A Scale Development for Innovation Capability Measurement

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***Abstract*—Innovation capability is one of the most important concepts for an organization to have competitive advantage. There has been not any consensus on defining and measuring innovation capability because of its nature. Thus, innovation capability and related concepts have been interchangeably used in the literature. This has caused confusion in measuring it. The aim of this paper is to generate a solution for this confusion by presenting a literature-based model and developing a measurement scale. For this purpose, the literature was thoroughly reviewed to identify innovation measurement-related studies and a model was presented. Measurement items were also gathered from literature and eliminated by evaluating each item in accordance with the model and pretest. In order to obtain a measurement scale, a survey was conducted with enterprises in Turkey. One general scale and a specific scale for Small and Medium Enterprises (SMEs) were developed by using factor analysis.**

***Index Terms*—innovation capability, model, measurement, scale**

I. Introduction

Organizations must be innovative to have a competitive advantage by developing new products, processes, novel marketing, and organizational methods. In order to become innovative, an organization has to develop and improve its innovation capability. Managing creativity and capabilities, such as innovation capability, is one of the basic elements of an innovative organization [1]. Innovation capability can be defined as "a firm's ability to apply the collective knowledge, skills, and resources to innovation activities relating to new products, processes, services, or management, marketing or work organization systems, in order to create added value for the firm or its stakeholders" [2]. In this study, we built our model on this definition. In the literature, innovation capability is mentioned in a good number of studies; however, the innovation capability measurement scale and proposed measurement models have been limited, because the measurement of innovation is likely to be difficult due the broad nature of the scope of innovative activities [3], [4]. It is difficult to measure innovation since innovation is a continuous and gradual process and [5] and is challenging because of its intangible nature [6], [1]. Ref. [6] also mentions that adequate measurement of innovation capability is difficult. Simultaneously, innovation capability and related concepts such as innovation performance, innovation capacity, innovative capability, innovativeness, organizational innovation, and innovation have been interchangeably used in the literature [2]. Interchangeable usage of these concepts has caused confusion in defining and measuring innovation capability. The main purpose of this study is to generate a solution in order to eliminate this confusion by presenting a literature-based model and developing a scale for measuring innovation capability.

For this purpose, first, a conceptual model of innovation capability measurement based on a review of the innovation capability and performance measurement literature was proposed. Each model in our literature review was analyzed based on its own focus to decide components of our model. After that, measurement scale items were gathered from literature and eliminated by evaluating each item while taking into account assumptions of proposed model consideration. Third, these items were sent to business and academic experts to evaluate the initial item pool in accordance with measuring innovation capability and then, we gained the final items pool. In order to validate the model, a survey was conducted to collect data after pretest. Finally, factor analysis was used to develop the final measurement scales, a general one for companies at any scale, and a specific one for SMEs.

This paper contributes to innovation capability literature by proposing a model to clarify the measurement of innovation capability and developing a useful tool to measure innovation capability. In the next section, the model development process is described and is followed by the third chapter that includes how item generation is done. After that in the fourth section, data analysis and results are explained. Finally in the last section, conclusion with further research ideas is expressed.

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II. Innovation Capability Measurement Models

In this phase, the main purpose is to capture the models that explain how innovation capability should be measured; nevertheless, all the articles that proposed measurement models related to innovation are also gathered to be examined. The measurements of innovation capability and innovation performance have been studied and have followed potential, process, and outcome approaches predominantly [7], [8], [1], [9]. Ref. [9] suggests that innovation measurement should consist of measurement of innovation capability, innovation output, and innovation performance. In their study, innovation capability is composed of innovation inputs, determinants, and activities; moreover, measurements of innovation types are addressed under measurement of innovation output. Similar to ref. [9] and ref. [8] distinguish concepts as innovation capability and output, whereas ref. [10] measures innovation capability as a measurement of innovation impacts. Furthermore, ref. [1] considers all the elements that influence an organization's capability to manage innovation, and they include results of innovation activities in innovation capability. Correspondingly, ref. [11] measures innovation to analyze financial performance of the organization via considering innovation input, innovation throughput, and innovation output. There are various approaches that models embrace; for instance, ref. [12] investigates innovation capability under capacity to innovate in their model. Moreover, ref. [13] defines innovation and draw borders of performance and capabilities with a different approach. They distinguish innovation into three phases: propensity, posture, and performance. Posture is clarified where the organization stands in the big picture of the system, and it also consists of culture, competition, and knowledge. Propensity is explained by the ability of the organization to capitalize the posture and contained processes, routines, and capabilities. Finally, performance includes output, outcome, and impacts of the system. Innovation capability takes place under propensity in this model. Simultaneously, while examining models, measurement scales were carefully scrutinized by taking pre-mentioned models into consideration. A substructure was prepared based on research on measurement scales from related databases. The questions in the scales and aspects of the models were compared. The reason behind this was to gain a measurement scale and to provide harmony between models and measurements in the literature. It was procured that the purpose of asking the questions of the models was unanimous. For instance, some authors have used qualitative questions to measure innovation performance, but if addressing of the questions points out innovation capability, the questions will be able to transform, if necessary, to innovation capability questions [14], [15]. Borders between innovation capability and innovation performance were drawn after investigating the models of ref. [1], ref. [9], and ref. [11] based on their structure. In this study, we propose that innovation capability should be measured by potential and process focused, which will be discussed in the following subsection.

A. Assumptions of the Model

In this subsection, we mention assumptions of our model considering literature that we discussed earlier.

1) Potential and process focused measurements should be conducted.

Not outcome-focused approach: The reason behind is that the tendency moved to innovation performance while focusing on outcome. Basis of measurement confusion is formed by not distinguishing innovation capability and innovation performance in the literature. Capabilities of the system are qualifications that enable innovation [5]. In addition, measuring outputs of the system is appropriate for just few types of innovations [1]. For small or service organizations, measuring outputs of the system is not recommended [6].

Not only potential (input) focused approach: Not every type of organization has equal opportunities to invest in R&D, but also it does not mean that innovation capability and R&D investments are directly proportional [6].

2) The model should include more than one dimension

Inconsistency also occurs in defining and distinguishing dimensions of innovation [2] that reflects dimensions of innovation capability. There are one-dimensional and multidimensional typologies of innovation in the literature. For instance, ref. [16] proposes five dimensions of innovativeness, such as product innovativeness, market innovativeness, process innovativeness, behavioral innovativeness, and strategic innovativeness. In a similar vein, four different types of innovations are included in ref. [17]: product innovation, process innovation, organizational innovation, and marketing innovation. Innovation capability, by its nature, supports multidimensional construct [2], as measurement of it cannot be directly conceivable [1]. In this study, OSLO Manual's dimensions are adopted to measure innovation capability related to process phase of the system.

Hence, while measuring innovation capability, potential and process are considered in accordance with the literature review. Potential part includes innovation resources and culture. Innovation resources cover R&D personnel, R&D budget, equipment, training, etc. whereas innovation culture means operational and managerial attitude, belief, approach, commitment, etc. towards on innovation. Moreover, innovation culture affects innovation resources and activities. At the same time, process part of the model includes four innovation types introduced by OECD and each type has three phases such as research, development, and commercialization/exploitation (Com/Exp). For each innovation type, after research and development phases, in order to create added value for products, processes, services, or management, marketing or work organization systems commercialization or exploitation phase is performed. The literature-based proposed model, in addition to inspiration from ref. [9], ref. [11], and ref. [13]'s models, includes innovation types and indicators. This model can be seen in Fig. 1.

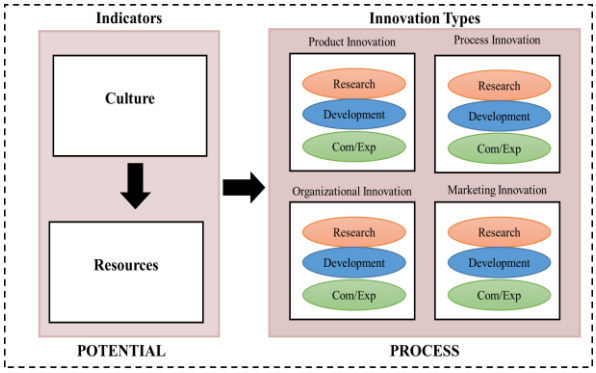

Figure 1. Proposed literature-based measurement model.

III. Item Generation

In this part of the study, literature was thoroughly reviewed to generate the scale item pool in accordance with the model. We used prominent online databases to perform the search: ABI Inform Complete, Academic search complete, Emerald Journals, Science Direct, IEEE, and Wiley. Articles were taken from many fields such as engineering, marketing, economics, computer science, business, and management, in order to increase content validity. We searched selected keywords and a combination of them ("innovation capability," "innovative*," "innovation capacity," "innovation performance," "evaluat*," "measure*," "scale," "develop*," and "indic*"). All articles from these databases were screened to identify relevant studies. We chose 61 articles with at least one dimension of innovation measurement within 163 articles from initial investigation. Then, we eliminated 13 articles based on quantitative measurement, as we used perceptual questions in this study, and finally, 48 articles that remained can be seen in Fig. 2.

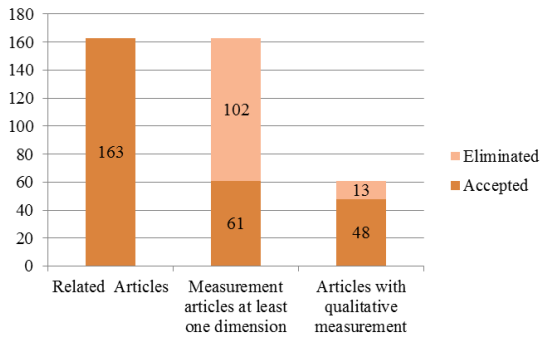

Figure 2. Studies screened to generate the initial item pool.

In this 48 articles, there were not only existing innovation capability measures but also scale development studies by ref. [18]; ref. [16]; ref. [19]; and ref. [2]. An initial item pool of 232 items was generated from all 48 articles. Since the aim was to maximize the content validity of the scale, a degree of redundancy was accepted in this stage of the scale's development [2].

A. Measurement Assumptions

As mentioned in the model development phase, measuring innovation capability with perceptual questions is more proper because innovation capability is input and process oriented. In a similar point, innovation performance is more suitable to quantitative measurement because of being result oriented. In the literature, this approach has become prominent. Ref. [20] measures innovation performance by using quantitative items, ref. [16] measures innovativeness with perceptual items. This is the critical point here that the same questions can be perceptual or numerical. In this study, we focus only on perceptual questions and do not incorporate numerical questions into the item pool. Moreover, we have some assumptions of inclusion or exclusion. First of all, items are used to measure innovation capability, innovative capability, and innovativeness; they are included directly, as these terms were used synonymously by authors. Innovativeness is defined by ref. [16] as organizational innovativeness and as an organization's overall innovative capability of introducing new products to the market, or opening up new markets, through combining strategic orientation with innovative behavior and process. Furthermore, ref. [21] uses innovativeness and innovation capability synonymously and interchangeably. Ref. [21] also mentions that his purpose of the study is to examine empirically the antecedents and consequences of innovativeness or innovation capability. Ref. [22] also uses the term "innovation capability" however, the same study is addressed in ref. [23]'s paper as the term of innovativeness. Second, items are used to measure innovation capacity and innovative capacity is incorporated into the item pool for the reason that innovation capacity is considered a component of innovation capability in our model. Third, we include items that whose innovation capability is measured under the term innovation performance that is measured perceptually by ref. [14], ref. [15]. Fourth, in a similar vein, potential- and process-oriented items are gathered from studies aiming at measuring the term "organizational innovation." For instance, while measuring the organizational innovation, ref. [4] cites some studies that used the term "innovativeness" such as studies by ref. [16].

We eliminated 112 items in accordance with the proposed model and measurement assumptions. Furthermore, 63 items that had a similar aim to measure any components of innovation capability were eliminated. Before pretest, 57 items were finalized by adding 5 novel items. These items were classified as product (Prod), process (Proc), organizational (Org), marketing (Mark), resource (Res), and culture (Cult) in accordance with the proposed model.

B. Pretest

In this stage, a pretest was conducted in order to increase content validity. A web based survey was prepared and sent to experts from academia and industry in order to select the most appropriate items. Totally, 10 academicians and 9 industry professionals responded to the survey. The experts were asked to review and evaluate the relevance of each item with respect to the definition presented for each of the dimensions on a five-point Likert-type scale that ranged from "not at all

representative" to "strongly representative" [2]. The score for each item was calculated with a simple average technique. Items with high score, ($x \geq 4.5$) were taken (8 items), and items with low score ($x<3.5$) were eliminated directly (5 items). Items with a score between ($3.5 \leq x < 4.5$) were evaluated by authors in terms of balancing among components of innovation capability. As a result, the final item pool consisted of 27 items. All these items with references can be seen in Appendix A. Fig. 3 shows the distribution of components in the pool before and after pretest.

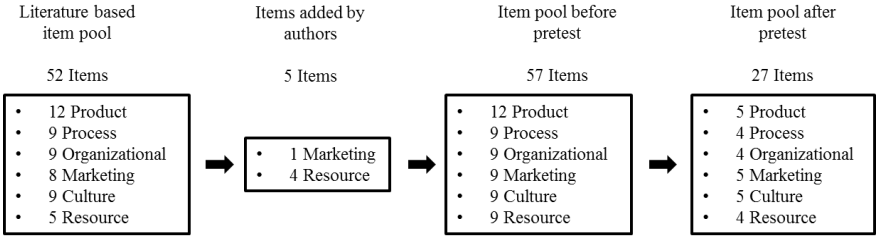

Figure 3. Items before and after pretest.

After pretest, we prepared a survey in order to collect data and analyze those using statistical techniques. We mention about data analysis and results in the next section.

IV. Data Analysis and Results

A web-based survey was prepared with explanatory information of the companies (year of establishment, sector, number of employee, and position of respondent) to collect data. An e-mail invitation that included a brief introduction and a link to the web questionnaire was sent to a senior manager to encourage them to participate. Each respondent had a unique ID code to ensure that each participant complete only one questionnaire. A number of screening questions were used to ensure only qualified respondents participated in the survey [2].The five-point Likert scales that ranged from "strongly disagree" to "strongly agree" was used to evaluate the questions. The questionnaire was sent to 624 firms from different sectors and scales. Overall, 126 questionnaires were returned, of which 107 were considered valid, and the response rate was 17%. The firms were ranged in terms of number of employee: 62% for SMEs (less than 250 employees) and 38% for large scale (more than 250 employees). According to sector, firms were manufacturing, service, and trade (72%, 22%, and 6%, respectively).

After descriptive statistics, in order to test the scale reliability, we used coefficient of Cronbach's Alpha. This coefficient should be above .70 [24], which is considered "acceptable" in most studies to provide scale reliability. Simultaneously, innovation capability types (18 items) and innovation indicators (9 items) were analyzed separately, because these components are analyzed separately while performing factor analysis. Cronbach's Alpha values of innovation capability types and innovation indicators were 0.923 and 0.903, respectively, and both these values indicated that the scales are very reliable to measure these items.

A. Factor Analysis

Explanatory factor analysis was used to identify the construct by performing Principal Axis Factoring with equamax rotation, using statistical package program SPSS Version 19. The Kaiser–Meyer–Olkin (KMO) measure of sample adequacy and Bartlett's test of sphericity were used to show the appropriateness of data for factor analysis. For this data set, KMO estimate is .903, which means excellent, and Barlett test is highly significant (<0.000). It indicates that using factor analysis is appropriate [25]. In Table I, we can see factors and their loadings. We eliminated items with a factor loading less than 0.50, and where an item had a cross-loading with any factor, its loading was above 0.4. This approach was more conservative than [26], so we could target to clarify the measurement items.

TABLE I. Factor Loadings and Cross-Loadings*

Items/ Factors	F1	F2	F3	F4	Remark
Mark3	0,73				
Mark2	0,70				
Mark1	0,60				
Mark4	0,53				
Org3		0,61			
Org2		0,59			
Org1		0,56			
Prod1		0,54			
Proc4		0,53		0,44	Eliminated due to high cross-loading
Org4		0,41			Eliminated due to low factor loading
Prod3			0,71		
Prod4			0,63		
Prod5			0,56		
Proc1		0,42	0,54		Eliminated due to high cross-loading
Proc2				0,62	
Proc3				0,61	
Mark5	.54			0,55	Eliminated due to high cross-loading
Prod2			0,43	0,44	Eliminated due to high cross-loading

* Factor loadings less than .4 were not indicated in the table

It can be seen that some items exchanged among factors compared with the earlier literature review classification. It indicated that there was confusion in the literature about measuring innovation capability. After this stage, all factors obtained were named in accordance with the model in the following way:

Factor1: Marketing Innovation Capability (4 Items)

Factor2: Organizational Innovation Capability (4 Items)
Factor3: Product Innovation Capability (3 Items)
Factor4: Process Innovation Capability (2 Items)

In a similar vein, the innovation determination group was analyzed by using Principal Axis Factoring factor analyses with equamax rotation. For this data set, KMO estimate is .89, which is very good, and Barlett test is highly significant (<0.000), which indicates that using factor analysis is appropriate [25]. In Table II, factors and their loadings can be seen. The same procedure was conducted for elimination.

TABLE II. FACTOR LOADINGS AND CROSS-LOADINGS*

Code	F1	F2	Remark
Cult4	0,87		
Cult3	0,80		
Cult1	0,72	0,41	Eliminated due to high cross-loading
Cult5	0,71		
Cult2	0,65	0,45	Eliminated due to high cross-loading
Res1	0,52	0,48	Eliminated due to high cross-loading
Res2		0,92	
Res3		0,84	
Res4		0,61	

* factor loadings less than .4 were not indicated in table

Similarly, obtained factors were named in accordance with the model in the following way:
Factor1: Innovation Culture (3 Items)
Factor2: Innovation Resource (3 Items)

TABLE III. SCALES AND ITEMS

Innovation Capability	General Scale		Scale for SMEs
Product Innovation Capability	1	Prod3	Prod3
	2	Prod4	Prod4
	3	Prod5	Prod5
Organizational Innovation Capability	1	Org3	Org3
	2	Org2	Org4
	3	Org1	Proc1
	4	Prod1	
Process Innovation Capability	1	Proc2	Proc2
	2	Proc3	Proc3
	3		Proc4
Marketing Innovation Capability	1	Mark3	Mark3
	2	Mark2	Mark2
	3	Mark1	
	4	Mark4	Mark4
Innovation Culture	1	Cult4	Cult4
	2	Cult3	Cult3
	3	Cult5	Cult5
Innovation Resource	1	Res2	Res2
	2	Res3	Res3
	3	Res4	Res4
Total		19	18

According to this results, the final measurement scale has 19 items that can be seen in Table III. The gray boxes indicate the different items on scale for SMEs apart from general scale.

Ultimately, all stages of the scale development process were performed. Table IV shows these stages and number of items obtained at each stage.

TABLE IV. STAGES

Stages	N of Items
First Item pool from literature	232
Items are accordance with the model	120
After elimination of similar targeted items	52
Items added by authors	5
Last Item pool (in Pretest)	57
Items after pretest(in Survey)	27
Final scale	19

At the same time, organizations have different sizes and operate in very different business areas. Therefore, we pursued to compare organizations in terms of size and sector. First, companies were grouped as SMEs and large-scales and compared by t-test to see if there is any differences. Some differences were found in terms of several factors. Thus, we intended to analyze these groups separately in order to create specific scale for each groups. However, there was not enough sample size from large-scales to conduct factor analysis. Therefore, the same analyses were conducted only for SMEs. Cronbach's Alpha values of innovation capability types and innovation indicators were 0.927 and 0.892, respectively. It means that the scale is reliable for these item groups. For this dataset, KMO estimates are .89 and .84, respectively, and Barlett test is highly significant (<0.000). It indicates that using factor analysis is appropriate [25]. A final measurement scale was developed for SMEs, specifically as a result of factor analysis in the same procedure that we mentioned earlier. The final measurement scale has 18 items that can be seen in Table IV. It shows that some items in the specific scale for SMEs were differentiated from general one. 1 item was added in process innovation, 1 item was removed from marketing innovation, and 2 items of organizational innovation were added instead of removed 3 items. Product innovation capability factor and innovation determinants factors had the same items for two scales.

The change in organizational innovation capability shows that it is harder to measure it than other types of innovation capability. All items of innovation resource and product innovation capability factors are steady, which means that these factors are more tangible and easier to measure. On the contrary, results show that the items of innovation culture factor are the same in different measurement scales, even though innovation culture is expected to differ in terms of company size. On the other hand, manufacturing and service sectors were compared but there were no differences between them in terms of factors that we obtained.

V. Conclusion and Further Research

In this study, our main purpose was to develop a scale in order to measure the firm's innovation capability. However, we faced challenges due to the intangible nature of innovation and difficulty in adequate measurement of innovation capability [6]. In addition, innovation capability and related concepts were interchangeably used in the literature. This usage caused confusion in defining and measuring innovation capability. We proposed a literature-based model and developed a scale for measuring innovation capability in order to present a solution for this confusion. Literature was thoroughly reviewed to propose a model and generate measurement items used in previous studies. The items had been eliminated in accordance with our proposed model after gathering from literature. Then, a pretest was conducted to obtain an initial measurement scale. By conducting reliability test and factor analysis, we created the final measurement scale. However, some differences were seen while comparing SMEs and large-scale companies. These differences showed that the firm size should be taken into consideration when measuring innovation capability. Hence, we conducted the same procedures and developed another specific scale for SMEs. These two scales can be used by companies to evaluate their innovation capability. Simultaneously, these scales can be used by policy makers to see the general picture of companies that are given public support in order to improve innovation capability.

On the other hand, this study has several limitations. Initially, we have not enough data to develop a specific scale for large enterprises. Moreover, even though we have a strong literature-based model and its items, we could not validate the scales because of the lack of data. Although these limitations are acknowledged, research findings provide a basis for future research. First, the developed measurement scales could be validated with large data and compared as business area and size. Second, researchers could ask whether there are any differences between younger and established companies about measurement scales. Finally, the scales could be used by researcher to show the relationship between innovation capability and other organizational factors, such as learning capability, absorptive capacity, and firm performance.

Appendix A Item Pool and References

Code	Item	References
Prod1	Provide our clients with services that offer unique benefits superior to those of competitors	[2]
Prod2	Our firm actively carries out its work on developing existing products and creating new products.	Adapted from [27], [28], [29], [30]
Prod3	We enhance the range of our products and services with not previously released products and services.	Adapted from [31], [28], [32]
Prod4	We try to acquire new products by differing technical specifications and functionalities.	Adapted from [33], [19]
Prod5	Our company sees creating new products and services as critical tools to reach success.	Adapted from [27], [29], [32]
Proc1	Our firm reduces the developing time of new products and services.	Adapted from [20], [31]
Proc2	Our company is flexible to provide products and services according to the demands of the customers.	Adapted from [34]
Proc3	Our company develops in-house solutions to improve our manufacturing processes.	Adapted from [29], [18], [32]
Proc4	Our company actively works to constantly adjust its business processes.	Adapted from [27], [16]
Org1	Our company adopts innovative work designs.	[35]
Org2	Our company has good mechanisms for using technology from research to product development.	Adapted from [36]
Org3	We are better than our competitors in the manner of developing new managerial work, processes, and systems	Adapted from [37], [38]
Org4	We are successful in commercializing and institutionalizing of new products.	Adapted from [38]
Mark1	It is important for our company to make changes in appearance, packaging, shape, and volume of our products.	Adapted from [33]
Mark2	Our company constantly looks for new ways to deliver our products to our customers.	Adapted from [27], [28], [2]
Mark3	We implement new marketing methods to promote our products.	Adapted from [33], [28], [2]
Mark4	We make improvements in the manner of customer relationships to obtain customer satisfaction.	Adapted from [33], [27] , [2]
Mark5	New ideas that come from customers and suppliers are evaluated continuously, and we try to include them into product development activities.	[39]
Cult1	Our company sees presenting new ideas and methods to improve business processes that are important for the success of the company.	Adapted from [27], [32]
Cult2	Our company supports employees to take initiatives in creating new ideas.	Adapted from [16], [39], [40], [30]
Cult3	Our employees cleverly transforms information from internal and external sources into valuable knowledge for our company.	[26]
Cult4	Our company encourages collaboration and exchange of ideas between the departments in order to produce new approaches.	Adapted from [26], [27],[41]
Cult5	Our company tries out new ideas and methods to provide innovative solutions to our clients' problems	Adapted from [2], [16]
Res1	We constantly benefit from technology to enhance quality of products and services.	Adapted from [30], [20]
Res2	Our company has strong capacity in innovative design and manufacturing applications.	Adapted from [42]
Res3	Importance is given to training R&D personnel.	Added by Authors
Res4	Our company constantly increases the allocated budget of R&D personnel.	Added by Authors

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