasing number of EMs are establishing similar systems to foster innovation and regional economic development consequently (Albuquerque et al., 2015). Other scholars, however, criticize the triple helix concept as not providing a realistic guiding framework to discuss UICs in developing countries (Eun et al., 2006).

Nevertheless, within a RIS or triple helix concept, in addition to specific demands and requirements from the firm side or governance claims of regional policymakers, universities play a particular role and need to adapt prior to an interaction with industrial firms. The provision of a university-trained workforce through their tertiary education function is thus only a basic requirement for firms' upgrading (Lall, 2000), with a much greater need for the development of universities from having a sole focus on teaching and basic research to a more widened perspective or emerging 'third role' in terms of entrepreneurial engagement and application or commercialization of scientific knowledge (Etzkowitz et al., 2000). Ultimately, applied knowledge becomes the relevant factor for interacting with partners outside the scientific environment and fosters firms' capability development in particular in EMs. Different features or cultures of universities and firms, however, can constitute a principal barrier to UICs. Overall, it is thus important to note that universities are not simple repositories of exploitable knowledge that are easily available to firms. In contrast, existing obstacles to communication and technology transfer in UICs need appropriate mechanisms to remove respective barriers and facilitate bi-directional interactions (Uyarra, 2010).

It is also relevant to consider that universities in EMs might not be able to contribute to upgrading at the firm or regional level immediately, but need time to transform their organizational and functional structures in the first place to develop academic capacities or evolve into an entrepreneurial university. For the case of Central and Eastern Europe, Stojčić (2021) reveals the only very limited extent of UICs with at best incremental innovations or imitations as outcome of such collaborations (Stojčić, 2021). In a study by Schiller and Lee (2015) from five emerging Asian countries, the authors show that UICs do not have a statistically significant impact on the catch-up process of the respective EMs. These findings are based on low academic and technological capabilities at the university as well as the firm level, and consequently lead to only minor UICs. Instead, domestic firms rely on foreign knowledge sources or collaboration with customers and parent companies (Schiller & Lee, 2015). Ranga et al. (2016) analyze the technology transfer capacities of Turkish universities critically and emphasize their still nascent stage of UIC experiences. This finding is mainly based on weak technological foci and a lack of market or commercialization orientation that lead to several obstacles in terms of licensing, patenting and spin-offs (Ranga et al., 2016). Moreover, Temel et al. (2013) explored the effects of firms' collaboration with external partners and their innovativeness and find that UICs do not enhance firms' innovation success. The authors explain this finding with a rather strong teaching focus of Turkish universities, low absorptive capacities of Turkish firms and only a few efficient technology transfer offices (TTOs) available (Temel et al., 2013). It is thus unclear to what extent universities in EMs are even able to generate new knowledge or commercialize their research, promote a technological upgrading process and thus function as a driver of a high-technological development (Chatterjee & Sankaran, 2015; Doutriaux, 2003), as they might merely contribute in their educative function to build up human capital within learning systems (Schiller & Liefner, 2007).

2.2 Barriers to UICs and hypotheses development

In the next section, we shed some light on the literature about UIC barriers with an emphasis on EMs overall and Turkey in particular. The literature has investigated how UICs can work successfully through insights from firms' activities in industrialized or newly emerged economy contexts. Many review articles by Agrawal (2001), D'Este and Patel (2007), Bekkers and Bodas-Freitas (2008), Mascarenhas et al. (2018), Skute et al. (2019) as well as Rybnicek and Königsgruber (2019) provide systematic overviews of the state of UIC literature and identify theoretical key aspects of transfer or interaction channels and promoting factors of UICs.

In regard to UIC barriers from the perspective of industrial firms and academics, Ankras and AL-Tabbaa (2015) outline factors that either facilitate or impede UICs and sort these into categories of capacities and resources, legal and contractual mechanisms, managerial and organizational issues, technology-related issues, political and social issues as well as other potential obstacles. De Wit-de Vries et al. (2019) identify influencing factors of knowledge transfer in academic engagement that are related to cognitive and institutional differences, varieties of goals and social capital. Nsanzumuhire and Groot (2020) categorize existing studies about UIC obstacles into misalignment, motivation, capability, governance, and context-related barriers, and furthermore distinguish between factors from developed and developing countries. In terms of inhibiting factors for UICs, it is also relevant how many UIC barriers firms perceive. Antonioli et al. (2017) show that firms which only face single constraints use cooperation as a coping strategy to deal with the respective

barriers, whereas the presence of multiple and varying barriers inhibits the establishing of UICs, particularly if firms lack financial resources, skills or knowledge about markets and technologies (Antonioli et al., 2017). We follow these previous studies by summarizing four distinct categories of barriers: R&D capability, lack of external support structures, mismatch with collaboration partners and administrative barriers. In the subsequent sections, we present the development of our hypotheses based on this literature.

2.2.1 R&D capabilities' impact on UIC barriers

Internal knowledge sources and absorptive capacities are the two main determinants for incorporating incoming spillovers and increasing the likelihood and intensity of R&D-related UICs (Aristei et al., 2016; Beyhan & Fındık, 2014). D'Este et al. (2014) highlight the relevance of R&D-related personnel at firm level. Therefore, high levels of human capital or internal R&D capabilities have a positive impact on reducing firms' barriers to achieve innovations and can thus facilitate successful knowledge transfers with universities. Kanama and Nishikawa (2017) likewise mention the importance of internal knowledge or human resources with specific skills. The authors emphasize that firms engage less frequently in UICs when they face a shortage of R&D-related personnel that is capable of conducting search activities for appropriate collaboration partners or technology transfer (Kanama & Nishikawa, 2017). In addition, not only internal skills or capabilities, but also external resources are highly important for firms' innovation and upgrading strategies (Chesbrough, 2010; Cohen & Levinthal, 1989, 1990; Teece et al., 1997). This becomes even more relevant if firms lack internal R&D resources or have no knowledge about the regional economic environment. Technology transfers via UICs as an external knowledge source might therefore gain center stage in firms' successful innovation processes. Other studies also clearly show that the intensity of internal R&D positively and significantly stimulates R&D activities with external partners such as universities (Becker & Dietz, 2004; Bercovitz & Feldman, 2007).

In a study on the innovation success of R&D-oriented companies in Turkey, Kleiner-Schäfer and Liefner (2021) show that for domestic Turkish firms, internal R&D resources are the main success factor for achieving innovations, whereas external R&D resources have no influence. Respective firms thus still need to build their internal capabilities prior to assessing and using external knowledge and technology sources for their innovation activities. This is particularly true for technological knowledge sources that are related to collaboration and learning from scientific partners (Kleiner-Schäfer and Liefner, 2021). Furthermore, De Fuentes et al. (2020) explored perceived barriers to innovation on the part of successful and unsuccessful innovating firms for the EM settings of Turkey and Mexico. The authors identify diverse firm and context specific characteristics that influence firms' perception of barriers and that differ between successful and unsuccessful innovators. Their findings relate to financial, organizational, labor, regulatory as well as public support barriers. As a result, De Fuentes et al. (2020) show that for large unsuccessful firms, barriers related to qualified labor and a lack of public support are most relevant, whereas small firms perceive regulatory barriers as most hindering. Overall and highly important, low numbers of R&D personnel are a commonly perceived barrier to innovation (De Fuentes et al., 2020). Firms' internal R&D capabilities thus constitutes a highly relevant factor for diminishing innovation obstacles at firm level. Our study builds upon these findings, but we further extend the understanding of firms' innovation success with more detailed information about firms' external knowledge sourcing in terms of UICs and particularly barriers

to such. By doing so, we emphasize on the importance of UICs for the innovation success of firms in EMs.

Based on the importance of firms' internal knowledge, abilities or capabilities for UICs, we assume that higher R&D capabilities lower the barrier of using UICs for achieving innovation. We thus hypothesize:

H.1 Higher 'R&D capabilities' decrease the barrier to using UICs for innovation. (R&D capabilities)

2.2.2 External support barriers

D'Este et al. (2014) show that financial obstacles in terms of missing external funding for innovation are a highly relevant barrier for firms that already engage in innovation (D'Este et al., 2014). Therefore, public financial support is an important factor to lower the barriers for firms to engage in innovation. Public R&D funding and particularly firm size positively influence a firm's R&D proportion in external partnerships with universities and increase the chances for further or more intense UICs and R&D collaborations (Aristei et al., 2016; De Fuentes & Dutrénit, 2016; Fontana et al., 2006; Laursen & Salter, 2004; Segarra-Blasco & Arauzo-Carod, 2008; Yu & Lee, 2017). If internal R&D capabilities are scarce or missing, based on relatively smaller firm size, political or public financial support is thus all the more important.

In a study from Mexico, Guerrero et al. (2019) show that firms predominately use UICs to explore new knowledge, to gain access to resources and capabilities from universities, to engage in long-term and radical innovation activities as well as to access public funds and subsidies that are tied to mandatory UIC activities (Guerrero et al., 2019). In addition, Guerrero and Urbano (2017) also highlight positive effects of financial support for innovation that are only evident if firms successfully collaborate with universities (Guerrero & Urbano, 2017). D'Este and Perkmann (2011) suggest, however, that instead of solely or excessively focusing on financial incentives for industrial engagement in UICs, a more comprehensive policy strategy should be pursued for promoting collaboration, referring to the needs and requirements of scientific personnel rather than expecting a merely entrepreneurial mindset of universities and their academic researchers (D'Este & Perkmann, 2011).

Within the Turkish context, Beyhan and Rickne (2015) point out the relevance of industry funding and academics' motivations towards knowledge commercialization during UICs (Beyhan & Rickne, 2015). Temel and Glassman (2013) also emphasize the importance or necessity of funds for UICs for the case of Turkish firms and universities (Temel & Glassman, 2013). In a study on collaboration activities of Turkish manufacturing firms, however, Cetindamar and Ulusoy (2008) find that firms only collaborate with other firms to a high degree, although the impact on their innovation performances is very limited. In fact, collaboration with universities or scientific partners could even be neglected in terms of its impact on firms' innovativeness (Cetindamar & Ulusoy, 2008). Şendoğdu and Diken (2013) also find a positive correlation between the frequency of UICs and upcoming problems among Turkish firms in Konya (Şendoğdu & Diken, 2013). It thus becomes evident, that external support from governmental institutions play an important role to foster UICs with different means. In this regard, Yüksel and Cevher (2014) conducted a study about UIC processes in Turkey and identified the relevant institutions or measures that foster collaboration activities. The authors describe UICs as an emerging concept within Turkey with potential for improvement and identify several governmental programs

and institutions that constitute relevant support infrastructure for UICs (Yüksel & Cevher, 2014). Nevertheless, Yalçıntaş et al. (2015) observe different forms of UICs as not known well enough among scientific personnel, meaning that insufficient information as well as the setup and management of R&D projects are perceived as highly negative aspects. In this, TTOs are described as the most advantageous and effective support structure for UICs (Yalçıntaş et al., 2015). Moreover, Ciritcioglu et al. (2016) identify key obstacles to UICs among firms in the woodworking industry in the East Marmara region. According to the authors, most firms have insufficient knowledge about collaboration opportunities or have little interest therein. In addition, miscommunication between firms and universities seems to be the main reason for weak UICs, meaning that TTOs or technology support facilities can be helpful to strengthen collaborations (Ciritcioglu et al., 2016).

In terms of the importance of knowledge about UICs as well as the relevance of financial and political support to establish such, we assume that a lack of respective factors might inhibit firms' use of UICs for achieving innovation. We consequently hypothesize that:

- H.2 'Lack of information about UIC opportunities' increases the barrier to using UICs for innovation. (Information barrier)
- H.3 'Lack of financial support for UICs' increases the barrier to using UICs for innovation. (Financial support barrier)

2.2.3 Collaboration partner barriers

Bjursell and Engström (2019) find several hindering factors that influence UICs on the individual as well as on the intra- and inter-organizational level. The authors highlight the importance of removing collaboration obstacles rather than adding driving forces for UICs. In this regard, establishing trust and openness towards varying collaboration partners' needs or goals as well as implementing rewards systems and resource allocations are the most important measures to diminish UIC barriers (Bjursell & Engström, 2019). De Wit-de Vries et al. (2019) also emphasize that trust, communication, experience and the use of intermediary institutions are highly relevant facilitators to help resolve UIC barriers (de Wit-de Vries et al., 2019). Furthermore, findings from Bruneel et al. (2010) likewise show that establishing trust between firms and universities is the main mechanism for lowering barriers in UICs. This holds particularly true for diminishing or mitigating orientation and transaction-related barriers, referring to divergent expectations, varying rules and regulations, and protection of intellectual property rights (IPRs) (Bruneel et al., 2010). Giaretta (2014) likewise emphasizes the importance of trust builders in technology transfer relationships between firms and their external knowledge sources. Hereof, the author encourages a problem solution at firm level by implementing a dialogue facilitation model with internal personnel as boundary spanners between institutions (Giaretta, 2014). Moreover, Oliver et al. (2020) also highlight the importance of high levels of trust for successful UICs. The authors identify two levels of trust on both the individual and organizational level. In this regard, scientists' reputation as well as shared values are vital trust factors on the individual level, whereas efficiency and contract specification are relevant trust builders on the organizational level. Overall, complex processes on both levels and a lack of

collaboration experience often result in huge challenges to build and maintain trust in UICs (Oliver et al., 2020).

Gilsing et al. (2011) focus on the difference of technology transfer mechanisms and barriers between science-based and development-based industries and identify key aspects in both regimes. While the transfer mechanisms are relatively different from each other, the authors find distinct similarities among major barriers to the technology transfer process, such as conflicts of interest, risk of information leakage or too general scientific knowledge (Gilsing et al., 2011). Aycan (2001) likewise mentions an imbalance between science and practice, describing a partly negative attitude of Turkish firms towards using scientific knowledge sources (Aycan, 2001). For the EM of Brazil, Garcia et al. (2019) find transactional barriers in terms of trust and IPR issues as important factor inhibiting more collaboration between academics and industrial partners (Garcia et al., 2019). Furthermore, Lopes and Lussuamo (2021) find low experience levels and a lack of inter-organizational trust between firms and universities as the most frequent UIC barriers for the context of developing regions in EMs (Lopes & Lussuamo, 2021). Hall et al. (2001) show that IPR issues might act as an unbridgeable barrier between firms and universities, particularly if projects are rather short-term and knowledge or technologies are difficult to commercialize. In contrast, fewest barriers are present if projects are long-term-oriented, technologies are applicable for firms, and lead participants in UICs have prior knowledge therein (Hall et al., 2001). In addition, Temel and Glassman (2013) further highlight firms' perception of less skilled or less knowledgeable scientific personnel than their own employees as a major barrier preventing R&D collaborations between Turkish firms and universities (Temel & Glassman, 2013).

In this respect, a lack of trust and perceived inadequately skilled universities in the view of firms can lead to considerable collaboration process barriers, preventing the emergence of successful UICs. We thus hypothesize:

- H.4 'Lack of trust in collaboration partners' increases the barrier to using UICs for innovation. (Trust barrier)
- H.5 'Perception of inadequately skilled collaboration partners' increases the barrier to using UICs for innovation. (Skill barrier)

2.2.4 Administrative barriers

Bruneel et al. (2010) identify more 'classic' barriers related to institutional differences such as time orientation and administrative procedures as still remaining substantial in UICs (Bruneel et al., 2010). Tartari et al. (2012) specify two main sets of barriers to UICs that are related to the orientation of academic research and the transactional costs of collaborating with industrial firms. The authors find differences in timescales between academic researchers and firms as most important barrier to UICs. In this regard, research orientation-related barriers can be reduced by academics' experience with UICs or industrial work. Reducing transactional costs, however, is more complex, as these are often related to conflicts with TTOs, based on the intermediaries' low profiles and lack of flexibility. As a consequence, the operating environment plays a vital role for academics' engagement in UICs (Tartari et al., 2012). Furthermore, Muscio and Vallanti (2014) indicate perceived barriers that relate to a misalignment of commercial benefits or incentives of UICs,

conflicting collaboration goals as well as too much cognitive distance between academic research and business needs. This holds particularly true if collaboration partners are inexperienced in UICs (Muscio & Vallanti, 2014). In addition, Ramli and Senin (2015) identify various factors for diminishing orientation and resource-related barriers to UICs, as limited time and lacking resources are key factors that hinder successful collaborations (Ramli & Senin, 2015). Garcia et al. (2019) also note that perceived transactional factors or costs such as bureaucracies or administrative procedures act as a major barrier or discouragement to more collaboration with industrial firms in the EM of Brazil (Garcia et al., 2019). In an analysis of firms' commercialization of innovation, Stojčić (2021) also shows cognitive proximity between collaboration partners as more important than other proximity factors such as geographical, organizational or social proximity (Stojčić, 2021).

For the EM of Turkey, Aycan (2001) shows that a main aspect of firms' bias towards collaboration with academics is the time intensive factor, which is considered as highly costly for firms. Instead, Turkish organizations mostly worked with consulting firms that based their practices and knowledge on sources other than scientific knowledge (Aycan, 2001). Moreover, Demirbas et al. (2011) examine perceived barriers to innovation activities of Turkish small- and medium-sized enterprises (SMEs) and find institutional barriers such as formal, informal as well as financial and skill-related factors hindering firms' innovation performances. These include a lack of governmental R&D policies, increasing costs of innovation and lacking internal resources at the firm level (Demirbas et al., 2011). In their qualitative study with academics and industry experts, Peksatici and Ergun (2019) find diverging institutional logics or cultures together with resulting pressures for both sides as the main barrier to effective UICs within the aviation industry in Turkey (Peksatici & Ergun, 2019). In their study of Turkish firms and local universities, Temel and Glassman (2013) identify major obstacles preventing R&D collaborations between the two institutions. From the perspective of firms, the most important UIC barriers are the required time of scientific research procedures, highly bureaucratic decision-making processes and administrative costs among other factors. In this regard, the authors develop a model of building awareness, building trust and experience as well as providing transition opportunities to collaborations to diminish barriers and further encourage more UICs (Temel & Glassman, 2013).

Based on these more 'classic' administrative barriers, we assume that administrative or transaction costs as well as differences in pace for decision-making are still relevant factors inhibiting successful UICs. Therefore, we hypothesize that:

- H.6 'High administrative costs of UICs' increases the barrier to using UICs for innovation. (Cost barrier)
- H.7 'Differences in pace for decision-making' increases the barrier to using UICs for innovation. (Pace barrier)

2.2.5 Perceived versus deterring barriers

An alternative explanation of how the perception of barriers by firms might be influenced comes from D'Este et al. (2012) who study barriers to innovative activities in general. They distinguish between perceived and deterring barriers to innovation. *Perceived barriers*, which the authors call revealed barriers, are only perceived as barriers to innovation by firms that already engage in innovative activities because they have experienced those

barriers. In contrast, they define *detering barriers* that actually prevent firms from carrying out innovation activities in the first place and are therefore mainly experienced by non-innovative firms. This distinction has since been used by others studying firm innovativeness, finding that the firm's assessment of innovation barriers also depends on country contexts (De Fuentes et al., 2020). We use these insights on barriers for general innovative activities to critically evaluate how firms' perception of our four categories of barriers affecting UICs might differ. *R&D capabilities* as well as *external support barriers* can therefore be described as *detering barriers*, as they have a strong impact on the search of collaboration partners and its implementation. They will therefore prevent UICs from forming even before the collaboration has begun. However, *collaboration partner barriers* and *administrative barriers* are barriers that require a certain knowledge of the collaboration process and might therefore be described as *perceived barriers*. Therefore, this distinction of perceived and detering barriers can be helpful to bear in mind when analyzing barriers to innovative activities and interpreting potential effects. However, it is not yet clear if this distinction created to better understand innovativeness yields insights when investigating collaboration barriers.

3 Contextual setting for innovation and UICs

For many years, Turkey has been the leading economic and financial center between South-eastern Europe and the Middle East, and is currently transforming from an emerging to an industrialized market country (Etkin et al., 2000; Tatoglu & Demirbag, 2008). Based on its unique location between advanced Western and emerging Eastern Markets, the country is attracting increasing numbers of FDIs and multinational enterprises (MNEs) that are locating their R&D activities in Turkey (Ayden et al., 2018; Karabag et al., 2011). Furthermore, the country is perpetually transforming its economic structures into a more knowledge-based system, fostering innovation activities of its domestic firms and implementing measures in education as well as public and private R&D (Bakirci, 2018; Yildirim, 2017). Nevertheless, limited R&D activities together with a lack of technological knowledge result in low value-added of many Turkish firms, meaning that the export of high technological products remains at low levels (Yaşar, 2019). Identifying ways to increase the value-added of its domestic firms to raise productivity and move up in global value chains (GVCs) is therefore a highly important success factor for the country's future economic development. In this regard, it is relevant to understand firms' innovation strategies and their use of external resources in terms of collaboration with universities and political institutions.

For capturing the most relevant segment of R&D-related or innovation-oriented firms for our analysis, this study focuses on a survey sample from Istanbul and the surrounding Marmara region. The majority of manufacturing clusters in Turkey are located in the central or western regions, for instance in Istanbul and its neighboring provinces (Akgüngör, 2006). In comparison to other major cities within the country, Istanbul shows by far the highest concentration of firms and headquarters (HQs) and is home to the largest number of HQs of the top 500 corporations in Turkey (Ersoy, 2018). Moreover, the city accounts for more than 45% of net value added and production profit as well as more than half of all exports nationwide (Ersoy, 2018). Furthermore, of all regions within Turkey, Istanbul displays the highest levels of scientific or R&D-related personnel, the highest amount of technology product exports as well as the highest number of patents granted (Belgin, 2019; TUIK, 2019). With its agglomerations of knowledge-intensive industries, the city also has

an important bridging function to globalized knowledge networks (Ersoy, 2018). In addition, the city's surrounding Marmara regions show the highest location quotient values for medium and high-technology sectors in Turkey (Çelik et al., 2019). The metropolitan area of Istanbul is thus a major hub for most innovation and R&D-related activities of different types of firms and in particular for inward FDI of foreign MNEs, which provides an ideal setting for our study.

4 Quantitative research method and findings

4.1 Survey sampling and data collection

In order to answer our research question concerning potential barriers that might inhibit firms of using UICs for innovation we compiled the survey sample for the subsequent data analysis as follows.

Firstly, we used a database from TÜBİTAK, the leading agency for funding, management and conducting research in Turkey, for identifying the most R&D-related segment of firms in Turkey. As of 2015, this database included over 8500 firms nationwide that completed at least one R&D project funded by TÜBİTAK and of which nearly 4000 firms are located in Istanbul and the Marmara region. From this database, we compiled a new subset only involving manufacturing firms that are geographically located in Istanbul and that finalized at least three R&D projects successfully. In result, we identified 838 firms whose general managers and R&D executives were approached to participate in our study. Consequently, we received 265 questionnaires, 40 of which we omitted due to missing values or a lack of R&D-related activities. Overall, having an effective 26.85% (225 of 838) response rate is a satisfactory result given the topic and potential respondents. In terms of content validity of the questionnaire measures, we adopted the procedures suggested by Hair et al. (2007). Firstly, we conducted interviews with local R&D experts from universities, technology parks, TTOs, state-level institutions and manufacturing firms about the regional innovation environment for UICs and firms' R&D-related activities in Istanbul. Based on these findings and the extent literature review, we then developed an initial version of the questionnaire. Secondly, we revised the survey draft through discussion with other scholar experts. Finally, a pre-test of the survey was conducted with randomly selected firms and adjusted accordingly until the questionnaire reached an adequate level of clarity and maturity. The final survey took place in the first half of 2016.

4.2 Research framework

Overall, it is evident from our literature discussion that barriers to successful UICs can have various causes, such as a lack of information about collaboration partners or opportunities, lacking financial political support, a lack of trust, a perception of inadequately skilled collaboration partners or divergent expectations, as well as high administrative and bureaucratic burdens such as cost and time-related obstacles. In order to address the research question: 'What barriers prevent firms' use of UICs for achieving innovation?', the statistical model analyzes the effect of these barriers on the likelihood of firms not using UICs for innovation. The research framework following the hypotheses for the statistical analysis of this study is shown in Fig. 1.

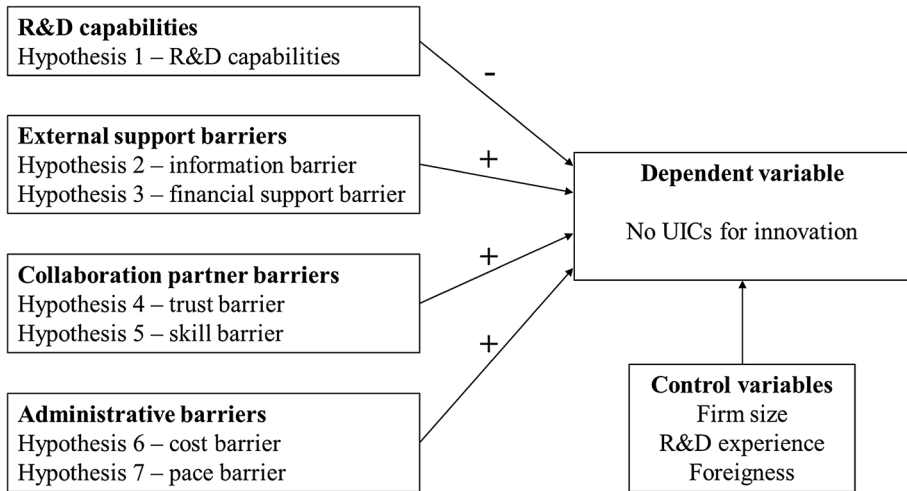


Fig. 1 Research framework. *Source:* own figure

4.3 Measurement of the variables

In the following section, the operationalization of these concepts as dependent, independent and control variables in the statistical analysis are described in detail and a summary is provided in Table 1.

The outcome or dependent variable is derived from a set of questions about firms' usage of various R&D resources during their innovation process: 'To what extent have the following aspects been used for achieving innovation in Istanbul and the Marmara region?' The respective answers were measured on a five-point Likert scale, ranging from '1-Frequently used' to '5-Never used' regarding the frequency of using 'collaboration with scientific partners' for achieving innovation. This variable is then transformed into a binary variable to distinguish firms that do and such that do not use UICs for their innovative activities. Firms that claim to 'never' or 'almost never' use UICs are denoted as 'not using UICs for achieving innovation' which is coded as 1 while other firms that use UICs for innovative activities are coded as 0.

The independent variable R&D capabilities is a categorical variable measured as R&D expenditure of total sales. The independent UIC barrier variables are derived from a question about different factors concerning barriers to collaboration with scientific partners: 'To what extent have the following aspects been important barriers to collaboration with regional scientific partners?'. The answers are likewise based on a five-point Likert scale, ranging in their importance levels from '1-Not at all important' to '5-Very important'. Consequently, the higher the value of the selected answer, the more relevant is the barrier to UICs. The variables are derived from the following items: 'Insufficient knowledge about collaboration opportunities' as *information barrier*, 'Insufficient financial support or incentives for collaboration' as *financial support barrier*, the mean score of 'Low confidence in collaboration partners concerning handling sensitive information' and 'Low confidence in collaboration partners due to intellectual property rights' together as *trust barriers*, 'Inadequately skilled collaboration partners (nothing to offer)' as *skill barrier*, 'High bureaucracy or administration costs' as *cost barrier* and 'Length of time for decision making or

Table 1 Operationalization of the variables used for data analysis. *Source:* own table

Variable name	Measurement	Description
<i>Dependent variable</i>		
No UICs for innovation	Binary (1/0)	UICs have never or almost never been used for achieving innovation in Istanbul (1) and UICs have sometimes, almost every time or frequently been used for achieving innovation in Istanbul (0)
<i>Independent variables</i>		
R&D capabilities	Ordinal (1–5)	R&D expenditure of total sales (percentage)
Trust barrier	Ordinal (1–5)	Low confidence in collaboration partners concerning handling sensitive information + Low confidence in collaboration partners due to intellectual property rights (Level of barrier importance for not using UICs)
Information barrier	Ordinal (1–5)	Insufficient knowledge about collaboration opportunities (Level of barrier importance for not using UICs)
Skill barrier	Ordinal (1–5)	Inadequately skilled collaboration partners (partners have nothing to offer) (Level of barrier importance for not using UICs)
Cost barrier	Ordinal (1–5)	High bureaucracy or administration costs (Level of barrier importance for not using UICs)
Pace barrier	Ordinal (1–5)	Length of time for decision making or response (Level of barrier importance for not using UICs)
Financial support barrier	Ordinal (1–5)	Insufficient financial support or incentives for collaboration (Level of barrier importance for not using UICs)
<i>Control variables</i>		
Firm size	Ordinal (1–6)	Total employees (number)
R&D experience	Ordinal (1–5)	Time spent conducting R&D in Istanbul (years)
Foreign MNE	Binary (1/0)	Foreign MNE (1) and Turkish firm (0)

response' as *pace barrier*. In the analysis, we test the impact of the respective barriers on using UICs as an external knowledge source for achieving innovation. Using this approach, we are able to identify barriers that actually prevent UICs and therefore represent a bottleneck to UICs.

In addition, we used control variables to control for additional influences and test the robustness of the observed results for UIC barriers that are also measured on a five-point Likert scale. The variables *R&D experience* and *firm size* control for firms' internal R&D capabilities. We assume that larger and more experienced firms have more resources to use UICs for achieving innovation. Moreover, studies show that firms' size structures provide consistently explanation for differences in overcoming barriers to UICs or R&D collaborations across all sectors (de Moraes Silva et al., 2018). The dichotomous variable *foreign MNE* observes the influence of firms' foreign ownership, as we assume that the respective group of firms tend to collaborate more successfully with universities. These control variables are commonly used in similar studies at the firm level (Fontana et al., 2006; Laursen & Salter, 2004; Liefner et al., 2006; Yu & Lee, 2017).

4.4 Data analysis

Firm-level barriers to UICs or innovation can be considered from different angles. Perceived barriers to innovation might be discerned by successful and unsuccessful innovators (De Fuentes et al., 2020), between postponed and abandoned innovation projects (Galia & Legros, 2004), by difficulties that prevent firms from undertaking innovation activities in the first place or differentiate between barriers that stop firms from further engaging during their innovation process (D'Este et al., 2012, 2014). In addition, Blanchard et al. (2013) highlight the importance of distinguishing between firms that either fail or do not even intend to innovate, to measure barriers to innovation performances properly. In our survey sample, we observed firms that engage in R&D-related activities and are willing to collaborate with universities, but which either do or do not use UICs as an external knowledge source for achieving innovation.

Subsequently, logistic regression analysis is used to estimate the effects of the barriers to UICs on the outcome variable of firms that do not use UICs for achieving innovation. For this, the logistic regression models can be expressed as:

$$P(Y_i = 1) = \frac{1}{1 + e^{-(\alpha + X_i\beta)}}$$

Here, Y_i is the dependent variable, which is a dummy variable with a value of zero or one, where a value of zero denotes the probability of an event not occurring rather than another denoted by one. The intercept is described as α , and X_i is the vector of the independent as well as control variables, with β as the vector of the regression parameters (Amemiya, 1981). The value of the regression coefficient β estimates the impact of the independent on the dependent variable, where a coefficient above one increases the probability of an event occurring, while a value below one implies the opposite effect on the outcome variable. Here, the regression coefficients estimate the probability of firms that are not using UICs for achieving innovation. Coefficient results are reported as exponentiation of the β coefficient ($Exp(\beta)$), given an odds ratio of the independent variables.

4.5 Descriptive statistics

Tables 2 and 3 provide a descriptive overview over the variables, differentiated between firms that use UICs for achieving innovation and firms that do not (No UICs). Table 4 provides the Spearman's rank correlation matrix of the independent and control variables for the survey. All correlation coefficients between the independent variables show positive and highly significant pairwise correlations with weak to moderate correlations (Akoglu, 2018). This shows that, as expected, all UIC barriers moderately and positively correlate among each other. In particular, both administrative barriers *cost barrier* and *pace barrier* as well as the external support barrier *financial support barrier* are positively correlated. Furthermore, most control variables indicate no correlation among each other or with independent variables; however, the *firm size* is correlated positively with the variable *R&D experience*. In addition, significant negative correlations of *financial support barriers* with *firm size* can be observed, indicating that large foreign firms might not assess a lack of financial political support as a relevant barrier to UICs.

4.6 Analytic statistical results

The subsequent results of the logistic regression analysis are reported in Table 5. In terms of hypotheses testing, model one serves as the baseline model and model two incorporates control variables to validate the effects of the independent variables.

Regarding model one, a total of five variables indicate a statistically significant impact on the outcome variable, however only two independent variables are positively related to not using UICs for achieving innovation. These are *information barriers* ($\text{Exp}(\beta) = 1.479$, $p < 0.1$) and *financial support barriers* ($\text{Exp}(\beta) = 1.734$, $p < 0.05$). Firms perceiving these types of barriers thus have a 47.9 and 73.4% higher chance of being prevented from using UICs for achieving innovation. Consequently, hypotheses two and three are accepted. Further, the variable R&D capabilities is significantly negative related to the dependent variable shown by an exponentiated value under 1 ($\text{Exp}(\beta) = 0.578$, $p < 0.05$), which confirms hypothesis one that lower R&D capabilities prevent from successful UIC collaboration in the innovative segment. In contrast, both variables concerning *trust barriers* ($\text{Exp}(\beta) = 0.571$, $p < 0.05$) and *skill barriers* ($\text{Exp}(\beta) = 0.536$, $p < 0.01$) have a significant negative impact on the independent variable. This means that those barriers are perceived as higher for firms that do use UICs for creating innovations. This is a highly interesting finding, as those variables are both collaboration partner barriers that indicate how firms perceived the relation to their university based partners. This finding suggests that firms that do successfully collaborate perceived trust issues and skill mismatch as higher barriers than firms that do not collaborate, indicating that these are issues that arise only during collaboration for innovation and seem not to be a concern before starting the collaboration. This finding therefore suggests that the distinction between *detering* versus *perceived* barriers might hold for some UIC barriers as discussed by D'Este et al. (2012) or innovativeness in general, because collaboration partner barriers might indeed be *perceived* barriers. The other two administrative barriers, *cost barriers* and *pace barriers*, have no statistically significant effect on the outcome variable and thus seem to be less relevant for explaining which firms are prevented from using UICs for innovation.

In model two, considering the control variables, the same five independent variables still show a statistically significant impact on the outcome variable. Both variables *information*

Table 2 Descriptive figures of the categorical variables. *Source:* own table and calculations

	Total		UICs		No UICs	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
<i>Firm size (total employees)</i>						
<250	112	50.0	88	46.6	24	68.6
250–499	43	19.2	39	20.6	4	11.4
500–999	23	10.3	20	10.6	3	8.6
1000–1999	11	4.9	9	4.8	2	5.7
2000–5000	19	8.5	18	9.5	1	2.9
> 5000	16	7.1	15	7.9	1	2.9
<i>R&D experience (time spent conducting R&D)</i>						
<5 years	39	17.7	29	14.4	10	31.3
5–10 years	57	25.9	49	26.1	8	25.0
11–20 years	54	24.5	50	26.6	4	12.5
21–40 years	45	20.5	36	19.1	9	28.1
> 40 years	25	11.4	24	12.8	1	3.1
<i>R&D capabilities (R&D expenditure of total sales)</i>						
<20%	110	50.5	83	45.1	27	79.4
21–40%	48	22.0	45	24.5	3	8.8
41–60%	28	12.8	25	13.6	3	8.8
61–80%	12	5.5	12	6.5	0	0
> 80%	20	9.2	19	10.3	1	2.9
<i>N</i>	225		190		35	

Table 3 Descriptive figures of the barrier variables. *Source:* own table and calculations

Barrier variables	Total			UICs			No UICs		
	\bar{x}	<i>SD</i>	<i>Mdn</i>	\bar{x}	<i>SD</i>	<i>Mdn</i>	\bar{x}	<i>SD</i>	<i>Mdn</i>
Trust barrier	3.24	1.05	3.50	3.32	1.03	3.50	2.77	1.05	3.00
Information barrier	3.32	1.20	3.00	3.31	1.17	3.00	3.33	1.36	4.00
Skill barrier	3.22	1.18	3.00	3.32	1.17	3.00	2.67	1.11	3.00
Cost barrier	3.31	1.25	4.00	3.35	1.21	4.00	3.03	1.42	3.00
Pace barrier	3.47	1.21	4.00	3.48	1.18	4.00	3.36	1.39	4.00
Financial support barrier	3.50	1.25	4.00	3.47	1.24	4.00	3.67	1.36	4.00
<i>N</i>	225			190			35		

\bar{x} arithmetic mean, *SD* standard deviation, *Mdn* median

barrier ($\text{Exp}(\beta)=1.572$, $p<0.1$) and *financial support barrier* ($\text{Exp}(\beta)=1.639$, $p<0.1$) have a positive impact on not using UICs for achieving innovation, with a 57.2 and 63.9% higher chance respectively. In the same way, the variables *trust barrier* ($\text{Exp}(\beta)=0.571$, $p<0.05$) and *skill barrier* ($\text{Exp}(\beta)=0.525$, $p<0.01$) indicate a negative effect on the dependent variable. No significant impact of the variables according to hypotheses six and seven can be found. Overall, results from baseline model one are robust.

Table 4 Correlation matrix (Spearman's r-square) of the independent and control variables. *Source:* own table and calculations

	R&D capabilities	Information barrier	Financial support barrier	Trust barrier	Skill barrier	Cost barrier	Pace barrier	Firm size
Information barrier	-0.060	1						
Financial support barrier	-0.062	0.393***	1					
Trust barrier	0.033	0.387***	0.297***	1				
Skill barrier	0.063	0.510***	0.394***	0.418***	1			
Cost barrier	0.054	0.342***	0.528***	0.258***	0.401***	1		
Pace barrier	0.012	0.439***	0.568***	0.277***	0.384***	0.665***	1	
Firm size	0.047	-0.072	-0.163	0.045	-0.017	-0.051	-0.056***	1
R&D experience	0.020	-0.026	0.035**	0.014	-0.026	0.106	0.039	0.328

*** $p < 0.05$; ** $p < 0.01$

Table 5 Logistic regression with 'No UICs for innovation' as dependent variable. *Source:* own table and calculations

	<i>Dependent variable</i> No UICs for innovation	
	(1)	(2)
	Logit	Logit
R&D capabilities	0.578** (0.340–0.872)	0.637** (0.381–0.952)
Information barrier	1.479* (0.955–2.343)	1.572* (0.982–2.602)
Financial support barrier	1.734** (1.113–2.803)	1.639* (0.984–2.854)
Trust barrier	0.571** (0.349–0.909)	0.571** (0.340–0.938)
Skill barrier	0.536*** (0.335–0.842)	0.525*** (0.320–0.837)
Cost barrier	0.728 (0.464–1.151)	0.696 (0.427–1.144)
Pace barrier	1.004 (0.593–1.710)	1.064 (0.603–1.909)
<i>Control variables</i>		
Firm size		0.910 (0.606–1.291)
R&D experience		0.826 (0.564–1.191)
Foreign MNE		0.191* (0.024–0.870)
Constant	1.701	3.340
Observations	211	206
Log likelihood	–73.239	–65.103
Akaike Inf. Crit	162.478	152.206
Model chi-square	33.115***	37.219***
Cox and Snell r-square	0.145	0.165
Nagelkerke r-square	0.253	0.297
Effect size (Nagelkerke r-square)	0.339	0.422
Hosmer and Lemeshow chi-square	8.738	3.270

95%-confidence interval in parentheses

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

Concerning the control variables in model two, only *foreign MNE* ($\text{Exp}(\beta) = 0.191$, $p < 0.1$) has a statistically significant negative impact on the dependent variable. Consequently, firms being of foreign ownership are more likely to use UICs for achieving innovation. Interestingly, both *firm size* and *R&D experience* in Istanbul have no statistically significant impact.

In summary, Fig. 2 provides the results for all hypotheses tested during the logistic regression analysis. We find full support for hypotheses one, two and three. Hypotheses four and five are rejected as the variables show an interesting negative relation to the

Hypotheses	Result
R&D capabilities Hypothesis 1 – R&D capabilities	➔ supported
External support barriers Hypothesis 2 – information barrier Hypothesis 3 – financial support barrier	➔ supported
Collaboration partner barriers Hypothesis 4 – trust barrier Hypothesis 5 – skill barrier	➔ reverse effect
Administrative barriers Hypothesis 6 – cost barrier Hypothesis 7 – pace barrier	➔ no effect

Fig. 2 Summary of results. Sources: own table

dependent variable contrary to what we would have expected from the literature. We find no evidence that would support hypotheses six and seven.

4.7 Robustness checks

Starting with the reliability measures reported for both models in Table 5, both models indicate a good overall fit for the chosen variables with highly significant chi-square values ($p < 0.01$), meaning that our predicted models fit significantly better for the survey sample than a null mode. Moreover, the Cox and Snell and Nagelkerke pseudo r-square values likewise indicate a good overall fit for both models. Based on the Nagelkerke r-square values, about 20% of the variance in baseline model one and about 30% in model two (with control variables) are explained. In addition, large effect sizes of both models indicate a good validity for subsequent data analysis (J. Cohen, 1992). Finally, chi-square values of the Hosmer and Lemeshow test indicate no significant differences between predicted and observed variables in both models. Consequently, another good overall fit for the independent and control variables can be assumed (Hosmer et al., 2013).

In order to account for multicollinearity in the models, we calculate the variance inflation factor (VIF) for the independent and control variables in Table 6. The results show that all values are rather low and no VIF is higher than 10 (Kutner et al., 2005) or even higher than the more strict threshold suggested by some which is 5. This shows that multicollinearity is not a problem in the statistical models for this analysis.

However, to address any potentially remaining endogeneity issues, we use an instrumental variable as a robustness check for the impact of the independent variable *information barriers*. We use the variable *low interest* representing *low interest in collaboration with scientific partners* as an instrument, as this variable has a direct influence on how the firm perceives barriers to collaboration. If the company has low interest in collaborating with scientific partners, it will perceive lack of information, which scientific partners would be fitting for a collaboration, as a higher barrier because it is less motivated to invest in an

Table 6 Variance inflation factor for independent variables.
Source: own calculations

Independent variable	VIF
R&D capabilities	1.024
Information barrier	1.816
Financial support barrier	2.340
Trust barrier	1.433
Skill barrier	1.611
Cost barrier	2.019
Pace barrier	2.517
R&D experience	1.176
Firm size	1.105
Foreign MNE	1.092

appropriate search strategy to overcome it. The instrumental variable is highly correlated with the variable *information barriers*. Moreover, this variable does not directly influence the dependent variable *No UICs for innovation* but only via the variable *information barriers*, making it a valid instrument for the robustness check (Wooldridge, 2002). We use the R package *ivtools* by Sjolander and Martinussen (2019) for the two-stage estimation. Moreover, we add a control function to the set of variables in the second stage model to reduce bias (Vansteelandt et al., 2011). The results in Table 7 show that using the instrument does not cause larger changes in the model. In fact, the effect size of most variables slightly increases and the statistical significance of the independent variable we used the instrument on increases. The results of this robustness check show that we do not expect any issues of endogeneity for this variable effect on the dependent variable of the model.

We also conducted a robustness check by including the independent variables as dummies in the Logit model as shown in the ‘Appendix’ in Table 8. The results show that the direction of the effects of all significant variables remains stable. The dummy for *information barrier* and *R&D capabilities* dummy now fall to a lower level of significance due to the reduction of information by dichotomizing the variables but the direction of the effect remains stable for both variables. The results can therefore be assumed robust.

5 Discussion

In the following, we are discussing the results of our survey data analysis. The statistical results show that external support barriers, in particular *information barriers* and *financial support barriers*, are the main barriers inhibiting UICs for the surveyed firms. These statistical results indicate that firms often recognize their need for R&D-related collaborations and have distinct ideas on what to develop, but still have no or only insufficient knowledge about where to find appropriate collaboration partners at universities. These findings thus emphasize the relevance of TTOs in the RIS for initiating UICs through providing information on collaboration opportunities and hence reduce search costs for firms.

Furthermore, our findings suggest that more common or ‘classic’ perceived barriers between firms and universities (Bruneel et al., 2010), which are presented in our analysis as administrative barriers such as *cost barriers* and *pace barriers*, do not influence firms’ usage of UICs in their innovation processes. For the surveyed firms in our sample, we find that these initial difficulties are no relevant obstacles to collaboration with universities. In

Table 7 Robustness check with instrumental variable

	<i>Dependent variable</i> No UICs for innovation	
	(2)	(5)
	Logit	2-stage GLM
R&D capabilities	0.637**	0.632**
Information barrier	1.572*	1.590**
Financial support barrier	1.639*	1.634**
Trust barrier	0.571**	0.597**
Skill barrier	0.525***	0.542**
Cost barrier	0.696	0.618
Pace barrier	1.064	1.071
Firm size	0.910	0.903
R&D experience	0.826	0.834
Foreign MNE	0.191*	0.207*
Constant	3.340	3.642
Observations	206	206

In model 3, the independent variable *information barrier* is instrumented with the variable *low interest*

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

addition, some barriers even have a statistically negative impact on the dependent variable. For instance, *trust barriers* has a significant negative impact on not using UICs for achieving innovation. This result suggests that for firms in our sample, IPR concerns do not act as a barrier to establish UICs in the first place and thus relate to findings by Bercovitz and Feldman (2007), who show evidence that firms prefer universities as external R&D collaboration partners over other firms, particularly if IPR conflicts are perceived (Bercovitz & Feldman, 2007). Moreover, the significantly negative relation here suggests that conversely IPR issues are only a concern for firms that already collaborate with scientific partners. In the same way, firms' perception of *skill barriers* has a significantly negative impact on not using UICs for achieving innovation. The *skill barrier* is thus perceived as higher by firms that already use UICs for innovation and does not prevent them from establishing collaborations in the first place, following the discussion on *perceived* versus *detering* barriers for innovations. This finding shows that in-depth knowledge about the skills of the partner is only gained after the collaboration started. Therefore, the surveyed firms that do not collaborate do not perceive universities as inadequate skilled collaboration partners, while firms that do collaborate find this an issue.

In previous studies, a lack of internal resources or absorptive capacities was found to be the main barrier for firms to access external knowledge sources and establish UICs in the first place. Our results emphasize the importance of high R&D capabilities for decreasing barriers to use UICs. In addition, we control for firms' size and their time spent conducting R&D in Istanbul as further determinants for absorptive capacities and successful collaboration with external partners (Fontana et al., 2006; Laursen & Salter, 2004; Liefner et al.,

2006; Yu & Lee, 2017). The statistical effects of firms' size and time spent conducting R&D in Istanbul are both insignificant. This indeed is the case, as we observed both large firms and SMEs that are successful in achieving innovation and keen to engage in UICs. We cannot confirm that smaller firms are less in favor of using UICs for achieving innovation. In terms of the time spent conducting R&D in Istanbul, the non-significant but negative impact might also be related to the mix of various firm types that have either operated in Istanbul for a long time, are young and only recently established firms, or are MNEs that have only recently invested in Turkey. The significantly negative impact of *R&D capabilities* on not using UICs elucidates the importance of internal R&D resources. Additionally, the dummy variable *foreign MNE* has a negative and significant impact on not using UICs, meaning that the probability of not using UICs in the innovation process is higher for Turkish firms and lower for foreign MNEs. These results are in contrast to findings from similar EMs or the Turkish context, in which the likelihood of universities collaborating with foreign firms' is not higher than for their domestic competitors (Beyhan & Findik, 2014; Segarra-Blasco & Arauzo-Carod, 2008).

6 Conclusion and implications

This study has focused on barriers to UICs in the EM of Turkey. In this regard, we conducted a logistic regression analysis with survey data from R&D-related manufacturing firms in Istanbul. By doing so, we addressed the research question: 'What barriers prevent firms' use of UICs for achieving innovation?'. In this last section, we point out the limitations of our study and provide theoretical, managerial and policy implications separately.

6.1 Limitations

There are some limitations to the results of this study. Firstly, using Turkey as a single-country setting might limit the generalizability of our findings to other EMs. It would thus be helpful to conduct similar research in other EM contexts to compare the outcomes of this study and further extend the literature on UIC barriers in EMs. Secondly, the geographical focus on Istanbul as well as on a R&D-related segment of manufacturing firms produces specific outcomes for a certain type of firm, particularly with regard to their innovation activities, UIC experience and in metropolitan regions. However, we gained important knowledge for a sub-group of firms that engage in innovation and R&D activities and differ between using and not using UICs as external knowledge source for achieving innovation. Finally, as the definition suggests, UICs are a two-sided topic and we only focused on the statistical analysis of barriers from the perspective of firms. It is clear that obstacles to UICs are not only one-sided, but affect both firms and universities in similar ways. In this study, we were only able to obtain statistical information from the viewpoint of firms. Nevertheless, there might be differences regarding what universities or firms perceive as the main barriers and how to deal with obstacles to UICs respectively that warrant further research. A qualitative analysis with relevant stakeholders or experts from the scientific

and political environment in Istanbul would be desirable in order to extend our understanding of UICs building upon our present findings.

6.2 Theoretical implications

Our findings contribute to the understanding of UIC barriers in EMs as well as to the understanding of the role of RISs for UICs in this setting. In this regard, our results reveal that the two most relevant barriers to using UICs for innovation are related to external support for UICs: a *lack of information about UIC opportunities* and a *lack of financial support for UICs*. Moreover, higher internal R&D capabilities significantly decrease barriers to UICs. ‘Classical’ barriers to UICs such as cost- and pace-related barriers show no significant effect on using UICs for innovation in our survey sample. These findings indicate that commonly anticipated barriers in previous studies from the Turkish or EMs’ context might be less relevant obstacles of using UICs for achieving innovation than previously assumed. For our R&D-related segment of firms, we thus assume that firms are already aware of the requirements and potential problems of UICs and mostly suffer from underperforming RISs with potentially ineffective TTOs that would be in charge of providing *information about UIC opportunities*. In this regard, our findings reconfirm the high relevance of variables that rely on a regional support infrastructure for the emergence of innovation activities and UICs in EMs. In terms of *insufficient financial support* for UICs, the significance of governance in RISs and a proactive fostering of firms’ innovation activities becomes evident. This is particularly important for firms that lack *R&D capabilities*, as having such internal resources significantly decreases barriers to UICs.

In terms of a *lack of information about UIC opportunities*, the need becomes relevant for a functioning support infrastructure with intermediary institutions at the regional level to ensure communications and interactions between firms, universities and politics (Cunningham & Link, 2015; Uyerra, 2010). Well-functioning innovation systems with close collaborations between all actors are the main success factor for diminishing previously identified barriers of insufficient knowledge about UIC opportunities that might hinder the emergence of such. Our findings hence suggest the importance of putting intermediary or organizational structures such as TTOs in place that raise the awareness for engagement between universities’ and firms’ with each other. Moreover, TTOs are thus not only important to act as boundary spanner to bridge potential problems or cognitive barriers during UICs, but could play an increasingly proactive role in signaling interest and providing *information about UIC opportunities* towards firms as part of a supporting RISs.

Another crucial insight this study provides to the literature, is that we find significant negative effects for *collaboration partner barriers* relating to a *lack of trust* and firms’ perception of *inadequately skilled collaboration partners*. This finding suggests that we need

to distinguish between barriers that prevent firms from seeking or establishing collaborations with scientific partners such as the *external support barriers* discussed, and barriers that are only relevant for firms that are already involved in UICs and prevent efficiency of ongoing collaborations, as these might considerably differ. This is similar to the discussion on barriers to innovative activities distinguishing between *perceived* and *deterring* barriers by D'Este et al. (2012) as well as recent findings by De Fuentes et al. (2020), and might be relevant for the context of UICs as well. Therefore, future studies should pay attention to differentiate between barriers in ex ante, early and mature stages of UICs in order to differentiate which barriers actually deter firms from collaborating. Moreover, more qualitative evidence is needed in order to assess if and how the concept of *perceived* and *deterring* barriers can be applied to research on collaboration barriers.

6.3 Managerial implications

Based on the firm-level evidence of this study, we are able to provide suggestions for managers to deal with barriers that might inhibit the use of UICs for achieving innovation. A main result of our analysis is that a *lack of information about collaboration opportunities* acts as a significant barrier, impeding UICs. In relation to this result, Fontana et al. (2006) highlight the importance of firms' openness to their external environment. This can be measured by a process involving the initial implementation of search strategies for potential collaborations, a subsequent in-depth screening to identify the best UIC opportunities, and a final signaling stage to convince prospective partners (Fontana et al., 2006). Developing strategies to identify potential collaboration partners are thus valuable suggestions for managers of our survey as well. Although the signaling of UIC opportunities or joint R&D projects is an associated task of universities or TTOs initially, firms likewise need to play a much more active role in searching for and screening of UIC opportunities as well as signaling interest to establish UICs consequently.

In addition, firms should continuously invest in highly skilled human capital and R&D-related personnel in particular, as these employees not only provide the firms with certain skills and knowledge, but are also a key success factor for identifying and establishing UICs, and hence for consistently overcoming major barriers to innovation activities (D'Este et al., 2014; De Fuentes et al., 2020). This is also reflected in our results that having *R&D capabilities* significantly decreases the barrier to use UICs for achieving innovation. Consequently, firms that invest highly in their internal R&D capabilities and personnel are less likely to face barriers to UICs. This also involves the search for *financial*

support from political institutions, particularly if internal resources or R&D capabilities are scarce.

6.4 Policy implications

The statistically positive impact of the *financial support barrier* indicates quite clear policy implications, however, financial support for UICs are not only relevant as a direct support measure to foster UICs. In this respect, Özçelik and Taymaz (2008) likewise show that public R&D support initiate more private R&D investments or R&D expenditures at the firm level, particularly for smaller firms and for EM contexts (Özçelik & Taymaz, 2008). Therefore, public R&D spending can simultaneously bolster firms' internal capabilities or absorptive capacities in the first place, enabling them to increasingly make use of external technologies or knowledge sources. This is particularly important as we find evidence that firms' *R&D capabilities* have a considerable positive effect to reduce UIC barriers. Therefore, it is highly important that policies reduce firms' perception of innovation costs to foster R&D investments at firm level and increase capacity building, particularly of domestic firms (Santiago et al., 2017). In addition, political institutions should not only increase the awareness of public support, but most notably improve the conditions for accessing public incentives, for instance through reducing bureaucracy and training for governmental staff (De Fuentes et al., 2020).

In addition, we observe *information barriers* as another highly relevant barrier that has an impeding effect on the use of UICs for innovation. In result, this calls for direct policy support or directing universities' attention to considering the high relevance of TTOs for UICs, as it would be the TTOs task to provide this information to firms. The creation as well as further support of TTOs would be a crucial strategy to pursue in the future, particularly as firms seem to have insufficient knowledge about collaboration opportunities. TTOs can be of great help in this regard, as to signaling interest in UICs towards firms, pointing out collaboration possibilities, actively approach firms and provide dependability during the collaboration phase. Consequently, developing the marketing skills of TTOs' personnel might be of great help in finding external collaboration partners as well as purchasers or users of applied scientific knowledge.

Overall, the key elements for future economic development within EMs is a mix of knowledge sources that are external to firms. Therefore, political support in the form of bringing firms and universities together and providing information about UIC opportunities are highly relevant success factors. In this regard, providing collaboration platforms and networking events for universities and industrial firms or creating online platforms to match overlapping research interests of institutions can be a very helpful policy assistance concerning this matter.

Appendix

See Table 8.

Table 8 Robustness check with independent variables as dummies

	<i>Dependent variable</i> No UICs for innovation (6) Logit
R&D capabilities dummy	0.157* (0.008–0.841)
Information barrier dummy	1.718 (0.673–4.486)
Financial support barrier dummy	4.568*** (1.717–13.352)
Trust barrier dummy	0.335** (0.127–0.827)
Skill barrier dummy	0.207*** (0.066–0.581)
Cost barrier dummy	0.739 (0.263–2.087)
Pace barrier dummy	0.844 (0.291–2.457)
Constant	0.202
Observations	211
Log Likelihood	– 73.380
Akaike Inf. Crit	162.759

95%-confidence interval in parentheses

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

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Availability of data and material Research data are not shared. The data are not publicly available due to privacy or ethical restrictions.

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