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DEVELOPING A TOOL FOR MEASURING KNOWLEDGE ABSORPTIVE CAPACITY AND ASSESSING ITS EFFECT ON INNOVATION PERFORMANCE OF IRANIAN PHARMACEUTICAL COMPANIES

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ABSTRACT: Now a day's establishing and sustaining competitive advantage depends on the effective development of Knowledge Absorptive Capacity (KAC) and innovations. This study evaluated the role of prior technical experiences in developing firm's absorptive capacity and the contribution of this type of capacity to the firm's innovation performance. In this study we designed a questionnaire to assess firms' KAC and innovation performance. First, the validity and reliability of the questionnaire were assessed. The data were collected from owners/managing directors or research and development managers of 20 Iranian pharmaceutical and biopharmaceutical companies. The following variables were measured: industrial and technical experiences of owners/managing directors and the members of research and development teams, KAC, innovation performance indices and control variables. The questionnaire had appropriate validity and reliability. The findings indicated that the breadth and the depth of the owner's/managing director's industrial experiences properly reflected KAC of a pharmaceutical company. In turn, the present research showed that the absorptive capacity of a firm could affect its innovation performance. Organizational strategic regeneration and innovation depends on two critical sources: learning at the organizational and individual levels. KAC plays a critical role in pharmaceutical company's innovation outputs.

INTRODUCTION: The concept of absorptive capacity has received much attention in academic literature [1, 2]. Researchers have depicted the relationship between absorptive capacity and innovation performance [3], organizational antecedents [4] and business performance, and organizational learning [5]. Cohen and Levinthal conceptualized absorptive capacity as a firm-level learning process and expanded their conceptualization in 1990. They defined absorptive capacity as "the firm's ability to value, assimilate, and apply external knowledge". Exploiting the knowledge acquired from external sources usually requires converting its content into operational

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form, in view of that Zahra and George expanded the absorptive capacity model and added transformation as a new dimension to the original three dimensional model (Acquisition, assimilation, and exploitation) [6]. In line with recent studies [3, 7, 8, 9, 10] this research follows the reconceptualized construct proposed by Zahra & George 2002 who discriminate between potential absorptive capacity (which includes acquisition and assimilation) and realized absorptive capacity (which includes knowledge transformation and exploitation). A considerable number of experimental studies have used Knowledge Absorptive Capacity (KAC). They typically measure this type of capacity using various Research and Development (R & D) proxies, such as firm's R & D outputs (*e.g*. number of patents), inputs (*e.g*. R & D intensity), and total investments in R & D [11].

However, the result of the application of these proxies may mislead the pharmaceutical managers about the essence and the role of absorptive capacity. For example, the use of the number of patents for measuring absorptive capacity of various firm (which differ in terms of their propensity to patent their innovations) may understate their real absorptive capacity [12]. In contrast, R & D expenditures is not the only source of absorptive capacity, because employees' skills and experiences and organizational experiences and experiments [13] can significantly affect a company's absorptive capacity. Accordingly, Lane suggests to measure a firm's absorptive capacity in non-R & D contexts by using indicators that capture different dimensions of absorptive capacity process [11].

These limitations clearly indicate our need for a valid measure which can simultaneously assess all the various dimensions of absorptive capacity. Based on KAC conceptualization, personnel in an organization should be enabled to assimilate, transform, and integrate new knowledge with the existing knowledge obtained from organization's prior knowledge. Two dimensions defined to measure prior knowledge of an organization are its breadth and depth. The breadth of or diversity in the staff's knowledge background and experiences contributes to the firm absorptive capacity. A greater depth of previous knowledge leads to a deeper perception of the new knowledge obtained from external knowledge sources, so it results in the development of a higher absorptive capacity [6]. Few studies have investigated the contribution of individual staff's prior knowledge to firm's KAC [11, 14]. In medium sized organizations a small number of R & D personnel are involved in research activities, so the breadth and depth of staff's prior industrial experiences have a stronger contribution to an organization's KAC and the R & D activity per se. Since the staff who are responsible for knowledge scanning in a firm are its owner and R & D personnel, consequently, they will have more technological information than inexperienced ones [15]. Thus it was hypothesized that the owner's/ managing directors and the R & D personnel's breadth and depth of technical experiences could positively affect firm's KAC.

Because of disruptive changes in the pharmaceutical industry in recent decades, new products can make additional changes to existing compounds. In most researches, the outputs of the development process in pharmaceutical firms are defined as patents, patent applications, products (both in pre-clinical and clinical trials), and products which have entered into the market [16, 17]. These outputs have a heavy weight in the evaluation of a pharmaceutical company in terms of financial performance. Deeds D (2001) assessed the level of technical development capabilities along with R & D investment and absorptive capacity with the proxy of number of research communities participating to investigate the impact of these variables on entrepreneurial wealth created in pharmaceutical biotechnology firms. Based on the results of their study, within a research-intensive environment, the strategy of product development through an increase in R & D investment and new ventures leads to the creation of entrepreneurial wealth [18].

Other studies have shown that more patents are produced when a pharmaceutical firm performs basic research, because such firms are better at capturing spillovers. Lim K (2004) approved this theory by investigating the impact of basic and applied research on innovation outputs in pharmaceutical industry [19]. Another study focused on the strategies and operations of US-based biotechnology firms to investigate the exploration and exploration of activities through alliances [20]. In contrast, some studies have assessed the link

between knowledge input and new product introduction in pharmaceutical companies. Although they showed that the firms with applied science foundation had more potential for introducing new products, they did not find a clear link between increasing absorptive capacity and innovation outputs [21]. Thus it is obvious that little attention has been paid to the effect of the possible interaction between knowledge absorptive capacity-building activities and firm's innovation performance in pharmaceutical companies, particularly generic-drug producers.

For this reason the second hypothesis of this study was set to explore the effect of the interaction between knowledge absorptive capacity and innovation performance. It was hypothesized that a higher level of firm's KAC would result in better innovation performance. **Fig. 1** presents the conceptual framework used in this study which is based on the two hypotheses.

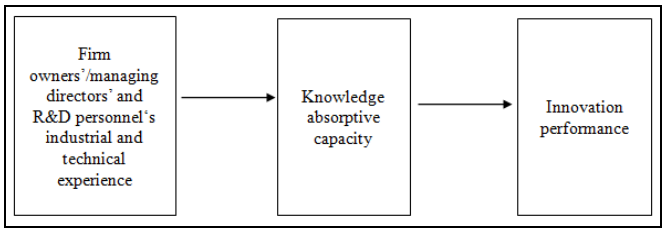

FIG. 1: A CONCEPTUAL FRAMEWORK OF KNOWLEDGE ABSORPTIVE CAPACITY AND INNOVATION

National pharmaceutical industry is experiencing a double digit growth in sales of products and is supplying a higher amount of pharmaceutical products domestically [22]. In a dynamic context which is emerging newly, US Food and Drug Administration is approving products as soon as they are introduced to the market, thus the industry is witnessing a phenomenal growth in the number of small sized companies in addition to the medium ones. Hence we found it very valuable with a great potential to investigate both categories in our model and hypotheses.

METHODS: We conducted a survey to address the aforementioned research objectives. Energy and time were devoted to design a questionnaire to obtain the best data from respondents based on the conceptual framework. Before the preparation of the questionnaire draft, the authors reviewed relevant models that had already been validated [23, 24, 25]. The proper items were generated on the basis of Iranian pharmaceutical context and the theoretical framework. The items were assessed in terms of validity and reliability. In order to assess face validity, the questionnaire was evaluated via a stepwise approach. In the first step, the primary draft of the questionnaire was evaluated and the changes required to increase the fluency and comprehensibility of each question were made during the several meeting of the authors. The second step was focused on the feasibility of using the questionnaire and comprehensibility of the sentences from respondent's perspective.

Therefore, 10 respondents were invited to give their option about the clarity of the questions. Their comments and ideas were collected and they were allowed to do any necessary changes. For the assessment of content validity, the relevance and clarity each item was evaluated during the team meetings and the changes were noted. Then the comprehensiveness of the questionnaire was evaluated. The item- and scale-related content validity indices and comprehensiveness of the questionnaire were calculated. Both clarity and relevance were evaluated on a scale ranging from 1 (inappropriate) to 4 (appropriate). The same scale was applied for comprehensiveness. Six professionals were asked to participate in validity assessment and make any changes to the items to improve their clarity when required; they were also recommended to add relevant items and delete irrelevant items in the questionnaire [26].

The inter-rater agreement was used to evaluate the reliability of the process of validity assessment. The mentioned approach was less conservative. "Agreement" was achieved when at least 80 percent of the respondents gave a score of 3 or 4 to an item. The minimum acceptable level for inter-rater agreement index was 70 percent which was calculated as the ratio of "agreement" items to the total number of items. In the next step, content validity index was calculated. This index was described as the average of the item content validity indices in each scale [26, 27]. The minimum acceptable level defined a priori for scale validity was 0.8. In following the item content validity index was defined as the number of rater who rated the similar scores (3 or 4) out of the total numbers of raters [28].

This index was used to make specific decisions about individual items, and the minimum acceptable level for this index was 78 percent. Comprehensiveness index was assessed by dividing the number of experts who judged the questionnaire as "somewhat comprehensive" and "comprehensive" by the total number of experts [26, 29, 30]. Cronbach'salpha was used to assess internal consistency of the questionnaire. Cronbach's alpha reliability is one of the most widely used measures of reliability in the social and organizational sciences., Cronbach's alpha >0.80 is an indication of high reliability whereas Cronbach's alpha <0.60 demonstrates a low level of reliability [31]. Cronbach's alpha of the scale was 0.83.

In this study, 22 domestic biopharmaceutical and pharmaceutical companies were chosen from among all the pharmaceutical and bio-pharmaceutical companies in Iran. Based on the inclusion criteria, we only selected the companies which had manufactured at least five new products a year in the past five years based on Iranian Food and Drug Administration Statistics Letter. Questionnaires were sent to the owners/managing directors and R & D managers of the firms then several methods were used to remind participants to complete the survey. As a result, 20 companies completed the questionnaire (a response rate of 90.9 percent). The number of personnel working in biopharmaceutical and pharmaceutical companies ranged from 56 to 935, and 65 percent of the companies had less than 400 employees. Most of them (63.2 percent) had less than 15 R & D personnel (range: 3-32). Their R & D intensity, defined as R & D expenditures divided by sales, ranged from 0.07 to 16 and in most companies (75 percent) it was less than 3 percent in the past five years. About 65 percent of the firms had a marketing intensity less than 3.5% (range: 0.04-12) and 55 percent of the selected companies a sales intensity less than 6% (range: 0.9-16).The research variables were measured by the questionnaire. The content of the questionnaire included the following items.

Knowledge Absorptive Capacity: Each firm's knowledge Absorptive Capacity (KAC) was measured by 23 items (Appendix, **Table 1**) which were designed based on the four dimensions of the capacity defined by Zahra and George, 2002.

- Knowledge acquisition; to measure a firm's ability in searching, evaluating, collecting, and documenting technical knowledge imported from useful external sources.
- Knowledge assimilation; to evaluate a company's ability to analyze and interpret acquired external knowledge and understands other external know-how in their own R & D procedures, resulting in the involvement of R & D personnel in various new knowledge investigation activities.
- Knowledge transformation; to assess R & D personnel involvement in organizing, storing, and maintaining assimilated external knowledge and engagement with other staffs and top managers in technical problem solving and organizational strategic planning.
- Knowledge exploitation; to measure the firm's ability to utilize transformed external knowledge in new products and technologies, and develop commercial capabilities.

The respondents were asked to rate each item by a five-point rating scale based on their company's behavioural manifestation in the past five years (2010-2014). Each company's KAC score was the sum of the 23 ratings, therefore, the higher the score, the higher was the KAC of the company.

Industrial and Technical Experience: A firm owner's/managing directors and R & D personnel's depth and breadth of industrial and technical experience were assessed separately. An owner's/ managing director's experiences were divided into three categories: marketing, R & D, and production operation. The breadth of experience was assessed by the number of activity categories he/she had ever performed till then in the biopharmaceutical and pharmaceutical industry. The five-point rating scale was designed to measure R & D staffs' breadth of experiences and their involvement in the five categories of jobs, including manufacturing operations, sales and marketing, production-related jobs, research and development related jobs, and marketing related jobs in pharmaceutical industry in the past five years. The sum of the five ratings represents the R & D personnel's breadth of experiences. Owner's/managing directors and R & D staffs' depth of experiences were assessed by the number of years they had been working in the pharmaceutical industry.

Innovation Performance: Six items were used to measure a biopharmaceutical and pharmaceutical company's performance in product and process innovation projects in the studied years (Appendix, **Table 2**). The respondents rated each item using a five point scale to assess the innovation performance on the basis of the targets they set at the start of the R & D programs. In the present study "innovation" was defined as "new for the company".

Control Variables: Innovation performance may differ because of the differences in the company age, size, number of R & D personnel and intensity, and marketing and sales intensity. These variables served as the controls in this study. The age of the firm was calculated since the introduction of the first product to the market till the time of the study. The size of the company was measured by its number of employees. The number of R & D personnel was defined as the number of staffs who were involved in innovation-related tasks. The R&D, marketing, and sales was measured by the ratio of the firm's expenditures on each item divided by the total sales in the past five years (2010-2014).

RESULTS: The questionnaire was developed based on the results of validity and reliability tests. Based on the results of interviews with 10 respondents, three items were revised. All the six raters completed the form. Based on the ratings and comments of the experts, inter-rater agreement for the clarity and relevance of all the items was 100 percent. The scale content validity index for both clarity and relevance were 93.6 percent and 99.4 percent respectively, which were higher than the minimum acceptable level (80 percent). The comprehensiveness of the questionnaire was calculated to be 100 percent. Panel data regression analysis was used to investigate the contributions of owners/managing directors and R & D staffs to knowledge absorptive capacity in bio-pharmaceutical and pharmaceutical companies in Iran and also their KAC relation to the company's innovation performance,. In this study, model 1 was used to investigate the impact of the control variables (age, size, number of R & D personnel, R & D intensity, marketing intensity, and sales intensity) on dependent variables. Then, in model 2 followed by the range of independent variables expressed in the research predictions to investigate the further contribution of these variables to a pharmaceutical firm's KAC or innovation performance.

Personnel Experience and Firms' Knowledge Absorptive Capacity: As the company's age, R & D intensity, and marketing intensity were not significantly related to KAC ($p>0.05$), these control variables were excluded in the regression analysis. Four remained control variables (R & D personnel, R & D intensity, marketing intensity, and sales intensity) together accounted for 11 percent of the total variance in pharmaceutical company's KAC **Table 1**. When the four experience variables were added to the model 2, there was 47 percent increase in the total variance and the size of total variance increased to 58 percent. The size (β = 0.01), sales intensity (β = 0.31), owner's/managing director's breadth (β = 0.39) and depth of experiences (β = 0.62) and R&D staffs' depth (β = 0.64) of experiences were significantly related to the firms' KAC. It is obvious that the owner's/managing director's experiences are more critical than the R&D staffs' experiences in contributing to a firm's KAC.

TABLE 1: RESULTS OF THE REGRESSION ANALYSIS OF BASIC FIRM VARIABLES AND PRIOR EXPERIENCES ON KNOWLEDGE ABSORPTIVE CAPACITY

	β	
Predictors	**Model 1**	**Model 2**
Size	0.01*	0.01***
Number of R & D personnel	0.06*	0.11
Sales intensity	0.37*	0.31*
Owner's/managing director's breadth of experience		0.39**
Owner's/managing director's depth of experience		0.62***
R&D staff's breadth of experience		1.18
R&D staff's depth of experience		0.64***
R^2	0.11	0.58
ΔR^2		0.47
F	2.25	10.89

*p < 0.05; **p <0.01; ***p <0.001

Knowledge Absorptive Capacity and Firm's Innovation Performance: The sales intensity was not significantly related to firm's innovation performance so it was not included as a control variable in the regression model. When value of KAC was entered into the regression analysis after control variables, it accounted for 24 percent increase in residual variance in firm's innovation performance (Model 2, **Table 2**). Knowledge absorptive capacity (β = 1.20) significantly contributed to and independently influenced innovation performance while the other variables including age (β = 2.23), R & D intensity (β = -6.29), marketing intensity (β = 9.98) had the same impact. It is worth noting that unlike most previous theories, R & D intensity had a negative impact on firm's innovation performance. However, our predication for an interaction effect between KAC and firm's innovation performance was approved.

TABLE 2: REGRESSION ANALYSIS OF THE CONTRIBUTION OF KNOWLEDGE ABSORPTIVE CAPACITY TO INNOVATION PERFORMANCE (AS THE DEPENDENT VARIABLE)

	β	
Predictors	**Model 1**	**Model 2**
Age	2.28*	2.22***
Size	0.25*	0.43
R & D intensity	-5.88**	-6.29**
Number of R & D personnel	5.99*	4.70*
Marketing intensity	10.06**	9.97**
Knowledge absorptive capacity		1.20***
R^2	0.23	0.47
ΔR^2		0.24
F	2.81	5.43

Notes: *p < 0.05; **p <0.01; ***p <0.001

DISCUSSION: The aim of the present study was to investigate the impact of personnel's prior technical experiences on a firm's KAC and the contribution of this capacity to Iranian pharmaceutical companies' innovation performance. In order to achieve this goal a valid and reliable questionnaire was developed to measure biopharmaceutical and pharmaceutical firms' KAC and innovation performance. Numerous instruments are presented in previous studies to evaluate organization absorptive capacity, but a small number of them have used a questionnaire. In this study both types of Iranian biopharmaceutical and pharmaceutical companies, *i.e*. semi public and private companies, were selected for the study, therefore we faced some limitations to collect the data. The authors believed that collecting data through a survey might demonstrate a better picture of the appropriateness of the conceptual frame work; the findings supported this idea.

In small and medium sized firms, the top manager and R & D staff may play an important role in acquiring and utilizing the new knowledge which is required for a better innovation performance [25, 32, 33]. In the present study it was assumed that the prior industrial experiences of owner/managing director and the R & D personnel had a major contribution to firm's KAC which in turn might influence knowledge exploration. The data collected from 20 Iranian pharmaceutical companies indicated that aside from company variables (size and sales intensity), the breadth and depth of owner's/ managing directors and R & D staff's prior technical experience significantly contributed to a firm's KAC. The data collected from the pharmaceutical companies provided a support for the results of prior investigations, indicating that an organization's KAC remains in both the organization itself and the individuals in the organization [11].

Moreover, the results support Lim's and Klbas's findings that the owners of smaller organizations play a more critical role in innovation and company's knowledge management [34]. In line with our findings about R & D personnel, Spithoven says that the employment of skilled R & D personnel can greatly contribute to internalizing external knowledge and firm's absorptive capacity [35], because in these organizations, unlike large enterprises, both top managers and R & D staff are the key persons involved in technological scanning and R & D investment strategies [15]. Hence, the our finding implies that in order to build and expand a firm's KAC, owner's or managing director's industrial experiences must be elevated and top managers should also employ qualified and well experienced R & D staffs to develop firm knowledge utilization's ability.

The collected data showed that the age of the company, number of R & D staff, and marketing intensity had a positive impact on a firm's innovation performance, but unlike most previous studies, for example studies by Stock, and Leahy and Neary, the interaction effect of R & D intensity

on firm's innovation outputs was not confirmed by the data [36, 37]. The lack of interaction effect may be attributed to the small sample size of this study (n=20). It might be also attributed to the argument that companies do not properly calculate their R & D expenditures or they do not accurately declare their R & D intensity due to some privacy concerns. Meanwhile the shortage in findings should not prevent the firm's manager or owner to invest in R & D activities. One of the strengths of the present study was the measurement of firm's KAC through a questionnaire not R & D proxies. Based on the results, marketing intensity showed a considerable contribution to a firm's innovation performance, because when a pharmaceutical company invests more in marketing activities, it can perform more precise and comprehensive market research which helps the company to understand market needs faster than its competitors. Watts AD found that the age of biotechnology firms was positively related to innovation profitability while this was not approved for pharmaceutical companies [38]. Our results showed that the age of both categories of firms, *i.e.* biopharmaceutical and pharmaceutical firms, played a role in company's innovation performance. The older companies have more potential and investment productivity for innovation performance. When the data on KAC were entered into the model, the contribution of other variable disappeared. This finding is consistent with the results of prior studies which investigated the relationship between firm's KAC and innovation performance.

Thus, the results indicated the appropriateness and robustness of our model implemented to assess Iranian biopharmaceutical and pharmaceutical companies' KAC and its impact on innovation outputs. KAC results in a considerable advantage for the company through increasing the productivity of the company's R & D investment and the return on R & D investment. Firms investing more in research activities which are aimed to enhance knowledge absorptive capacity will provide superior search, in terms of importance of innovative outcomes. Furthermore, the studies on organizational innovation argue that information acquired from external sources facilitate the generation of new ideas and enhance product invention.

CONCLUSION: The results of this study suggest that organizational strategic regeneration and innovation depends on two critical sources *i.e.* learning at the organizational and individual levels. The results of the study reflect that the owners or managing directors of a company must enrich the breadth and depth of their own industrial experiences and actively use future opportunities through acquiring various sources of knowledge.

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