The relationship between university–industry collaboration, absorptive capacity, and technological innovation: Evidence from Turkey

Üniversite-sanayi iş birliği, özümseme kapasitesi ve teknoloji inovasyonu arasındaki ilişki: Türkiye'den kanıtlar

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Abstract

University-Industry Collaborations (UICs) are a priority in the literature as significant research areas. However, the relationship between university-industry collaborations and technological innovation performance is still in its infancy in emerging countries, such as Turkey. This research aims to investigate the relationships among UICs, firms' absorptive capacity (both potential and realized), and technological innovations (exploitative and exploratory). The research gap in this area continues. Thus, drawing on a mediation analysis of 170 firms in Istanbul, this study finds a positive relationship between UICs and potential absorptive capacity (PACAP), realized absorptive capacity (RACAP), and exploitative technological innovation. RACAP positively affects exploitative and explorative technological innovations and mediates the relationship between UICs and exploitative technological innovation. PACAP positively influences RACAP. Based on these findings, the research discusses theoretical and practical implications.

Keywords: Collaborations, Absorptive Capacity, Technological Innovation

Jel Codes: O31, O32, O33

Öz

Üniversite-Sanayi İş Birlikleri (ÜSİ), literatürde önemli bir araştırma alanıdır. Özellikle, üniversite-sanayi iş birlikleri ile teknoloji inovasyonu arasındaki ilişki Türkiye gibi gelişmekte olan ülkelerde ivme kazanmaya devam etmektedir. Bu çalışma, üniversite ve sanayi iş birliklerinin firmaların özümseme kapasitesi (potansiyel ve gerçekleşmiş özümseme kapasitesi) ve teknoloji inovasyonları (fayda sağlayan ve keşfedici) ile ilişkisini ortaya koymayı amaçlamaktadır. Bu alanda hâlen önemli araştırma boşlukları bulunmaktadır. Böylelikle, İstanbul'daki 170 firmanın katılımıyla, ÜSİ'lerin potansiyel özümseme kapasitesi, gerçekleşmiş özümseme kapasitesi ve fayda sağlayan teknoloji inovasyonuyla ilişkisinin pozitif olduğu bulunmuştur. Gerçekleşmiş özümseme kapasitesi, fayda sağlayan ve keşfedici teknoloji inovasyonunu olumlu yönde etkilemektedir ve üniversite-sanayi iş birlikleri ile fayda sağlayan teknoloji inovasyonu arasındaki ilişkiye aracılık etmektedir. Ayrıca, potansiyel özümseme kapasitesi gerçekleşmiş özümseme kapasitesini olumlu yönde etkilemektedir. Araştırmada, bulgulardan yola çıkarak, teorik ve pratik çıkarımlar tartışılmaktadır.

Anahtar Kelimeler: İş Birlikleri, Özümseme Kapasitesi, Teknolojik Yenilik

JEL Kodları: O31, O32, O33

Introduction

University-Industry Collaborations (UICs) have been a significant research topic in the literature due to the rapid pace of scientific and technological progress, changing market conditions, short product life cycles, and intense global competition (Wright et al., 2008; Hemmert et al., 2014). UICs refer to collaborative relationships between units of the higher education system and industry that promote the exchange of knowledge and technology-related information (Bekkers, Bodas, and Freitas, 2008; Ankrah and Al-Tabbaa, 2015). Accordingly, firms prefer to cooperate with universities to enhance their internal R&D capabilities, increase their scientific productivity, and boost their innovation performance (Makri et al., 2010; Belderbos et al., 2016). Compared to Western countries, university-industry collaboration in Türkiye regarding technology and innovation initiatives is not at a sufficient level. Executives and senior officials of Turkish firms of various sizes are sceptical about universities' effectiveness as partners. Delays in feedback, especially regarding technical processes, are a source of dissatisfaction. The bureaucratic, burdensome decision-making processes at universities are a significant reason for these delays. This situation leads to a loss of revenue (Temel et al., 2013).

While UICs support the firm's innovation performance, researchers mostly ignored the specific role of UICs on the technological innovation of firms that covers exploitative (e.g., upgrading, improving, and expanding existing technologies) and explorative (e.g., offering novel designs, creating new markets and technologies) technological innovations (Enkel et al., 2017). Here, investigating the relationship between UICs and technological innovation will enhance researchers' understanding of how UICs provide complementary effects and driving factors to advance firms' exploitative and exploratory technological innovation activities, which are more pronounced and often serve as a competitive advantage (Wu et al., 2019). Additionally, researchers will be able to distinguish the effects of UIC on exploitative and explorative innovation, as each type of innovation effort has contrasting determinants and outcomes (Benner and Tushman, 2003).

Even though UICs support the firm's technological innovation, the study argues that exploitative and explorative technological innovation activities are distant outcomes of the UICs. Investigating the explicit primary mechanisms, as more proximal organisational factors, in the connection between UICs and technological innovation leverages the current understanding of how UICs cultivate firms' technological innovation, which has not been addressed or examined in the UIC literature. Remarkably, organisational capability-related factors, which significantly affect innovation struggles (Do et al., 2022), are neglected mainly in UIC-related studies.

This study investigates organisational absorptive capacity as the mechanisms that affect UICs and technological innovation links. Some researchers provided clues that UICs are likely to impact firm innovation through absorptive capacity, which refers to the ability to recognise, assimilate, and transform external knowledge into commercial output. Apa et al. (2021) and Zhang et al. (2022) investigated the mediating role of absorptive capacity in the relationship between UIC and firm innovation performance. However, how sub-dimensions of absorptive capacity involving potential (i.e., the ability that allows a firm to gain external knowledge and assimilate that knowledge) and realized (i.e., the capacity that permits a firm to transform external knowledge and implement that new knowledge) act as mediators in the relationship between UICs and exploitative and explorative technological innovations remains unclear, this way, researchers will understand that potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP) are significant steps toward improving technological innovation. Then, researchers will understand which types of absorptive capacity matter more to firms' technological innovation.

Finally, the impact of UICs on firms' capabilities and technological innovation across countries remains largely unexplored (Hemmert et al., 2014). This effect differs between developed and emerging countries. Perkmann et al. (2013) emphasise that countries at different stages of economic development and with mismatched innovation systems will exhibit distinctive UIC patterns with varied outcomes. Though researchers found a positive impact of engaging in R&D collaboration on innovation performance (Nijssen et al., 2012; Belderbos et al., 2004; Harhoff et al., 2014; Mention, 2011; Leiponen and Helfat, 2010), previous studies on UICs were mainly conducted in the USA and Europe (Hemmert et al., 2014) and other emerging East Asian countries, such as China, Taiwan, and Korea (Eun et al., 2006; Chang et al., 2006). As a developing country, Turkey has a persistent gap between universities and industry. Most companies in the International Association of Universities (UIC) disregard the role of Turkish universities in their innovation strategies. This approach enables researchers to understand how UICs impact potential absorptive capacity (PACAP), realized absorptive capacity (RACAP), and technological innovation, particularly in firms from diverse cultural backgrounds.

This study has three main contributions. First, it leverages the research on UICs by differentiating its influences on technological innovation. Second, it elaborates the mediating role of potential and realized absorptive capacity, which were mainly investigated as moderating variables in collaboration studies (Kafouros et al., 2020; Escribano et al., 2009; Flor et al., 2018; Santoro et al., 2018). Third, it assesses potential absorptive capacity (PACAP) and potential absorptive capacity (RACAP), including technological innovation, through alliances with universities and firms in Turkey with Near Eastern traditions.

Background

Theoretical framework

This study investigates the relationships among UICs, potential and realized absorptive capacity (PACAP and RACAP), and explorative and exploitative technological innovation.

UICs and absorptive capacity

The UICs indicate an inter-organisational network in which organisations come together to exchange information/knowledge, and resources for a shared goal (Steinmo and Rasmussen, 2018). In these collaborations, universities bring varied expertise to firms, increase their current knowledge systems and their capacity to solve specific and complex technology-related problems, and reduce R&D-related costs, uncertainties, and risks (Ankrah and Omar, 2015). So, UICs gain significant attention in emerging countries. Universities are a critical source of skills, scientific and technological development (Eun et al., 2006; Suzigan et al., 2009). One of these innovation types is technological innovation by firms, which refers to the ability to perform technical activities that enable the development of new products and processes (Teece et al., 1998).

Researchers have found that exploitation and exploration are complementary strategies for technological innovation (Zhang and Luo, 2020), although they comprise distinct perspectives (Enkel et al., 2016). For instance, exploitative technological innovation focuses on short-term survival and competitiveness. It involves incremental innovation that strengthens existing products, skills, processes, and structures, aiming for predictable, positive profits (Enkel et al., 2016). Explorative technological innovation guarantees the long-term survival and competitiveness of firms. It shows the experimental processes that lead to inventions in new product and market domains (Hagedoorn and Duysters, 2002). It also defines a split from the existing structure, rules, norms, routines, and activities, as seen in radical innovations (Enkel et al., 2016). Employing these two types of innovations enhances firms' performance in emerging countries and their competitiveness in global markets.

Firms have absorptive capacities to achieve practical technological innovations. The impact of potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP) on firms' technological innovation strategies when collaborating with universities in emerging countries remains unclear. Also, PACAP and RACAP may offer different benefits to the firm's innovation capability in emerging countries, but this remains unclear.

Potential absorptive capacity signifies a firm's knowledge-seeking capabilities (Zahra and George, 2002). It refers to acquiring critical knowledge from external sources and assimilating it so that firms can internalise and adapt it to their operations (Chang et al., 2022). It contributes to firms' accumulation and updating of knowledge stocks, enabling the exploration of external knowledge (Chang et al., 2022).

Realized absorptive capacity describes a firm's ability to transform, exploit, or use external knowledge. It reveals a firm's ability to develop new insights and capabilities, and to create new products and services by blending external and internal information or by applying the latest insights to business operations (Lu et al., 2021). The distinction between PACAP and RACAP is valuable, as it helps explain why some firms fail to transform external knowledge into innovative products. Firms may gain and assimilate knowledge (PACAP), yet they may not transform and utilise (RACAP) for innovation efforts or vice versa (Muraliraj et al., 2020).

Hypotheses development

This study tests (1) the relationship between UICs (University and Industry Collaborations) and PACAP (Potential Absorptive Capacity) and RACAP (Realized Absorptive Capacity), (2) the relationship between PACAP and RACAP and technological innovation, and (3) the mediating role of PACAP and RACAP in the relationship between UICs and technological innovation in the emerging country context (Figure 1).
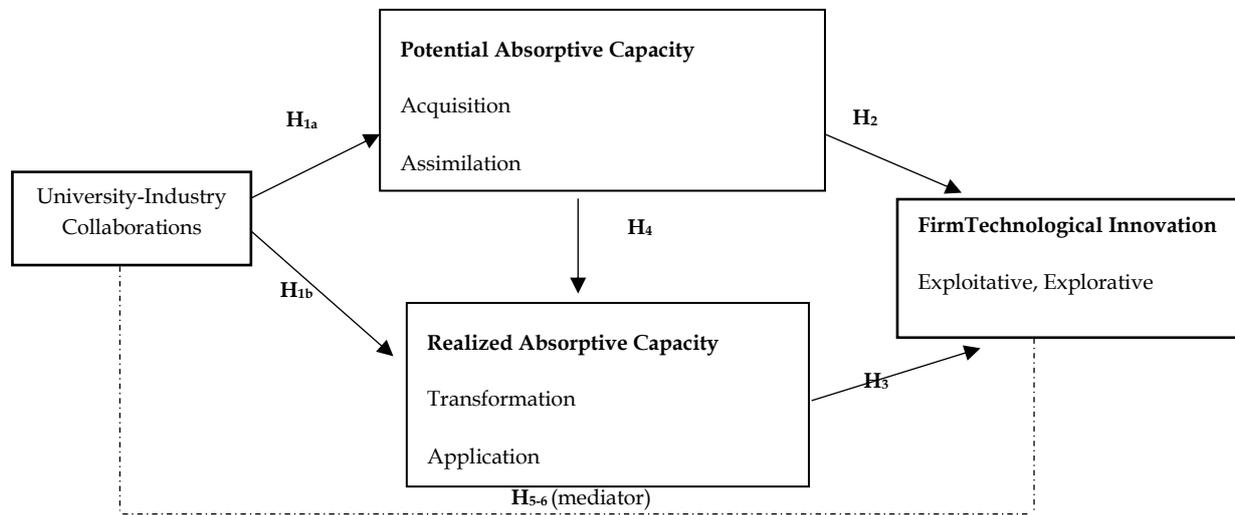
Figure 1: Research Model

The relationship between UIC and absorptive capacity

Previous studies have revealed the role of collaboration in absorption capacity, a unidimensional variable in prior research. For instance, Cohen and Levinthal (1989) argued that firms require a sufficient absorptive capacity to acquire and expand knowledge from universities and integrate it into their processes. Motohashi (2005) emphasises that firms should develop ad hoc capabilities to capitalise on the potential advantages of collaborations with universities. However, in past studies, absorptive capacity has typically been measured as a composite score of its four sub-dimensions (e.g., knowledge acquisition, assimilation, transformation, and application). They did not demonstrate a more detailed understanding of UICs in firms' absorptive capacity.

The authors argue that UICs influence the potential and realized absorptive capacity of firms in emerging countries. Specifically, UICs influence potential absorptive capacity by leveraging universities' awareness of new knowledge. Indeed, firms would be operating in a vacuum without awareness of new knowledge. Firms learn about their current needs (e.g., new product ideas), discover unique needs in advance (e.g., new forms of organisation and solutions to existing problems), and recognise the value of integrating explicit knowledge, thereby enhancing absorptive capacity (Camison and Forés, 2010).

UICs also affect realized absorptive capacity by strengthening firms' knowledge bases. Firms expand their knowledge base, enrich their worldview, and gain access to resources and opportunities essential for R&D activities (Zahra and George, 2002). This way, they successfully suppress external knowledge in their processes and activities and visualise it in the preferred results (Lu et al., 2021). In addition, as UICs lead firms to benefit from the specialised expertise of universities, these firms transform their inter-organisational processes, reshape their business models, and develop new policies and procedures, supporting RACAP (Camison and Forés, 2010; Cohen and Levinthal, 1990). Therefore, the first hypothesis:

H$_1$: UICs positively relate to the firm, a) Potential Absorptive Capacity, and b) Realized Absorptive Capacity.

The relationship between absorptive capacity and technological innovation

A sufficient absorptive capacity enables firms to interpret current technological developments, predict the direction of technological advances, and their future commercial applications (Cohen and Levinthal 1994; Grimpe and Sofka, 2009). The study suggests that a firm's potential and realized absorptive capacities impact exploitative and exploratory technological innovation in emerging countries. Specifically, potential absorptive capacity enables exploitative and explorative technological innovations by fostering knowledge amplification within firms (Holsapple and Singh, 2005; Liu et al., 2014). When firms access knowledge from universities, they expand and update their knowledge stocks and deliberately integrate it with diverse knowledge bases to generate new combinations and configurations of knowledge. Ultimately, they promote various innovations. Additionally, potential absorptive capacity enables firms to apply, understand, and assimilate new external knowledge more effectively, thereby solving specific technology-based problems (Lane et al., 2006).

Realized absorptive capacity supports both exploitative and exploratory technology development by leveraging new external knowledge resources alongside its existing knowledge base. It motivates firms to leverage their existing knowledge and routines by integrating suppressed external knowledge and applying new resource alignment to evaluate market opportunities (Cho et al., 2022). This way, the firms gain a deep understanding of a broad range of knowledge resources to create new products and make better, more innovative strategic decisions. Patel et al. (2015), for instance, argue that realized absorptive capacity will strengthen a firm's current resource base, thereby enhancing ambidexterity by applying and assigning various resources to products and services. Therefore, hypotheses 2 and 3:

H_2: Potential Absorptive Capacity (PACAP) has a positive relationship with both a) exploitative and b) explorative technological innovations.

H_3: Realized Asorptive Capacity (RACAP) has a positive relationship with both a) exploitative and b) explorative technological innovations.

Potential absorptive capacity does not lead to improved performance. For it to affect the organisation, realized absorptive capacity needs to be realized (Zahra and George, 2002). Voudouris et al. (2012) argued that external knowledge is insufficient to increase a firm's innovative activities. Firms should leverage their expertise to strengthen product development capabilities. Thus, PACAP influences the RACAP in the study. Such that PACAP increases the likelihood of RACAP in firms. Here, PACAP presents firms a repertoire of ideas and interpretations that may be useful (Zahra and George, 2002). PACAP contributes to the firm by disseminating insights in the organisation to transform and apply new knowledge. Therefore:

H_4: PACAP has a positive relationship with RACAP.

The mediating role of absorptive capacity

The study argues that potential absorptive capacity (PACAP) and realized absorptive capacity (RACAP) mediate the relationship between UIC and technological innovation. Prior literature showed that collaboration with universities enhances firms' innovation performance (Alcalde and Guerrero, 2016; Slavova and Jong, 2021). Beyond their role in firm technological innovation, PACAP and RACAP influence technological innovation in H_2 and H_3. Similarly, it is not enough for firms to rely on universities to provide resources to boost technological innovations. In this context, PACAP and RACAP should be part of this agenda to integrate internal and external resources and support firms in improving their technological innovations. Specifically, PACAP mediates the relationship between UICs and technological innovation by establishing a synergy between universities and firms. Here, PACAP will help firms surface and realise universities' specialised mental models, assumptions, ways of acting, and competencies (García-Morales et al., 2007). In this respect, Lichtenthaler and Lichtenthaler (2009) defined firms with effective PACAP as those that quickly provide partners with access to their competencies and resources, thereby improving innovation performance when collaborating with external partners. In addition, PACAP enables firms to engage in rich, detailed communication with universities, generating new ideas or solutions for product design. In addition, PACAP enables firms to engage in rich, detailed communication with universities, generating new ideas or solutions for product design.

RACAP also mediates the relationship between UICs and technological innovation by fostering the development of organisational structure, culture, and forms. According to previous studies, absorption capacity includes organisational culture change, interaction mechanisms, and technology diffusion channels (Bstieler et al., 2015; Al-Tabbaa and Ankrah, 2016). Firms develop routines and processes that integrate existing knowledge with newly acquired knowledge and address new knowledge (Zahra and George, 2002). Indeed, UICs enable a firm to access previously unfamiliar scientific understanding. This knowledge may offer differentiated approaches to reasoning, problem formulation, and solution development (Tsai, 2009). Further, RACAP leverages external knowledge derived from UICs to inform its market expansion strategy. Researchers suggest RACAP is essential for firms seeking to expand their market share. Firms benefit from the knowledge assimilated and configured by universities, adding new products to their portfolios and making strategic decisions, such as how to respond to new competition and design innovative products (Ferreras-Méndez et al., 2015). Accordingly, the hypothesis:

H_5: PACAP mediates the relationship between UICs and a) exploitative and b) explorative technological innovation.

H_6: RACAP mediates the relationship between UICs and a) exploitative and b) explorative technological innovation.

Research methodology

Measures

The use of multi-item scales adapted from prior studies provides a valid basis for assessing the study variables. The measurement of the variables (e.g., UICs, exploitative and exploratory technological innovations) uses 7-point Likert scales ranging from "strongly disagree" (1) to "strongly agree" (7). Absorptive capacity questions (e.g., knowledge acquisition, assimilation, transformation, and application) were measured employing an itemised rating scale from "much worse" (1) to "much better" (7). The ratio scale for control variables, such as firm size and age, was preferable. Appendix C shows the question items for variables and their respective sources.

The translation of question items from English into Turkish is a process offered by Usunier (2011). Semantic and cultural attempts were more preferable than lexical/mechanical ones in translation. The adjusted interpretations of the question items and their retranslation into English were valid after discussions during translation, establishing a shared conceptual basis. A pilot test involving selected industry executives proved favourable in addressing ambiguous expressions and grammatical errors after dispute resolution.

The sampling

The study draws on data collected from MBA and graduate-level courses at three universities in Istanbul, Turkey. This sampling approach follows a parallel design employed in prior studies (e.g., Akgün, 2020). As contact persons, these students and, primarily, managers in their respective firms who were willing to participate in the research were selected. The students answered whether their firms developed new products, sold them in domestic and global markets, and met European quality standards. They also responded to whether their firms are collaborating with universities. After their firms passed the selection criteria, each student had at least two knowledgeable key informants at their firms to answer the survey questions, thereby reducing the problem of single sourcing (Kumar et al., 1993).

Of the 230 firms approached, 170 participated in the study and returned usable surveys, resulting in a final sample of 170 firms and 342 questionnaires in total suitable for analysis. In the sample, the respondents are senior employees and engineers (18%), product/project managers (15%), functional managers (17%), R&D managers (14%), engineers and technicians (32%), and others (top management) (4%). The departments involved were engineering/design (17%), R&D (27%), marketing (11%), finance/accounting (10%), manufacturing/production (22%), human resources (3%), and others (the sales and quality departments) (4%). The industries surveyed were information technologies/software development (33%), manufacturing (16%), chemical (10%), service (8%), machinery (6%), textile (6%), telecommunications (6%), aviation (4%), healthcare (4%), and others, such as banks, food, transportation (7%). Absorptive capacity questions are not in the Appendix because they are too long (see Camisón and Forés (2010, p. 714) for the items).

Measure validity and reliability

The study comprises Confirmatory Factor Analysis (CFA) to test the reliability and validity of the variables (Fornell and Larcker, 1981). In testing for unidimensionality, there are three subsets of measurements consisting of theoretically related variables: (1) four absorptive capacity measures (i.e., information/knowledge acquisition, assimilation, transformation, and application), and (2) two innovation outcome measures (i.e., exploitative and explorative technological innovation) using AMOS. Removing any problematic items, which had low factor loadings or were cross-loaded with other variables, the findings showed that three models fit sufficiently, namely, four absorptive capacity variables (c2(84)=335.78, CFI=0.92, RMSEA=0.09), and two technological innovation variables (c2(13)=19.86, CFI=0.99, RMSEA=0.04).

To test discriminant validity, restricted models were compared with an unrestricted model through 45 two-factor models, as suggested by Bagozzi, Yi, and Phillips (1999). The results showed that the chi-square change (Dc2) for both the constrained and unconstrained models was significant (Dc2 > 3.84), indicating satisfactory discriminant validity. Further, a CFA model included all absorption capacities, UICs, regulatory variables, and technological innovation-related variables. It produced reasonably well-fit indices, such as $\chi2(629) = 1833.55$, $\chi2/df = 2.95$, a comparative fit index (CFI) = 0.89, an incremental fit index (IFI) = 0.89, and RMSEA = 0.08. All items loaded significantly on their corresponding constructs, giving support for needed convergent validity. Table 2 illustrates the correlations among all variables, Cronbach alphas, average variance extracted (AVE) for each variable, and AMOS-based composite reliabilities, all of which were above acceptable levels (Fornell and Larcker, 1981). Also, as

Fornell and Larcker (1981) recommended, the square root of each variable's AVE was greater than the latent factor correlations between the pairs of constructs, further indicating discriminant validity.

Common method bias test

Harman's one-factor test was functional for evaluating the Common Method Bias problem (Podsakoff and Organ, 2001). The unrotated principal components analysis accounted for 80.65% of the total variance, producing several factors; the largest single variance component was 26.57%. The use of the Common Method Variance (CMV) factor test was preferable for evaluating parameter estimates, as controlled CMV was more appropriate than uncontrolled CMV (Podsakoff et al., 2003). The path coefficients were not substantially affected, and there were no significant changes in the fit measures between the model with and without a common method factor ($\chi2/df$= 2.95; CFI= 0.89; RMSEA= 0.08) and the model with a common method factor ($\chi2/df$= 2.86; CFI= 0.89; RMSEA=0 .07). These results prove that common method bias was not statistically severe in this study.

Hypothesis testing

Before initiating any analysis, individual responses (surveys) were aggregated at the firm level. All inter-rater agreement (rwg) values ranged from 0.65 to 0.87, above 0.60 (Hurley and Hult, 1998), indicating a high level of consistency among participants and a reasonable rwg level for each aggregate measure within a firm. For a smaller sample size of 170 firms, the PLS technique was applied. Smart-PLS 3.0 and bootstrapping resampling (i.e., creating 500 sub-samples of selected cases) were used to test the hypotheses.

The choice of PLS-SEM (Partial Least Squares Structural Equation Modelling) is justified based on both methodological and model-related considerations. The study includes second-order (hierarchical) constructs, such as Potential Absorptive Capacity (PACAP) and Realized Absorptive Capacity (RACAP), originally conceptualised by Zahra and George (2000). These constructs are multidimensional and modelled as higher-order structures composed of lower-order dimensions (e.g., acquisition, assimilation, transformation, exploitation). PLS-SEM is particularly suitable for estimating hierarchical component models (HCMs), especially when using approaches such as the repeated indicators or two-stage method. The use of PLS-SEM is appropriate given that the research model incorporates formative measurement structures, adopts a prediction-oriented objective, involves a relatively complex structural framework, and is based on a moderate sample size. PLS-SEM is particularly well-suited to such conditions because it does not require strict distributional assumptions and performs well in estimating complex models that include multiple constructs, indicators, and mediating and moderating relationships.

The use of 500 bootstrap resamples was based on earlier PLS-SEM applications, where 500 resamples were commonly considered sufficient for estimating standard errors and testing path significance. However, more recent methodological guidelines (e.g., Hair et al., 2017) recommend using at least 5,000 bootstrap resamples to ensure greater stability of standard error estimates and more precise confidence intervals. In response to this recommendation, the analysis has been re-estimated using 5,000 bootstrap resamples. The results remain substantively unchanged, indicating that the findings are robust and not sensitive to the number of bootstrap resamples.

Since PACAP is conceptualised as a second-order reflective-reflective structure comprising information/information acquisition and assimilation, the second-order structure was evaluated in the PLS model (Becker et al., 2012) by treating all first-order items together. In this context, confirmatory tetrad analysis (CTA-PLS) was performed as suggested by Gudergan et al. (2008). It was found that all tetrad values were significant, and all values of the lower limit of the adjusted confidence interval were negative. In contrast, all values of the upper limit were positive, demonstrating that all latent items are reflective. Similarly, since RACAP is conceptualised as a second-order reflective-reflective structure comprising information/information transformation and use, similar procedures were applied to assess whether it is a second-order structure. It was confirmed that all CTA-PLS values were not significant, and all values of the lower limit of the adjusted confidence interval were negative. In contrast, all values of the upper limit were positive, indicating that all latent items are reflective.

Model C in Table 3, comprising UICs, PACAP, and RACAP, and technological exploitative and explorative technological innovation, indicates that UICs are positively related to PACAP (β = 0.32, $p <$ 0.01) and RACAP (β = 0.14, $p <$ 0.1), supporting H_1. Table 3 also reveals that PACAP is not statistically related to exploitative technological innovation (β = 0.05, $p >$ 0.1) or exploratory technological innovation (β = -0.13, p > 0.1), thereby not supporting H_2. RACAP is positively related to exploitative technological innovation (β = 0.40, p < 0.01) and explorative technological innovation (β = 0.53, p < 0.01),

supporting H3. Furthermore, Table 2 indicates that PACAP is positively related to RACAP ($\beta = 0.43$, $p < 0.01$), supporting H4.

The Stone-Geisser test (Q^2) values exceeded 0, indicating good predictive significance (Chin, 1998). Finally, we found that the composite base standardised root mean square residual (SRMR) is 0.10, which is at the threshold, confirming the overall fit of the PLS path model (Henseler and Sarstedt, 2013). To test the mediating effects of PACAP and RACAP on UICs and exploitative and exploratory technological innovation, the Baron and Kenny (1986) procedure was employed. So, as demonstrated in Table 3, there are three different PLS models:

a) Model A, including the UICs, exploitative and explorative technological innovation and control variables, indicates that UIC is positively related to the exploitative technological innovation ($\beta = 0.20$, $p < 0.01$). In contrast, it was not statistically related to explorative technological innovation ($\beta = 0.12$, $p > 0.1$), and $R_{2exploitative} = 0.12$, and $R_{2\ explorative} = 0.05$.

b) Model B containing the UICs, PACAP, and RACAP indicates that UICs are positively associated with PACAP ($\beta = 0.35$, $p < 0.01$) and RACAP ($\beta = 0.28$, $p < 0.1$), and $R_{2pacap} = 0.12$, $R_{2\ racap} = 0.08$

c) As shown in Model C, after UICs is controlled, it was found that RACAP was statistically related to exploitative technological innovation ($\beta = 0.40$, $p < 0.01$) and explorative technological innovation ($\beta = 0.53$, $p < 0.01$). PACAP was not statistically related to exploitative technological innovation ($\beta = 0.05$, $p > 0.1$) and explorative technological innovation ($\beta = -0.13$, $p > 0.1$). As shown in Table 3, RACAP reduce UIC's effects on the exploitative technological innovation, and inclusion of the RACAP in the model increase the R_2 of exploitative technological innovation ($R_{2exploitative} = 0.21$). On the other hand, it was found that the relationship between UICs and explorative technological innovation ($\beta = 0.02$, $p > 0.1$) was still not related.

Lower and upper bound confidence intervals were also analysed to confirm the importance of PACAP and RACAP as mediating variables in the relationship between UICs and exploitative and explorative technological innovation, including the method of Baron and Kenny (1986) (Williams and MacKinnon, 2008). A bias-corrected and percentage bootstrap method was applied to a sample of 1000 with a 95% confidence interval. The standardised indirect effect of the UICs → RACAP → explorative technology innovation was significant ($\beta = 0.07$, $p < 0.07$, bootstrap 95% CI, lower level = 0.001, upper level = 0.16). The result demonstrates that UICs have an indirect effect on explorative technology innovation through RACAP. Based on the results, RACAP fully mediates the relationship between the UICs and exploitative technological innovation, partially supporting H_5. On the other hand, PACAP does not mediate the relationship between the UICs and exploitative and explorative technological innovation. Thus, H_6 was not supported.

Discussion and implications

Theoretical contributions

The study first shows that UICs are positively associated with exploitative technological innovation among firms in emerging countries. Firms collaborating with universities maintain their market position by continually improving existing products through incremental technological innovations. The study explicitly highlights the notion of mimicking firms in emerging countries. Firms in emerging countries often imitate pioneer firms and their related technologies and products in the market by leveraging universities' knowledge, experiences, and expertise (Luo et al., 2011; Wu et al., 2019).

The study clarifies the non-significant direct relation between UICs and explorative technology innovation. The finding contradicts past studies in the USA and Europe that focus on universities as a source of exploratory technological innovation (Hemmert et al., 2014; Belderbos et al., 2004; Slavova and Jong, 2021). This study shows that exploratory technological innovation is less likely to be preferred in emerging countries due to the risks or costs of radical innovation processes and the scarcity or instability of resource combinations (Jansen et al., 2006; Subramaniam and Youndt, 2005). It also refers to existing barriers, such as the information barrier, financial barrier, administrative barrier, and support barrier (Schafer and Schaefer, 2022).

Secondly, the study shows that UICs influence firms' development of PACAP and RACAP. This finding elucidates how firms enhance their capabilities by drawing more knowledge from external partners, such as universities. Indeed, past studies have mostly focused on demand-pull absorptive capacity (how firms gather relevant information/knowledge from customers, competitors, and suppliers) rather than on science-push absorptive capacity (how firms absorb information/knowledge from universities) (Schweisfurth and Raasch, 2018). This study demonstrates that the impact of UICs on PACAP is higher

than on RACAP. It shows that UICs influence PACAP, which, in turn, affects RACAP due to the significant relationship between PACAP and RACAP. Accordingly, the finding contains the path-dependent talent development in firms within the context of UIC. When firms collaborate with universities, they acquire and understand external knowledge, then intentionally develop routines, procedures, and norms to enhance it. The study also classifies the absorptive capability context as potential and realized in the UICs context of emerging countries.

Third, the study displays that PACAP indirectly influences technological innovation through RACAP. Such that the knowledge transformed into organisational activities and strategies through PACAP impacts firms' exploitative and explorative technology innovations. The finding suggests that firms are likely to benefit from PACAP, which improves their capacity to innovate. Indeed, when firms search for and acquire external knowledge from universities, they encounter familiarity traps (Zahra and George, 2002). As such, firms narrow their knowledge base, thereby risking core rigidity and learning myopia by assimilating external knowledge alongside internally generated knowledge (Petruzzelli and Rotolo, 2015). Thus, firms need RACAP to complete the absorptive capacity cycle and be effective in innovation efforts.

Fourth, the study extends the UIC literature by the mediating role of the firm's absorptive capacity and RACAP in the relationship between UICs and exploitative technological innovation. Here, external knowledge gained through UICs enhances the firm's capabilities and expands technological innovation through RACAP. In a sense, firms with deficient RACAP struggle to transform and integrate new external knowledge with existing internal knowledge, thereby hindering innovation and limiting the firm's commercial benefits. This finding highlights that PACAP is a learning process that promotes the creation and consolidation of knowledge to a higher degree.

Studies reveal that the learning process underlying exploitative technological innovation is significant (Ebers and Maurer, 2014; Escribano et al., 2009). Firms with greater RACAP can develop new organisational routines, transform existing processes, and effectively orchestrate corporate resources (e.g., human resources and equipment) to increase the benefits and the development of exploitative innovations. PACAP does not directly mediate the relationship between exploitative technological innovation and UIC. It does not mean that PACAP is not an essential mediating variable. Past studies empirically employed PACAP as a mediator between collaborations, firm process innovation (Aliasghar et al., 2019), and organisational creativity (Zhang and Zhu, 2021). The current study's findings also indicate that RACAP mediates the relationships among UICs, PACAP, and exploitative technological innovation. For instance, the indirect path of UICs → PACAP → RACAP → explorative technology innovation was significant ($\beta = 0.06$, $p < 0.05$, bootstrap 95% CI, lower level = 0.012, upper level = 0.15). This result indicates that UICs had an indirect effect on explorative technology innovation through RACAP.

The study also demonstrates that PACAP and RACAP do not mediate the relationship between UICs and that exploratory technological innovation is closely related to the emerging-country context. The non-significant mediating role of absorptive capacity in the UICs-technological innovation link is due to firms' weak technological capacity (Gupta et al., 2006). Firms need technological competence, financial support, and time to expand their absorptive capacity and get explorative technology outputs through knowledge in UICs in emerging countries (Radosevic, 2011; Rapini et al., 2009; Thrane et al., 2010) Firms with weak technical competence praise universities' strategic significance in applying exploitative rather than explorative technological innovations in emerging countries (Rapini et al., 2009). As a result, expanding the knowledge pool through UICs may make firms dependent on existing capabilities and hinder the development of explorative innovations.

Managerial implications

This study offers some suggestions for managers. Drawing on the knowledge universities provide, managers should formulate strategies to accelerate technological innovation and strengthen the firm's presence in local and global markets. To achieve this, managers should organise and design the corporate structure by monitoring collaboration processes, focus on periodic employee training on new technological developments, and conduct learning activities with universities, as new technologies require continuous learning or learning-by-doing. They should also organise various social activities for the collaboration teams during the joint attempts and expand the human resources pool with the help of university partners. In this flow, managers should leverage university-sourced skilled staff (such as undergraduate and graduate students) to drive technological innovation. Managers should also encourage exploratory technological innovation strategies in specific areas by following the different trajectories of technological advancement, strengthening innovation through existing technologies,

ensuring sustainability in current markets with the help of universities, and creating diverse options for customers.

Managers must restructure organisational dynamics (e.g., routines, procedures, and relationships among people) to address firms' inadequate absorption capacity. They should implement innovative technologies to facilitate information processing (e.g., acquisition, assimilation, and use) and streamline university activities. In addition, managers should expand the firm's knowledge stock within its absorptive capacity by improving human resource capabilities, increasing search activities with universities, and investing more resources. To derive more benefit from UICs and better manage innovation efforts, managers must understand and skillfully utilise the unique applications of PACAP and RACAP. Thus, for instance, universities' Technology Transfer Offices (TTOs) provide companies with a high-quality foundation for their knowledge flows. The commercialisation of knowledge produced within the university ecosystem will positively impact competitive advantage in the market.

Furthermore, transforming outputs into learning mechanisms will help develop new training modules. Ultimately, the interaction between profit-oriented practices and educational processes supports the sustainability of firms through effective intellectual property/patent management, robust reporting and coordination structures, and targeted process improvement actions. On the other hand, the accumulated experience shaped by the commercialisation of knowledge updates educational content.

This study has some methodological limitations. Specifically, collecting a cross-sectional survey did not allow us to examine the true relationships among the variables or identify how they unfold. For instance, PACAP, RACAP, and innovation programs may change as new information and more experienced universities become available. Thus, a longitudinal research design can further elucidate the reverse and dynamic relationships among UICs, PACA, PACAP, and exploitative and exploratory technological innovations.

Using data based on individual statements can lead to the common problem of method variance. Although our analysis shows that mutual method variance is insignificant in this study, this problem may still arise. In this regard, objective measures of the variables (e.g., the number of new products developed and launched over the last five years) may enhance this study's reliability. Since the study focused on Turkish firms, there are limitations in understanding and applying its results. Then, outputs can vary across cultures and nations.

The study provides some opportunities for future research. For instance, researchers can investigate the relationships among UICs, absorptive capacity, and exploitative and exploratory technological innovation within specific sectors (e.g., manufacturing, metals, electronics) in emerging countries. Researchers can also expand the scope of UICs to include organisational innovation, organisational change capacity, organisational resilience, firm performance, and sustainability.

In the study, PACAP and RACAP were under observation. However, there are various absorption capacities within a given knowledge domain (e.g., marketing, cultural, and information technology). These capacities help firms acquire, assimilate, and absorb external IT, market, and technological knowledge (Chang et al., 2019). In future studies, researchers can examine the role of UICs on these subsets of absorptive capacities. In addition, researchers can study the mediating role of partner-specific absorptive capacity or relative absorptive capacity, which is deemed comparable to the distinct knowledge source rather than in an absolute sense, in the UICs-innovation performance link.

Researchers can investigate moderating variables in the UIC context. For instance, the impact of the existence of intermediary institutions (e.g., research centres, technology transfer offices, university-industry liaison offices) on the flow of technological knowledge between universities and firms could be a research topic.

Finally, the disadvantages of UIC for firm competency development and higher innovation performance can be a topic for further research. In developing countries, insufficient technology transfer and the negative impacts of intellectual property and patent disputes on innovation processes and firms' integration capacity are potential areas for research.

Conclusion

The study examines the expanded UIC concept from the perspective of developing countries and its impact on firms' PACAP and RACAP, as well as on technological innovation. It presents that firms prioritise collaborations with universities to sustain technology-based innovations and develop new products and services that provide a competitive edge in both domestic and global markets. A new understanding of PACAP and RACAP as mediating factors in the links between UICs and technological

innovation of developing countries has emerged. In conclusion, shifts in the global business landscape, new business models, and social changes across countries provide a rich and fruitful environment for research on UICs and various types of innovation.

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Appendix

Appendix 1 – The Measures

* denotes the dropped items

University-Industry Collaboration (Adopted from Schleimer, Schulman, 2011; Gretsch et al., 2019)

- Our firm collaborates closely with the universities.
- Our firm is satisfied with the relationship with the universities.
- Advice and counsel are shared by each other.
- Suggestions are encouraged by one another.
- In this relationship, it is expected that any information is provided which might help the other party.
- Units of both partners were engaged equally in decision-making processes.
- Employees of our firm tend to collaborate with the university.
- Our firm communicates openly with the universities.*
- Our company and university representatives help each other in R&D planning activities.*
- Both firms shared proprietary information.*
- Our firm and the university try to complement one another as best as they could.*
- Our firm and the university share collective responsibility for all results of the development.*

Technological Innovation (Adopted from Enkel et al., 2017)

Explorative Technological Innovation

- We regularly discover new products and services.
- We commercialise products and services that are new for our company.
- During the search for new technological ideas, we look outside the box.
- Our success is based on the capability to discover new technologies.

Exploitative Technological Innovation

- We continuously extend offerings of existing products and services.
- We regularly make small adaptions to existing products and services.
- We regularly launch incrementally improved products and services in our local market.
- We improve efficiency in the delivery of products and services.*
- Our success is based on capabilities to optimise existing technologies.*

Appendix 2 – The Tables

Table 2: Correlations and descriptive statistics

Mean	S.Dev	Variables		1	2	3	4	5	6	7	8	9	10	11	12
5.56	1.74	UIC	1	(.86)											
5.25	1.42	Acquisition	2	.20***	(.88)										
5.03	1.12	Assimilation	3	.28***	.29***	(.69)									
4.97	1.49	Transformation	4	.24***	.28***	.32***	(.80)								
4.49	1.46	Application	5	.16***	.39***	.28***	.23***	(.81)							
5.22	1.53	Exploitative tech. innov.	6	.15***	.23***	.23***	.21***	.55***	.15***	.21***	.13**	(.86)			
4.45	1.69	Explorative tech. innov.	7	.19***	.11**	.13**	.34***	.11*	.19***	.12**	.20***	.23***	(.84)		
1.22	.41	Firm age (logarithmic)	8	.08	-.14**	.01	.13**	-.04	-.06	-.08	.08	.02	.18***	-	
2.06	.94	Firm size (logarithmic)	9	.14**	-.11**	.02	.25***	-.12**	-.11**	-.05	.13**	.05	.29***	.62***	--
		Composite reliability		.95	.93	.73	.88	.88	.95	.92	.91	.89	.91	NA	NA
		Variance extracted		.75	.77	.48	.64	.65	.90	.78	.72	.74	.71	NA	NA
		Cronbach's α		.94	.93	.74	.88	.89	.95	.92	.90	.89	.91	NA	NA
		Inter-rater agr. (r_{wg})													

*p <.1, **p < .05, ***p < .01

Diagonals show the square root of AVE

Table 3: The Results of the Path Model

Hypothesis	Relationship	Model A	Model B	Model C	Results
H1	UICs → PACAP		.35***	.32***	Supported
	UICs → RACAP		.28***	.14*	Supported
	PACAP → RACAP			.43***	Supported
H2a	PACAP → Exploitative innov.			.05	Not Supported
H2b	PACAP → Explorative innov.			-.13	Not Supported
	RACAP → Exploitative innov.			.40***	Supported
	RACAP → Explorative innov.			.53***	Supported
	UIC → Exploitative innovation	.20***		.08	
	UIC → Explorative innovation	.12		.02	
	Firm size → Exploitative innov.	.04		-.01	
Control	Firms size → Explorative innov.	.31***		.24***	
Variables	Firm age → Exploitative innov.	.007		.03	
	Firm age → Explorative innov.	-.001		-.02	

Fit measures	Endogenous construct	R^2	R^2	R^2	Q^2
	PACAP		.12	.10	.05
	RACAP		.08	.24	.10
	Exploitative innovation	.12		.21	.15
	Explorative innovation	.05		.33	.25

*$p<.1$, **$p<.05$, ***$p<.01$