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How Does External Knowledge Sourcing Affect Business Performance in Large-Scale Firms? The Mediating Role of Open Technology Strategies

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***Abstract*—This article examines the mediating impact of open technology strategies (OTS) on the link between three types of external knowledge sources (i.e., scientific, institutional, and indirect partners) and business performance (BP). Structural equation modeling is conducted in order to test the research model based on a survey of 241 companies drawn from the database of Turkey's largest 500 manufacturing companies. The study's findings indicate that the implementation of OTS mediates the relationships between external knowledge sourcing (EKS) from scientific partners and indirect partners with BP. However, no support is found for the mediation effect of OTS on the link between EKS from institutional partners and BP. This article extends the innovation literature by empirically investigating open innovation in large-scale companies in emerging country settings.**

***Index Terms*—Business performance (BP), external knowledge sources, open innovation (OI), open technology strategies (OTS), Turkey.**

I. Introduction

SINCE Chesbrough's [1] seminal work on open innovation (OI), the notion of external knowledge sources in the OI field has received mounting interest in both academic and business circles [1]–[5]. Focusing only on internal research and development (R&D) cannot be seen as sufficient to sustain a company's competitiveness and innovativeness. Companies can acquire crucial knowledge for OI from several external sources, including universities, laboratories, start-ups, customers, and consultants. There are several advantages of relying on external knowledge sources, ranging from enabling much more exchange of new ideas, reduced R&D costs to acceleration of the innovation process [6].

However, acquiring knowledge from external sources is not sufficient *per se* to have a higher level of OI efficiency. External knowledge needs to be integrated into the company's internal R&D processes to facilitate the effective implementation of OI. Nowadays, even the large-scale companies that rely merely on internal R&D efforts can no longer create sustainable product advantages [6]. They should acquire technology from outside sources using well-crafted open technology strategies (OTS) to cope with the ever-increasing complexity and speed of new product development (NPD) [7]. These OTS are generally grouped under three main categories, including technology acquisition (e.g., buying patents, copyrights, and trademarks), technology exploitation (e.g., selling patents, licenses, and trademarks), and coupled strategies (e.g., open production, open-sourced projects, and strategic alliances with external partners).

Despite the growing popularity of OI, the relationship between OI and business performance (BP) is not well understood. Existing research on the OI-performance relationship has generated mixed results. Some scholars found positive, curvilinear, or even negative relationships between OI and performance (e.g., [2], [3], [8], [9]). While there are also several studies investigating the direct effects of external knowledge sources and technology strategies as the key components of OI on BP [3], [10]–[13], there is an obvious gap in OI literature that attempts to unbundle the link between various types of external knowledge sources and BP. In order to fill this lacuna, our study first offers a new conceptual framework to consider the influence of OTS as a mediator on the links between three types of external knowledge sources (i.e., scientific partners, institutional partners, and indirect partners) and BP.

Second, there is a paucity of empirical studies on OI within the context of companies from emerging market settings, as most of the studies have focused on innovating companies from developed countries. However, emerging country companies might have different perspectives with respect to their search for various types of external knowledge sources, as they are more in need of external knowledge to nurture their growth easily. At the same time, they may not be technology-savvy enough to access, identify, and absorb such knowledge using OTS [10]. Our survey setting, Turkey, serves as an appropriate country setting to represent emerging economies due to its sizeable economy and its close resemblance to many other big emerging market

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economies in terms of the industrial and institutional environment [14]. The Turkish government recognizes the importance of technology diffusion and innovation, having set ambitious targets with a focus on the private sector. Accordingly, both public expenditures on science and technology and share of the private sector in total R&D expenditures have increased considerably in recent years [15].

Third, this article relies on a survey of 241 companies drawn from the database of Turkey's largest 500 manufacturing companies. Although early studies on OI research were undertaken with large-scale companies [16]–[21], most of the subsequent studies shifted their attention to small- and medium-sized enterprises (SMEs) [22]–[30]. As compared to SMEs, large-scale companies may display different patterns regarding the innovation process. For example, SMEs have organizational flexibility and greater incentives to carry out riskier and more unusual innovative projects, provided that they can finance them. In contrast, while large-scale companies are good at large-scale development, manufacturing, and marketing, they are at a comparative disadvantage in managing innovation research because of the costs associated with conducting a heterogeneous set of tasks [31], [32]. Also, bureaucratization within the large companies and financial constraints imposed by capital markets are likely to hamper the innovation process.

Finally, we employ structural equation modeling (SEM) to test our proposed model, involving direct and indirect links between external knowledge sources, OTS, and BP. The SEM method enables researchers to simultaneously estimate and test complex theoretical models with empirical data [33].

The rest of this article is organized as follows. The next section reviews the relevant literature and sets out the study's hypotheses. The third section explains the research methodology, followed by the results. The final section concludes this article.

II. Literature Review and Hypotheses

A. Theoretical Background

Although OI has become one of the key themes in innovation literature, there is still a dearth of strong theoretical knowledge about our understanding of the OI concept. In order to develop a coherent body of knowledge about OI, Vanhaverbeke and Cloodt [34] argue that there is a need to combine existing management theories as none of them can entirely explain how companies benefit from OI. In a similar vein, Huizingh [35, p. 3] asserts that *open innovation is not a clear cut concept. Open innovation comes in many forms and tastes, which adds to the richness of the concept but hinders theory development. Therefore, it is necessary to develop open innovation frameworks*. For instance, the network perspective on OI calls for an integration of several theoretical lenses such as transaction costs paradigm, resource-based view, value chain analysis, and the relational view of the company [36]. OI has been considered as an organizational innovation by which large companies seek to adapt to these changes and has led researchers to examine a new phenomenon of strategic management [37].

Similarly, the important role of external knowledge sources as determinants of OI has also been stressed in innovation literature from different theoretical perspectives ranging from the knowledge-based view of the company and an interorganizational perspective to evolutionary theory and a multilevel organizational perspective. The knowledge-based view of the company argues that knowledge is the crucial input in manufacturing and is an essential value source [38]. Moreover, intercompany collaboration may enhance the efficiency with which specialized knowledge is utilized [39]. Besides, the perspective of the interorganizational network suggests that external partners are a significant aspect of the innovation process that frequently requires knowledge flow among companies [40], [41]. Internally focused logic drawing on an old-fashioned closed innovation paradigm is no longer sustainable for being innovative; instead, a sophisticated set of interactions with external organizations is required [1]. Companies access external knowledge through the interorganizational networks that they cannot produce internally. The term OI reflects the networked nature of innovation. As put forward by Chesbrough [1, p. xxiv], OI is *a paradigm that assumes that companies can and should use external ideas as well as internal ideas … as the firms look to advance their technology.*

On the other hand, evolutionary theorists propose that innovation involves a process of open-ended technological change, the combining of knowledge located at different sites, and interactive learning between the company and the diverse agents surrounding it. System diversity affects innovation since it influences technical and organizational learning and also contributes to the knowledge base of the economy [42]–[44]. Transmission of knowledge crucially affects how companies can effectively get access to knowledge externalities and innovative opportunities [45].

B. External Knowledge Sourcing and Open Technology Strategies

The openness of the companies to external knowledge sources is a significant component of OI when determining their innovation capacity [46]. External knowledge sources can span numerous types of innovation partners, who relate to various knowledge flows and may provide access to widely different realms such as technology, science, product-market trends, customer insights, design, and societal trends [23]. Based on previous literature and widely acknowledged business practices, we categorize external knowledge sources under three groups, namely scientific partners, institutional partners, and indirect partners [3], [10], [19], [47]–[49].

Scientific partners as academic organizations develop and spread avant-garde knowledge to companies for producing cutting edge technology. Scientific research supported by governmental and charitable agencies that is performed in academic and governmental research institutions is a driving force behind producing high technology and economic growth [50]. The fruitful economic and social benefits of universities and research institutes such as conducting academic research and generating scientific knowledge, educating graduates and postgraduates, providing life-long learning opportunity to society, creating instrumentation infrastructures have long been recognized as crucial source for industrial innovation [50]–[54].

Institutional partners are those organizations or institutions which may include international trade fair organizations, international exhibition associations, chambers of trade and industry, and patent institutions. In this article, external knowledge sourcing (EKS) from institutional partners essentially cover the following activities: fairs, exhibitions, conferences, and meetings or publications and documents published by these institutions (e.g., scientific journals and trade/technical publications, patents, public databases) providing objective information to the public. Companies are increasingly using exhibitions, fairs, public databases, expert magazines, customers, and clients for knowledge transfer due to their ease of accessibility [55].

Indirect partners are not among the primary close technology sources with which the company communicates and generally include those companies that are not direct competitors or involve those operating in other industries. There are weaker relationships with indirect partners than directly related partners. According to the weak-tie theory originally developed by Granovetter [48], infrequent and distant (indirect-weak) relationships are efficient for knowledge sharing because those partners provide access to novel information and opportunities by bridging otherwise disconnected individuals and groups in an organization [47], [56]. Companies with many indirect partners are privy to more knowledge than companies whose reach in the network is more restricted [57].

OTS constitute one of the most important aspects of the OI process in a company powered by EKS. Chesbrough and Crowther [58] define two types of OI that companies may engage in. These are, namely, inbound (outside-in) and outbound (inside-out) OI movements of ideas and technologies and are also labeled as "technology acquisition" and "technology exploitation," respectively [21], [29]. At the core of the OI phenomenon, competitive advantage usually emanates from *inbound-outside to in OI*, "which is the practice of leveraging the discoveries of others: companies need not and indeed should not rely exclusively on their own R&D" [58, p. 229]. *Outbound-inside to out OI* is the practice of building relationships with external partners in order to exploit innovative opportunities commercially [59]. Besides inbound and outbound aspects, Gassmann and Enkel [60] propose an additional driver, the *coupled OI process,* which refers to coupling the inbound and outbound processes by working in alliances with complementary partners in which give and take is critical for success.

In this article, we focus on technology acquisition strategy and coupled strategy perspectives rather than technology exploitation strategy. Most Turkish companies, including business groups like their counterparts in other emerging countries, were predominantly more in favor of technology acquisition and coupled strategy rather than technology exploitation strategy due to their failure of developing sufficient technological capabilities for technology exploitation [61]. Technology acquisition strategy refers to purchasing an intellectual property from external sources, such as copyrights, patents, or trademarks [2], [62], [63] via technology licensing, R&D cooperation, spin-ins, and corporate venturing [64], [65]. Implementing technology acquisition strategy has various strategic benefits, such as reducing the high costs of internal R&D and transaction costs [66], achieving fast growth, risk reduction, increasing returns to manufacturing and marketing investment [67], accelerating the invention process [68], and even gaining access to "state of the art" technology [69]. Vanhaverbeke *et al.* [70] assert that a company utilizing technology alliances to learn from its external partners may accomplish high innovative output and enlarge its technological knowledge base. Besides, the coupled strategy requires coinnovation with complementary partners through structured collaboration such as joint ventures, alliances, open-sourced projects, and open production.

EKS help to develop new technological capabilities while also reinforcing existing capabilities [71]. Developing technological knowledge is expensive, tacit, and time-consuming [72]. Technology acquisition strategy requires the use of external knowledge. Its integration with the knowledge of the company is a significant determinant of a company's ability to gain a competitive advantage in markets. Also, it enables companies to benefit from cutting edge technologies through integration with external partners that could improve the company's innovativeness [73]. However, sometimes OI can be expensive, time-consuming, and laborious [3]. Establishing relations with different external knowledge sources is costly as companies need to respect and understand these distinct organizational attributes such as habits, norms, and rules. Furthermore, when companies build too many external relations, they are probably to experience attention allocation problems and, therefore, cannot benefit effectively from the available external knowledge [74]. On the other hand, implementing OTS may also have costs in some respects. According to the Christensen, Olesen, & Kjær [75], alliances and licensing contracts between large incumbents and technology entrepreneurs frequently suffer from high coordination costs, including contractual renegotiation costs that may cause the alliances quite inefficient.

Collaborating with external partners in order to acquire their knowledge can improve a company's technological capabilities, allowing it to better integrate the external knowledge sources into its innovation processes [76], [77]. A company successfully utilizing external knowledge is likely to improve its performance by gaining access to a technological know-how that it lacks [78]. Collaboration among companies is positively related to such outcomes as patenting, R&D performance, learning, and knowledge acquisition [79]–[82]. For example, patents, as one of the external knowledge sources, contain vital information for technology management [83].

We assert that the EKS from scientific partners to develop OTS [84] is an interesting research topic in the context of emerging countries. Industry–university collaboration has been one of the technology acquisition channels discussed extensively in the literature [65], [85]–[89]. Moreover, establishing institutional partnerships provides companies with publicly available and reliable knowledge and thus are the most frequently used by companies as external sources of ideas to improve or develop products and processes [49]. Besides, indirect partners act as a significant knowledge channel between the company and many indirect contacts, leading to new alliances between companies [47], [90]. Ahuja [57] noted that indirect partners had a positive effect on innovation. In an interorganizational technology linkage network, a company's indirect connections serve as a mechanism for knowledge spillovers and contribute significantly to its innovation output. Salman & Saives [47] considered indirect partners as one of the company's intangible strategic resources.

These relationships facilitate cooperation between different partners and help develop OTS, such as acquiring technology, open production, or developing open collaborative projects. This interaction may enhance innovative outputs.

Thus, we assume the following multipart hypothesis that seeks to investigate the effects of EKS from all three types of external partners on implementing OTS.

H1a: External knowledge sourcing from scientific partners has a positive effect on the implementation of open technology strategies.

H1b: *External knowledge sourcing from institutional partners has a positive effect on the implementation of open technology strategies.*

H1c: *External knowledge sourcing from indirect partners has a positive effect on the implementation of open technology strategies.*

C. *Open Technology Strategies and Business Performance*

A company acquiring external technologies can enhance its technological knowledge heterogeneity, leading to innovative products with substantial enhancements [7], [91]. External technology acquisition strategies are valuable because they lead to further innovation [92]. Matching external technology acquisition with internal capabilities is likely to generate a more profound impact for large-scale companies desiring to improve their performance. By acquiring external technology, companies may gain various advantages, such as reducing the time and risks required to develop the technology. In addition, companies can enhance their performance by expanding their acquired technological knowledge [13], [68]. A company that adopts technology acquisition strategy can increase its technological knowledge and strengthen its capability by the external search [93]. This leads to higher performance through the process or product innovation [13].

On the other hand, implementing OTS may also have costs in some respects. According to the Christensen, Olesen, & Kjær [75] alliances and licensing contracts between large incumbents and technology entrepreneurs frequently suffer from high coordination costs that may cause the alliances quite inefficient. These costs generally arise from the following sources: bargaining power and asymmetric information problems, difficulties of subtle financial incentive conflicts and associated opportunistic behavior (i.e., rents sharing from the joint production), and trust and communication problems due to cultural differences, procedures, norms, and language between the parties.

Even though coupled strategy is a complex process due to its interactive nature and longevity [94], it enables the cocreation process with partners to produce more innovative products or technologies. In order to improve the BP, implementing coupled strategies may enhance the investment level of the NPD process with collaborating external partners. This allows a closer interaction to create opportunities for both sides to generate high return value; provides more opportunity to monitor behaviors and strengthen relationships, and enables risk reduction on each side [95]. Synergies arise when partners with different abilities work together in the NPD process, which can positively affect the company's performance by increasing innovative outputs.

When viewed from the previous literature, some support has been noted concerning the impact of OTS on company-level performance outcomes. Aschhoff and Schmidt [96] found that R&D collaboration with research institutes has a positive effect on a company's financial performance with market novelties; on the other hand, R&D collaboration with competitors leads to considerable cost savings in innovation processes. From a different perspective, Tsai and Wang [97] revealed that inward technology licensing did not contribute significantly to innovation performance, and internal R&D investment moderated the impact of R&D outsourcing on innovation performance negatively. Besides, internal R&D investment contingently affects the different partner types in innovation performance. Collaboration with different partners is an appropriate means to obtain external technological knowledge for enhancing innovation performance. Mazzola *et al.* [12] show that acquisition affects both kinds of performance differently; it positively influences financial performance while negatively affecting innovation performance. Furthermore, manufacturing alliances have a simultaneous negative effect, while copatents positively influence both types of performance. Copatents appear to have a simultaneous impact on performance by reducing lead times and costs of new patent development as well as improving technological quality and market adaptability of innovative outputs.

Hung and Chou [11] found a positive association between external technology acquisition and BP. In contrast, they did not find any support regarding the relationship between external technology exploitation and BP. In their study of 168 R&D-intensive companies from Japan, the U.S., and Europe, Belderbos *et al.* [98] found an inverted-U type relationship between the share of explorative technological practices and financial performance. In their study with 120 biopharmaceutical companies, Mazzola *et al.* [99] revealed that in-licensing and platform biotech companies negatively influence innovation performance while positively affecting financial performance. Moreover, the number of copatents the company develops with other organizations is negatively associated with the growth of revenue, while it is positively related to the number of patents. Likewise, the number of strategic alliances the company establishes is negatively associated with the growth of revenue, while it is positively linked with the number of patents.

Based on the arguments above and confirming evidence from the previous literature, we assume the following hypothesis:

H2: *The implementation of* open *technology strategies has a positive effect on business performance.*

D. *Mediating Effect of Open Technology Strategies*

When viewed from the relevant literature [10], [91], [100]–[102], companies with a heterogeneous network of different types of external partners have been found to have better innovation performance as synergies arise from a networked innovation approach [100], [103]. EKS from different partner types brings companies a large spectrum of sources for innovation [10]. Cohen and Levinthal [104] argue that the ability to exploit external knowledge is a crucial constituent of innovation performance. Especially for companies in emerging markets, access to external knowledge sources becomes a critical driver for innovation performance due to their limited and weak resources. For example, Miotti and Sachwald [102] argue that cooperation with different partners positively affects innovation success. Becker and Dietz [100] also reached a similar conclusion, suggesting that the mix of heterogeneous partners in R&D collaboration releases synergies, improves the productivity of research, and heightens the probability of NPD. Furthermore, the likelihood of realizing product innovations increases with the number of partners involved in R&D cooperation. Consequently, companies have a positive influence on creating new products by utilizing technological opportunities and obtaining additional resources. Faems *et al.* [105] noted an indirect association between technology alliance portfolio diversity (i.e., external knowledge sources) and product innovation performance via internal innovation efforts. According to Lundvall [44], an external knowledge search that takes place in science-oriented or academic organizations outside the private companies brings forward another sort of raw materials for the innovation process.

Although it is generally acknowledged that the EKS may positively affect various company-level performance outcomes [10], [106], [107], companies cannot solely hinge on external knowledge sources to accomplish their goals. They can only strengthen the company's engagement with external partners or help to improve its knowledge base. Only through the proper implementation of OTS, EKS is likely to improve a company's innovation capacity, which in turn positively influences BP.

Collaborating with scientific partners not only helps to identify relevant academic research, whether published or not, but also provides the company with gaining access to the tacit knowledge and enabling them to quickly build on the latest research findings [9], [108]. Moreover, R&D collaboration with scientific partners enables access to a wide range of knowledge base for product innovation [109]. Collaborating with universities and their research centers also improves new technology implementation, NPD and spin-offs, manufacturing costs, and lead time; reduces production and R&D costs; and increases the number of patents [110].

Institutional partners provide novel and objective knowledge to the company. For instance, trade fairs contribute to the meeting of partners in the NPD process [111]. Thus, an environment conducive to developing new product ideas and effective OTS can be created. By displaying new product prototypes, ideas can be exchanged with the experts, enabling the production of more developed prototypes. In addition, scientific/technical journals, public databases, and patents provide proven information. Therefore, these external knowledge sources can help businesses to develop smart OTS.

It is widely acknowledged that indirect partners foster the conditions for OI by enabling of information sharing and knowledge transfer [47]. This leads companies to design more astute OTS. Acquiring technology or implementing coupled strategies with external partners may enhance the BP of the large-scale manufacturing companies, particularly in emerging markets. Consistent with earlier arguments, the successful implementation of OTS is a precursor to BP and serves a mediating role in the relationships between EKS from all three types of external partners and BP. Then, we assume the following three-part hypotheses:

> **H3a:** *The implementation of open technology strategies mediates the relationship between external knowledge sourcing from scientific partners and business performance.*
>
> **H3b:** *The implementation of open technology strategies mediates the relationship between external knowledge sourcing from institutional partners and business performance.*
>
> **H3c:** *The implementation of open technology strategies mediates the relationship between external knowledge sourcing from indirect partners and business performance.*

Our proposed model, along with the hypothesized relationships, are shown in Fig. 1.

III. Research Methodology

A. Sample and Data Collection

A cross-sectional survey design was adopted to examine the hypothesized links in our research model. A survey instrument relying on a self-administered questionnaire was designed. The questionnaire was piloted several times to confirm that the wording, format, and sequencing of questions were appropriate and also to enhance its content validity. It was then reviewed by eight academics and eight business professionals with relevant knowledge and experience in innovation practices to give its final shape.

The database of the Istanbul Chamber of Industry was identified as the sampling frame of this survey. The sampling frame consists of Turkey's largest 500 manufacturing companies operating in various industries. Questionnaires were mailed to all 500 companies. It was solicited that the questionnaire is filled out by a senior manager in charge of R&D or an executive with at least some knowledge and expertise in innovation practices. After two reminders, a total of 241 usable questionnaires were received, indicating an effective response rate of 48.2%, which was excellent, given the confidential nature of the questionnaire and the position of respondents.

The key features of the sample are briefly shown in Table I. The survey sample consists of the largest industrial companies in Turkey, with the mean number of employees being 1349. The sample represents companies from various industries, including iron, steel, and metal (20.3%); food and beverages (19.1%); automotive and related industries (12.4%); consumer durables (11.2%); textile and apparel (10.8%); and construction (10.8%). The majority of the sample companies (74.3%) have been operational for at least 20 years. With respect to equity ownership, the majority of the sample includes domestic companies (74.3%), while the remainder has varying levels of foreign ownership.

B. Measurement of Variables

The ensuing subsections present brief descriptions of the variables, alongside with the control variables. All of the study's constructs were measured using seven-point Likert scales. The

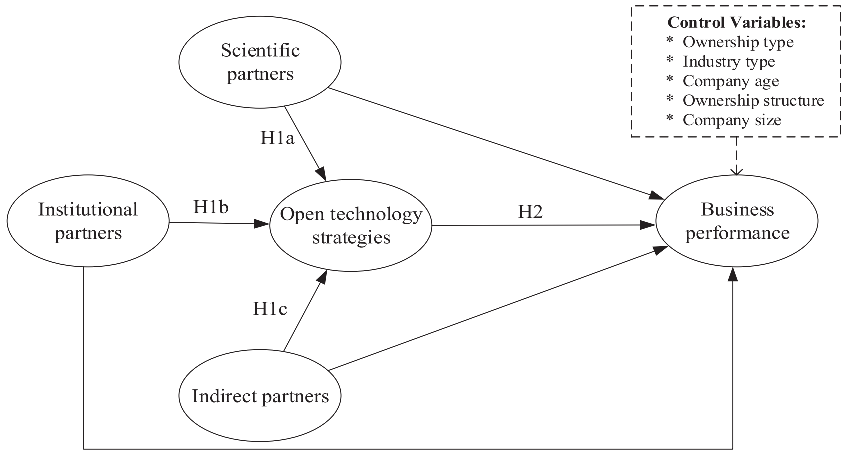

Fig. 1. Proposed model. Mediation hypotheses: H3a: Scientific partners → Open technology strategies → Business performance. H3b: Institutional partners → Open technology strategies → Business performance. H3c: Indirect partners → Open technology strategies → Business performance.

TABLE I
CHARACTERISTICS OF THE SAMPLE

Characteristics		***Number***	***%***
Company age (Years)	Young companies (Less than 20 years)	62	25.7
	Middle-age companies (20-40 years)	92	38.2
	Mature companies (More than 40 years)	87	36.1
Ownership type	Domestic	179	74.3
	MNC subsidiary	62	25.7
Industry type (Technology level)	Low-technology	82	34
	High-technology	159	66
Industry	Food and beverages	46	19.1
	Chemical and pharmaceuticals	24	10.0
	Iron, steel, and metal	49	20.3
	Automotive and related	30	12.4
	Consumer durables	27	11.2
	Textile and apparel	26	10.8
	Construction industry	26	10.8
	Other manufacturing	13	5.4
Company size (Number of employees)	Less than 500	74	30.7
	500-1000	54	22.4
	1001-1500	39	16.2
	1501-2000	33	13.7
	More than 2000	41	17
Ownership structure	Listed	32	13.3
	Unlisted	209	86.7
Total		*241*	*100.0*

operationalization of the study's constructs and the exact wording of the questions and their sources are provided in the Appendix.

1) Dependent Variable: BP is measured by three dimensions: *financial performance, NPD performance*, and *OI performance*. Assessing BP through various dimensions may provide a more realistic measurement than a single performance dimension, such as financial or innovation performance. All three dimensions constituting BP consist of 16 items and are drawn from previous studies [2], [12], [112]–[114].

2) Independent Variable: EKS was measured by 18 items adapted from earlier studies [3], [19]. EKS essentially consists of three types of external knowledge sources: scientific, institutional, and indirect partners.

3) Mediator Variable: OTS were broadly classified into two categories (i.e., technology acquisition and coupled strategy), consistent with earlier research [2], [12], [112]. The implementation level of OTS was measured by a total of 12 items, of which eight items represent the *coupled strategy* and the remaining four denote *technology acquisition strategy*, respectively.

4) Control Variables: The following three control variables were included to check the likelihood of extraneous

effects on BP.

Ownership type (OWN). The sample consists of Turkish domestic companies and subsidiaries of multinational corporations (MNC) operating in Turkey. MNC subsidiaries can obtain benefits from the parent companies, for example, more sophisticated technology and better management techniques, than is available to domestic companies. They are also likely to have greater access to finance to engage in innovation activity. Hence, MNC subsidiaries may have a greater ability to develop new products and processes. Therefore, given the presumed likelihood of different propensities to innovate, we control for the ownership type, which is measured by a categorical variable where 0 denotes domestic company, 1 represents a subsidiary of MNC.

Industry type (IND). Industry differences based on technological intensity should be considered when examining the effect of EKS on BP. In some industries, for example, those highly dependent on R&D, innovation is a critical element of competition where companies frequently launch new products or services to address quickly changing customer needs. In other industries where consumers respond less to innovativeness, there is not the same obligation for companies to regularly introduce new products [115]. The industry type is included as a categorical variable where two groups of industries are created (i.e., low versus high-technology) based on the OECD's classification of industries in line with their level of R&D intensity [116]. The OECD's classification of industries is based on a sample of 37 OECD countries, including emerging countries such as Turkey, Brazil, Colombia, Chile, and Estonia, among others. Hence, it is seemingly applicable to other emerging countries.

Company age (AGE). Newer companies are supposed to be more entrepreneurial and innovative than mature companies [117]. While younger companies may be more flexible and agile, more mature companies might emphasize established core routines. As a result, pursuing innovation in young companies may be much easier than mature companies, such that the former may benefit more from innovation than the latter [118]. Hence, three broad age categories are created to control for the effect of company age. Young companies include those aged less than 20 years, middle-aged companies include those whose ages vary between 20 and 40, and mature companies are those aged over 40 years.

Company size (SIZE). Company size was captured using five categories, based on the number of employees (i.e., 1 = "less than 500," 2 = "500–1000,", 3 = "1001–1500," 4 = "1501–2000," and 5 = "more than 2000").

Ownership structure (STR): Companies are categorized into listed versus unlisted firms based on whether their shares are quoted in Borsa Istanbul (BIST). A value of 1 is assigned to listed firms (32 firms) and 0 for unlisted firms (209 firms).

IV. RESULTS

The proposed research model, as displayed in Fig. 1, was tested by SEM using AMOS. The data analysis was undertaken at four steps. In the first step, an exploratory factor analysis (EFA) with varimax rotation was conducted to identify the underlying dimensions of EKS, OTS, and BP. The second step included testing of the measurement models for each construct using confirmatory factor analysis (CFA) in order to verify if the extracted factors in step 1 exhibited a good fit to the data. Next, common method bias (CMB) and endogeneity were checked. Finally, we tested our hypothesized relationships using covariance-based SEM.

A. Exploratory Factor Analysis

An attempt was made to generate a parsimonious set of distinct nonoverlapping variables from the full set of items constituting each construct. EFA using varimax rotation was executed distinctly on the EKS, OTS, and BP in order to reveal the dimensions of each construct. Tables II–IV show the results of EFA. A content analysis was performed to purify the uncovered factors as items measuring the same factor must have consistent meanings. Thus, items that had inconsistent substantive meanings with the factor or that had low factor loadings were omitted from further analysis.

The EFA on EKS yielded four factors initially. In line with the purification process, four items were removed (see Appendix), and the remaining 14 items were again factor analyzed and generated three factors, which explained 63.45% of the observed variance, as shown in Table II. Based on the item loadings, these three factors were very much in line with our typology of EKS identified *a priori* and thus were labeled, respectively, as *scientific partners, institutional partners,* and *indirect partners.* The Cronbach's alpha values of reliability for the underlying factors ranged from 0.74 to 0.90, denoting a satisfactory level of construct reliability [119].

Similarly, EFA was conducted to generate a set of parsimonious dimensions of OTS. The EFA produced three factors that explained 73% of the observed variance (see Table III). Cronbach's alphas for the underlying factors ranged from 0.74 through 0.87. These factors were named as *collaboration strategy with partners*, *technology acquisition strategy*, and *open production strategy*. While the OTS was initially categorized into two dimensions, the EFA revealed three dimensions. This stems from the division of *coupled strategy* further into two parts as *collaboration strategy with partners* and *open production strategy* and makes conceptual sense.

To extract the underlying dimensions of the BP, the EFA generated three factors, explaining 65% of the observed variance (see Table IV). These factors were, respectively, labeled as *NPD performance*, *OI performance*, and *financial performance*. Again, the Cronbach's alpha values for the underlying factors exhibited a satisfactory level of construct reliability.

B. Confirmatory Factor Analysis

CFA tests the measurement model of variables. In order to assess the construct validity, EKS, OTS, and BP were tested with

TABLE II
FACTOR ANALYSIS OF EXTERNAL KNOWLEDGE SOURCES

External knowledge sources		Factor loadings (EFA)	Factor loadings (CFA)	Eigen-value	Variance explained (%)	Cumulative (%)	Cronbach alpha
Scientific partners				4.15	29.66	29.66	.90
EKS8	Private research institutes	.81	.77				
EKS7	Commercial laboratories/R&D enterprises	.81	.76				
EKS9	Universities or other higher education institutions	.78	.79				
EKS10	Government research organizations	.77	.80				
EKS6	Experts/consultants	.68	.65				
EKS17	Technoparks and enterprises in technoparks	.65	.72				
EKS18	Technology transfer offices/centers (TTO/TTC)	.63	.70				
Institutional partners				2.85	20.37	50.03	.79
EKS14	Scientific journals and trade/technical publications	.72	.65				
EKS12	Fairs, exhibitions	.71	.66				
EKS11	Conferences, meetings	.71	.82				
EKS15	Public databases	.70	.59				
EKS16	Patents	.66	.60				
Indirect partners				1.88	13.42	63.45	.74
EKS4	Other enterprises in your sector that are not direct competitors (e.g., operating in different geographic regions)	.86	.66				
EKS5	Other enterprises in other sectors	.81	.90				

Notes: K-M-O Measure of Sampling Adequacy = 0.896.
Barlett Test of Sphericity = 1589.21, $p < 0.01$.

TABLE III
FACTOR ANALYSIS OF OPEN TECHNOLOGY STRATEGIES

Open technology strategies		Factor loadings (EFA)	Factor loadings (CFA)	Eigen-value	Variance explained (%)	Cumulative (%)	Cronbach alpha
Collaboration strategy with partners				2.41	26.74	26.74	.87
CS1	In innovation projects, our enterprise usually integrates all internal and external partners' information.	.88	.82				
CS2	In innovation projects, our enterprise coordinates the activities of exchange of information among partners.	.83	.88				
CS3	In innovation projects, our enterprise keeps internal and external partners updated about new information.	.83	.78				
Open production strategy				2.18	24.23	50.97	.81
CS7	Our enterprise conducts open production through the community's participation (peer to peer production).	.86	.77				
CS8	Our enterprise aims to enhance knowledge production by setting up joint ventures.	.80	.80				
CS6	Our enterprise develops open-sourced projects.	.77	.72				
Technology acquisition strategy				1.98	22.03	73.00	.74
TA3	Our enterprise often buys R&D-related services from external partners.	.87	.84				
TA4	Our enterprise usually buys an intellectual property, such as patents, copyrights, or trademarks, from external partners to be used in our innovation projects.	.81	.65				
TA2	All our innovation projects are highly dependent upon the contribution of external partners.	.71	.62				

Notes: K-M-O Measure of Sampling Adequacy = 0.838.
Barlett Test of Sphericity = 1250.63, $p < 0.01$.

TABLE IV
FACTOR ANALYSIS OF BUSINESS PERFORMANCE

Business performance (BP)		Factor loadings (EFA)	Factor loadings (CFA)	Eigen-value	Variance explained (%)	Cumulative (%)	Cronbach alpha
	New product development performance (NPDP)			3.92	24.53	24.53	.90
NPDP3	Degree of new product differentiation	.80	.77				
NPDP4	First to market with new applications	.79	.79				
NPDP6	Acquiring the image of an innovative supplier	.78	.79				
NPDP2	New product success rate	.77	.76				
NPDP1	New product introduction rate	.76	.76				
NPDP5	New product cycle time (e.g., inception to rollout)	.72	.70				
	Open innovation performance (OIP)			3.73	23.33	47.86	.87
OIP3	The number of R&D agreements	.82	.90				
OIP4	The number of R&D joint ventures	.82	.92				
OIP2	The number of co-patents	.79	.64				
OIP6	The number of joint ventures for co-production	.79	.62				
OIP5	The number of manufacturing agreements	.72	.62				
OIP1	The number of patents	.60	.51				
	Financial performance (FP)			2.74	17.14	65.0	.82
FP2	Sales	.82	.83				
FP3	Market share	.78	.76				
FP1	Return on investment	.75	.69				
FP4	Profitability	.74	.65				

Notes: K-M-O Measure of Sampling Adequacy = 0.867.
Barlett Test of Sphericity = 2122.60, $p < 0.01$.

TABLE V
CONFIRMATORY FACTOR ANALYSIS

Factors	χ^2/df	GFI	AGFI	CFI	TLI	RMSEA
External knowledge sourcing	1.53	.95	.92	.98	.97	.04
Open technology strategies	2.28	.95	.91	.96	.95	.07
Business performance	1.86	.92	.88	.96	.95	.06

a first-order confirmatory factor model. Table V indicates that the model fit indices were within generally accepted ranges, displaying an excellent level of fit to the data. The values of (χ^2/d*f*) for EKS, OTS, and BP are 1.53, 2.28, and 1.86, respectively, and within the range of 0–5, where smaller values indicate better fit [120], [121]. Moreover, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and Tucker–Lewis index (TLI) for all three constructs were highly satisfactory, as these indices are closer to 1 and show a good fit [122]. The root mean square error of approximation (RMSEA) was also satisfactory as RMSEA values for all three constructs were lower than the threshold value of 0.08 [123].

Tables VI–VIII show the reliability and validity of the underlying constructs of EKS, OTS, and BP, respectively. In addition to the Cronbach alpha values reported earlier in Tables II–IV, all of the underlying dimensions of the three constructs also had high scores of the composite reliability, which also exceeded the threshold value of 0.70, denoting acceptable levels of *construct reliability* [124], [125].

The *convergent validity* of the measures was examined by the average variance extracted (AVE) values of the constructs. Tables VI–VIII show that the AVE values were higher than the threshold value of 0.50, verifying the convergent validity of the constructs [126]. Moreover, highly significant standardized regression weights of the individual variables ($p < 0.01$), as shown in Tables II–IV, are acknowledged as the indicators of convergent validity [127].

As displayed in Tables VI–VIII, the AVE values of the constructs were all greater than their respective values of maximum shared squared variance (MSV), confirming the *discriminant validity* of the study's constructs [126].

C. Common Method Bias and Endogeneity

We employed different techniques to cope with the likelihood of CMB for our study. First, we used several design-related methods to mitigate potential CMB. In so doing, we initially prequalified potential respondents that had a basic knowledge

TABLE VI
RELIABILITY AND VALIDITY OF EXTERNAL KNOWLEDGE SOURCES[a]

External knowledge sources	Composite reliability	AVE	MSV	Scientific partners	Institutional partners	Indirect partners
Scientific partners	.90	.57	.41	*.75*		
Institutional partners	.76	.51	.41	.64*	*.72*	
Indirect partners	.76	.62	.27	.52*	.33*	*.79*

Notes: [a] Italicized values on the diagonal are the square root of the AVE values.
$*p < 0.01$.

TABLE VII
RELIABILITY AND VALIDITY OF OPEN TECHNOLOGY STRATEGIES[a]

Open technology strategies	Composite reliability	AVE	MSV	Collaboration with partners strategy	Technology acquisition strategy	Open production strategy
Collaboration with partners strategy	.87	.68	.36	*.83*		
Technology acquisition strategy	.75	.50	.10	.28*	*.71*	
Open production strategy	.81	.58	.36	.60*	.31*	*.76*

Notes: [a] Italicized values on the diagonal are the square root of the AVE values.
$*p < 0.01$.

TABLE VIII
RELIABILITY AND VALIDITY OF BUSINESS PERFORMANCE

Business performance	Composite reliability	AVE	MSV	New product development performance	Open innovation performance	Financial performance
New product development performance	.89	.58	.28	*.76*		
Open innovation performance	.86	.51	.12	.46*	*.72*	
Financial performance	.82	.54	.28	.53*	.27*	*.74*

Notes: [a] Italicized values on the diagonal are the square root of the AVE values.
$*p < 0.01$.

of the research subject. Next, we assured all respondents that their responses would be confidential and anonymous and could not be traced to identify the individual at any stage of our research. Moreover, we separated the dependent and independent variables from each other and randomized the items within each construct.

Second, we conducted Harman's single factor test to examine whether a single factor could explain the majority of the variance [128]. In this single factor test, all of the items in this study were subjected to EFA [129], [130]. The number of factors extracted from the EFA was forced to one. If there is considerable common variance, the single factor is expected to generate the majority of the covariance among all factors. The results revealed that the common method variance accounted for 21.58% of the total variance. Hence, the CMB is not considered to be statistically significant since it is lower than the threshold value of 0.50 [129], [130].

Before testing the hypotheses, we also considered necessary to check if endogeneity is a serious concern due to reverse causality [131]. Therefore, we conducted a number of tests to determine whether endogeneity is likely to pose a serious threat.

First, we performed a two-stage least squares (2SLS) regression using instrumental variables. Industry type denoted by the level of technological intensity and ownership structure (i.e., listed versus unlisted) were selected as potential instrumental variables because they were not significantly correlated to OTS (see Table IX). Additionally, customer integration, adapted from earlier studies [132], [133] (see Appendix for the measurement items), was selected as another instrumental variable because it is likely to be associated with each type of external knowledge sources but is not necessarily correlated with OTS. According to 2SLS, we first regressed all three dimensions of external knowledge sources (i.e., scientific, institutional, and indirect

TABLE IX
SUMMARY STATISTICS AND CORRELATION COEFFICIENTS

Variable names	Definitions	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
External knowledge sourcing	1. Scientific partners	4.90	1.21	1													
	2. Institutional partners	5.29	1.04	.54**	1												
	3. Indirect partners	4.37	1.39	.44**	.25**	1											
Open technology strategies	4. Collaboration strategy with partners	4.77	1.24	.32**	.30**	.15*	1										
	5. Open production strategy	3.90	1.50	.53**	.33**	.37**	.50**	1									
	6. Technology acquisition strategy	3.61	1.40	.30**	0.08	.21**	.23**	.27**	1								
Business performance	7. New product development performance	5.27	1.12	.17**	.25**	.19	.26**	.30**	.06	1							
	8. Financial performance	5.57	.98	.01	.16*	.04	.07	.12	-.04	.46**	1						
	9. Open innovation performance	3.56	1.41	.39**	.28**	.20**	.24**	.47**	.22**	.42**	.26**	1					
Control variables	10. Ownership type	.26	.44	-.00	-.02	.03	.03	.01	.11	.11	.09	.07	1				
	11. Industry type	.66	.48	.03	.03	.05	.04	.03	-.12	.15*	.12	.16*	.10	1			
	12. Company age	2.10	.78	.03	.01	-.08	.02	-.07	-.10	-.05	.03	-.06	-.08	-.00	1		
	13. Ownership structure	.13	.34	.19**	-.04	-.05	.06	.01	.07	.11	.12	.08	.16*	.05	.31**	1	
	14. Company size	2.64	1.46	-.12	-.13	-.15*	.19**	-.04	-.15*	-.02	.02	.09	.06	.16*	.19**	0.11	1

Notes: $*p < 0.05$, $**p < 0.01$.
S.D. = Standard Deviation.

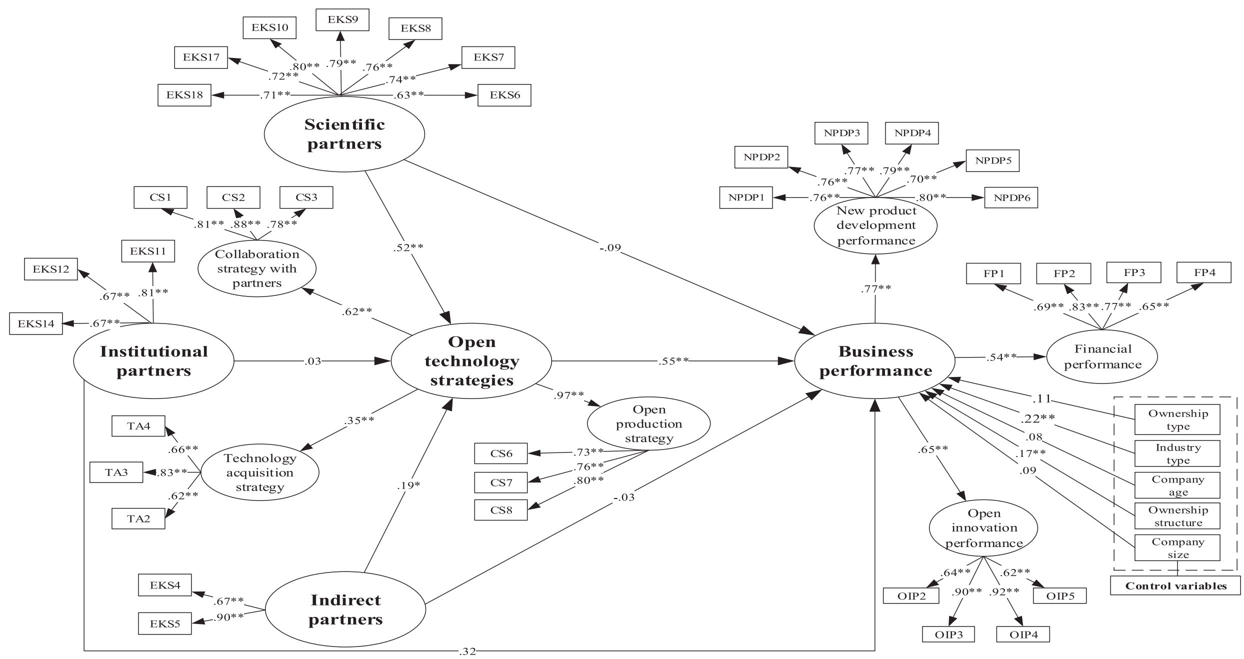

Fig. 2. Results of the structural model. *Notes:* $*p < 0.05$ $**p < 0.01$.

partners) on controls and instrumental variables, then used the residual of this regression as an additional regressor in our hypothesized equations. The parameter estimates for the residual were not significant, indicating that external knowledge sources were not endogenous in our setting, consistent with our conceptualization.

Second, we conducted the Durbin–Wu–Hausman endogeneity test to determine if the exogenous variables are endogenous. The results of this test were not significant ($p > 0.1$), suggesting that the estimates of the OLS and 2SLS models do not differ from one another. Thus, the test results confirm the validity of instruments indicating that our results are unlikely to be influenced by endogeneity.

D. Hypotheses Testing

The final stage involved testing the hypothesized paths in our research model. SEM results are displayed in Fig. 2. In addition, summary statistics, including correlation coefficients among the constructs, are given in Table IX. There are significant correlations among EKS, OTS, and BP constructs.

The model parameters related to our hypotheses, as shown in Fig. 2, were computed with the maximum likelihood estimation method in SEM. The fit indices for the model were highly adequate (χ^2/df = 1.56, GFI = 0.85, CFI = 0.93, AGFI = 0.81, TLI = 0.92, RMSEA = 0.05) [125].

Table X shows the results of hypotheses testing. Strong support is found for our direct hypotheses, H1a and H1c, in that the EKS from scientific partners ($\beta = 0.52$, $p < 0.01$) and indirect partners positively affect OTS ($\beta = 0.19$, $p < 0.05$). In other words, collaborating with scientific partners and indirect partners triggers the development and implementation of OTS. No support, however, is found for H1b regarding the direct effect of EKS from institutional partners on OTS ($\beta = 0.03$, $p > 0.1$).

In a similar vein, H2, which postulates that OTS has a direct and positive influence on BP, also receives strong support ($\beta = 0.55$, $p < 0.01$).

TABLE X
HYPOTHESES TESTING RESULTS

Hypotheses	Total effect	Direct effect	Indirect effect (CI)	Level of support
Direct effects				
H1a: Scientific partners → Open technology strategies		.52**		Supported
H1b: Institutional partners → Open technology strategies		.03		Not supported
H1c: Indirect partners → Open technology strategies		.19*		Supported
H2: Open technology strategies → Business performance		.55**		Supported
Indirect effects				
H3a: Scientific partners → Open technology strategies → Business performance	.22**	-.07	.29** (0.09, 0.61)	Supported
H3b: Institutional partners → Open technology strategies → Business performance	.34**	.32**	.02 (-0.09, 0.10)	Not supported
H3c: Indirect partners → Open technology strategies → Business performance	.14*	.03	.11* (0.01, 0.22)	Supported
Control variables				
Ownership type → Business performance		.11		
Industry type → Business performance		.22**		
Company age → Business performance		.08		
Ownership structure → Business performance		.17**		
Company size → Business performance		.09		

$*p < 0.05$; $**p < 0.01$ (two-tailed).
Bootstrapping $N = 5000$, CI = Upper and lower limits of 99% confidence interval.

The mediation hypotheses in our model (H3a to H3c) can be tested by examining the relationship of the direct and indirect effect (via mediator) between two latent variables [125]. Table X shows that the total effects between the independent variables (i.e., scientific partners, institutional partners, and indirect partners) and the dependent variable (i.e., BP) are all significant in the absence of the mediator variable (i.e., OTS) [scientific partners $\rightarrow$ BP $= 0.22$, $p < 0.01$; institutional partners $\rightarrow$ BP $= 0.34$, $p < 0.01$; indirect partners $\rightarrow$ BP $= 0.14$, $p < 0.05$]. Then, we applied the traditional Sobel test approach [134], [135] in order to test the existence of the mediation effects. To do this, we computed indirect effects between independent variables and dependent variable using a mediator. As shown in Table X, there is a strong support for H3a and H3c, confirming the full mediation effect of OTS on the relationship between EKS from scientific partners and BP [(scientific partners $\rightarrow$ OTS)$*$(OTS $\rightarrow$ BP) $= 0.52*0.55 = 0.29$; Sobel test statistics $= 2.56$, $p < 0.01$] as well as on the relationship between EKS from indirect partners and BP [(indirect partners $\rightarrow$ OTS)$*$(OTS $\rightarrow$ BP) $= 0.19*0.55 = 0.11$; Sobel test statistics $= 1.97$, $p < 0.05$]. No support, however, is found for H3b concerning the mediating effect of OTS on the link between EKS from institutional partners and BP. It should be noted that although there is no mediation effect of OTS on the relationship between institutional partners and BP, a significant link exists between institutional partners and BP.

The presence of mediation effects was also tested using the bias-corrected bootstrapping technique. The use of this technique has been recommended over the traditional Sobel test, or the causal steps approach, as the bootstrapping method has higher power in controlling type I error [136]. To run the bias-corrected bootstrapping technique, as suggested by Hayes and Preacher [137], 5000 resamples were produced to examine if the indirect effect differed significantly from zero. For the mediation to be established, the confidence interval (CI) must be entirely above or below zero. Bias corrected bootstrapping analysis showed that the standardized CI limits for the indirect effects of both EKS from scientific partners (lower CI $= 0.09$, upper CI $= 0.61$) and EKS from indirect partners (lower CI $= 0.01$, upper CI $= 0.22$) on BP through OTS are also in line with the suggested standardized CI limits, attesting the full mediation effect of OTS.

Among the control variables, only industry type and ownership structure were noted to have a significant effect on BP ($p < 0.01$). In other words, companies operating in high-technology industries and those that are listed in BIST have higher BP compared to those in low-technology industries. These companies are characterized by high level of corporate reputation and brand equity and also have better corporate governance practices that are likely to have a positive effect on their BP.

V. CONCLUSION

Companies are progressively looking to the outside for novel ideas and new knowledge, and acquiring technology, and cooperating with partners in order to strengthen their technological capabilities as a means of gaining competitive advantage. By unlocking the black box between EKS from three types of partners (i.e., scientific, institutional, and indirect partners) and BP by investigating the role that OTS play as a mediating variable, this article has contributed to the innovation literature within the context of large-scale companies from a key emerging country setting. Relying on a sample of 241 companies drawn from Turkey's largest 500 manufacturing companies, this article's findings reveal that the association between EKS from scientific partners and indirect partners and BP becomes stronger with the mediating role of implementing technology acquisition or coupled strategies with external partners. While there is a significant link between EKS from institutional partners and BP, implementation of OTS is noted to have a no mediating effect on the relationship between institutional partners and BP.

EKS from scientific partners and indirect partners focuses on creating novel technologies that can be converted eventually into commercial development. Our results suggest that such knowledge sourcing was an effective mechanism for large-scale companies in emerging countries to overcome the innovation challenges they face. In the context of emerging countries, both scientific partners and indirect partners seem to be providing companies with cutting-edge knowledge that promotes developing high-tech products, processes, and innovation outcomes. On the other hand, the finding that implementing OTS does not mediate the relationship between EKS from institutional partners and BP is not particularly surprising. This may be explained by large-scale companies' proclivity not to feel obliged to pursue a particular open technology strategy while leveraging institutional partners' knowledge. The knowledge obtained from institutional partners is proven and reliable and thus, is likely to have a direct effect on BP.

A. Managerial Implications

This article suggests some managerial implications for senior executives and innovation managers of large-scale companies. From an emerging country perspective, OI is an effective strategy to catch up with the leading economies in many industrial sectors. OI can be a vital tool to enlarge the company's strategy space, and it might assist senior managers in identifying new opportunities and avoiding competitive threats by enabling strategic innovation [138].

First, managers should focus on searching for knowledge from beyond the company's boundaries because such focus is beneficial for gaining access to extraordinary ideas, new technology, and further knowledge, facilitating the creation of new ideas for products or processes, and providing market opportunities. Nevertheless, keeping close connections with all types of external partners necessitates significant effort and time. In order to acquire higher OI efficiency, companies are recommended to determine the most appropriate external partners that are suitable for their capabilities [10]. Within the context of emerging countries, it should be noted that large-scale companies place more emphasis on collaboration with scientific partners and indirect partners than institutional partners in gaining access to external knowledge sources because scientific partners may provide more convenient access to scientific knowledge and technology. Cooperation with the universities, research centers, technoparks, and technology transfer offices/centers may offer several benefits to companies. Besides, it is expensive and cumbersome for companies to invest in technology and produce new technological knowledge with their internal resources, as well as to acquire a highly talented workforce to generate this knowledge and continuously improve it. Thus, thanks to the synergy created by university–industry cooperation, companies are likely to increase the output of innovative products by evaluating the technological knowledge developed by scientists and the technological investments of the universities. It should also be noted that EKS not only affects BP positively but also contributes to the reduction of R&D costs by enabling the new technology developed by the scientific partners to be placed into companies' operational processes easily and quickly. Moreover, indirect partners can enhance BP through developing OTS. Indirect partners, as a type of EKS, even if they are not frequently used, can facilitate companies to connect with many different sources. Also, they contribute to the adaptation of innovations and practices in different sectors to innovation processes by benchmarking. On the other hand, while we found that EKS from institutional partners directly affects BP, implementing OTS does not have any indirect effect on the relationship between EKS from institutional partners and BP.

Second, while the diversity of external knowledge sources adds value to the innovation process, it is insufficient to increase BP alone. However, it is also equally important to what extent the company incorporates the knowledge obtained from these sources into its processes. This integration can be possible with the adoption of well-crafted OTS. The interaction between EKS and implementation of technology acquisition, open production, and collaboration strategy with partners may lead to better performance for large-scale manufacturing companies. Therefore, large-scale companies should consider the execution of OTS as a facilitating strategy tool for improving BP. In addition to gaining access to external knowledge sources, managers should also be cognizant of integrating this novel input correctly into their companies' internal innovation processes.

B. Limitations and Future Research Agenda

As in most studies, this article is also subject to some limitations. First, this article is based on the managerial perceptions of single respondents; it would have been ideal to acquire data from multiple respondents. We should also admit that the accuracy of perceptual data is likely to pose a serious issue in studies like ours. Still, for some constructs (e.g., EKS and OI adoption), it is difficult to develop objective measures. Nevertheless, we urge researchers to supplement perceptual data with more objective data whenever possible. We essentially focused on the largest 500 manufacturing companies in Turkey without sectoral separation. Future research can investigate OI in specific sectors or focus on certain industries to enable sectoral comparisons and detect the differences among them. In addition, examining OI from a comparative perspective, which may involve companies regardless of size, could be a useful addition to the literature. As our study looked at the Turkish context, future studies can design their research by comparing the effectiveness and adoption of OI in different emerging markets and may shed light on the potential impact of the cultural differences in implementing OI in emerging market contexts.

Moreover, future research should not only focus on the managers' viewpoint but also include the employee's perspective for an improved understanding of the links among EKS, OI, and performance. As also put forward by Randhawa *et al.* [139], existing research has hitherto mainly concentrated on the company-centric OI features when studying R&D, technology, and knowledge. However, incorporating networks, users, and community perspectives provide some useful directions for future research to develop a more rounded view of OI.

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Appendix
Measurement of Constructs

Construct	Items	Source
External knowledge sourcing	Over the past three years, please indicate to what extent each of the following external knowledge sources has been used in your company's innovation activities (1= "not used/no information was obtained"; 7= "key source/crucial information was obtained"). 1. Suppliers of equipment, materials, components, or software* 2. Customers* 3. Rivals* 4. Other enterprises in your sector that are not direct competitors (e.g., operating in other geographic regions) 5. Other enterprises in other sectors 6. Experts/consultants 7. Commercial laboratories/R&D enterprises 8. Private research institutes 9. Universities or other higher education institutions 10. Government research organizations 11. Conferences, meetings 12. Fairs, exhibitions 13. Professional and industry/trade associations* 14. Scientific journals and trade/technical publications 15. Public databases alien to your company (e.g., Internet)* 16. Patents* 17. Technoparks and enterprises in technoparks 18. Technology transfer offices/centers (TTO/TTC)	[3] [19] [112]
Open technology strategies	Please indicate your level of agreement/disagreement regarding the use of following open technology strategies in your company's innovation activities (7-point scales, where 1= "strongly disagree" to 7= "strongly agree").	
Technology acquisition strategy	1. External partners are directly involved in all our innovation projects.* 2. All our innovation projects are highly dependent upon the contribution of external partners. 3. Our enterprise often buys R&D-related services from external partners. 4. Our enterprise usually buys an intellectual property, such as patents, copyrights, or trademarks, from external partners to be used in our innovation projects.	[2]
Coupled strategy *(Collaboration strategy with partner - Open production strategy)*	1. In innovation projects, our enterprise usually integrates all internal and external partners' information. 2. In innovation projects, our enterprise coordinates the activities of exchange of information among partners. 3. In innovation projects, our enterprise keeps internal and external partners updated about new information. 4. Generally, designing new products by setting up strategic alliances with complementary partners is considered very important to our success.* 5. Our enterprise combines knowledge from acquired by the external sources with internally produced knowledge and commercialize them.* 6. Our enterprise develops open-sourced projects. 7. Our enterprise conducts open production through the community's participation (peer to peer production). 8. Our enterprise aims to enhance knowledge production by setting up joint ventures.	[2] [112]
Business performance	Relative to your major rival in your industry, please indicate your company's performance over the past three years on each of the following criteria (1= "much worse", 7= "much better").	
New product development performance	1. New product introduction rate 2. New product success rate 3. Degree of new product differentiation 4. First to market with new applications 5. New product cycle time (e.g., inception to rollout) 6. Acquiring the image of an innovative supplier	[113]; [2]
Open innovation performance	1. The number of patents* 2. The number of co-patents 3. The number of R&D agreements 4. The number of R&D joint ventures 5. The number of manufacturing agreements 6. The number of joint ventures for co-production	[112]; [12]
Financial performance	1. Return on investment 2. Sales 3. Market share 4. Profitability	[114]
Customer integration	Please indicate your level of agreement/disagreement regarding the extent of your customer's involvement in your company's innovation activities (7-point scales, where 1= "strongly disagree" to 7= "strongly agree"). 1. We frequently are in close contact with our customers. 2. Our customers give us feedback on our quality and delivery performance. 3. We consider our customers' forecasts in our supply chain planning. 4. Our customers do not have access to our production plans. 5. We consider our customers as our partners. 6. Our customers involve us in their improvement efforts.	[132]; [133]

Notes: The marked (∗) items are deleted and removed from further analysis.

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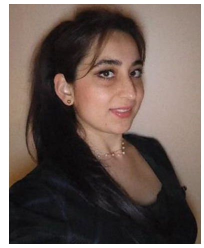

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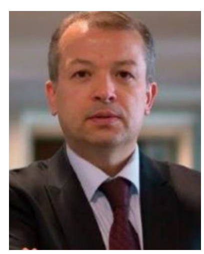

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